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THE QUARTERLY BULLETIN OF THE SOCIETY FOR THE STUDY OF AMPHIBIANS AND REPTILES

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ROBERT W. HANSEN
16333 Deer Path Lane
Clovis, California 93619-9735 USA
HerpReview@gmail.com

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Index Editor

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Section Editors

Book Reviews
AARON M. BAUER
Villanova University, USA
aaron.bauer@villanova.edu

Current Research
BECK A. WEHRLE
University of California, Irvine, USA
bwehrle@uci.edu

BEN LOWE
University of Minnesota, USA
lowe0160@umn.edu

Conservation
PRIYA NANJAPPA
Association of Fish & Wildlife Agencies,
USA
pnanjappa@fishwildlife.org

Geographic Distribution
INDRANEIL DAS
Universiti Malaysia Sarawak, Malaysia
idas@ibec.unimas.my

JERRY D. JOHNSON
The University of Texas at El Paso, USA
jjohnson@utep.edu

ALAN M. RICHMOND
University of Massachusetts, USA
alanr@bio.umass.edu

GUSTAVO J. SCROCCHI
Fundación Miguel Lillo, Argentina
soniak@webmail.unt.edu.ar

DAVID C. BLACKBURN
California Academy of Sciences, USA
david.c.blackburn@gmail.com

STEPHEN RICHARDS
South Australia Museum, Australia
steve.richards@samuseum.sa.gov.au

Zoo View

JAMES B. MURPHY
Smithsonian National Zoological Park,
USA
jbmurphy222@gmail.com

Nomenclature

JAY M. SAVAGE
San Diego State University,
California, USA
savy1@cox.net

Herpetoculture
ROBERT HILL
Zoo Atlanta, USA
rhill@zooatlanta.org

WULF SCHLEIP
Meckenheim, Germany
wshleip@leiopython.de

Natural History Notes
JAMES H. HARDING
Michigan State University, USA
hardingj@msu.edu

SEAN P. GRAHAM
Pennsylvania State University, USA
grahasp@tigermail.auburn.edu

JACKSON D. SHEDD
TNC Dye Creek Preserve,
California, USA
Jackson.Shedd@gmail.com

JOHN D. WILLSON
University of Arkansas, Fayetteville, USA
hr.snake.nhn@gmail.com

DAVID A. STEEN
Auburn University,
Auburn, Alabama, USA
hr.snake.nhn@gmail.com

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Saint Louis University
aldridge@slu.edu

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aaron.bauer@villanova.edu

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mpreest@jcd.claremont.edu

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distichus@hotmail.com

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ssar@herplit.com

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jmendelson@zooatlanta.org

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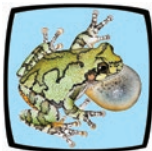
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The Society for the Study of Amphibians and Reptiles, the largest international herpetological society, is a not-for-profit organization established to advance research, conservation, and education concerning amphibians and reptiles. Founded in 1958, 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 bulletin, *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

2014 — Chattanooga, Tennessee, 30 July–3 August (JMIH with ASIH, HL, and AES)

2015 — Lawrence, Kansas 30 July–3 August (SSAR with PARC and KHS)

ABOUT OUR COVER: *Lanthanotus borneensis*



Lanthanotus borneensis, the Bornean Earless Monitor, surely among herpetology's "holy grails," is a 200-mm (SVL) varanoid lizard whose common name reflects the lack of an ear opening. This poorly known, enigmatic species is considered to be the sole living representative of the family Lanthanotidae. The only other taxon allocated to the Lanthanotidae is *Cherminotus longifrons*, from the Upper Cretaceous

in the Gobi Desert, Mongolia (Borsuk-Białynicka 1984. *Palaeontol. Polonica* 46:5–105), although this taxonomic allocation has been challenged (Gao and Norell 2000. *Bull. Amer. Mus. Nat. Hist.* 249:1–118).

The name *Lanthanotus* is derived from Greek, meaning "hidden ears," but a shallow tympanic cavity is present. Males show blunt, rectangular jaws, while females have relatively pointed jaws. The dorsal surface is brownish-orange, sometimes with a dark vertebral stripe, and the venter is yellow with brownish-orange and ochre mottling; the tongue is pink.

The Lanthanotidae has been assigned to the anguimorph lizard (McDowell and Bogert 1954. *Bull. Am. Mus. Nat. Hist.* 105:1–142), but the relationships among these families have been the subject of debate. Lee's cladistic analysis (1997. *Phil. Trans. Royal Soc. London B* 352:53–91), based on osteological characters, reveals that the lanthanotids and varanids are the closest relatives of snakes. An early molecular study of Fuller et al. (1998. *Mol. Phylogen. Evol.* 9:294–307), using 12S rRNA sequences, showed surprisingly low sequence divergence between these two groups, and a sister-taxa relationship was revealed by Ast (2001. *Cladistics* 17:211–226). More recent molecular studies of global squamates using nuclear genes confirm the position of the Lanthanotidae within the Anguimorpha, with a sister relationship with the Varanidae; these two lineages, along with Shinisauridae, are sister to the Helodermatidae and other members of the Anguimorpha (Wiens et al. 2012. *Biol. Letters* 8:1043–1046; Pyron et al. 2013. *BMC Evol. Biol.* 13:93). The most recent common ancestor node for the family corresponds to the

Mid-Cretaceous, 108 mya (Douglas et al. 2010. *Mol. Phylogen. Evol.* 55:153–167).

Described by Fritz Steindachner (1877. *Denkschr. Kais. Akad. Wiss., Wien* 38:93–96) based on a specimen now in the Vienna Museum of Natural History (Naturhistorisches Museum Wien 16365) from Sarawak, *Lanthanotus borneensis* is known to inhabit lowland forests and low hills of northwestern Borneo, including the states of Sarawak (Malaysia) and Kalimantan Barat (Indonesia), and is seldom encountered. Consequently, little is known of its field biology, and this subfossorial and aquatic species feeds on earthworms and crustaceans, and probably fish. Nocturnal, its daytime retreats include burrows up to about 30 cm, under vegetation, rocks, and litter of rocky stream banks. Semi-torpid by day, at night it forages on land and in water. Typically sluggish, it can flatten its body when touched, and other behaviors associated with threat response includes struggling, defecating, hissing, and biting. Skin is shed in a single piece, similar to that in some other anguimorph squamates and snakes. Mating has been observed in early February, females producing 2–5 oval, leathery-shelled eggs that measure ca. 30 mm in length.

Our cover image was captured by **Indraneil Das** in western Sarawak, East Malaysia (Borneo), using a Nikon D600 and AF-S VR Micro-Nikkor 105mm f/2.8G IF-ED lens. Shutter speed set at 1/60 sec, f/18, using an off-camera Nikon SB-910 flash unit, attached to a Lastolite Ezybox Hotshoe.

Das is Professor at the Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak. His current research centers on ecology and conservation of amphibians and reptiles, especially the role of fragmentation and other landscape change, and the systematics and natural history of these species, especially in tropical Asia. His work on *Lanthanotus* was supported by a Mohammed bin Zayed Species Conservation Grant.



PHOTO BY PUIYONG MIN

SSAR BUSINESS

2013 Annual Meeting, Albuquerque, New Mexico

The 56th Annual Meeting of SSAR took place from 10–15 July 2013 at the Albuquerque Convention Center in Albuquerque, New Mexico, USA (Fig. 1). Organizing societies this year were Society for the Study of Amphibians and Reptiles (along with the International Society for the History and Bibliography of Herpetology), American Elasmobranch Society (celebrating its 29th annual meeting), American Society of Ichthyologists and Herpetologists (celebrating its 93rd annual meeting) and The Herpetologists' League (celebrating its 71st annual meeting). The meeting was hosted by the University of New Mexico and the Museum of Southwestern Biology. The local hosts were Tom Turner, Lex Snyder, Steve Ross, Tom Giermakowski, Steven Platania, Norman

Mercado-Silva, and Mason Ryan. They were assisted by a small army of volunteers including Meghan Balk, Olivia Chavez, Tracy Diver, Elizabeth Gallagher, Levi Gray, Victoria Hansen, Angela Hung, Ian Latella, Lorraine McInnes, Tyler Pilger, Jolene Rearick, Mason Ryan, Brad Truett, and Rhiannon West. Thanks to K-State University Division of Continuing Education. We thank all of the above for a fun and successful meeting.

Nearly 900 herpetologists and ichthyologists attended the meeting. This number includes 417 students and 303 members of SSAR. The meeting included 45 oral sessions and five symposia. Symposia topics included "Detectability and Studying Rare Species: When Cryptic Natural Histories Defy both Conventional



FIG. 1. Welcome poster (Native American pottery designs from southwestern Pueblo group) designed by David Dennis and given by SSAR to all who attended the annual meeting. SSAR thanks James and Sarah Christiansen for their sponsorship.

and Progressive Statistics,” “Fishes and Morphology Today,” and “Fish Out of Water: Evolutionary and Ecological Issues in the Conservation of Fishes in Water-Altered Environments.” SSAR sponsored a symposium entitled “Impact of Energy Development on Amphibians and Reptiles in North America.” This timely topic attracted a diversity of speakers ($n = 16$) and a large audience (Fig. 2). We thank Jeff Lovich and Priya Nanjappa for co-organizing this symposium.

Following the usual pre-conference day of Board and Executive Committee meetings, the JMIH began officially with the Plenary Session on July 11th. Local Host Committee Chair, Tom Turner, welcomed us warmly to Albuquerque and thanked the other members of the local committee and the many donors who contributed to the 2013 JMIH. He then introduced Ray Powell (New Mexico Commissioner of Public Lands and a veterinarian) who spoke about the importance of scientists engaging actively with government and other elected officials. He noted that these officials don’t know who we are or what we have to offer, hence the need for us to approach them, to communicate with them, and to “make them look good!”

Following Commissioner Powell’s talk, various awards were presented. Bill Matthews presented the Robert H. Gibbs Award



FIG. 2. Participants in the SSAR-sponsored symposium “Impact of Energy Development on Amphibians and Reptiles in North America.” L to R: Steve Spear, Denim Jochimsen, Doug Keinath, Priya Nanjappa, Wendy Palen, Barry Sinervo, Jeff Lovich, Lee Fitzgerald, Jen Williams, Jessica Homyack, Jackie Guzy.



FIG. 3. Some of us escaped from the meeting and the heat for a few hours. Here, Lynn Haugen, Marcus Simons, and Julian Lee enjoy the view from the top of the aerial tramway on Sandia Peak.

to Lynn Parenti who noted that this was the 37th ASIH/JMIH meeting in a row that she has attended. The Henry S. Fitch Award for Excellence in Herpetology was presented *in absentia* to Roy McDiarmid by Henry Mushinsky. The Robert K. Johnson Ward for Excellence in Service to ASIH was presented *in absentia* to Pat Gregory by Al Savitzky. Steve Mullin announced Craig Guyer as the winner of the 2013 SSAR/HL/ASIH Meritorious Teaching Award in Herpetology. The PARC Alison Haskell Award for Excellence in Herpetological Conservation was given to Charlie Painter and the first Joseph Nelson Award for Lifetime Achievement in Ichthyology was presented to Gerald Smith.

Tom Turner then introduced the Keynote Speaker, William deBuys, a writer and conservation biologist, who entitled his talk “Hotter and Drier: Life in the 21st Century Southwest.” The speaker particularly focused on rainfall and water availability, but also spoke about models and observations, record climactic events in the past few years (e.g. according to records, New Mexico has just experienced its driest 24 months and its hottest month in July of 2012), increases in CO₂ concentrations, the impacts of increased energy on the Earth, expansion of Hadley cells, and the recession of sea ice. An interesting point the speaker made was that, unlike other major natural disasters (e.g., tornados and hurricanes),

which tend to bring people together, drought divides people, often bitterly. He finished by noting that, just like the Mount Graham Ground Squirrel, humans also live on a habitat island (in our case, the Earth) and commented that he sees much beauty on Earth in the diversity of organisms and their adaptations, especially in the desert southwest and that as long as there is beauty, there is something to protect. The talk was a fitting way to open a meeting in such a beautiful location (Fig. 3).

Gregor Caillet, the AES plenary speaker, then spoke on “Unravelling the Secret Lives of Sharks and Rays” and David Sever, the Herpetologists’ League Distinguished Herpetologist gave a presentation on his career as a “HistoHerpetologist.” Dave noted that he started his herp collection at the age of 14 (much of which is now at University of Michigan) and joined SSAR, ASIH, and HL at the age of 15. He then commented on his interest in skin glands in salamanders—a field in which he found his “special niche.” His take home message was “if you love research, you’ll find the time and the funds to do it.”

The ASIH Past Presidential Address officially titled “Physiological Ecology: Past, Present, and Future” was then given by Steve Beaupre. The actual title Steve admitted was “Cool Stuff I’ve Learned about Rattlesnakes.” He decided to become a herpetologist at age 7 and confessed that rattlesnakes had become an obsession. A key aspect of his research is trying to understand the effects of the laws of thermodynamics on organisms, and in his career he has addressed questions on metabolism, bioenergetics, heat budgets, mass budgets, and behavior. He spoke about his work in Big Bend, Texas on two populations of Rock Rattlesnakes, in which he looked at the effects of elevation, temperature, and rainfall on bioenergetics. One of the key things he learned to appreciate was how flexible these snakes are in their ability to cope with the environment. Steve spoke about his postdoctoral research in which he particularly focused on terrestrial ectothermic vertebrates as low energy systems and began connecting energetic costs with behaviors. Steve’s research at the University of Arkansas has included long-term studies

of Timber Rattlesnakes, focusing on “boom and bust” years for snake populations. He noted dramatic changes in field metabolic rates, growth rates, and reproductive activity over the years and referred to the snakes as classic bet-hedgers, able to tolerate extreme starvation, but with the capacity for rapid physiological upregulation in acorn (and thus small mammal) mast years.

Following the Plenary Session, we congregated on steps in the large Civic Plaza opposite the Convention Center for the group photo (Fig. 4).

Social and Professional Events

Past-President Joe Mendelson, III (Zoo Atlanta) gave the 2013 SSAR President’s Travelogue (“The Ballad of Gringo Perdido: The Art of Getting Lost”) on the evening of July 10th (Fig. 5). Joe spoke of the role of serendipity and the art of noticing things in his career as a herpetologist. He noted the importance of access to natural history collections and living specimens when trying to answer questions such as “where is it? where is it not? what is it? what does it do?” Joe noted his predilection for turning a hotel room into a lab and a truck into a home and commented that “finding new species never gets old.” Based on many years’ worth of field work, Joe made the following astute recommendations: put energy not into not getting lost, but into getting “unlost,” always check out field sites in the day time, just stop talking after the third day on a long field trip, and if you get sick or stranded in the field, just don’t care and then it’s not a problem!

One hundred twelve students attended the SSAR/HL Student Reception late afternoon on July 11th. Thanks to the donors of door prizes and the 31 professionals who attended. The Student Reception was followed by the Joint Meeting Reception at the Albuquerque Museum of Art and History. We enjoyed southwestern food and wandering through the exhibits.



FIG. 4. Waterfall in the Civic Plaza opposite the Convention Center where the group photo was taken. On the evening of July 12th, a showcase concert and competition of *Mariachi Spectacular de Albuquerque* was held here.

PHOTO BY R. W. HANSEN

PHOTO BY M. PREEST



FIG. 5. Joe Mendelson, III President's Travelogue speaker in front of the SSAR welcome poster.

PHOTO BY GREG WATKINS-COLWELL



FIG. 6. Pre-auction dinner for some of the volunteers. L to R: Kevin Neal, Catriona Hendry, Kirsten Nicholson, Jeremy Brown, Steve Mullin, Sara Ruane.

The SSAR/HL live auction was held on July 14th. Despite the monsoon rains of New Mexico, it was well-attended and good fun and we raised over \$5,000. After all bills are paid, including beer and audio-visuals, proceeds will be split 50-50 with HL. Auctioneers Steve Mullin, Sean Graham, and Sara Ruane were ably assisted by Greg Watkins-Colwell and a number of hard-working students (Elyse Freitas, Catriona Hendry, Kevin Neal, Rachel Skinner, and James Stroud; Figs. 6, 7). Meredith Mahoney

and Kirsten Nicholson were also integral to the operations of another successful live auction and we saw the return of Samantha Kahl, who had served as a student volunteer for several years and is now back assisting with the operations of the live auction. Justin Rheubert and Dustin Siegel were also on hand to provide assistance. Highlights included a very special t-shirt featuring some editorial comments on the taxonomy of North American herpetofauna.

Mike Jorgensen and Vinny Farallo (co-chairs, Silent Auction Committee) were unable to attend the meeting. In their absence Chris Howey and Matt Lattanzio did an excellent job organizing the Silent Auction. The auction items were set up in the lobby of the conference center. Once again, the ten recipients of the \$400 SSAR Student Travel Awards took turns to work the silent auction table for 2–3 h throughout the course of the meetings. The Silent Auction raised over \$800.

This was a very special year for ASIH—the 100-year publication anniversary of *Copeia*. To celebrate this event, ASIH provided meeting attendees with reprints of the first issue of *Copeia*, published in New York on Dec 27, 1913 (Fig. 8). Included was a transcript of the keynote address given by John Nichols (grandson of the founder of the society, John Treadwell Nichols) at the 75th annual meeting of ASIH in 1991. On the evening of July 12th, in a packed meeting room we were treated to another address by John Nichols. He admitted that he knew nothing about fishes, snakes, turtles, or frogs, but was here because his name is John Treadwell Nichols. He spoke of his grandfather as an “old-fashioned naturalist” and described him in the field wearing a white shirt and tie, with a fedora that looked like it had been sat on hundreds of times. He recounted stories of his father and grandfather working together on Long Island doing bird counts and the “pickling and preserving” they did with “formaldehyde and arsenic becoming like heroin and cocaine”—something they couldn’t live without. The talk was wonderful, a real highlight of the meeting!

The end-of-meeting banquet was held on July 15th. Prosanta Chakrabarty served as Master of Ceremonies. On behalf of the JMIH societies he thanked the local hosts and the K-State staff for a successful and memorable meeting. He then introduced those at the head table (including SSAR President-Elect Bauer, representatives of SSAR and ASIH, members of the host committee and surprise guest Edward Drinker Cope) and asked past-presidents of the societies in attendance to stand (including several past-presidents of SSAR). ASIH election results were announced, certificates of appreciation were presented, resolutions were read, attendees from 19 countries were recognized, and Prosanta briefly interviewed E. D. Cope. Various awards from ASIH, HL, and Neotropical Ichthyological Association were announced. Prosanta and “Professor Cope” closed the final JMIH banquet with humorous verses and invited those assembled to attend the 2014 JMIH in Chattanooga, Tennessee (July 30–August 3).

Board, Long Range Planning, and Business Meeting Summaries

SSAR Board Meeting

Society President Bob Aldridge called the Board Meeting to order at 0800 hrs on July 10th, 2013 in the Albuquerque Convention Center, Albuquerque, New Mexico. In attendance were the following members of the Board of Directors, Editors and

Committee Chairs: Kraig Adler (Editor, *Contributions to Herpetology*; Chair, Long Range Planning Committee), Bob Aldridge (President), Breck Bartholomew (Publications Secretary), Aaron Bauer (President-Elect; Editor, *Facsimile Reprints in Herpetology*), Rafe Brown (Chair, Seibert Award Committee; Chair, Local Meeting Committee, 2015), Alison Cree (Board Member, non-US 2016), Brian Crother (Chair, Standard English and Scientific Names Committee), Raul Diaz (Webmaster), Tiffany Doan (Board Member, Reg. 2014), Richard Durtsche (Coordinator, Symposium Committee), Marina Gerson (co-Chair Membership Committee), Robert Hansen (Editor, *Herpetological Review*), Travis LaDuc (Board Member, at-large 2014; co-Editor *CAAR*), Lisa Hazard (Board Member, Reg. 2016), Joseph Mendelson, III (Immediate Past-President), Kirsten Nicholson (Past-Treasurer), Ann Paterson (Treasurer; co-Chair, Membership Committee), Gad Perry (co-Editor, *Journal of Herpetology*), Marion Preest (Secretary), Al Savitzky (SSAR Representative to AIBS and BioOne), Greg Watkins-Colwell (Board Member, Reg. 2016; Organizer, SSAR/HL Live Auction), and Dawn Wilson (Chair, Student Participation Committee). Additional society members present included Jim Christensen, Vic Hutchison, Samantha Kahl, Henry Mushinsky, Justin Rheubert, and Tony Wilmes.

Introductions were made and those present were reminded of the open meeting regarding the activities of the Long Range Planning Committee to be held on July 13th. Minutes of the 2012 Board of Directors Meeting (Vancouver, British Columbia, Canada) were approved.

Officers' Reports

President Bob Aldridge reported that he and Past-President Joe Mendelson sent a letter to 492 lapsed SSAR members in Dec 2012 encouraging them to renew their membership. Bob plans to resend a letter in December of this year. He signed a letter written by the members of the Conservation Committee to the Honorable Puerto Rico Planning Board encouraging them to disallow any development activities that could even remotely lead to the loss, or "incidental take" of individuals of the threatened Puerto Rican Crested Toad (*Peltophryne lemur*). Additionally he wrote "An Open Letter to the WikiHerps Community from the Officers and Editors of SSAR," stating that it is a copyright violation to post PDF versions of *Herp. Review*. Bob thanks Kraig Adler for composing the initial draft of the letter and Bob Hansen and Breck Bartholomew for advice. The letter was posted by Joe Mendelson on April 10, 2013.

In the June issue of *Herp. Review*, an open letter from President Aldridge was published in which he introduced himself and stressed the importance of membership in our Society. President Aldridge signed an "Invitation to Membership" letter that was distributed along with an issue of *Herp. Review* to attendees at the 1st North Carolina Congress of Herpetology, held at the North Carolina Zoo, Asheboro, NC. SSAR was a sponsor of this meeting and also donated books for their auction.

President Aldridge reappointed Kraig Adler Chair of the Long Range Planning Committee and invited Past-President Mendelson to present the 2013 Travelogue at the JMIH. Bob met with the JMIH MMPC in Albuquerque in April to plan the 2013 JMIH. The MMPC arranged times and places for business meetings, symposia, oral presentations, social events, etc.

Immediate Past-President Mendelson reported a quiet final few months in his Presidency. He wrote a final Presidential essay that was published in *Herp. Review* that focused on outreach education. Joe solicited Carol Spencer to lead the SSAR Website



Fig. 7. Rachel Skinner and Kevin Neal preparing for the live auction.

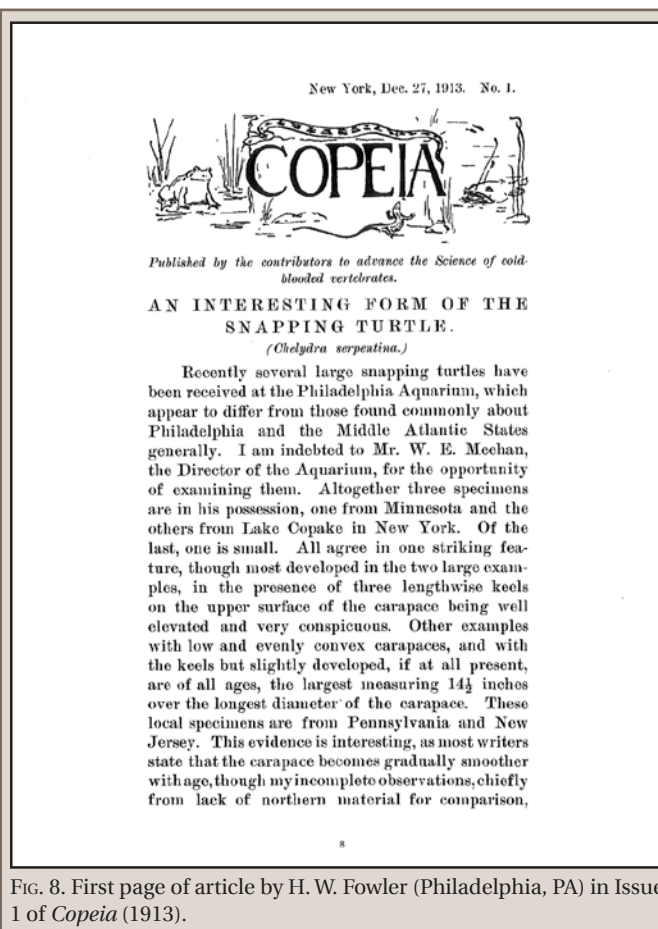


Fig. 8. First page of article by H. W. Fowler (Philadelphia, PA) in Issue 1 of *Copeia* (1913).

Committee and was involved in Travis LaDuc and Chris Bell taking over as co-Editors of *CAAR*. He signed the online publishing agreement with Allen Press that was approved by the Board in 2012 and a contract with EBSCO to expand electronic publishing with them to include *Herp. Review*.

Ann Paterson and Kirsten Nicholson (the Current- and Past-Treasurers respectively) reported that SSAR experienced another sound financial year during 2012 and say that the future is looking bright in the recovering economy. Overall, SSAR underspent the 2012 budget (by \$42,516) which is good news given recent changes to journal formats. However, some points of discussion are the transition to stricter policies regarding notification/payment of page charges, and a possible increased push towards more active acquisition of paid advertisements in *Herpetological Review*. Membership numbers are down slightly, but hardly noticeable. Royalty income has remained fairly steady, which is somewhat unexpected, as we had been predicting a steady increase in payments. We also received several generous donations for special projects, in particular from Ronald Javitch and George Zug, and several others in honor of Andy Price. Our investment portfolio enjoyed substantial growth during 2012 (up \$85,000 from the previous year), and 2013 is showing continued growth as well.

The Society's investments increased during 2012, in keeping with trends in the global market. The total market value as of December 31st, 2012 was \$645,096. By June, 2013 we had increased further to \$666,022. Examination of the performance of our funds shows that their percent yields have increased over 2012 and 2013.

The transition to our new Treasurer, Ann Paterson, began early in 2013 and Kirsten has been assisting greatly with this change. Ann is working on changing some investments and is trying to get our taxes finalized earlier in the year.

The approved 2012 budget was balanced. Although some expenses went over budget, most were under budget. *CAAR* was nearly double the expected cost, but was catching up with several accounts. The appearance of the Publications Secretary (Breck Bartholomew) being over budget is erroneous because that office has taken over the handling of memberships from Allen Press, so what was a separate expense paid out to Allen Press is now subsumed within Breck's expenses. The 2011 JMIH meeting was well over budget and SSAR was hit with a very large fee as a consequence. Last year's meeting fees however were paid for by the WCH and we were spared that expense. Both *JHerp* and *Herp. Review* were under budget. There was no return on the Auctions again this year (2012), as we voted to donate the money to the WCH. At the 2013 meetings, Kirsten and Ann hope to discuss details and problems regarding the efficient running of the auctions, as the cost of running them severely cuts into making profits to fund student travel awards.

Joe Mendelson commented on SSAR being under budget and asked whether we needed to spend more money. As a not-for-profit organization, there are IRS regulations in regards to this. Breck Bartholomew noted that many of the funds raised in the past year are due to one-off donations and that SSAR can't count on receiving them in the future.

Secretary Marion Preest summarized the 2012 World Congress of Herpetology for publication in *Herp. Review*. She kept track of changes in personnel and regularly updated SSAR letterhead, informed the Editors of *JHerp.* and *Herp. Review* of these changes, and provided various updates to Webmaster Raul Diaz. She wrote letters to student winners of awards (e.g., Kennedy,

GIH, etc) and prepared announcements for publication in *Herp. Review*. The Secretary compiled the 2013 Annual Report and prepared agendas for the Board and Business Meetings for the 2013 JMIH. She was again involved in helping to organize a reception for student members of SSAR and HL to be held at the JMIH. Marion corresponded with the Board regarding various issues that needed a vote, e.g., a proposal regarding remaindering some SSAR publications, symposium proposals, etc. She circulated documents that needed to be signed by members of the Board (e.g., Conflict of Interest), confirmed eligibility for participation in various student activities (e.g., Travel Awards, Poster Awards, Seibert Awards, etc.), and dealt with many emails from SSAR members and the general public.

Breck Bartholomew reported that total income from the Publications Office in 2012 was \$124,714.01. He is requesting a budget for 2014 that includes funds to cover rent, utilities, insurance etc. for the office, as Breck is closing down his business *Bibliomania* (which has, for many years, covered these costs for the Society). Breck has contacted book dealers and authors regarding remaindering books to try and deal with excess inventory. Breck suggested that we think of other publication avenues (e.g., iTunes, Ebooks, etc.)

George Pisani reported that he again filed SSAR's annual corporate report with the Office of the Kansas Secretary of State.

Editors' Reports

Co-Editors of the *Catalogue of American Amphibians and Reptiles*, Chris Bell and Travis LaDuc took over the reins of *CAAR* at the beginning of 2013. They wish to thank Bob Powell for completing and publishing the last of the accounts that were submitted to Andy Price. Chris and Travis assumed all of the editorial responsibilities in an effort to maintain the high standards of the series, particularly in the formatting and completeness of the literature citations, personally vetting every citation just as Andy Price and Bob Powell did before them. They have revised the *CAAR* instructions to authors and, as of May 31, 2013, have received six account submissions and corresponded with several potential authors on an additional 10–15 accounts. They established a new "dibs" list for taxa reserved by authors.

During the transition period, there were questions about the suitability and logistics behind revising previously published species accounts. Chris and Travis found precedence for this in the history of the series. Five accounts were revised over the 50-year history of the series, and each revision was published under a new account number, with no specific notations indicating the previous *CAAR* account number and no secondary authorship granted to the author(s) of a previous account. The online system makes it easy to cross-link the new account to the previous one.

Publication of the series is now electronic, and accounts are issued immediately upon acceptance and may be downloaded on demand from the *CAAR* website. The co-Editors hope to bring the number of annually published accounts to a minimum of 15. Because publishing and all correspondence are now electronic, costs for editing the series are extremely low. Chris and Travis wish to thank Breck Bartholomew who was instrumental in scanning and posting all previous accounts to the web, where they are now available to members (<http://www.zenscientist.com/index.php/filedrawer/Open-Access-Journals/caar/>).

The lack of an ISSN number for the *CAAR* series has now been rectified. Regulations require separate ISSN for the print and online versions. They are ISSN 2325-4882 (print) and ISSN 2325-5021 (online).

Contributions to Herpetology Editor Kraig Adler reported that “*Contributions to the History of Herpetology*,” vol. 3, by Kraig Adler, John S. Applegarth, and Ronald Altig was published in 2012. A paper-bound version was presented to all delegates at the WCH. Costs were subsidized with a \$5,000 donation plus a further \$10,000 for the other congress giveaways. “*A Contribution to the Herpetology of Northern Pakistan*,” by Rafaqat Masroor was also published in 2012. “*Contributions to the History of Herpetology*,” vol. 1, by Kraig Adler, John S. Applegarth, and Ronald Altig will be reprinted (with annotations and corrections to volumes 1, 2, and 3) in 2014 (making all three volumes available at the same time). “*Herpetology at the University of Kansas*,” by William E. Duellman, will be issued in 2015 prior to SSAR’s meeting at KU. This is a detailed history of one of the most distinguished herpetological research and graduate education programs, beginning with Edward H. Taylor, the first curator, and concluding with the current era of herpetologists. It will include a description of Henry Fitch’s long-term program at the Natural History Reservation, biographies of all herpetological graduates of the KU program, numerous photographs, and summaries of major expeditions, meetings, and other activities. “*A Guide to the Snakes of the Philippines*” by Rafe Brown, Alan Leviton, Maren Gaulke, and Arvin Diesmos, “*Field Guide to Amphibians and Reptiles of the West Indies*” by S. Blair Hedges, and “*Lizards of Southern Africa*” edited by William R. Branch and Aaron Bauer are also planned beyond 2013.

Editor Aaron Bauer (*Facsimile Reprints in Herpetology*) reported that the monumental “*Erpétologie Générale ou Histoire Naturelle Complète des Reptiles*” (1834–1854) by Duméril, Bibron & Duméril was published in December 2012 with Kraig Adler as guest editor. This work of 7000+ pages, including 240 plates, significant new material by Roger Bour, and a comprehensive index, was produced in a run of 400 sets. The cost of this work was generously supported by Ronald Javitch, and SSAR funding was spread out over a two-year period. Two works nearing completion have been offered to the facsimile series. Both are collected works with substantial new material. “*The Collected Herpetological Works of Giorgio Jan*” has an introduction, annotated bibliography, and extensive systematic comments by Roy McDiarmid and Jay Savage. The collected snake publications of Jan were published in 1857–1882 in French, Italian, and German. The plan is to publish the facsimiles four pages to one page in order to accommodate 500+ pages of new material by McDiarmid and Savage. “*The Collected Herpetological Works of J. V. Barboza du Bocage (1823–1907)*” has an introduction, annotated bibliography, and data on types by Luis Ceriaco. Bocage was the most important Portuguese vertebrate zoologist of the 19th Century and published extensively on all groups, mostly based on collections from the far-flung Portuguese colonies of the day (Angola, Mozambique, Cape Verde, Timor, Guinea, São Tomé, Macau). He also published on Portuguese mainland taxa and other areas, notably New Caledonia. In all, he authored 69 herpetological papers between 1863 and 1905, nearly all in Portuguese or French. Most are relatively short (<20 pages), but his magnum opus: *Herpétologie d’Angola et du Congo* (1895), was 223 pages long, with 19 plates. The total pagination of Bocage’s herpetological works is 759 pp. The facsimile will include approximately 100 pages of new material dealing with Bocage’s life and works, his complete bibliography, and short accounts for each of the 104 species of amphibians and reptiles he described. Ceriaco anticipates an interest by the Portuguese Academy of Sciences in supporting the work through co-publishing.

John Moriarty (Editor, *Herpetological Circulars*) reported that *Herpetological Circulars* 41 (*A Guide to Tissue Collection, Preservation, and Management for Reptiles and Amphibians*) is in final review and is expected to be published in November 2013.

Editor of *Herpetological Conservation*, Joe Mitchell, reported that no inquiries for publication were received in 2012 and he plans to advertise for submissions soon. His criteria are that the topic be broadly applicable to herp conservation and management, that the geographic coverage not be limited to one country but, preferentially, global in scope or at least regional, and the work makes an important contribution that will be cited extensively. The Board discussed the fact that *Herp. Conservation* volumes don’t need to be, and in fact haven’t always been, large tomes and encourages Joe to think of smaller projects (in addition to large ones).

Robert Hansen, editor of *Herpetological Review*, reports continued smooth operation. Volume 43 consisted of 632 pages and Volume 44 is projected to run ~700 pages. Personnel changes include the resignations of Brad Lock, Michael Grace, and Emily Taylor and the addition of Robert Hill, Scott Boback, David Blackburn, Stephen Richards, and David Steen. Over two years ago, Denise Wilson Mayer, a volunteer at Zoo Atlanta, undertook the daunting task of indexing all back issues of *Herp. Review*. She made excellent progress before moving on to other pursuits. Meanwhile, Ruthe Smith, associated with the SSAR Publications Office as a part-time employee, has been indexing each new issue. To date, all issues of *Herp. Review* have been indexed, with the master file currently in EndNote format maintained by Breck Bartholomew. The next step is to make this index file publicly available through the SSAR web page. The Board returned to the issue of *Herp. Review* being made available through BioOne (part of the impetus for indexing the journal). Hansen will contact BioOne to see where we stand.

Co-Editors of *Journal of Herpetology*, Erin Muths and Gad Perry, report that former Editor Geoff Smith remains an Associate Editor (AE) for special projects and Paul Andreadis remains the Index Editor. The AE roster at the end of 2012 contained six new names and many continuing ones: Paul Bartelt (US), Phil Bishop (New Zealand), Xavier Bonnet (France), Rafe Brown (US), Tracey Brown (new, US), Russ Burke (US), Steve Corn (US), Tiffany Doan (US), Jennifer Gillette (New Zealand), Evan Grant (new, US), Brian Greene (US), James Harris (Portugal), Tibor Hartel (new, Romania), Toby Hibbitts (US), Hinrich Kaiser (new, US), Nancy Karraker (newly in the US), Edgar Lehr (US), Marc Mazerolle (Canada), Frank Mazzotti (US), Don Miles (US), John Rowe (US), Christopher Salice (new, US), Glenn Shea (new, Australia), Stephen Tilley (US), Tony Tucker (new, Australia), James Watling (US), and Eric Wild (Brazil); both Editors also function as AEs. Ximena Bernal (US), Nancy FitzSimmons (Australia), Walter Meshaka (US), and Phil Smith (US) ended their tenure as AEs in 2012. Expanding the AE base, especially by adding additional colleagues from other countries, remains a challenge. Erin and Gad are especially interested in expanding representation from Brazil and Asia.

Overall, new submissions declined slightly in 2012. Manuscripts from 35 countries were submitted in 2012. As in previous years, the US remains the leading source of manuscripts (~43% of all submissions) and Brazil remains the second highest source (~14% of submissions). Despite availability of the free editing service from SSAR, language remains a concern for many manuscripts from non-English-speaking countries. The larger number of such manuscripts places an added burden on the editorial

process, particularly at the final editing stages. According to the AP "Member Submissions Report," 35% of all submissions in 2012 and 2011 had one or more authors who are SSAR members, compared to 35% in 2010, 38% in 2009, 39% in 2008, and 38% in 2007 and 2006. Submissions so far for 2013 (117 as of June 15th) are lower than the number submitted during the same period in 2012 (172). The amount of time needed to reach initial and final decisions remains similar or is slightly improved compared to the past few years, but the wait between acceptance of a paper and publication remained approximately 12 months in 2012. Gad and Erin have taken several steps to address this, including instructing AEs to reject a greater proportion of submissions and publishing an especially large December issue in 2012 and March issue in 2013. These measures have helped us catch up with the buildup of manuscripts and reduce the wait from acceptance to publication to approximately 9 months.

The Journal now has an official website (<http://journalofherpetology.org>), maintained by Allen Press. This site offers access to information needed by authors, articles published in the journal (free to SSAR members), pre-publication versions of upcoming papers, and links to SSAR. The site also allows us to post "online only" supporting material such as video, sound files, and raw data.

Another recent change is associated with new technology at AP, allowing us to publish all-color at no extra cost. As currently published articles were accepted before this change, the transition to more color will be ongoing. However, authors are being contacted and offered an opportunity to replace b&w figures with color ones.

The co-Editors have used Editorial Board members this year for several quick turnaround reviews and in addressing an issue of plagiarism. This issue was identified by a reviewer, and reported by the AE to the Editors. They checked the data and used the expertise of the Editorial Board to vet their response to the authors. After ample opportunity to rebut and defend their manuscript, the paper was rejected and all authors were informed that manuscripts by them would not be accepted by the *Journal of Herpetology* for two years. The information was also shared with the editors of other herpetological journals, as part of a multi-society effort to reduce ethical problems within the profession.

The new page charge policy is now in place: If at least one author is an SSAR member in good standing, page charges are not levied. However, if funding allows, members are encouraged to assist in the production of the journal by contributing to page charges. Page charges for non-members are \$150 per page. If there are unusual circumstances, a waiver may be requested by contacting Breck Bartholomew.

Obtaining qualified AEs and reviewers remains a huge challenge and Erin and Gad expect this problem to get worse, given the increasing shift of academic institutions to a for-profit managerial style.

The co-Editors raised four issues for the Board to consider:

- *Replacement of Editors.*—Erin and Gad are asking to conclude their tenure as co-Editors for the *Journal of Herpetology* on January 1, 2014, following four years of service. They propose to remain actively involved in the publication of the journal through July 2014 to facilitate transition to a new Editor or co-Editors. They will both serve on the Editorial Board and Erin Muths will remain as an AE.

- *Electronic publishing.*—Establishment of the new journal's website is an important development and Erin and Gad are pleased that the Society is looking at professionalizing its Web

presence. They believe that there is a need for careful consideration of the not-far future move to an all-digital journal, and to funding models that would support the Journal and society when that happens.

- *Co-publishing proposal.*—In 2011, the Board rejected the AP co-publishing proposal. Erin and Gad feel that this option should be reconsidered in 2014 after the new editor(s) meet with Allen Press for updated details.

- *Reward for AE service.*—The co-Editors would appreciate the Board reconsidering membership as token recognition to be granted only to those AEs who have served for over a year and completed their reviews in a timely manner.

In their requested budget for 2014 (\$128,150), the co-editors have added the cost for maintenance of the Journal website by AP. They expect to publish a similar number of papers in 2014 as in 2013, and anticipate an increase in mailing costs, but expect no change in editorial office costs.

Standing Committee Chair Reports

The Conservation Committee consists of Ross Alford, April Barreca, Jennifer Germano, John Jensen, Nancy Karraker, Karen Lips, Gad Perry, Stephen Richter, and Betsie Rothermel (Chair). Two new graduate student members (Nicole Angeli and Cecilia Langhorne) joined the committee in 2012. In July 2012, the Center for Biological Diversity petitioned U.S. Fish & Wildlife Service (FWS) to list 53 species of reptiles and amphibians under the Endangered Species Act. The consensus of the Conservation Committee was to not take any action at that time, but rather to wait and submit comments on particular species if/when there is a full status review by FWS. In August 2012, SSAR signed on to a letter sent to the U.S. Senate Interior and Environment Appropriations Subcommittee opposing drastic cuts in FY13 funding for the State and Tribal Wildlife Grants Program. In April 2013, they sent a letter to the Southeast region of U.S. Fish & Wildlife Service regarding habitat protection for the Puerto Rican Crested Toad (*Peltophryne lemur*). Specifically, they urged the agency not to add this species to the list of species covered under an incidental take permit for a proposed wind energy facility.

Joe Beatty, Chair of the Dean Metter Award Committee, received 39 proposals this year and **Mitch Tucker**, a Ph.D. student at University of Missouri, was selected as the winner. Mitch's proposal was entitled, "Behavioral consequences of polyploidy in Gray Treefrogs, *Hyla chrysoscelis*." A key component of the proposal hinges upon being able to generate autopolyploid frogs in the lab, which Tucker is able to do with a "cold-shock" treatment developed by him and his supervisor, Carl Gerhardt. The committee thought Tucker's proposal was especially innovative and experimental and takes an approach involving fieldwork as well as laboratory work to provide insight to a particularly interesting biological system.

The 21st annual Seibert Awards competition (Rafe Brown, Chair) was run at the 55th Annual Meeting of SSAR in Vancouver. There were 53 eligible presentations. The Seibert Award winners for 2012 were: Systematics/Evolution: **Sara Ruane** (College of Staten Island), "Speciation in the milksnake (*Lampropeltis triangulum*)."
Ecology: **Thomas Luhring** (University of Missouri), "Islands in the sun: nutrient cycling in isolated systems is mediated by canopy cover, predation, and the complex life-histories of their transient tenants."
Physiology/Morphology: **Rory Telemeco** (Iowa State University), "Effects of temperature during development on the offspring phenotype of a facultative thermo-regulator, the Southern Alligator Lizard (*Elgaria multicarinata*).

Anguidae)." Conservation: **Shawn McCracken** (Texas State University, San Marcos), "Living on the edge: oil road effects on the occupancy and abundance of anurans inhabiting an upper canopy tank bromeliad (*Aechmea zebryna*) in lowland rainforest of the Yasuni Biosphere Reserve, Amazonian Ecuador." All winners received a check for US \$200 and a book from University of California Press. Honorable mentions were: Systematics/Evolution: **Hilton Oyamaguchi** (University of California, Los Angeles), "Divergence along a Brazilian rainforest-savanna gradient and the role in generating diversity." Ecology: **Julia Riley** (Laurentian University), "Should I stay or should I go? Influence of environmental factors on *Chrysemys picta* hatchling overwintering strategy." Physiology/Morphology: **Gareth Hopkins** (Utah State University) "Embryonic survival in salt among Rough-skinned Newt (*Taricha granulosa*) families."

No report was received from the Herpetology Education Committee (Hinrich Kaiser, Chair).

The winning paper for the 2012 Kennedy Award (Lynnette Sievert, Committee Chair) is by **Alexa K. Fritzsche** (coauthored with **Stacey L. Weiss**), "Effect of signaler body size on the response of male striped plateau lizards. *Journal of Herpetology* 46:79–84." Alexa will receive a check for \$200 or \$400 equivalent in SSAR publications.

Kraig Adler, Chair of the Long Range Planning Committee (LRPC), reported that Carol Spencer (newly appointed Chair of the Website Committee) has been added to the LRPC. Following a very active year after being revived in late 2010, the committee as a whole was quiescent for much of 2012 and 2013. Kraig however was busy coordinating SSAR's contributions to the World Congress in Vancouver, e.g., a giveaway poster featuring an original drawing by David Dennis, a giveaway issue of *Herp. Review*, a membership brochure, a giveaway book and two booklets ("Contributions to the History of Herpetology, Vol. 3" by K. Adler, J. S. Applegarth, and R. Altig; and two booklets on the scientific and standard vernacular names of amphibians and reptiles in North America north of Mexico, in separate English [B. Crother, editor] and French [D. M. Green, editor] versions), etc. Kraig wishes to particularly thank Breck Bartholomew, Bob Hansen, John Moriarty, and Kirsten Nicholson for their assistance. SSAR was recognized by WCH as the sole Gold-Level Sponsor for our many contributions. Kraig was also involved with Rafe Brown and others in the KU local committee with early planning for the 2015 meeting. He helped them prepare the first ad for the meeting, which appeared in the December 2012 *Herp. Review*, and approached PARC (Partners in Amphibian and Reptile Conservation) to join us at KU as our co-sponsor.

Chair of the Meeting Management and Planning Committee, Rafe Brown, presented information about progress to date in planning for the 2015 meeting at University of Kansas. The local committee consists of Rafe Brown (Chair), Richard Glor, William Duellman, Linda Trueb, and George Pisani. Organizing societies are SSAR, PARC, and Kansas Herpetological Society. Tentative dates are July 29th to Aug 3rd (includes a "zero" day at the beginning for the SSAR Board Meeting). There will likely be two plenary lectures, a number of symposia, a student workshop, a live animal display, and tours of the Museum and the Henry Fitch Natural History Reservation. Social events will include those we have come to expect at JMIH, some new events, and other old favorites that have been revived, e.g., the President's Travelogue, the student reception, a social specifically to recognize senior herpetologists, the revised (now digital) audiovisual shows of David Dennis and Eric Juterbock ("Amphibians of the

Appalachians," "Herps of the American West," "Herpetologists Then and Now"), live and silent auctions, a herp art exhibit, the herp quiz, a picnic, etc. Projected prices for registration and accommodation are very reasonable (Registration: \$280 regular members, \$140 students and retired members, Accommodation: \$34–\$150/night)

In the past year the Membership Committee (Ann Paterson and Marina Gerson, co-Chairs) was less active than it has been previously while it was waiting to see the results of the 2011 proposals. The Committee has been more closely following membership data to examine patterns and develop procedures for more closely monitoring and analyzing these patterns, developing proposals for possible correspondence with new members and with members who fail to renew, continuing to compile a list of other herpetological societies, and responding to concerns and comments from members and non-members as needed. The detailed proposals for possible correspondence with members are available upon request. Ann Paterson will be discussing them with Bob Aldridge to coordinate with other activities.

Ann and Marina now receive monthly membership data. They remarked on the continued decrease in membership. They noted that more people are taking advantage of the online and senior membership categories, but that there are declines in other categories. The recent dues increase explains the increase in membership income and possibly also the decrease in membership numbers. It is hoped that access to membership data will allow the committee to examine the effect of various activities (e.g., mailings) on membership trends. Breck commented that the membership office sees an increase in renewals and in new memberships around the time Roger Conant GIH proposals, travel award applications, etc., are due.

The Board discussed the idea of making student dues available to individuals for 1–2 years after they are no longer students as a way of encouraging continued membership. This would not require creating another category of membership (of which we already have many) and would need to be advertised. As there is every year, there was discussion of why someone should become a member of SSAR in the first place and why they should renew their membership annually. There is concern over the "revolving door" of members, i.e., individuals (usually students) are members for a few years and then fail to renew, only to be replaced equally temporarily by other young members. The importance of reaching out to undergraduates was emphasized. Someone remarked that there are professional herpetologists who themselves are not members of the society even though they come to the meetings, send their students to the meetings, publish in our journals, etc. The importance of professionals setting examples for their students and encouraging, or even requiring, them to become members and attend meetings was stressed. A comment was made that we need to focus on our core mission and current demographic and make the Society work in whatever form it exists, i.e., we can't force people to become members. Along the same lines, Al Savitzky asked us to think about whether we are currently operating under a model that is not sustainable in the long term.

Kris Kaiser (Chair, Mentorship Committee) reported that, in its first year, the Mentorship Program paired 14 students with mentors. Follow-up surveys showed a general satisfaction with the program, and gave useful feedback for year two of the program. The program this year was advertised in *Herp. Review*, on the SSAR website, and on the JMIH registration page under "Graduate Student Information," and applications were

accepted for both mentors and mentees. The committee is considering working with the MMPC to make this part of the actual meeting registration next year to increase visibility.

The Nominations Committee (Greg Watkins-Colwell, Chair) compiled a list of nominees for the positions of President-Elect, Treasurer, Regular Board Member (three needed), and a non-US Board Member. Marion Preest was willing to run again for the position of Secretary. Voting was carried out electronically with photographs of the candidates being made available. Upon completion of the 2012 election, Greg Watkins-Colwell resigned his post as Nominations Chair, to be replaced by Robert Espinoza. The nominees:

President-Elect.—Aaron Bauer, Geoff Smith

Treasurer.—Ann Paterson

Secretary.—Marion Preest

Board Member (Regular).—Frank Burbrink, Richard Durtsche, Marina Gerson, Lisa Hazard, Greg Watkins-Colwell
Board Member (non-US).—Alison Cree, Carlos Navas, Hidetoshi Ota, Wolfgang Wüster

Rob Denton (Resolutions Chair) presented resolutions at the SSAR Business Meeting in Vancouver in 2012. These have been published in *Herp. Review*.

Josh Kapfer (Chair, Roger Conant Grants-in-Herpetology Committee) received 80 proposals. Most applications were in the “Laboratory Research” category. The winners each received US \$500 and they are:

Conservation.—Todd Pierson, University of Georgia

Education.—Tiffany Vanderwerf, Buffalo Zoo

The Andrew H. Price Field Research Grant in Herpetology.—Mark Oliva, California State University-Northridge

Laboratory Research.—Schyler Nunziata, University of Kentucky

Travel.—Justin Lawrence, The University of Mississippi

International.—Jessica Hacking, Flinders University, Australia

Josh reported that, as approved by the Board in 2012, he now requests that a signed waiver of liability (available on the GIH website) be included with all grant applications. Josh continues to have difficulties with reviewers submitting assessments on time. As approved by the Board, the Field Research category has been renamed the Andrew H. Price Field Research Grant in Herpetology. It will continue with this name for as long as funds permit.

Brian Crother, Chair, Standard English and Scientific Names Committee, reported that the 7th edition was released last year at the WCH, and work is yet to start on the next edition. The 7th edition has not yet been posted on the SSAR website, but the CNAH and the Reptile Database sites have the list up. The list is also being used by the iNaturalist site and the names are being used for the development of a Global BioBlitz.

Erin Muths was the lead organizer of a lunchtime student workshop sponsored by SSAR and HL at the WCH in Vancouver. The workshop was titled “How to Turn Your Thesis or Dissertation Chapter into a Publishable Manuscript & Participate in the Peer-Review Process.” Editors or Associate Editors from six herpetological journals from the U.S. and Europe participated in the panel presentation. The workshop and panel discussion was designed for graduate students interested in turning their graduate work into publishable manuscripts and learning about the publication process and details on incorporating peer review into their professional career. The goals of the workshop were

to provide an understanding of the mechanics of submitting a manuscript and successfully seeing it through the publication process. Topics included transforming the thesis into a manuscript, de-mystifying the review process, interpreting reviews, responding to reviewers, and participating in the peer review process.

Over 80 students attended, the question and answer session was useful, and feedback during the rest of the WCH was positive. Discussion by the editors after the workshop included decisions to post the PowerPoint presentation on the websites of HL and SSAR and the European societies (this is pending) and to consider presenting the workshop every 3–4 years. Dawn Wilson (Chair, Student Participation Committee) indicated that she will ask for ideas about future workshops from students. A suggestion was made that we record and upload the workshops on the new SSAR website.

The second annual SSAR Student Poster Awards (Tiffany Doan, Chair) were presented during the Annual Meeting of the SSAR at the WCH in 2012. There were 40 eligible posters, twice the number of the inaugural year. In recognition of outstanding student poster presentations at the annual meeting, the following awards (a check for US \$100 and a book from University of California Press) were made: Evolution, Genetics, & Systematics: **Luke Frishkoff**, Stanford University, “Body size evolution and the colonization dynamics of a radiating Caribbean frog lineage (*Eleutherodactylus*).” Conservation & Management: **Julia Riley**, Laurentian University, To conserve and protect: evaluation of a turtle conservation tool, nest caging, ecology, natural history, distribution, & behavior; **Matthew Lattanzio**, Ohio University, “Habitat use, phenotypic variation, and grazing: The responses of tree lizard populations to altered landscapes.” Physiology & Morphology: **Nicole Christie**, Sonoma State University, “Effects of nest temperature variation on viability and sex determination of western pond turtles.”

Chuck Crumly worked for a number of years for University of California Press and generously donated UC Press books to the winners of the Seibert Awards, and more recently to winners of the poster awards. Chuck has left UC press and there was discussion of where we might obtain books for paper and poster winners. We could use SSAR books, or the chairs of the Seibert and Poster Awards committees could contact book publishers to see if any are willing to donate books. A point was made that the books needed to be equally attractive to US and non-US members of SSAR, i.e., not necessarily with a strong North American focus.

In 2012, Mike Jorgensen and Vinny Farallo (Co-Chairs, Student Travel Awards Committee) received 41 applicants for the travel award, about equal to the number in previous years. The ten recipients of the US \$400 SSAR Student Travel Award took turns to work the silent auction table for 2–3 h over the course of the WCH. Location of the auction was in a low foot-traffic area at the WCH and probably contributed to the difference in total earnings from the previous year in Minneapolis. Since the WCH, it was proposed that the silent and live auctions be coordinated by a single committee in order to streamline the donations to each.

Carol Spencer (Chair), Joe Mendelson, Raul Diaz, Vincent Farallo, Michelle Koo, and Todd Pierson serve on the recently revived Website Subcommittee. In 2011 the Board designated US \$10,000 for a one-time complete overhaul of the Society’s website, with US \$3000 per annum for upkeep and renovations, if needed. This group has met several times in 2013 (both in person and via Skype). Three potential website designers/programmers

have been asked to submit bids for redesigning the SSAR website using content and renovation suggestions from the subcommittee and the LRPC. The subcommittee welcomes feedback and suggestions from any member of SSAR.

Coordinators' Reports

Election Officer, Dan Noble, reported that most ballots were submitted electronically in 2012 and the following individuals were elected:

President-Elect – Aaron Bauer

Treasurer – Ann Paterson

Secretary – Marion Preest

Board Member (Regular) – Frank Burbrink, Lisa Hazard, Greg Watkins- Colwell

Board Member (non-US) – Alison Cree

The Live Auction Committee coordinator is Greg Watkins-Colwell, who reported that the proceeds from the 2012 SSAR/HL Live Auction (\$4072) benefited the WCH. Efforts were made to include as many different auctioneers (with different auctioning styles) as possible and to rely upon the help of students who had not assisted with the auction in the past. Following the auction, Kirsten Nicholson, Meredith Mahoney, and Gregory Watkins-Colwell immediately began discussions of how to improve upon the live auction model.

Representative to AIBS and BioOne, Al Savitzky, reported that BioOne, a nonprofit electronic publishing consortium, continues to provide online publishing services for the society and to return both royalties and profit-sharing proceeds to its member publishers. Al has moved away from the mid-Atlantic region, and no longer attends the annual BioOne Publishers and Partners Meeting. He suggested that the society may wish to identify someone closer to Washington, DC, to serve as its representative to BioOne, although, given that most of the presentations at those meetings are archived on the BioOne website, this may not be a major concern to the society.

According to a 2012 year-end summary provided in the April 2013 newsletter, BioOne ended its 11th year online with over 100,000 articles and 900,000 pages in its collection. Those papers have attracted over 18.9 million hits. These represent contributions from 129 publishers, producing 171 titles. Significantly, 42% of BioOne.1 subscribers and 56% of BioOne.2 subscribers are located outside of North America. Furthermore, BioOne makes its content available free to 2500 institutions in developing countries. Revenue sharing in 2012 increased by 6.3% over the previous year. Presentations at the 2013 Publishers and Partners Meeting included a discussion of the changing state of academic libraries in China; a description of BioOne's first self-published title (*Elementa: Science of the Anthropocene*, a fully open-access, online journal due to appear this July); an extensive presentation on citation metrics (especially the h statistic); and a presentation on alternative search strategies for online exploration of the literature (including the beta version of Microsoft Academic Search).

The American Institute of Biological Sciences (AIBS) is an umbrella organization that serves about 160 member societies and organizations (MSOs), most of them in the broad areas of organismal biology and ecology. The most recent AIBS Council meeting, in December 2012, focused on the history and future of scholarly societies in the biological sciences, including a presentation by organizational consultant Mary Byers. As part of its strategic planning process, the AIBS Board of Directors has reviewed two books by Harrison Coerver and Mary Byers, *Race*

for Relevance: 5 Radical Changes for Associations and *Road to Relevance: 5 Strategies for the "New Normal."* Coerver and Byers maintain that factors such as a tighter economy, technological advances, and a generational shift in membership have left traditional nonprofit professional associations struggling to survive. Among the threats to their survival are the failure of organizations to focus on their core strengths (as opposed to constantly trying out new services); failure to confront and resolve redundancies among organizations or chapters; and either inertia or pressure from the "old guard" to maintain the status quo or to anticipate failure from changes "so they can advocate a return to the traditions of the past [*Road to Relevance*, p. 143]." Confronting its own decline in individual membership, AIBS has transformed its governance structure and focused its mission over the past few years through intensive strategic planning and introspection. If the threats to organizational survival that Coerver and Byers perceive are true for many scientific organizations, as they appear to be, the three North American herpetological societies should be aware of these trends.

As part of its own strategic planning process, AIBS surveyed representatives of its MSOs concerning trends in their various societies and organizations, and the results have now been made available to the broader community. They received 110 responses from society officers, and the resulting report is available for free viewing and download at <http://www.jstor.org/stable/full/10.1525/bio.2012.62.4.3>. Similarly, an extensive survey was sent to over 15,000 individual biologists and a detailed report, based on over 4000 responses, is available at <http://www.access.aibs.org/page/Index/?>. That report includes a wealth of information on attitudes toward professional societies at different stages of individuals' scientific careers, from undergraduates to emeriti. Careful attention to the results of that survey would better inform decisions by the Board of our society concerning the interests and priorities of our members.

AIBS continues to focus much of its service to MSOs in two areas, education and public policy. AIBS has been especially active as an advocate for organismal biology, biological collections, and ecology at the national level. AIBS has also taken a major role in development of an Implementation Plan for a Network Integrated Biocollections Alliance; supporting sound scientific integrity policies at the National Park Service and the National Science Foundation; and opposing the federal budget sequestration due to its impacts on scientific funding. Individual society members are encouraged to register with the AIBS Legislative Action Center (<http://capwiz.com/aibs/home/>), which provides timely notices of significant policy issues and makes it easy to respond with messages to one's senators and representatives.

This year, SSAR Symposium Coordinator Richard Durtsche received one symposium proposal: "Infrared Imaging: Cellular/Molecular Mechanisms, Behavioral Biology and Ecology of Pit Vipers, Pythons and Boas" (Michael S. Grace, lead organizer). This symposium will bring together a diverse group of biologists from a variety of fields to discuss the current state of knowledge of, and research on, infrared imaging systems and their roles in the lives of snakes. The goals also include an analysis of the next important steps in research of snake thermal biology, the ecological implications of invasions of exotic species possessing novel "weaponry," and a look at the technological advancements that may derive from a thorough understanding of the mechanisms of snake infrared imaging. The symposium proposal was sent out for external review and received comments from two reviewers. The reviews and proposal were submitted to the SSAR

Board for consideration of sponsorship and the Board approved the proposal.

New Business

President Aldridge informed the Board that President Mendelson signed a five-year contract with K-State Conference Services in 2012. Contained in this contract is a provision allowing any of the participating societies to withdraw from a particular meeting by providing a three-year notice.

There was discussion of “WikiHerps” posting full copies of SSAR publications, e.g., copies of *Herp. Review* have appeared on-line within 1–2 days of issuance. The site also provides links to book-length publications. Although the Society wants to encourage access to scholarly publications and is well aware that ease of access varies worldwide, these actions clearly represent a violation of copyright and they have important implications for SSAR. Various officers and editors were involved in recent months in determining an appropriate way of dealing with this issue. On the morning of the Board meeting, President Aldridge uploaded an open letter addressed to the administrators of WikiHerps in which he outlined how the Society operates (i.e., we are a volunteer organization that is primarily member-supported) and the potential effects of the actions of WikiHerps on our membership and our long-term survival as a Society. We were pleased that WikiHerps responded positively to this letter and the Society is in ongoing discussions with WikiHerps.

Greg Watkins-Colwell and Kirsten Nicholson presented various ideas regarding changes to the Live and Silent Auctions. We now have a single committee overseeing both auctions. This will help to ensure that items are funneled towards the appropriate event. Discussion turned to the cost of running the Live Auction (this is significant and cuts into the contribution to the Student Travel Awards budget) and ways of lowering expenses, e.g., implementing a cover charge, finding a local brewery willing to donate beer or a sponsor willing to cover costs, holding the auction at a nearby bar or restaurant, etc. It was emphasized that attendees needed to be reminded that, in addition to being a fun social event that can encourage membership and involvement in SSAR, the main point of the Live Auction is to raise funds to support student members.

A suggestion was received from the Membership Office that, on an annual basis, we acknowledge and publicly thank Life and Sustaining members of the Society by publishing a list of their names in *Herp. Review*. This was last done in 2004. The Secretary will contact Life and Sustaining members to request permission to publish their names and will ensure that this list appears annually.

Dick Durtsche requested that, if, in a given year, SSAR sponsors just one symposium at the Annual Meeting, the Board consider allocating the entire symposium budget (currently \$3,000) rather than the normal \$1,500. The Board approved this request. Gad Perry suggested that participants in SSAR-sponsored symposia consider contributing a special section to *J. Herp.*

The Board then turned to the 2014 budget. A doubling of funds allocated to the Student Poster Awards and the Roger Conant Grants in Herpetology Awards, a 50% increase in funds for the Student Travel Awards, and a request from the Student Mentorship Committee to support a lunch meeting for mentors and mentees were approved. A balanced budget of \$320,000 for 2014 was approved by the Board.

The meeting was adjourned at 1339 h.

LRPC Meeting

An open meeting of the Long Range Planning Committee (LRPC) occurred on July 13th. LRPC Chair Kraig Adler called the meeting to order. In attendance were the following members of SSAR: Kraig Adler, Bob Aldridge, Ann Paterson, Aaron Bauer, Rafe Brown, Raul Diaz, Linda Ford, Bob Hansen, Kris Kaiser, Joe Mendelson, Gad Perry, Marion Preest, Dawn Wilson. Kraig distributed an agenda and introduced members of the LRPC and other officers present. Four main topics were discussed.

SSAR Website.—Joe Mendelson and Raul Diaz (members of the Website Subcommittee) reviewed the status of the website update. The Society needs a revamped website that is easily updatable with lots of imagery and capable of webcasting. We need to avoid redundancy between the ZenScientist and SSAR websites, while still making it easy to bounce from one site to the other. Ideally officers and committee chairs would be able to update their own material (e.g., the Seibert Chair could post information about the award winners). Some training would likely be necessary. Joe and Raul recommended that we provide the webmaster with a list of “trigger dates” on which he/she would contact the appropriate person for a particular update. A suggestion was made that portraits and short bios of “key” people in the Society be posted. There was discussion of posting the budget and IRS tax forms to make the finances of the Society as transparent as possible and also to make it clear that we are a volunteer society (i.e., none of the officers, editors, committee chairs, etc., makes any salary from SSAR) and that more than half of our annual budget relies on member dues. There was also some discussion of making at least part of the website available in a language other than English (e.g., Spanish, Portuguese), and of having a non-graphics version available for those with limited internet access. Kraig requested that the subcommittee keep members of the LRPC updated as proposals for redesigning the website are received and as various decisions are being made.

SSAR Publications Office.—There was discussion of trying to reduce our stock of old journals and books that are no longer selling. The Society has sent some copies to various places, e.g., to individuals teaching herpetology classes accompanied by invitations to join SSAR. It is not clear whether this has resulted in any new members. We now order fewer extra copies of our publications. This reduces our holdings, but we still need to ensure that we have sufficient extra copies to provide a full year’s worth of journals as we recruit new members. There was a suggestion that we provide some incentive to try to avoid the necessity of over-printing, e.g., if someone does not join or renew by a certain date, they would only be able to receive electronic versions of our journals.

In light of the closure of his business *Bibliomania*, Breck Bartholomew has offered to step down as Publications Secretary. The Society has received an offer from another vendor to take over. Kraig Adler reviewed the services that Breck has provided SSAR for many years. After some discussion (including mention of Breck’s generosity, loyalty, and long-standing service to the Society and the excellent job his office does of handling membership issues), the LRPC voted unanimously to recommend to President Aldridge that we remain with Breck.

New Member-, Publicity-, and Income-Generating Ideas.—Various ideas for increasing membership, publicity, and income were discussed. One idea was to publish anthologies of all of the *Herp. Review* articles about, for example, *Ambystoma*, or larger groups (frogs, salamanders). Bob Hansen pointed out that this would not be an easy task because, even though all issues of *Herp. Review* are now electronic, they are in PDF form, which makes searching them difficult. Bob also did not think these kinds of anthologies would generate much income. A suggestion was made that regional aggregations of articles (e.g., all of the *Herp. Review* articles about species in a particular US region) might be popular.

There was ongoing discussion of having *Herp. Review* picked up by BioOne or JSTOR. “Repackaging” *Herp. Review* (e.g., moving the “news” section to the end or placing it on the website) may make it more attractive to these outlets. Ann, Bob Hansen, and Breck will contact BioOne to ask them about the criteria they use when deciding whether to accept a given publication.

Increasing SSAR’s Reach Overseas.—A number of suggestions regarding raising SSAR’s profile internationally were discussed. For example, the Society should be keeping track of when non-US herp societies meet and send membership information for distribution. Aaron Bauer suggested that we also send information about articles of relevance to members of these societies (e.g., send a list of articles from *Herp. Review* and *J. Herp* about herps in Africa to the meeting of the Herpetological Association of Africa) to make them aware of the fact that SSAR truly is an international society.

We need to do a better job of making overseas students (both our members and members of other herp societies) more aware of our travel and research awards. A suggestion was made that we use the additional funds just allocated to the Student Travel budget to specifically target overseas members. It would be useful to get feedback on the perceptions towards SSAR of overseas herpetologists who are not members of the society (i.e., are we relevant to them and if we are not perceived in that way, what can we do to change that perception?). We need to promote the new policy of \$0 page charges for members, as well as the underutilized pre-submission manuscript review service.

There was a suggestion that we target large Herp Expos, e.g., in Anaheim, Chicago, Arlington, etc. Some of these expos will give the society access to a free, 10 x 10 ft draped booth in which we could stock membership brochures and publications.

SSAR Life and Sustaining Member Recognition

SSAR wishes to publicly acknowledge the following Life and Sustaining Members. We would also like to thank those members who support the Society at these levels, but wished to remain anonymous. Anyone interested in becoming a Life or Sustaining Member, please contact Breck Bartholomew at the Membership Office (breck@herplit.com).

Life Members.—Kraig Adler, Kevin Arbuckle, Teresa Avila Pires, Mark Bailey, Breck Bartholomew, Thomas Beauvais, Brian Bastarache, Karen Bjorndahl, David Blackburn, I. Brisbin, Edmund Brodie, Rafe Brown, Stephen Busack, Donald Buth, John Cadle, David Canatella, William Carter, Jean-Phillippe Chippaux, Wen-Hao Chou, James Christiansen, Justin Congdon, Merel Cox, Ronald Crombie, Stephen Darbyshire, Kevin de Queiroz, Rafael

A local member could be persuaded to give an evening lecture or show one of the updated SSAR Dennis and Juterbock audiovisual shows at one of these expos.

Some SSAR members currently sponsor (or have sponsored in the past) individuals who either cannot afford membership dues or they pay a one-off membership as a way of encouraging individuals to become long-time members. We could think about formalizing a program that matches non-members with potential sponsors. Alternatively, we could have a checkbox on the membership renewal form in which a member indicates if they wish to contribute to support a new member or if they wish to contribute to the meeting registration costs of a current overseas member. Ann agreed to follow up on these suggestions.

SSAR Business Meeting

The Annual SSAR Business Meeting was called to order by President Aldridge (1800 h, July 13th). Seventy-nine members of SSAR were present. Officers, Editors, and Committee Chairs introduced themselves to the other attendees and gave brief summaries of their Annual Reports and relevant information from the Board Meeting. Henri Seibert and Student Poster Awards were presented by Rafe Brown and Tiffany Doan, respectively. The meeting was adjourned at 1906 h.

List of Abbreviations Used

AIBS - American Institute of Biological Sciences

AP - Allen Press

CAAR - *Catalogue of American Amphibians and Reptiles*

EBSCO - Elton Bryson Stephens Company

IRS - U.S. Internal Revenue Service

JMIH - Joint Meeting of Ichthyologists and Herpetologists

LRPC - Long Range Planning Committee

MMPC - Meeting Management and Planning Committee

MSO - Member Societies and Organizations

PARC - Partners in Amphibian and Reptile Conservation

WCH - World Congress of Herpetology

—Respectfully submitted by **MARION PREEST**, SSAR Secretary
(with assistance gratefully acknowledged from
Aaron Bauer and Greg Watkins-Colwell)

de Sá, William Degenhardt, David Dennis, Michael Dix, Wei-Guo Du, Arthur Echtenacht, Stephen Edwards, Robert Feuer, Clyde Fisher, Lee Fitzgerald, Neil Ford, Michael Forstner, M.J. Foubette, Ruben Franco, Thomas Fritts, Andrew Gardner, Frederick Gehlback, Alberto Gonzalez-Romero, Eli Greenbaum, Celio Haddad, Stephen Hammack, David Hardy, Larc Hayes, Harold Heatwole, Fred Hendricks, Ronald Heyer, Tsutomu Hikida, Walter Hödl, Rebecca Homan, Kim Howell, Andrew Huck, James Huheey, M. Hunter, Herman in den Bosch, John Iverson, Morris Jackson, Dora Jacobs, Ronald Javitch, Mark Jennings, Eeiti Kasuya, J.P. Kennedy, Douglas Kibbe, Dirk Kreulen, William Lamar, Macreay Landy, Robin Lawson, Adam Leache, Carl Lieb, James List, James MacMahon, Anne Maglia, Eugene Majerowicz, Roy McDiarmid, Wolfgang Michl, Nicholas Millichamp, Joseph Mitchell, Stephen Mullin, Hidetoshi Ota, Margalee Patton, Eric Pianka, George Pisani, Dwight Platt, Harvey Pough, Robert

Powell, Thomson Reuters, Yukio Sakisaka, Frederick Schlauch, Norman Scott, Richard Scott, Diane Secoy, Frank Slavens, Ian Straughan, Douglas Taylor, Robert Thomas, Stephen Tilley, Linda Trueb, Thomas Uzzell, Eddie van Dijk, Frank Velte, Bonnie Walters, Joseph Ward, Gregory Watkins-Colwell, Robert Webb, Yehudah Werner, Chris Williams, Kelly Zamudio, Robert Zappalorti.

Sustaining Members.—Jae Abel, Diane Barber, Catherine Bevier, Peter Bloom, Russell Burke, Oswald Burkhard, Marlin Corn, Maureen Donnelly, Todd Esque, Chris Feldman, Byron Fiegel, Nirvana Filoramo, Thierry Fretey, Jerry Johnson, J. E. Juterbock, Teresa Mayfield, Peter Mayne, Michael McCoid, Robert McKeever, Francis Mondrosch, Eric Munscher, J. Martha Patricia Ramirez Pinilla, David Wales, Kirwin Werner.

SSAR Student Poster Awards

The SSAR Poster Awards will provide recognition for the best student posters presented at the annual meeting of the SSAR. To be eligible, the presented poster must be the result of research conducted by the individual making the presentation. The research must have been conducted while the student was enrolled in either an undergraduate or graduate degree program. Students entering the competition must be members of SSAR. The presentations will be judged by the SSAR student poster prize committee. One SSAR Poster Award of U.S. \$200 (plus a book gift from an academic press that supports the award) may be given in each of the following four categories:

- Evolution, Genetics, & Systematics
- Ecology, Natural History, Distribution, & Behavior
- Physiology & Morphology
- Conservation & Management

The SSAR Poster Award will be judged by the following criteria:

- Quality of Research
- Quality of the Visual Display of the Research
- Professionalism and Confidence of the Presenter

Students may win the award only one time. Please indicate the appropriate category for which you are applying on the abstract submission form. Contact Tiffany Doan at tiffperu@yahoo.com or 860-839-2944 for further information.

Recommendations to Students Entering the SSAR Poster Competition

The SSAR Poster Award was presented for the first time at the 2011 Joint Meeting. The SSAR Board of Directors wishes to recognize that poster presentations are an important part of the annual Joint Meeting event and that they are an important component of the graduate and undergraduate experience. The presentation of some research projects is better suited to a poster session, which allows much greater communication between the presenter and the audience. The following recommendations are intended to aid students in improving the quality of their poster presentations. The criteria presented below are applicable to any poster given at a scientific meeting.

Preparing the Presentation

A. The Poster

- More so than an oral presentation, a poster needs to visually draw in the audience. When hundreds of posters are up at the same time, one's poster needs to stand out to be noticed.
- Put the poster up as early as is allowed by the conference center. That way you will have as many viewers as possible.
- Organization is key—a cluttered poster that is hard to read will not keep the attention of the audience.
- Use large fonts: at least 28–36 size font for the smallest words; approximately 90 size for the title.
- Use *sans serif* fonts such as Arial, Helvetica, and Calibri, which are easy to read from a distance.
- Use as many figures as possible, including graphs and photographs, to display your data.
- Use color to your advantage, but do not make it overwhelming. No one wants to look at a black-and-white poster, but too much color can be distracting.
- Do not include paragraphs on your poster (no one wants to stand there and read them). Bullet points or short sentences are much easier to read.

B. Oral Presentation

- Prepare a short explanation to your poster so that viewers do not have to read everything.
- Anticipate questions that the audience might have.
- Be prepared to discuss further research that you may later perform based on the results from the project about which you are presenting.
- Remember that other scientists have stopped at your poster because they are interested in your research. Relax and enjoy the experience of “talking shop” with other scientists who have similar interests.

Describing Your Research

A. Design

- Present your research in a larger context by addressing previous studies (choose 1 or 2 to make your point). Relate your data to the knowledge of your field.
- Clearly state your hypothesis(es) and/or objectives up front.
- Flag techniques that are original to your study (i.e., this study is the first to address this question or to use this technique).

B. Summary of Results

- Present your results clearly. Tables with N and P values are fine (but not necessary) if they are readable. Always indicate your sample sizes.
- Indicate the importance of your results. How do they relate to previous studies? Biology in general?

C. Importance of Study

- An abstract, summary, or conclusions section of your poster is helpful in tying together many results.
- State the importance of your study and how your research has added to knowledge of the subject presented. Are your results generally applicable to larger biological questions?

NEWSNOTES

Kentucky Collections Consolidated

Thomas More College has donated the previously orphaned amphibian and reptile collections from the Baker-Hunt Foundation Museum (Covington, Kentucky aka The Williams Collection), the University of Kentucky (the Roger Barbour collection), and the University of Louisville (the Burt L. Monroe collection) to the Cincinnati Museum Center. Further information on these collections may be obtained from John Ferner (fernerj@thomasmore.edu) and Herman Mays (hmays@cincymuseum.org).

Internship at Smithsonian's National Zoo



An unpaid internship position is available at the Smithsonian's National Zoological Park (N.Z.P.) in the herpetology department. N.Z.P. exhibits living animal and plant collections and conducts research in conservation biology and reproductive sciences as well as providing educational and recreational environments for the visiting public. The diverse living amphibian and reptile collection is housed in one of the most beautiful reptile buildings in the world, built in 1931. The N.Z.P. mission is to celebrate, study, and protect the diversity of animals and their habitats. N.Z.P. operates a public zoo of 167 acres in Washington, D.C. and is home to a diverse animal collection, ranging from frogs to elephants. N.Z.P. also manages the Smithsonian Conservation Biology Institute (SCBI) with a Smithsonian George Mason University campus on 3150 acres at Front Royal, Virginia. Research programs in animal health, behavior, medicine, and reproduction takes place in N.Z.P., SCBI, and in field locations throughout the world.

For additional information, including qualifications, job description, and application procedures, please contact: Dr. James B. Murphy, Curator at murphyj@si.edu, (tel. 202-633-3251). Information about the Zoo's program can be found by consulting Murphy and Xanten (2007. Seventy five years of herpetology at the Smithsonian's National Zoological Park. *Herpetol. Rev.* 38:262-273).

Partners in Amphibian and Reptile Conservation Receives Award

At the annual meeting of The Wildlife Society in Milwaukee, Wisconsin, in October 2013, Partners in Amphibian and Reptile Conservation (PARC) received The Wildlife Society's Group Achievement Award, which recognizes an organization's outstanding wildlife achievement. PARC joins other eminent conservation organizations, including the Wildlife Management Institute, the Nature Conservancy, the [International] Association of Fish and Wildlife Agencies, and many other productive and respected wildlife conservation groups as a recipient of this award. Read more about the award and past winners here: <http://www.wildlife.org/who-we-are/awards/group-achievement>.

Special thanks to Dr. Jessica Homyack, current SE PARC Senior Co-chair and active member of The Wildlife Society, who submitted the nomination with support from several active PARC members, including those who are also members of The Wildlife Society. This award also reflects the tireless efforts of members and product/project development volunteers through the USA who engage through Regional Working Groups and a growing number of State Chapters.

Amphibian & Reptile Conservation Announces New Issue and Website



**AMPHIBIAN & REPTILE
CONSERVATION**
Worldwide Community-Supported Herpetological Conservation
amphibian-reptile-conservation.org

Amphibian & Reptile Conservation (ISSN: 1083-446X; eISSN: 1525-9153) (ARC) is an open-access international journal that publishes original peer-reviewed research, reviews, short communications, new species descriptions, country overviews, and more, that focus on a variety of topics relating to the biology, conservation, natural history, and diversity of amphibians and reptiles. ARC is now published semi-annually and each issue typically focuses on one country or subject but not exclusively, with general issues being produced as well. The most recent issue (September 2013) focuses on Mexico and includes seven papers. An upcoming issue on the country of Colombia is being developed for 2014. Potential author(s) are encouraged to submit papers directly to the editor at: arc.publisher@gmail.com and/or for further discussion and consideration.

The NEW journal website is now located at: amphibian-reptile-conservation.org and is the official journal destination for news, updates, current and past papers published in the journal, and more. All current and previously published papers of ARC have been added to *ZenScientist.com* and can be downloaded for free there as well as on the official ARC website (amphibian-reptile-conservation.org):

<http://www.zenscientist.com/index.php/filedrawer/Open-Access-Journals/Amphibian--and--Reptile-Conservation/a>

MEETINGS

Sustainable Amphibian Conservation of the Americas Symposium

The first meeting of the Sustainable Amphibian Conservation of the Americas Symposium (SACAS) occurred in Siquirres, Costa Rica on 30 July—5 August 2013. The conference was a first of its kind for bringing together academicians, zoo professionals, amphibian enthusiasts, and conservationists in a forum where they could share expertise from a wide array of backgrounds. The five-day event was an exciting mixture of invited lectures, roundtable discussions, and field trips to nearby natural areas containing high amphibian diversity and endemism, including the Costa Rican Amphibian Research Center (CRARC). Local expeditions yielded exceptional opportunities for the participants to catch glimpses of and photograph gorgeous salamanders and frogs such as the critically endangered Lemur Leaf Frog (*Agalychnis lemur*; Fig. 1). The distinguished speakers included specialists from *ex situ*-focused amphibian conservation projects in Colombia (Tesoros de Colombia), Costa Rica (Costa Rican Amphibian



PHOTO BY BRIAN KUBICKI

FIG. 1. A Critically Endangered Lemur Leaf Frog (*Agalychnis lemur*) from the Costa Rican Amphibian Research Center reserve, one of the many species of amphibians and reptiles seen by participants during the field trip outings in reserves around Siquirres and at La Selva.

PHOTO BY AURA REYES



FIG. 2. Participants of the Sustainable Amphibian Conservation in the Americas Symposium held 30 July—5 August 2013 in Siquirres, Costa Rica. Back row (L to R): Brian Kubicki, Jan Post, Eric Andersen, Erick Berlin, Richard Revis, Federico Bolaños, Justin Yaeger, Erin Kelley, Devin Edmonds, Jason Brown, Colin Clark, Henry Krull, Brent Brock, Chris Sherman, Lucio Sepe, Gabriel Schmied, Jan Dohnal, Steven David Johnson; middle row (L to R): Holly Schroeder, Aura Reyes, Jennifer Pramuk, Matthew Mirabello, Sara Erickson, Ariel Horner, Lola Guarderas, Michael Wallitis, Ivan Lozano Ortega, Christin Schwarz; front row (L to R): Aaron Tuggle, Ed Smith, Lincoln Erickson, Ron Skylstad, Teresa Sepe, Dave Huth, Roberto Ibañez. Not pictured: Tim Herman, Aura Kubicki, Stefan Lötters, Mark Pepper, and Evan Twomey.

Research Center), Ecuador (Wikiri), Peru (Understory Enterprises), and Madagascar (Association Mitsinjo). One of the more interesting themes of this meeting was the concept of “conservation through bio commerce” where revenue generated from surplus captive bred offspring is helping to support in country amphibian conservation efforts. More specifically, several of the speakers highlighted during the conference are maintaining colonies of threatened amphibians and developing partnerships with federal governments. Profits from the sale of certified captive bred offspring to the international commercial trade are returned to the country of origin to support habitat protection, education, research, and other conservation efforts. These captive breeding programs also can help assure the survival of focal amphibian species in areas where emerging threats such as amphibian chytrid fungus (*Bd*) are present or where other threats such as rampant habitat alteration cannot be mitigated in a timely fashion. By flooding the market with certified captive bred stock, these projects also might reduce illegal collection of wild amphibians common in the pet trade. For example, all commercial trade of the endangered Golden Poison Frog (*Phyllobates terribilis*) endemic to Colombia currently is sustained with illegally collected animals. Bio commerce and captive breeding could discourage wildlife smuggling and encourage legal purchase of this charismatic species. Additional speakers from the United States representing Toledo Zoo, Woodland Park Zoo, and Tree Walkers International presented lectures on amphibian-focused *ex situ* recovery projects, reintroduction programs, and education efforts. Lectures by accomplished researchers from Germany, Guatemala, Mexico (including the keynote speaker Federico Bolaños), and United

States provided overviews of cutting-edge research being performed on the evolution, taxonomy, and natural history of dendrobatids and other amphibian taxa.

This symposium also was intended as a fundraising event from which proceeds will be disbursed among five *ex situ*-focused amphibian conservation projects. The last evening of the meeting included a live auction of donated items as well as sales of a t-shirt designed for the event. Throughout the week, the well-organized field trips offered tours of local reserves (e.g., Cahuita National Park, La Selva Biological Station), a botanical garden, an indigenous-run chocolate farm, as well as daytime and lively nighttime treks at the CRARC by renowned glass frog expert Brian Kubicki.

In all, more than 40 participants representing a dozen countries, all with an interest in neotropical amphibian conservation and biology, were in attendance. This symposium's success is the result of its thoughtful development and organization by Michael Wallitis and Richard Revis from Black Jungle Terrarium Supply who have had a life-long interest in dendrobatid and other tropical species and their conservation. Additional kudos to go Erik Anderson and Holly Schroeder who organized the symposium's successful fundraising efforts. Arguably, SACAS's most valuable outcome was the sharing of information that occurred throughout the week among its participants representing a wide diversity of expertise (Fig. 2).

—JENNIFER PRAMUK, Curator, Woodland Park Zoo, 601 N. 59th Street, Seattle, Washington 98103, USA

Meetings Calendar

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

9–10 January 2014—California / Nevada Amphibian Population Task Force Annual Meeting, Beatty, Nevada, USA. Information: <http://www.canvamphibs.com/>

21–23 February 2014—39th Annual Desert Tortoise Council Symposium, Ontario, California, USA. Information: <http://www.deserttortoise.org/symposium/index.html>

18–20 May 2014—6th Conference on the Biology of Plethodontid Salamanders, University of Tulsa, Tulsa, Oklahoma, USA. Information: <http://plethodontides2014.weebly.com>

4–7 June 2014—Biology of the Pitvipers 2, Tulsa, Oklahoma, USA. Information: <http://www.biologyofthepitvipers.com>

16–20 July 2014—International Herpetological Symposium, Riverside, California, USA. Information: <https://www.facebook.com/InternationalHerpetologicalSymposium>

30 July–3 August 2014—Joint Meeting of Ichthyologists and Herpetologists (SSAR, HL, ASIH), Chattanooga, Tennessee, USA. Information: <http://www.dce.k-state.edu/conf/jointmeeting/>

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, Beck Wehler or Ben Lowe; e-mail addresses may be found on the inside front cover.

Two Turtle Genomes Shed Light on the Evolution and Development of Turtle-Specific Morphology

Turtles have a unique body plan compared to other vertebrates, complicating morphology-based attempts to place turtles in the vertebrate phylogeny and shed light on their morphological evolution. To better understand the evolutionary history of turtle armor, modified scapulae, and lack of temporal fenestra and to elucidate the lineage's phylogenetic placement, the authors conducted a phylogenetic analysis with new genomic data. The authors used shotgun sequencing to generate genomic sequence data for a soft-shell turtle (*Pelodiscus sinensis*) and the Green Sea Turtle (*Chelonia mydas*). From these data, a series of sequence contigs were formed through *de novo* assembly averaging in excess of 3.3 megabases in length (N50), and resulting in genomes 2.2 gigabases in size. A concatenated dataset of 1113 homologous genes was generated that included both turtle species, as well as ten other vertebrates including birds, crocodylians, a lizard, mammals, an amphibian, and a fish. Several phylogenetic applications were then employed to infer the phylogenetic relationships and divergence times of these taxa. These phylogenetic analyses placed turtles as the sister taxon to crocodylians and birds, consistent with other recent genomic studies. Furthermore, these analyses revealed the turtle-archosaur split to have occurred sometime between 248 and 268 million years ago, coinciding with the earliest hypothesized stem turtle, *Eunotosaurus*, dated to roughly 260 million years. Interestingly, the olfactory receptor gene family has undergone substantial diversification in turtles, with the majority of the expansion occurring after the divergence of *P. sinensis* and *C. mydas*. Other genes controlling hunger and taste perception appear to have been lost in these turtles. The authors identified suites of genes that showed accelerated evolution, suggesting that these increased rates are tied to morphogenesis. One gene showing a highly accelerated rate of evolution in these turtles is *Mgs3t*, which has been reported in other taxa to reduce oxidative stress, possibly contributing to the decreased senescence and longevity observed in turtles. The authors also collected and sequenced RNA samples from turtle and chicken at different developmental stages. They found that these animals fit the "Hourglass Model" of vertebrate development, where developmental differentiation (and therefore gene expression) between two organisms is greatest early and late in development and reduced at mid-development, when the general vertebrate body plan is developing. Sure enough, despite

exhibiting a radically divergent body plan, they found weak but significant support for turtle mid-development gene expression being similar to that of birds relative to early and late development. Furthermore, they found 233 genes with increased expression in turtles after the split from their sister group, many of which are likely involved with ossification and extracellular matrix regulation, including the formation of the turtle-specific carapacial ridge. These findings serve to broaden our understanding of amniote relationships and morphological evolution, as well as evolution within testudines.

WANG, Z., N. IRIE, AND COLLEAGUES. 2013. The draft genomes of soft-shell turtle and Green Sea Turtle yield insights into the development and evolution of the turtle-specific body plan. *Nature Genetics* 45:701–706.

Correspondence to: **NAOKI IRIE**, RIKEN Center for Developmental Biology, Kobe, Japan; e-mail: asurain@cdb.riken.jp

New Frog Pheromone Found

Males of most frog species bear nuptial pads, swollen regions on the hand that develop during the mating season. The sexually dimorphic and seasonal nature of these structures strongly supports the hypothesis that they have a reproductive function. It has historically been thought these structures function to aid in gripping females during amplexus, necessary either because females are slippery or other males are intent on dislodging these competitors. The authors of this paper propose a new theory of function of nuptial pad function: pheromone production and delivery. The presence of glandular tissue in anuran nuptial pads has been noted previously, the product of which has been presumed to provide additional grip during amplexus. To investigate these structures further, the authors subjected nuptial pad tissue from breeding *Rana temporaria* to micro-CT scanning and histological staining. Furthermore, to understand their biochemical makeup, RNA transcripts were taken from the nuptial pad of a breeding frog. These transcripts were reverse-transcribed, cloned, and sequenced, as well as subjected to 3' RACE-PCR (a similar method that selectively amplifies the 3' side of transcripts that share a specific motif). Finally, high-performance liquid chromatography (HPLC) and mass spectrometry was performed on samples from nuptial pads from breeding and non-breeding frogs to characterize and quantify the constituent molecules. They found that the nuptial pads possess two distinct dermal gland types, each with pores exiting on the skin surface. The first gland type is a large gland with a thin epithelial layer and large lumen and the second is smaller with a thick epithelial layer and limited lumen. The transcriptome analyses discovered that the most abundant transcript type coded for five variants of a single protein, which the authors christened "amplexin." A search for similar known proteins (BLAST) found it most closely matched the salamander pheromone Plethodon Modulating Factor (PMF), strongly suggesting a pheromone function for amplexin. Furthermore, this finding may indicate a pheromone class that evolved in the branch leading to Lissamphibia (assuming lissamphibian monophyly). The HPLC and mass spectrometry

analyses showed that amplexin concentration spiked during the breeding season, and amplexins were completely absent outside the breeding season. As female frogs frequently exhibit skin abrasions in the pectoral region subsequent to ovipositing, the authors posit that nuptial pad bearing frogs may be delivering pheromones transdermally, as some plethodontid salamanders do. If so, this represents the first evidence of frog pheromones that are passed directly from male to female, rather than through the environment.

WILLAERT, B., I. VAN BOCXLAER, AND COLLEAGUES. 2013. Frog nuptial pads secrete mating season-specific proteins related to salamander pheromones. *Journal of Experimental Biology* (*in press*) doi:10.1242/jeb.086363.

Correspondence to: **INES VAN BOCXLAER**, Vrije Universiteit Brussel, Biology Department, Amphibian Evolution Lab, Pleinlaan 2, B-1050 Brussels, Belgium; e-mail: ivboxcla@vub.ac.be

Temperature Affects the Growth of Chytrid Fungus

Many pathogens are affected by environmental conditions such as temperature, precipitation, and humidity. Thus, anthropogenic changes in the environment can spark disease outbreaks. Chytrid fungus (*Batrachochytrium dendrobatidis* or *Bd*) is recognized as one of the leading causes of amphibian declines worldwide, with infections presenting as more intense and more common at cooler times of year and at high elevations. It has been proposed that *Bd* strains can adapt to their local environments. Understanding the properties of *Bd* across the narrow thermal range in which it can grow optimally can help predict effects on amphibian populations as climates change. Three strains of *Bd* from widely different locales in Australia were isolated from a Green-eyed Treefrog (*Litoria serrate*, Queensland), a Booroolong Frog (*L. booroolongensis*, New South Wales), and a Whistling Treefrog (*L. ewingii*, Tasmania) tadpole. The strains were grown *in vitro* at ten different constant temperatures (13–28°C) to examine the effects of temperature on growth and to determine the thermal tolerances of the fungus. The density of each isolate at each temperature was measured every 24 h over 15 days using spectrophotometry, at which point the density reached a plateau. The authors measured reproductive output and growth over 3–4 days by sacrificing a replicate colony and determining the zoospore concentration in 30 µl of sample. Temperature most affected *Bd* growth during the logarithmic growth phase. During this phase, the Queensland strain (QLD) grew the fastest from 15°–25°C, the New South Wales strain (NSW) grew fastest from 19°–23°C, and the Tasmania strain (TAS) grew the fastest from 19°–25°C. By growth plateau, NAW and TAS had reached the highest *Bd* density at 13°C. The QLD isolate grew the slowest at 26° and 27°C, whereas the TAS strain showed moderate growth and NSW strain did not grow at these temperatures.

No strains grew at 28°C. Time to zoospore release was not different by strain, but increased at warmer temperatures, while zoospore activity decreased with warmer temperatures. This study better elucidates the stark effects that temperature can have on *Bd* virulence and shows evidence for thermal adaptation in this fungus. This increased understanding of *Bd* ecology

can be used to predict effects on amphibian populations with changing environmental conditions.

STEVENSON, L. A., R. A. ALFORD, S. C. BELL, E. A. ROZNIK, L. BERGER, D. PIKE. 2013. Variation in thermal performance of a widespread pathogen, the Amphibian Chytrid Fungus *Batrachochytrium dendrobatidis*. *PLoS ONE* 8:e73830.

Correspondence to: **LISA STEVENSON**, School of Marine and Tropical Biology, James Cook University, Townsville, Queensland, Australia; email: lisa.stevenson@my.jcu.edu.au

Latitudinal Patterns of Amphibian Diversity Evaluated with Phylogenetics

It has long been noted that across the tree of life, organismal group diversity tends to increase as distance from the equator decreases—and amphibians are no exception to this phenomenon. Several hypotheses have been erected to explain the high species richness in the tropics, including more niches, long-term climate stability, elevated primary productivity, longer regional presence, elevated speciation rates, decreased extinction rates, and elevated and/or greater opportunity for immigration. The authors of this paper made use of a previously published, time-calibrated phylogeny of 2871 amphibians (~40% of extant species) in an effort to test some of these hypotheses. They employed methods that can simultaneously estimate rates of speciation, extinction, and other processes across a phylogeny. These analyses take advantage of the fact that lineages with identical net-diversification rates (speciation minus extinction) but different extinction/speciation ratios will exhibit differently structured phylogenies. Specifically, lineages with higher ratios will appear to have undergone a recent burst of diversification, as extinction has a disproportionate effect on older branches. Methods aiming to estimate these rates solely from information on extant taxa are somewhat controversial, as they assume that rates have remained constant through time, but simulations have shown that model performance improves with sample size and coverage. The authors also compiled geographic range data for 6117 species. From these, the distributional center was calculated and an ecological value was assigned (the first axis of a principal component analysis of 21 climatic and ecological variables, PC1, which was closely correlated with latitude). To investigate inter-region dispersal, they compiled a dataset wherein 6576 species were assigned to one or more of twelve global ecoregions. Suffice it to say there is inadequate space here to describe all that was tested in this paper, however the results of these analyses are fascinating. The hypothesis that high amphibian diversity in the tropics can be explained solely by there being more adjacent land in the tropics and thus more opportunities for immigration was rejected. They did indeed find higher speciation rates and near zero extinction rates in the tropics, and moderate extinction rates in the temperate zone. Despite these dynamics, dispersal rates into the tropics from temperate regions were found to be five times higher than movement in the other direction. Clade richness was positively correlated with area occupied and negatively correlated with latitude and PC1. Also, lineages with low stem- to crown-age ratios are relatively species poor, having suffered disproportionate levels of extinction. Some findings were at odds with recent, family-level studies of amphibian diversity,

such as the amount of time regions have been occupied having no correlation with richness, and increased niche evolution not conferring increased speciation rates. The authors conclude that increased speciation, low extinction, and lopsided dispersal rates explain the high diversity of the tropics, despite longer lineage occupation times in temperate regions. The authors suggest that constrictions of habitable area and drops in temperature experienced during glacial cycles could account for increased extinction rates in temperate regions.

PYRON, R. A., AND J. J. WIENS. 2013. Large-scale phylogenetic analyses reveal the causes of high tropical amphibian diversity. *Proceedings of the Royal Society B* 280:20131622.

Correspondence to: **R. ALEXANDER PYRON**, Department of Biological Sciences, The George Washington University, 2023 G Street NW, Washington, DC 20052, USA; e-mail: rpyron@colubroid.org.

Turtle Embryos Move Within Eggs for Thermoregulation

Behavioral thermoregulation is common in post-hatchling ectotherms and allows them to maintain their preferred body temperatures, increasing fitness through optimized processes from locomotion to digestion to reproductive output. It was thought that only post-hatching developmental stages used this strategy until a recent study on demonstrating that embryos of the Chinese soft-shelled turtle (*Pelodiscus sinensis*) can move to warmer parts of the egg. Yet it was not clear if these movements were due to embryo behavior, or to fluid dynamics within the egg. Additionally, it was not known if the embryos could move to cooler areas within the egg when temperatures rose above their optimal temperatures. The authors incubated 125 eggs from the Chinese Three-keeled Pond Turtle (*Chinemys reevesii*) at temperatures ranging from 26°C to 33°C, as this species has low hatching success above 32°C. Eggs were assigned to one of five temperature treatments, either being held constant at 26°C, dorsally heated to 29°C, or laterally heated to 29°, 30°, or 33°C. Eggs were candled and the midpoint of the embryo was marked on the egg and re-measured a week later. The authors found that the thermal treatments affected the position of the embryos. Embryos moved towards areas where the egg surface temperature was 29°–30°C, yet moved away from the too hot 33°C areas. To test if this was in fact due to behavior, at ten days, the halfway point of incubation, half the embryos were euthanized by injection and again the embryo position was remeasured a week later. Dead embryos did not move towards the heat source. These results support that embryonic turtles can indeed behaviorally thermoregulate, moving to parts of the egg with preferred temperatures. This may be especially important in turtles and other animals with temperature dependent sex determination as it could be a mechanism under which sex can be influenced by embryonic behavior.

ZHAO, B., T. LI, R. SHINE, W. DU. 2013. Turtle embryos move to optimal thermal environments within the egg. *Biology Letters* 9:20130337.

Correspondence to: **WEI-GUO DU**, Key Laboratory of Animal Ecology and Conservation Biology, Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China; email: duweiguo@ioz.ac.cn

Frogs Without Middle Ears Use Mouths to Hear

The middle ear is an adaptation that allows land dwelling animals to hear in air, yet some frogs that lack this structure still can hear and produce auditory signals directed at conspecifics. The mechanisms allowing sound to be transferred to the inner ear without a tympanic middle ear are unknown. It has been hypothesized that sound could be transferred via the lungs, the opercular system, and/or through bone conduction in these “earless” frogs. The authors recorded calls from male *Sechellophryne gardineri* (Sooglossidae), a diminutive frog from the Seychelles islands and one of the world’s smallest tetrapods. They analyzed call characteristics and performed playback experiments with males in the field to evaluate intensity of responses. Males did not modulate the frequency or amplitude of their calls. For every experimental playback, *S. gardineri* called back, suggesting hearing. Three-dimensional imaging of mass density was generated via holotomography for four earless frogs (all four extant Sooglossidae species including *S. gardineri*), as well as four eared frogs from the Caribbean. Morphology of the skull and distance between the inner ear and air were measured for the frogs and sound resonance frequencies were calculated for these structures. *S. gardineri* were found to have no tympanum, middle ear cavity, or a columella (a middle ear bone present in most living amphibians and reptiles). The authors identified a number of morphological characteristics likely tied to hearing, such as high density, thin tissues around the inner ear, low mineralization of the skull, and overall high ossification. Since the volume of the lungs was smaller than that of the mouth, the pulmonary system is an unlikely route of sound transmission. Additionally, the lungs had a higher resonance frequency than those that made up the calls of the frogs. The resonance frequencies of bone structures was found to weakly match to the frequencies of the calls produced by *S. gardineri*, whereas the resonant frequency of the oral cavity closely matched that of the dominant call frequency. Thus, vibration of the oral cavity appears to be the mechanism to bring sound to the inner ear of these earless frogs.

BOISTEL, R., T. AUBIN, P. CLOETENS, F. PEYRIN, T. SCOTTI, P. HERZOG, J. GERLACH, N. POLLET, AND J.-E. AUBRY. 2013. How minute sooglossid frogs hear without a middle ear. *Proceedings of the National Academy of Sciences* 110:15360-15364.

Correspondence to: **RENAUD BOISTEL**, Centre de Neurosciences Paris-Sud (CNPS), Centre National de la Recherche Scientifique (CNRS) Unité Mixte de Recherche (UMR) 8195, Université Paris XI, 91405 Orsay, France; e-mail: renaud.boistel@univ-poitiers.fr

Stable Isotopes Reveal Tadpole Niche Not Filled by Insect Grazers Following Amphibian Decline

With biodiversity losses, it is important to understand how a whole ecosystem will be affected. Catastrophic amphibian declines in the Neotropics have been hypothesized to have widespread consequences on stream ecosystems. Using stable isotope analyses, the authors identify community responses to tadpole declines in the Río María, a headwater stream in central Panama. In 2006, more than 20 species of tadpoles were present in the stream, yet over the subsequent two years, tadpole

biomass dropped 98%. The authors predicted that insect grazers would move in to the tadpoles' dietary niches, specifically that of the dominant tadpole grazer, *Lithobates warszewitschii* (Ranidae). By measuring the biomass and characterizing the diet of *L. warszewitschii* pre-decline and the four most common insect grazers (*Stenonema* sp., *Thraulodes* sp., *Psephenus* sp., and *Petrophila* sp.) both pre- and post-decline, they were able to compare trophic niches. Insects were collected in the dry seasons 2006 and 2008, identified to genus, and sorted into feeding classes. Organic material was collected from stream rocks during the same periods, whereas *L. warszewitschii* tadpoles were only collected in 2006. Each type of sample was dried at 50°C, ground up, and subjected to ¹⁵N and ¹³C analysis. For each sample, N isotope ratio was plotted against C isotope ratio, and the 2-dimensional mean and spread were identified for the tadpoles and each insect species pre- and post-frog decline. The guts were removed from five of each insect grazer per collection year, as were foregut segments from five *L. warszewitschii* tadpoles collected in 2006, and their contents were determined. The authors found that insect biomass in the stream did not change from 2006 to 2008, though the biomass of organic material on rocks more than doubled post-tadpole decline. Despite no change in organic material isotope ratios, three of the four insect taxa shifted their isotopic niche in the direction of *L. warszewitschii* subsequent to the decline. Yet the carbon and nitrogen isotopic niches of the grazing insects did not overlap with that of the tadpoles either pre- or post-decline. *L. warszewitschii* were found to primarily eat non-algal biofilm, and two insect taxa consumed a greater proportion of non-algal biofilm post-decline. The increase in organic material in the stream coupled with the lack of insect biomass increase post-tadpole decline supports the conclusion that despite shifts in diet, the insects did not move into the open tadpole dietary niche. This is one of the first studies to use stable isotopes to quantify effects of biodiversity loss in an ecosystem, showing that tadpole loss does indeed affect the nutrients available in the system.

BARNUM, T. R., P. VERBURG, S. S. KILHAM, M. R. WHILES, K. R. LIPS, C. COLÓN-GAUD, AND C. M. PRINGLE. 2013. Use of stable isotope ratios to characterize potential shifts in the isotopic niches of grazing insects following an amphibian decline in a Neotropical stream. *Journal of Tropical Ecology* 29:291–299.

Correspondence to: **THOMAS BARNUM**, Odum School of Ecology, University of Georgia, Athens, Georgia, USA; e-mail: barnutr@uga.edu

Sea Snake Disappearances from a Biodiversity Hotspot

Biodiversity declines are widespread across vertebrates, often tied to habitat destruction and over-exploitation. Yet in some cases, the causes of population declines are unknown, posing a great challenge to conservation efforts. Many snake declines in the last decade have occurred in protected areas, with evidence for factors leading to reduced population carrying capacity. Sea snakes have historically been found with great species diversity and individual abundances in the Timor Sea off the coast of Australia. The remarkable diversity and abundance of sea snakes at one site in particular, Ashmore Reef, has been known since the early twentieth century, and snake surveys have been conducted there regularly since the early 1970s. However, recent evidence of

snake declines at Ashmore Reef have surfaced, though no cause has been identified. To assess the status of sea snake populations in this hotspot, a combination of 11 survey efforts conducted between 1973 and 2010 were compiled from previous studies or conducted by the authors to estimate abundances and species diversity. The authors collected data on habitat complexity of the reef and estimated benthic cover using transects. In 1973 and 1994, more than 40 sea snakes were found per day. By 2002, only 21 snakes were found per day, decreasing to averages of 1–7 snakes found daily in subsequent years, despite increases in researcher sampling efforts. Additionally, there were concomitant decreases in sea snake species found, dropping from 9 species per day found in 1973, to 5 species in 2002, and 1–2 species in subsequent years, with some species disappearing from the site entirely. Habitat areas used by sea snakes also began shrinking after 2002. From their 2010 surveys, the authors found significant differences in coral cover and habitat complexity in different portions of the reef. Since 1983, Ashmore Reef had been a protected area, suggesting that habitat protection alone is not sufficient to curb these sea snake disappearances. Though the causes of these declines are unknown, the authors propose and discuss the following mechanisms of decline: habitat loss, prey loss, poaching and incidental capture, disease, invasive species, pollution, and recruitment failure. However, the authors did not find evidence to support any of these hypotheses, but do identify areas for further study, specifically work on reproductive condition of sea snakes from this area. They conclude that these enigmatic declines are likely due to multiple environmental and biological factors and that more research on other sea snake populations may yield clues to how best to manage these declining populations.

LUKOSCHEK, V., M. BEGER, D. CECCARELLI, Z. RICHARDS, AND M. PRATCHETT. 2013. Enigmatic declines of Australia's sea snakes from a biodiversity hotspot. *Biological Conservation* 166:191–202.

Correspondence to: **VIMOKSALEHI LUKOSCHEK**, Australian Research Council Centre of Excellence for Coral Reef Studies, Room 120, DB032, James Cook University, Townsville, QLD 4811, Australia; e-mail: vimoksalehi.lukoschek@jcu.edu.au

OBITUARIES

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Robert R. Capranica (1931–2012) and the Science of Anuran Communication

Field herpetologists—and field biologists generally—have been entertained, soothed, and sometimes even seduced by the nocturnal serenades of frogs and toads. A harbinger of spring in the temperate zone and of the rainy season in the tropics, those who have not experienced a frog chorus have missed out on one of Nature's great spectacles.

Aristophanes, the comic playwright of ancient Athens, was the first to describe a frog's mating call in written form (in 405 BCE). It wasn't until 1905, however, that Robert M. Yerkes, a psychologist then at Harvard University, showed conclusively that frogs could actually hear the calls! Two Cornell University ornithologists, Arthur A. Allen and Peter Paul Kellogg, made the first sound recordings of frog calls (on the optical sound track of movie film in 1935). The original use of "sonographs" (sound spectrograms) to visualize frog calls was by W. Frank Blair of the University of Texas at Austin (1954), and Bernard S. Martof, then at the University of Georgia, was the first to conduct playback experiments with tape-recorded calls (1958). During this same period, Charles M. Bogert, of the American Museum of Natural History, provided a functional classification of frog vocalizations and addressed many issues about the biological significance of frog calls including their role as isolating mechanisms in reproduction.

It could be attested, however, that the subject of anuran communication did not truly become a rigorous experimental science until the research performed by a young electrical engineer-turned-neuroscientist was initiated in the early 1960s. Robert R. Capranica, one of the founders of neuroethology (a branch of biology that seeks to understand the neural basis of natural animal behaviors), began his research career in the Department of Sensory and Perceptual Processes at Bell Telephone Laboratories in Murray Hill, New Jersey, and then, in 1969, moved to the Department of Neurobiology and Behavior at Cornell University in central New York State. It was Capranica who pioneered the use of quantitative behavioral analyses to determine key features in a frog's complex vocal signal and later combined these studies with electrophysiological analyses of the frog's auditory system,

thus firmly establishing the connection between brain and behavior. He set the stage for numerous investigations that linked hearing and decoding mechanisms in frogs with both their ecological setting and their evolutionary diversification. Capranica forever changed the standards for bioacoustics research, and he trained and inspired several generations of biologists and engineers to study animal communication from this same broad biological perspective. In doing so he made frog communication one of the best-studied phenomena in biological science.

Robert Rudy Capranica, who died last year a few weeks shy of his 81st birthday, was born in Los Angeles, California, on 29 May 1931, and raised in southern California. His formal education was entirely in electrical engineering (University of California at Berkeley, B.S. 1958; New York University, M.S. 1960; Massachusetts Institute of Technology, Sc.D. 1964). Since 1958 he had been working at the famed Bell labs where they had supported his research on the auditory system of frogs, which formed the basis



KRAIG ADLER

*Cornell University, Department of Neurobiology and Behavior
Ithaca, New York 14853-2702, USA*

e-mail: kka4@cornell.edu

PETER M. NARINS

*University of California at Los Angeles, Departments of Integrative Biology
and Physiology and of Ecology and Evolutionary Biology*

Los Angeles, California 90095-1606, USA

e-mail: pnarins@ucla.edu

MICHAEL J. RYAN

*University of Texas at Austin
Department of Integrative Biology
Austin, Texas 78712-8058, USA*

e-mail: mryan@mail.utexas.edu

for his doctoral dissertation. What he produced has been referred to as “. . . arguably the most elegant dissertation research ever completed in animal bioacoustics.” This was published as a book by MIT Press in 1965—entitled “The Evoked Vocal Response of the Bullfrog [*Lithobates catesbeianus*]. A Study of Communication by Sound”—and is now a classic in the field. In it he pioneered the use of synthetic calls for playback experiments, showed that the mating call of the bullfrog was species-specific, and systematically demonstrated that the two principal components of the bullfrog’s mating call (its high- and low-frequency energy bands) must be present simultaneously to evoke a vocal response from an isolated male. It was a first attempt to answer the query, “What does the frog’s ear tell the frog’s brain?” and he spent the rest of his career attempting to answer this fundamental question.

Although Capranica devoted much of his time studying the function of calls of various species in the field and the lab, his ultimate goal was to understand how acoustic signals are processed. Prior to his work, it was thought that the decoding of sensory information was done solely in the brain and that the ear was simply a passive conduit for information. He demonstrated that much of the signal processing was, in fact, done within the inner ear organs themselves, an example of what is called “peripheral processing.” Capranica and his colleagues also followed this message to the brain and determined how information is processed through a series of brain nuclei, culminating in a “mating call detector” in the frog’s thalamus.



After arriving at Cornell, Capranica the engineer also became an accomplished field naturalist. His first overseas field trip was to Puerto Rico in 1973, together with his wife (Patricia), a new postdoc from Murray Littlejohn’s lab in Australia (Jasper Loftus-Hills), and one of his first graduate students (Peter Narins). He was involved in all aspects of the field work, experimental design, and testing. Narins was searching for an appropriate species to study for his dissertation research and thought that the ubiquitous and abundant Puerto Rican Coqui (*Eleutherodactylus coqui*) would be a likely candidate. He wanted a frog that produced a call with a sequence of simple notes to replicate in the time domain what Capranica had studied with bullfrogs in the frequency domain, in order to determine if the normal note sequence was required for a natural behavior. The coqui frog seemed to be ideal because males produce a two-note call (“co-qui”); each note is spectrally simple and easily synthesized (a Cornell graduate student, Bruce Land, built the first portable “co-qui” synthesizer in 1972); and this species is large enough to permit electrophysiological recordings from its auditory system.

On this first trip to Puerto Rico, a series of acoustic playback experiments with male coquis revealed that the natural (actually, a synthetic version of the natural) two-note call evoked a characteristic one-note (“co” only) response from males in the field nearly half the time it was played. Moreover, both the sequence-reversed call (“qui-co”) and the single note (“co”) were equally effective at evoking the one-note response, but the “qui” note alone was almost completely ineffective. Capranica’s enthusiasm for these field experiments was infectious and inspiring to everyone around him.

Capranica financially supported field studies by his own students and postdocs, and also by those working in other Cornell labs. Loftus-Hills was not directly involved in these Puerto Rican experiments, but on this same trip he discovered a spectacular new species of coqui calling from water-filled bromeliads 10 m above the ground, on the basis of its previously unrecognized call. After his untimely death in 1974, the frog was named for him by George Drewry and Kirkland Jones in *Journal of Herpetology* (1976). This species—the Golden Coqui (*Eleutherodactylus jasperi*)—was the first and is still the only ovoviviparous frog known from the Western Hemisphere. Narins returned to Puerto Rico in 1974 to continue his field studies, accompanied by a fellow graduate student in another lab, Kent Wells, who was thus introduced to Neotropical frogs and their behavioral ecology.

Many in his own field of neuroethology were unaware of Capranica’s influence on studies of animal speciation. Species-recognition studies in frogs offered important proof that behavioral isolation could drive speciation. Blair, Littlejohn, and Carl Gerhardt, Capranica’s first postdoc, all made seminal contributions to this field by showing how the mating call and its recognition resulted in species-specific mating preferences by females. All of these results were consistent with Capranica’s studies of how the auditory system, inner ear, and brain bias the perception of females to find calls of their own species more attractive.

Capranica also teamed up with the noted Israeli biologist, Eviatar Nevo, to extend the concept of species recognition to that of dialect recognition. Combining ecological surveys of the calls of cricket frogs (*Acris*) throughout much of the United States with detailed studies of auditory neurophysiology, Capranica and his colleagues showed how variation in calls and the neural mechanisms that decode them can co-vary from one population to the next even within one species. Although he was trained as an electrical engineer and practiced as a neuroethologist, he knew how

important sexual communication was to evolutionary biology. As such, even the evolutionary biologists who spent time at his bench, such as Michael Ryan, were made to feel welcome.

Capranica's lab at Cornell was home to an interdisciplinary hive of graduate and postdoctoral students drawn from engineering, psychology, neuroscience, and animal behavior. They studied communication and the evolution of sound processing in a diverse array of anuran taxa including *Ascaphus* and *Xenopus* and in representatives of many families of advanced frogs. They also studied the lateral-line sensory organs in *Xenopus*. Among the young scientists he mentored were his own graduate students (including Karen Mudry Avil, Christine Boake, Eliot Brenowitz, Avis Cohen, Martha Constantine-Paton, Frank Dodd [his only student who worked with reptiles—on the vocalizations of geckos], Albert Feng, Peter Narins, John Paton, Gary Rose, David Yager, and Harold Zakon), his postdocs (Deana Bodnar, Carl Gerhardt, Jasper Loftus-Hills, Michael Murray, Andrea Megela Simmons, Walter Wilczynski, and Nigel Woolf), and rotational students from other labs (Stephen Nowicki and Michael Ryan).

In the lab, Capranica worked closely with his long-time technician, Anne Moffat, and together they carried out long electrophysiological experiments in which they would record from single fibers in the auditory systems of frogs. Their studies were usually done on Fridays, a day that was held sacred and thus unavailable for student lab research, but the students would often hang around the lab on those days simply to watch the master at work. The experiments would begin in the morning when the animals were anesthetized, the surgery was done, and the frogs were then placed in the soundproof chamber and the electrode was poised to enter the auditory nerve. The recordings were done in the afternoon but often extended beyond dinner and into the late hours of the evening.

Capranica also served his discipline as a highly dedicated associate editor for section A (sensory, neural, and behavioral physiology) of the *Journal of Comparative Physiology* (1974–1986) and thereby helped to raise its standards to become the leading journal for neuroethology. In attracting manuscripts

from around the world, he would often re-write entire papers into proper English in order to help make neuroethology a more international discipline. In the early 1980s, together with a small group of Europeans and Americans, he founded the International Society for Neuroethology, which now awards the Capranica Prize each year for the best paper published in the field of neuroethology. His well-known sense of humor and infectious laughter made him a popular teacher, lecturer, and friend.

Only on one occasion did Capranica attend a herpetological meeting. At the SSAR meeting in 1976, held at Miami University in Ohio, he participated in a symposium, entitled “Reproductive Biology of Amphibians” (published the next year under the editorship of Douglas Taylor and Sheldon Guttman). After listening to a speaker remark how he tested the toxicity of skin secretions of frogs—by requiring his entire class of students to lick them—Capranica exclaimed, “You herpetologists really are crazy.” One might infer from this comment that he did not consider himself to be a card-carrying herpetologist, but his research nevertheless is counted among the most important bodies of work ever conducted with amphibians.

Capranica's major research accomplishments include: 1) multiple studies showing that the auditory systems of different species of frogs have different spectral sensitivities; 2) the discovery of acoustic dialects in frogs and the existence of distinct call types in allopatric populations; 3) the introduction of the concept of the “matched filter” to provide an underlying basis for the co-evolution of sender and receiver; and 4) studies on the remarkable temporal sensitivity found in the cells of the anuran central nervous system that are often closely matched to advertisement call features. Together with his Cornell colleague, Watt Webb, an engineering physicist, he applied the then-novel technique of laser Doppler vibrometry to measure the nano-scale vibrations in the eardrums of frogs and other animals. LDV is now a standard technique in the auditory mechanics community.

Robert Capranica died on 11 May 2012 in Tucson, Arizona, where he had retired in 1993. He is survived by his wife, Patricia Alna Capranica (née Mullen).

ARTICLES

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Caretta caretta in Tunisia: Natural History and Report of a New Regular Nesting Area

Five sea turtle species have been recorded in the Mediterranean Basin (Delaugerre 1988; Rivera et al. 2011); however, only three species occur regularly. The Leatherback (*Dermochelys coriacea*) regularly enters the Mediterranean for foraging, with no documentation of nesting activity to date (Casale et al. 2003). The Green Turtle (*Chelonia mydas*) breeds only in the eastern Mediterranean, with the main nesting populations occurring in Turkey, Cyprus, and Syria (Kasperek et al. 2001; Rees et al. 2008). The Loggerhead (*Caretta caretta*) is the most common species, widely distributed in the Mediterranean Sea, with an average of 7200 nests documented annually (Casale and Margaritoulis 2010). However, nesting is almost entirely confined to the eastern Mediterranean Basin, with the main nesting sites being concentrated in Greece, Cyprus, Turkey, and Libya (Casale and Margaritoulis 2010). Minimal to moderate nesting has been recorded in Egypt, the Gaza strip, Lebanon, Israel, Italy, Syria, and Tunisia (Campbell et al. 2001; Margaritoulis et al. 2003; Casale and Margaritoulis 2010). Recently, sporadic nesting has also been recorded in the western Mediterranean, namely in Spain, Corsica, Sicily, and along the Tyrrhenian coast of Italy (Delaugerre and Cesarini 2004; Casale et al. 2012). The Loggerhead is the only species of sea turtle known to nest on Tunisian beaches (Laurent et al. 1990).

Since the initiation of monitoring of sea turtle activity in the Mediterranean (nesting, foraging, bycatch, and live/dead strandings), it was evident that Tunisian beaches represent the westernmost nesting grounds, albeit minor, for Loggerheads in the southern Mediterranean (Laurent et al. 1990), as there are no records of regular Loggerhead nesting activity in Algeria or Morocco (Casale and Margaritoulis 2010). However, the full distribution of nesting activity in Tunisia remains poorly documented. Many potential nesting sites have not been monitored since the first mission of WWF in Tunisia (Laurent et al. 1990) and only one monitoring program has been implemented since 1997, on the Kuriat Islands, which are considered to be the only regular Loggerhead nesting site in Tunisia (Casale and Margaritoulis 2010). Tunisia has many other potentially suitable sites for Loggerhead nesting, with nesting activity being occasionally reported on various beaches by local inhabitants (Laurent et al. 1990).

In this paper we aim to increase available information about Loggerhead nesting activity in Tunisia. At a national scale, we assimilated all available records from the published literature of Loggerhead records and nesting events to determine this species' distribution in Tunisia since the 18th century. At a local scale,

we report the nesting activity of Loggerheads at Essir beach in the city of Chebba (Mahdia Governorate). We describe the characteristics of the beach and identify possible threats to nesting activity.

Methods.—Tunisia has approximately 1250 km of coastline, of which 400 km is sandy beaches. A third of the coastline is located in the western basin of the Mediterranean Sea and is mainly characterised by a rocky zone with intermittent small beaches. The remaining coastline extends along the eastern basin of the Mediterranean and is mainly characterized by large sandy beaches.

Our observations took place on the beaches of Chebba, which is located on the eastern coast of Tunisia (35°14N, 11°9E). Chebba is situated 60 km N of the city of Sfax and 30 km S of the city of Mahdia (locality 11 in Fig. 1). The Chebba coast extends 29 km and includes several small islands. Almost all of the Chebba shoreline is rocky, with dead sea grass (*Posidonia oceanica*) deposited on submerged rocks; however, there are two sandy beaches: Sidi Massouad (length 100 m and mean width 25 m) and Essir (length 400 m and mean width 35 m). The Kuriat Islands represent the closest known Loggerhead nesting sites and are located about 65 km N of Chebba (locality 10 in Fig. 1).

Our investigations were based on several lines of evidence, including 1) information received from people frequenting the two beaches at night; 2) records of recently hatched turtles being captured in fishing nets close to the beach; and 3) direct observations made by us from 2003–2013. We did not dig to confirm the presence of potential nests. We used only track morphology to infer whether a clutch had been laid or not and made direct observations of hatchling turtles on the beach.

Results.—The first reports of the presence of Loggerheads in the Gulf of Gabes were made in 1889 (Servonet 1889). Subsequently, the presence of Loggerheads was mentioned by Olivier (1896) in the region of Tunis and Bizerte, Mayet (1903) and Seurat

JIHÈNE BEN HASSINE*

Faculty of Sciences of Tunis, Department of Biology,
University of Tunis-El Manar, 2092 Tunis, Tunisia

DANIEL ESCORIZA

Institute of Aquatic Ecology and Department of Environmental Science,
University of Girona, Campus Montilivi, Faculty of Sciences, 1
7071 Girona, Spain

*Corresponding author; e-mail: jihenbenhassine@gmail.com

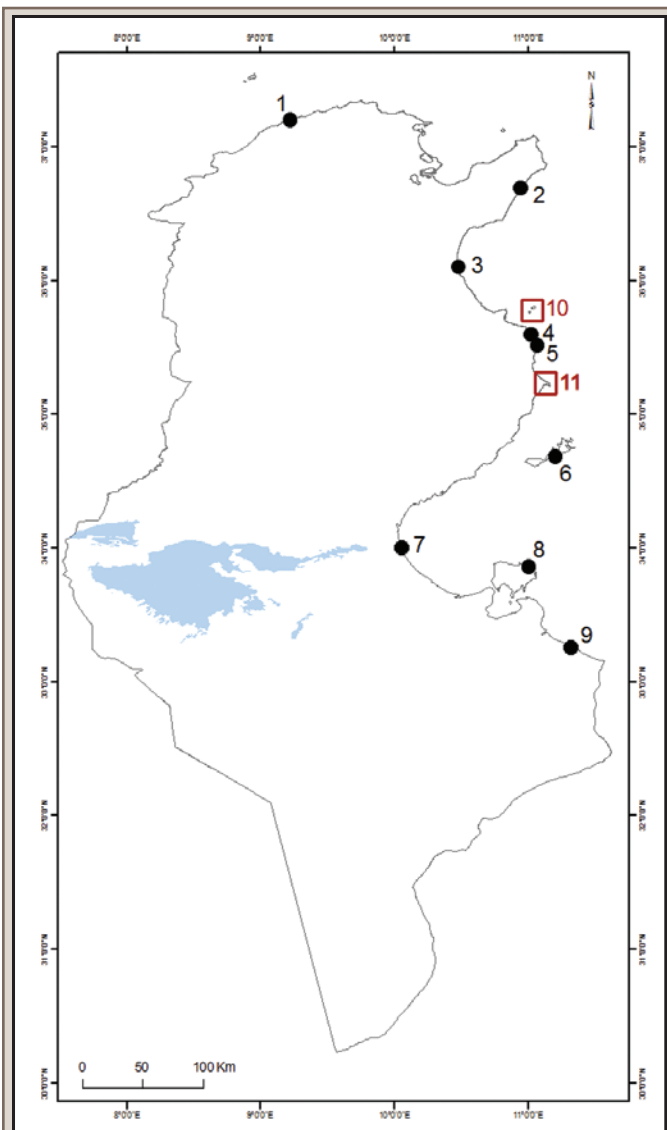


FIG. 1. Distribution of nesting sites of *Caretta caretta* in Tunisia. Black circles: literature sites. Red rectangles: documented nesting sites. 1) Cape Serrat; 2) Nabeul; 3) Hammamet; 4) Ras Dimas; 5) Mahdia; 6) Kerkennah Island; 7) Ghannouche (Gabes); 8) Sidi Mehrez (Jerba Island); 9) El bibane to Libyan borders; 10) Kuriat Island; 11) Chebba.

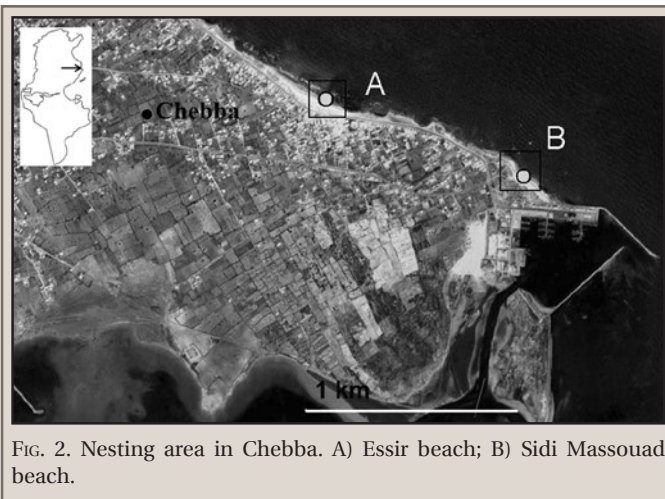


FIG. 2. Nesting area in Chebba. A) Essir beach; B) Sidi Massouad beach.

(1934) in the Gulf of Gabes, Mosauer (1934) in Sfax, and Blanc (1908, 1935) and Domergue (1959) along the entire coast of Tunisia. According to these authors, Loggerheads were very common throughout Tunisia. Other publications have reported the presence of large numbers of sea turtles, which were probably Loggerheads; according to Bouchon-Brandely and Berthoule (1890) and Charcot (1924), sea turtles were very common in the areas of Sousse and Banc des Esquerquis (northeastern Bizerte), with fishing boats potentially landing five or six turtles a day.

There is a paucity of published information about Loggerhead nesting activity in Tunisia. According to Blanc (1935), Loggerheads lay eggs on the islands, islets, and deserted beaches of Tunisia. Knoepffler (1962) and Parent (1981) mentioned that Loggerheads nest on “petite Syrie” (Gulf of Gabes) and the beach of Bougrara. However, Argano (1979) stated that the eastern coast of Tunisia represented the most important region in North Africa for Loggerhead nesting activity, considering the immense range of uninhabited beaches.

In the past, intense and widespread nesting has been observed along the Tunisian coastline; however, nesting numbers subsequently collapsed because of habitat degradation and intense fishing activity (Bradai et al. 2008). According to Laurent et al. (1990), Schleich et al. (1996), Bradai (2000), Chaeib et al. (2011), and the testimonies of the fishermen and local inhabitants, there is evidence of past nesting activity on the beaches of Salakta, the beaches between Chebba and Gdhabna, Eddouwira beach, the beaches between Mahdia-Hiboun (locality 5, Fig. 1) and Ras Dimas (locality 4, Fig. 1), the beaches of Ghannouche (Gabes; locality 7, Fig. 1), the beaches between El Bibane, Zarzis, and the Libyan border (locality 9, Fig. 1), the beaches of Nabeul (locality 2, Fig. 1), the beaches south of Hammamet (locality 3, Fig. 1), and the beaches of Kerkennah Island (locality 6, Fig. 1) and Sidi Mehrez (Jerba Island; locality 8, Fig. 1). Only Groombridge (1990) reported Loggerhead nesting activity in northern Tunisia, at Cape Serrat (locality 1, Fig. 1). The identity of nesting sea turtles in Tunisia as Loggerheads was first confirmed between 1987 and 1988 by Laurent L. and A. Jeudy de Grissac (Laurent et al. 1993; Fig. 1), on a beach situated between Ras Dimas and Mahdia (25 km south off Monastir), the Kuriat Islands (15 km off the coast near Monastir), and at Sidi Massaoud beach in Chebba (Ellouze 1996; Fig. 1).

The southern part of the Gulf of Gabes (Tunisia) is considered to be an important overwintering and foraging region for juvenile and adult Loggerheads in the Mediterranean (Laurent and Lescure 1994; Margaritoulis et al. 2003). However, nesting activity has not been reported on the beaches between Sfax and the border of Libya (RACSPA 2001).

The Kuriat Islands are two small islands (Little Kuriat and Great Kuriat) off the east coast of Tunisia that represent the only known stable and regularly used nesting site for Loggerheads in Tunisia (Casale and Margaritoulis 2010). However, only a small number of nests are deposited each year, with annual numbers ranging from 3–15 (Jribi et al. 2009). Since 1993, nesting activity was not recorded in Hiboun or between Mahdia and Ras Dimas beaches (Ellouze 1996). In addition, nesting has not been reported on Sidi Massaoud beach since 1997 and this nesting area was considered to be used only irregularly (Casale and Margaritoulis 2010).

After the initial record of Loggerhead nesting activity on Sidi Massaoud beach in Chebba (Fig. 2) in 1994 (two nests) and in 1995 (one nest; Ellouze 1996), follow-up surveys during 1996–2000 recorded no further nesting activity. This lack of nesting

was possibly due the physical artificial alteration of this beach (Bradai et al. 2008; pers. observ.). However, during the summer of 2003, vacationers found hatchlings on the road close to Essir beach (probably due to artificial lighting behind the beach disorienting the hatchlings and drawing them inland). Since then and until summer 2013, hatchling turtles have been recorded emerging from the sand of Essir beach every summer (from mid-August to the mid-September) or have been caught in fishing nets close to the coast (Fig. 3). The crawl tracks of nesting females were recorded on Essir beach from late June to July in 2005 and 2008. Recently, female Loggerheads have possibly shifted nesting locations from Sidi Massaoud beach to Essir beach, about 1.24 km further north (Fig. 2). This change in nest-site fidelity is probably a consequence of disturbance affecting Sidi Massaoud beach, where a large section of beach area has been destroyed (Fig. 4). Sidi Massaoud beach decreased from 150 m in length and 50 m in width at the central point during 1994 (Ellouze 1996) to 100 m in length and 25 m in width at the central point during 2013 (pers. observ.; Fig. 4A). Although Essir beach is also subject to intensive human recreational use during summer, in July 2013, a total of 97 hatchling turtles emerged from two nests at Essir Beach (Fig. 2). Many of them were found lost on the road paralleling the beach by local people. However, in September 2013 hatchling turtles were found for the first time since 1997 at Sidi Massaoud beach, possibly in relation to a reduction of human disturbance.

Discussion.—Our observations, in combination with the literature review of turtle nesting activity, indicate that the number of Loggerhead nesting beaches in Tunisia may be underestimated and that Chebba beaches represents the southernmost regular nesting site for Loggerheads in Tunisia. In summer 2013, a dead adult female was found at Eddouwira beach. This suggests that nesting activity may also exist between this unfrequented beach and Ghabna beaches. Our observations indicated that the nesting period on Chebba beach is limited to the last two weeks of June and the first two weeks of July, which is similar to that recorded at almost all the Mediterranean nesting sites (Margari-toulis et al. 2003). According to Ellouze (1996), the hatching success (percentage of eggs hatched) and hatchling emergence success (percentage of hatchling emerged) on Chebba beach were 81% and 74%, respectively, indicating that this beach is suitable for incubating Loggerhead nests. On the Kuriat Islands, which is currently the only location in Tunisia where Loggerhead nesting beaches have been monitored and protected, the mean hatching success and hatchling emergence success were 73% and 70%, respectively (Jribi et al. 2006).

The sea turtle nesting season in Tunisia coincides with the tourist high season, both occurring during the summer months of June to August. Certain tourism activities may prevent turtles from nesting. The Loggerhead sea turtle is subject to several threats in the area of Chebba beach, both on the beach and in the sea. On Chebba beach, camping and sun-umbrellas risk damaging nests through piercing the eggs and potentially lowering incubation temperatures (Fig. 4B). When incubation temperatures drop below 24°C, embryonic development stops irreversibly (Yntema and Mrosovsky 1982). In addition, the lowering of incubation temperatures might alter hatchling sex ratios, as more males are produced at temperatures below 29°C (Kaska et al. 1998). The artificial lights adjacent to or directly behind the beach (harbor and corniche) have been shown to disorient hatchlings, which are attracted to light, consequently increasing the time that hatchlings spend on the beach, increasing their



FIG. 3. Emergent hatchling turtle on Essir Beach, Chebba (17 August 2013).



FIG. 4. Anthropogenic activity in the nesting area of *Caretta caretta* in Chebba. A) Sidi Massaoud beach; B) Essir beach.

vulnerability to desiccation or predation by cats and sea birds that frequent Chebba beach (Lorne and Salmon 2007). The mechanical cleaning of Essir beach (to remove rubbish and sea grass) and the use of four-wheel drive cars on the beach obliterate turtle tracks and nests, which confounds monitoring routines and more importantly may destroy nests (through compacting the sand and crushing eggs). The physical alteration of the Essir nesting beach (due to the placement of sun-umbrellas, sunbeds,

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boardwalk, two wooden cabins, and beachfront construction) and reduction in nesting habitat through building permanent structures on the beach of Sidi Massouad may prevent female turtles from reaching a suitable nesting location on the beach, leading to a direct impact on hatchling emergence and hatching success. Evidence of this threat was observed in September 2010, when more than 100 hatchlings were found dead, trapped under a boardwalk that is installed every summer in the first week of July. Furthermore, human use of the beach at night risks disturbing female turtles and may prevent them from emerging onto the beach to nest. In Tunisia, in addition to mortality rates caused by fishing methods (Jribi et al. 2007), marine turtles may, on occasion, be intentionally killed by some fishermen in Chebba.

At present, national marine turtle conservation strategies in Tunisia are primarily focused on reducing the at-sea mortality of adult and juvenile Loggerheads (Jribi et al. 2010; Casale et al. 2010) and on protecting the nesting sites on the Kuriat Islands. Beyond the Kuriat Islands, the protection of nests on beaches along the Tunisian coastline would contribute appreciably toward improving Loggerhead numbers and, possibly, genetic diversity. Therefore, large-scale national surveys are required to determine whether other previously described areas with low levels of Loggerhead nesting activity, such as Chebba, might also have undetected nesting activity. To support the conservation of Loggerhead sea turtles, we strongly recommend the introduction of a large-scale conservation approach that reduces at-sea mortality in parallel with protecting known and suspected nesting areas, through a nationwide replicated survey of all potential nesting sites.

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Inferring Sea Turtle Recapture Rates Using Photographic Identification

The ability to consistently identify individuals over time is essential when studying population parameters such as growth rates, age structure, migratory movements, survivorship, residency, and population size (Stevick et al. 2001; Williams et al. 2002; McMahan et al. 2007). Individual recognition often is accomplished by capturing animals and applying a unique marker such as artificial tags or brands that allow for identification upon recapture (McMahan et al. 2007). Such marking techniques are successfully used by many capture-mark-recapture (CMR) studies; however, marked animals may experience adverse physiological or behavioral effects as a result of the capture process and marking procedure and markings may cause pain or infection, reduce survival and reproduction, or increase risks of entanglement (see Walker et al. 2012 for a review). Additionally, the loss of identification markers can compromise estimates of demographic parameters (Arnason and Mills 1981; McDonald et al. 2003).

Identifying individuals by their natural markings serves as an alternative to physically marking animals and is a technique that has been used in long-term studies of a variety of terrestrial and aquatic species (see Morrison et al. 2011 for a review). The process, known as photographic identification (hereafter referred to as photo-ID), involves photographing distinctive characteristics (i.e., spot, pigmentation, or scale patterns, dorsal fin shape and scarring) of an individual to determine if it is a new capture or a recapture (Wursig and Jefferson 1990; Kelly 2001; Frisch and Hobbs 2007; Speed et al. 2007). Photo-ID techniques have been used to examine a wide range of population parameters, some of which include the effect of human interactions on animal behavior (Constantine 2001; Samuels and Bejder 2004), estimates of survival (Langtimm et al. 2004), population size (Karanth and Nichols 1998; McClintock et al. 2013), growth rates (Graham and Roberts 2007), the prevalence of disease (Thompson and Hammond 1992; Bennet et al. 2000), foraging behavior and group dynamics (Hoelzel 1993), and site fidelity and movement patterns (Karlsson et al. 2005; Baird et al. 2008).

Most studies of sea turtle populations use external (e.g., plastic or metal Inconel) and/or internal (e.g., Passive Integrated Transponder [PIT]) tags to identify individuals (Balazs 1999). These tagging methods have greatly improved our understanding of sea turtle movements, reproductive biology, strandings, growth rates, and residency (Balazs 1999); however, errors

associated with tag loss have been identified (Balazs 1982; Mrosovsky and Shettleworth 1982; Bjørndal et al. 1996; Bellini et al. 2001; Rivalan et al. 2005; Reisser et al. 2008; Braun McNeill et al. 2013), as have complications with the tagging, handling, and capture processes (Nichols and Seminoff 1998; Broderick and Godley 1999; Wyneken et al. 2010). Photo-ID is becoming an increasingly popular tool for the study of sea turtles because of its nonintrusive nature and the low-cost of digital technology, and it is a technique that has been used to examine a variety of demographic characteristics and conservation issues related to turtle populations (McDonald and Dutton 1996; Bennett et al. 2000; Bounantony 2008; Pauwels et al. 2008; Reisser et al. 2008; Schofield et al. 2008; Jean et al. 2010; Lloyd et al. 2012; Goncalves and Loureiro 2013). For instance, photo-ID has been used to avoid the repeat satellite tagging of individual sea turtles (Schofield et al. 2013a,b), revise remigration estimates (McDonald and Dutton 1996), identify the number of individuals potentially injured by boat strikes (Schofield et al. 2013a), examine the regression of fibropapillomas (Bennett et al. 2000), assess behavioral interactions of conspecifics (Schofield et al. 2007), estimate tag loss (Reisser et al. 2008), and determine operational population sex ratios (Schofield et al. 2009; Hays et al. 2010) and breeding periodicity (Hays et al. 2010).

Beginning in 1989, the National Marine Fisheries Service (NMFS) instituted an in-water CMR project using traditional tagging methods (double Inconel tagging since 1989 and PIT tagging since 1995) to identify individual loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles in the estuarine waters of North Carolina (Epperly et al. 1995). However, beginning in 2008, permitting restrictions prevented the application of tags to turtles captured during a fishery-dependent catch-per-unit-effort (CPUE) study

APRIL GOODMAN HALL*

National Marine Fisheries Service, 101 Pivers Island Road
Beaufort, North Carolina 28516, USA

JOANNE BRAUN McNEILL

National Marine Fisheries Service, 101 Pivers Island Road
Beaufort, North Carolina 28516, USA
e-mail: Joanne.B.McNeill@noaa.gov

*Corresponding author; e-mail: April.Goodman@noaa.gov

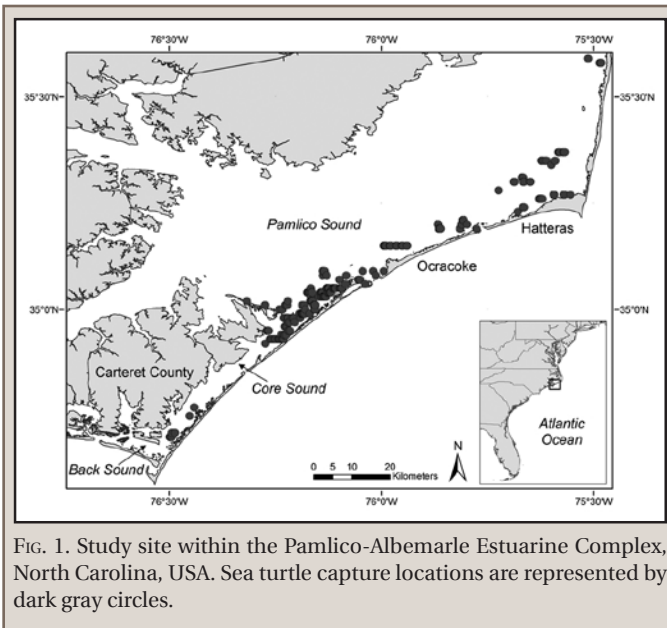


FIG. 1. Study site within the Pamlico-Albemarle Estuarine Complex, North Carolina, USA. Sea turtle capture locations are represented by dark gray circles.

designed to estimate the local abundance of turtles. As a result, we began using photo-ID, thereby allowing us to continue identifying recaptured turtles and thus improve our estimate of unique individuals captured. In this study, we (1) describe the photo-ID technique, (2) compare our 2008 and 2009 estimates of turtle recapture rates using photo-ID with those determined prior to 2008 using Inconel and PIT tags, (3) estimate the number of turtles that may have been misidentified as unique individuals because no photograph was taken or because of poor image quality, and (4) discuss the application of photo-ID as a tool to examine sea turtle abundance. To the best of our knowledge, this is the first study to estimate sea turtle recapture rates during a CPUE study exclusively using photo-ID as a means of identification.

Materials and Methods.—The study site included eastern Pamlico, Core, and Back Sounds, which are part of the Pamlico-Albemarle Estuarine Complex (PAEC; Fig. 1). This system consists of shallow, productive, lagoonal-type ecosystems (Roelofs and Bumpus 1953; Copeland and Gray 1991) that are bounded on the east side by barrier islands, commonly known as the Outer Banks. The PAEC is an important developmental and foraging habitat for juvenile Loggerhead, Green, and Kemp's Ridley turtles from April through December (Epperly et al. 1995; Epperly et al. 2007).

Sea turtles were captured in commercial pound nets from early autumn (mid-September) to early winter (mid-December) in 2008 and 2009 (see Epperly et al. 2007 for a detailed description of the pound net fishery and capture methods). Fishers were chosen at random each week from the State's pound net registration files. Four observers attempted to sample three fishing trips each on a weekly basis. One observer worked with fishers from Hatteras Island, one with fishers from Ocracoke Island, and two with fishers from Carteret County.

Upon capture, turtles were scanned for PIT tags and their flippers were examined for Inconel tags. An Olympus Stylus 850 SW (8.0 megapixel) digital camera was used to photograph the carapace (Fig. 2) as well as the left and right lateral (Fig. 3) and dorsal views (Fig. 4) of the head of each turtle. Photographs of the carapace and dorsal view of the head were taken at a distance of 0.5 to 1 m from the turtle, and the left and right lateral views of

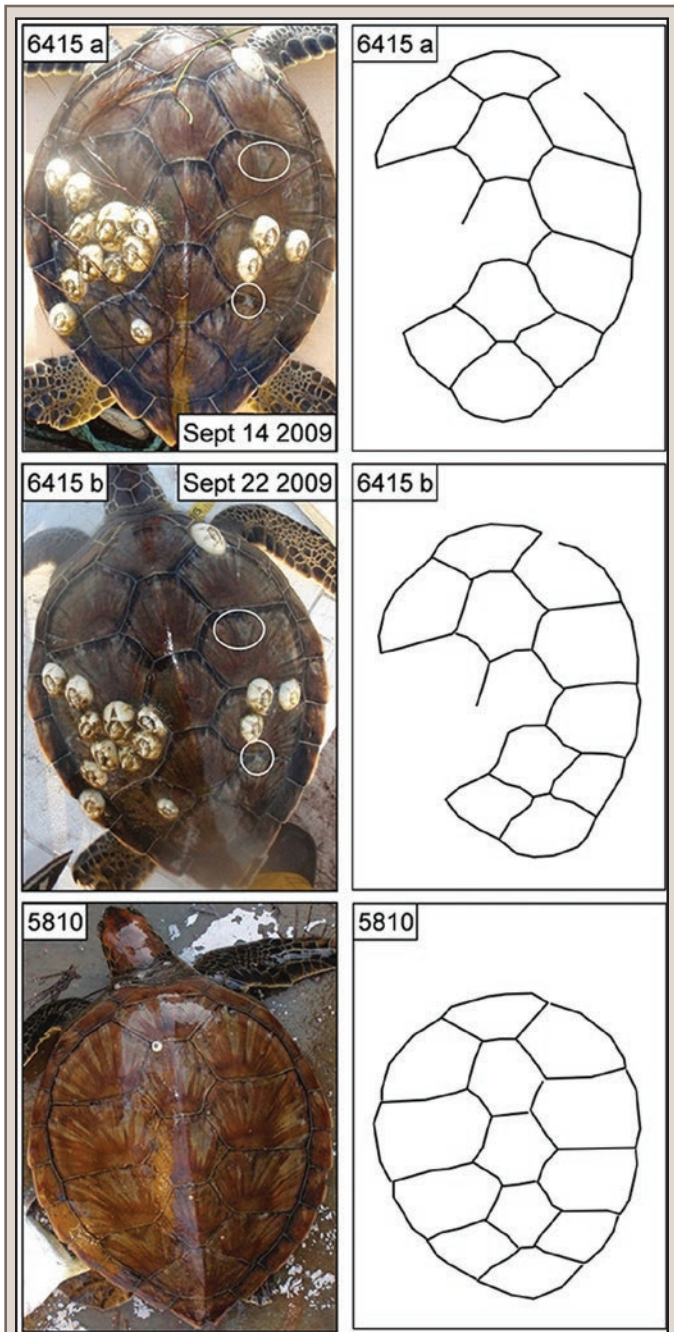


FIG. 2. Photographic view of the carapace that was used to identify recaptured turtles. Images 6415a and 6415b are of the same individual on two different survey days (see capture dates on images). Image 5810 is of a different individual, and is provided to show the difference in scute characteristics. Unique scute colorations that were used to identify 6415 as a recapture are surrounded by white circles. The shape of scute outlines (traced in black and located to the right of each image) varies among individuals and also was used to identify recaptures.

the head were photographed 15 to 30 cm from the turtle. Upon returning from the field, turtles were assigned unique identification numbers which were saved with their corresponding images. The best-quality (e.g., in focus, good lighting, no or very low glare, proper angle of the turtle to the camera) image of each photographic view was cropped to isolate the desired view using

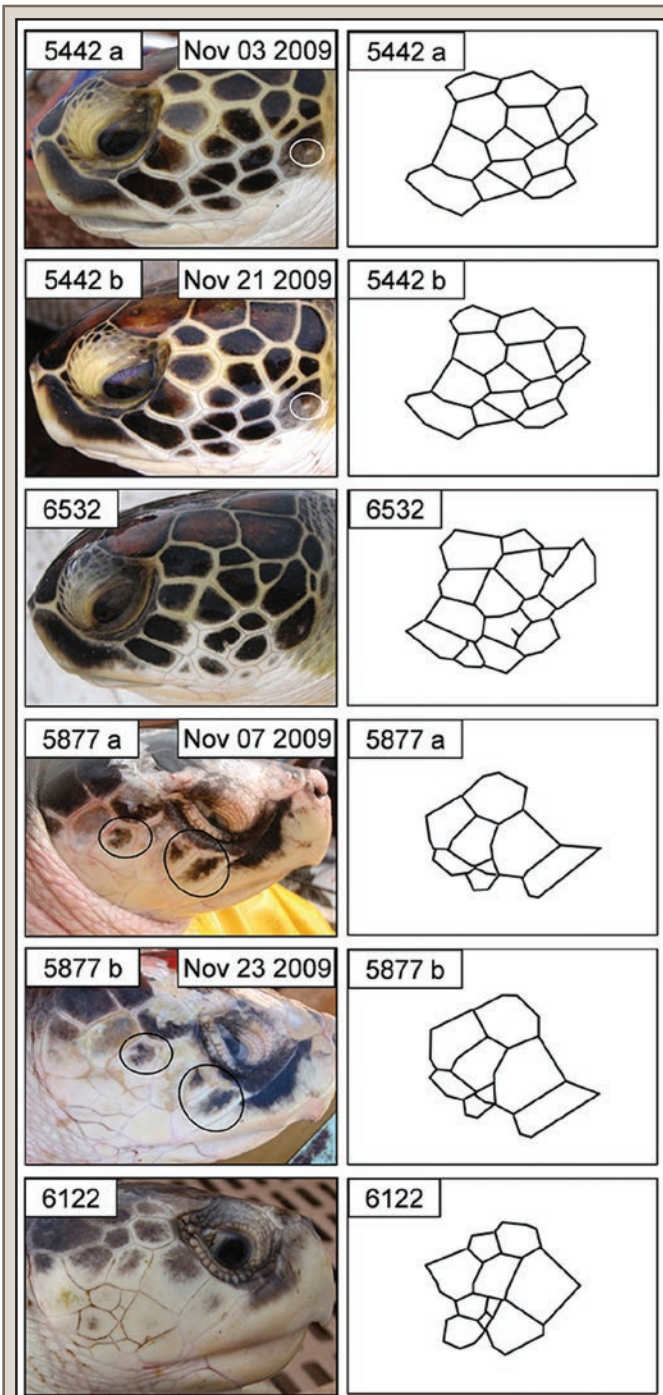


FIG. 3. Photographic view of the left and right lateral sides of the head that was used to identify recaptured turtles. For the left lateral view (top three images), images 5442a and 5442b are of the same individual on two different survey days and image 6532 is of a different individual. For the right lateral view (bottom three images), images 5877a and 5877b are of the same individual and image 6122 is of a different individual. Unique scale colorations are surrounded by white or black circles. The shape of scale outlines were traced in black and are located to the right of each image.

Microsoft Office 2010 Picture Manager. Images were cataloged by capture year, species, and photographic view.

Three observers (O1, O2, and O3) independently compared the coloration and outline of facial scales and carapace scutes

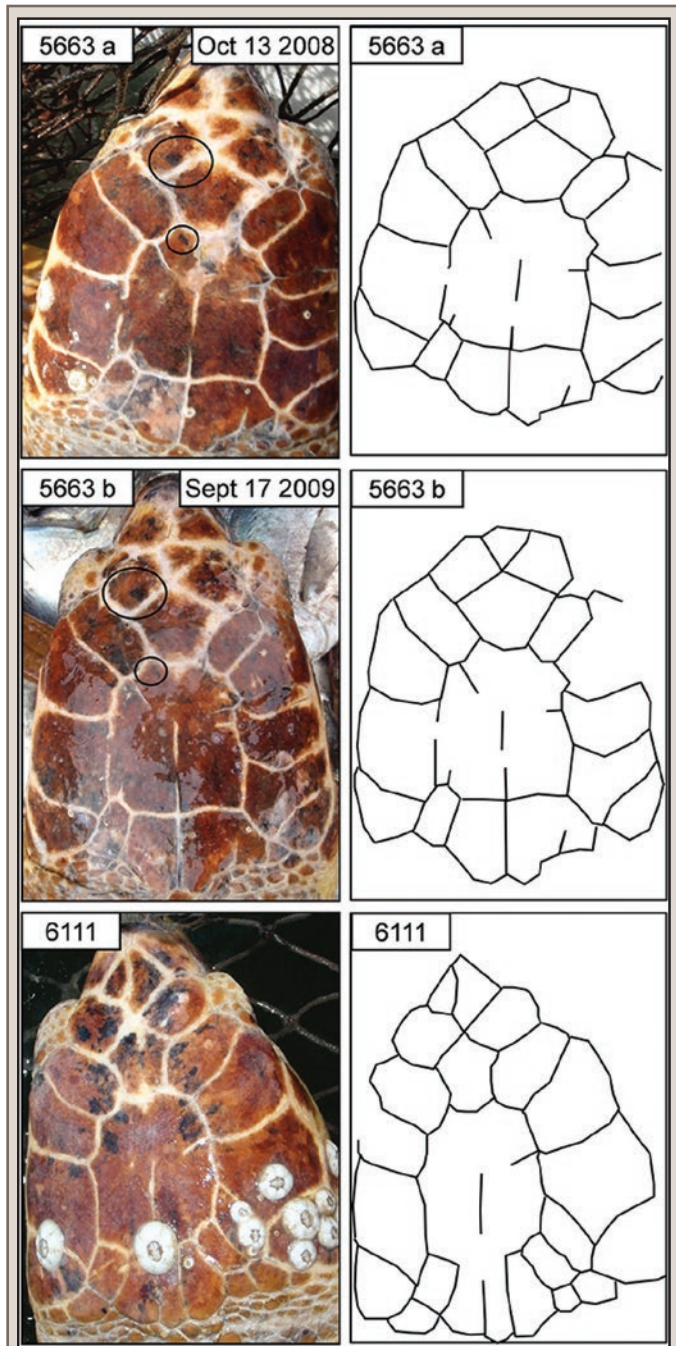


FIG. 4. Photographic view of the dorsal portion of the head that was used to identify recaptured turtles. Images 5663a and 5663b are of the same individual on two different survey days, and image 6111 is of a different individual. Unique scale colorations are surrounded by black circles. The shape of scale outlines were traced in black and are located to the right of each image.

among all individuals of the same species to identify recaptured turtles (Figs. 2, 3, and 4). O1, O2, and O3 were the same individuals throughout the study. O3 examined only the 2008 dataset. Turtles were examined within and between study years. Two additional viewers confirmed turtles identified as recaptures by O1, O2, and O3.

Capture-mark-recapture studies that use photographs of natural markings to identify individuals often rate the quality of photographs and the distinctiveness of an individual's marks

because these characteristics influence the probability of identifying a previously photographed individual (Friday et al. 2000). We rated the quality (Q) of photographs (Table 1), but did not assign a distinctiveness rating because the distinct scale and scute patterns of individual sea turtles allow for their identification as long as image quality is good. We modeled our rating system for image quality after Urian et al. (1999) and Friday et al. (2000).

We compared our 2008 and 2009 sea turtle recapture rates to recapture rates of sea turtles sampled in the PAEC during autumn and early winter of 1995–1997 and 2001–2003 (Epperly et al. 2007) and 2007 (NMFS Southeast Fisheries Science Center [SEFSC], Beaufort, North Carolina [NC], unpublished data) to see if our estimates of recapture rates were within the range of these previous studies. All studies were conducted using the same sampling protocols, with the exception that Inconel and PIT tags could be applied to turtles prior to 2008. Therefore, our 2008 and 2009 estimates of sea turtle catch rates were derived from photo-ID, while catch rates prior to 2008 were obtained using Inconel and PIT tags. Similar to Epperly et al. (2007), we estimated the total number of unique individuals captured annually for each species by subtracting the number of within-year recaptured turtles from the total number of turtles captured. Individuals identified as being recaptured twice on one day were not considered to be recaptures.

One assumption of CMR studies is that all previously marked animals are identified as such upon recapture (Stevick et al. 2001). When identifying individuals by their natural markings, errors can occur if an observer incorrectly concludes that two captures of the same individual represent two different individuals (a false negative) or if captures of different individuals are identified as a single individual (a false positive; Stevick et al. 2001). To ensure that false positives were not included in our analysis, all turtles identified as recaptures were confirmed by O1, O2, and O3, as well as by two additional viewers. To address false negatives, we assumed that the unique scale and scute pattern of turtles would allow for individual identification if images were of good (Q2) or excellent (Q3) quality. However, the identification of individuals without images (Q0) would not be possible, and individuals with poor-quality images (Q1) may only be identified some of the time, thus resulting in an inflated estimate

TABLE 1. Image quality (Q) rating system for sea turtles captured by pound net and digitally photographed in the Pamlico-Albemarle Estuarine Complex of North Carolina, USA, during autumn and early winter of 2008 and 2009.

Rating	Criteria
Q0	Image unavailable. Turtle escaped from the net before a photograph was taken.
Q1	Poor-quality image. Image out of focus; strong glare; photographic view is angled or a portion of the desired view is missing; epibiota concealed scute or scale patterns.
Q2	Good-quality image. May be slightly out of focus; some glare; photographic view is slightly angled or a small portion of the desired view is missing; epibiota may be present, but does not significantly conceal scute or scale patterns.
Q3	Excellent-quality image. Image is clear; no/very low glare; desired photographic view is directly facing the camera; epibiota may be present, but does not conceal scute or scale patterns.

of unique individuals. To account for the number of turtles that may have been misidentified as unique individuals, we applied the following equation to the estimated total number of unique individuals for each species in 2008 and 2009:

$$X = (Q0 + Q1) - Q1^*$$

Where X is the number of turtles possibly misidentified as unique individuals, Q0 is the number of individuals without photographs, Q1 is the number of individuals with poor-quality

TABLE 2. Comparison of photo-ID derived recapture rates for sea turtles in the Pamlico-Albemarle Estuarine Complex, North Carolina, USA, during 2008 and 2009, with inconel and PIT tag derived turtle recapture rates from previous studies^{a,b} conducted in the same region. Photo-ID recapture rates during 2008 and 2009 are highlighted in gray. In the column ‘recaptures within year,’ the percentage of recaptures within each year for each species is in parenthesis. For each species in 2008 and 2009, the percentage in parenthesis in the column ‘turtles possibly misidentified as unique individuals,’ refers to the percentage of turtles captured that may have been misidentified as unique individuals because no image was available to identify them by, or image quality was poor.

Year	Total captured	Recaptures within year	Estimated total unique individuals	Turtles possibly misidentified as unique individuals
<i>Caretta caretta</i>				
1995 ^a	111	9 (8%)	102	—
1996 ^a	97	5 (5%)	92	—
1997 ^a	156	3 (2%)	153	—
2001 ^a	258	33 (13%)	225	—
2002 ^a	207	16 (8%)	191	—
2003 ^a	158	11 (7%)	147	—
2007 ^b	81	2 (2%)	79	—
2008	175	18 (10%)	157	13 (7%)
2009	201	25 (12%)	176	12 (6%)
<i>Chelonia mydas</i>				
1995 ^a	42	1 (2%)	41	—
1996 ^a	33	0 (0%)	33	—
1997 ^a	31	1 (3%)	30	—
2001 ^a	67	4 (6%)	63	—
2002 ^a	44	0 (0%)	44	—
2003 ^a	29	0 (0%)	29	—
2007 ^b	142	1 (<1%)	141	—
2008	105	8 (8%)	97	8 (8%)
2009	151	4 (3%)	147	3 (2%)
<i>Lepidochelys kempii</i>				
1995 ^a	1	0 (0%)	1	—
1996 ^a	4	1 (25%)	3	—
1997 ^a	10	0 (0%)	10	—
2001 ^a	30	1 (3%)	29	—
2002 ^a	18	0 (0%)	18	—
2003 ^a	7	0 (0%)	7	—
2007 ^b	9	0 (0%)	9	—
2008	31	1 (3%)	30	6 (19%)
2009	41	0 (0%)	41	4 (10%) ^a

^aEpperly et al. 2007

^bNMFS Beaufort Lab unpublished data

photographs, and $Q1^*$ is the number of individuals with poor-quality photographs that were identified as recaptures.

Results.—A total of 376 Loggerheads, 256 Greens, and 72 Kemp's Ridleys were captured in 2008 and 2009 (Table 2). Of these, 43 Loggerheads, 12 Greens, and 1 Kemp's Ridley were identified as recaptures using photo-ID. The identification of three of these recaptures was confirmed by Inconel and/or PIT tags applied prior to 2008. When examining recaptures among years, no Green or Kemp's Ridley turtles captured in 2008 were identified as recaptures in 2009, and eight Loggerhead turtles captured in 2008 were identified as recaptures in 2009. Time intervals between initial capture and recapture ranged from 1 to 386 days.

Observer O1 identified a total of 27 recaptures for 2008, 29 recaptures for 2009, and 8 recaptures when comparing 2008 and 2009 captures. All turtles identified as recaptures by O2 and O3 also were identified as recaptures by O1. Observer O2 identified 20 recaptures for 2008, 27 recaptures for 2009, and 8 recaptures when comparing 2008 and 2009 captures. Observer O3 identified 21 recaptures for 2008. No observers identified a capture as a false positive recapture. The two additional viewers concurred that all turtles identified as recaptures by the observers were recaptures.

The percentage of turtles that we identified as recaptures in 2008 and 2009 for each species (Loggerheads ranged from 10–12%, Greens from 3–8%, and Kemp's Ridleys from 0–3%) was comparable to recapture estimates from the 1995–1997, 2001–2003, and 2007 studies (Loggerheads ranged from 2–13%, Greens from 0–6%, and Kemp's Ridleys from 0–25%; Epperly et al. 2007; NMFS SEFSC Beaufort, North Carolina, unpubl. data; Table 2). The percentage of turtles possibly misidentified as unique individuals in 2008 and 2009 ranged from 6–7% for Loggerheads, 2–8% for Greens, and 10–19% for Kemp's Ridleys.

Of the four views photographed in 2008, the dorsal view of the head contained the most Q2 and Q3 images (89%), followed by the carapace (77%), and right (73%) and left (69%) lateral sides of the head. Because the dorsal view of the head was often the best-quality image, and since we found that examining all photographic views was very time consuming (on average, it took 10–15 minutes to compare one image to 200 other images), the dorsal head view was the only photographic view examined in 2009 and when comparing individuals among years; however, the other three views were examined if the dorsal view was of poor quality (<Q2). Image quality of the dorsal head views improved in 2009 (94% of images were \geq Q2; Table 3).

In some cases, recaptured individuals could be identified from poor-quality (Q1) images; 12% of recaptures in 2008 and 8% in 2009 were identified from Q1 images (Table 3). We also found that distinguishing features such as scars, sloughing of the scales or scutes, skin colorations, and barnacle patterns on the carapace and head could aid with the identification of individuals (Figs. 2–5), and that these characteristics were especially helpful when viewing images of poor quality (Fig. 5). However, caution was needed when viewing barnacle patterns because some barnacle formations grew quickly, while others moved in a short (within weeks) amount of time (Fig. 6).

Discussion.—Many studies of sea turtle populations rely solely on the application of identifying markers to recognize individuals; however, the usefulness of photo-ID as a tool to study sea turtle populations is increasingly becoming apparent. Photo-ID served as a valuable resource to our study by providing us with an alternate method for identifying individual turtles when traditional tagging methods could not be used. As a result, we were able to identify recaptured turtles during our study, thereby allowing for an improved estimate of unique individuals captured. The information derived from these data will allow for evaluations of the status of sea turtle populations in this region, which is imperative for the development of conservation policies. These findings also further support the application of photo-ID as a means to monitor sea turtle populations and the lessons we learned can serve to aid others who are considering applying the technique to their research program.

In-water studies using both photo-ID and Inconel/and or PIT tags to monitor sea turtle populations have indicated that individual turtles can be consistently identified upon recapture by the unique variations of their facial scales (Reisser et al. 2008; Schofield et al. 2008). Because it was not possible to confirm the identity of many of the individuals we identified as recaptures using photo-ID (since so few recaptured turtles had been previously tagged), we compared our photo-ID recapture rates with those derived from Inconel and/or PIT tags during previous studies (Epperly et al. 2007, NMFS SEFSC Beaufort, North Carolina, unpubl. data) within the survey region. While we found that our recapture rates were within the range of those established during these studies, the limited timeframe of our study and the differing methods used to identify recaptures limits our ability to make a detailed comparison. Furthermore, comparison of the two identification methods is complicated by the likelihood that photo-ID recapture rates may be greater than those associated

TABLE 3. Number of sea turtles captured and subsequently identified as a recaptures in 2008 and 2009, binned by the quality rating of the photograph of the captured turtle. All photographs were of the dorsal head view. NA= not applicable, and refers to inability of observers to identify recaptured turtles if image quality was 0. The percentage of turtles identified as a recapture within each quality rating bin is in parentheses.

Year	Species	Quality 0		Quality 1		Quality 2		Quality 3	
		Total	Recaptures captured	Total	Recaptures captured	Total	Recaptures captured	Total	Recaptures captured
2008	<i>Caretta caretta</i>	2	NA	16	5	28	7	129	21
	<i>Chelonia mydas</i>	0	NA	9	1	17	2	79	13
	<i>Lepidochelys kempii</i>	0	NA	6	0	7	0	18	2
	Total:	2 (1%)	NA	31 (10%)	6 (12%)	52 (17%)	9 (18%)	226 (72%)	36 (70%)
2009	<i>Caretta caretta</i>	0	NA	15	3	33	7	153	36
	<i>Chelonia mydas</i>	0	NA	4	1	21	0	126	6
	<i>Lepidochelys kempii</i>	0	NA	4	0	8	0	29	0
	Total:	0 (0%)	NA	23 (6%)	4 (8%)	62 (16%)	7 (13%)	308 (78%)	42 (79%)

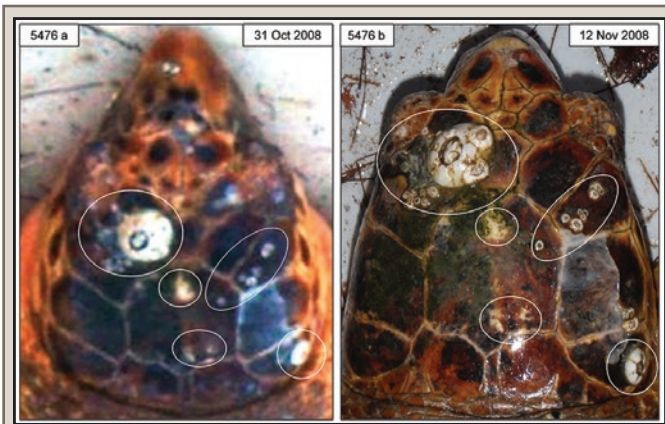


FIG. 5. Poor-quality images (5476a) could occasionally be used to identify recaptured turtles (5476b), especially if unique scale characteristics and/or barnacle patterns (circled) were present on the turtle.

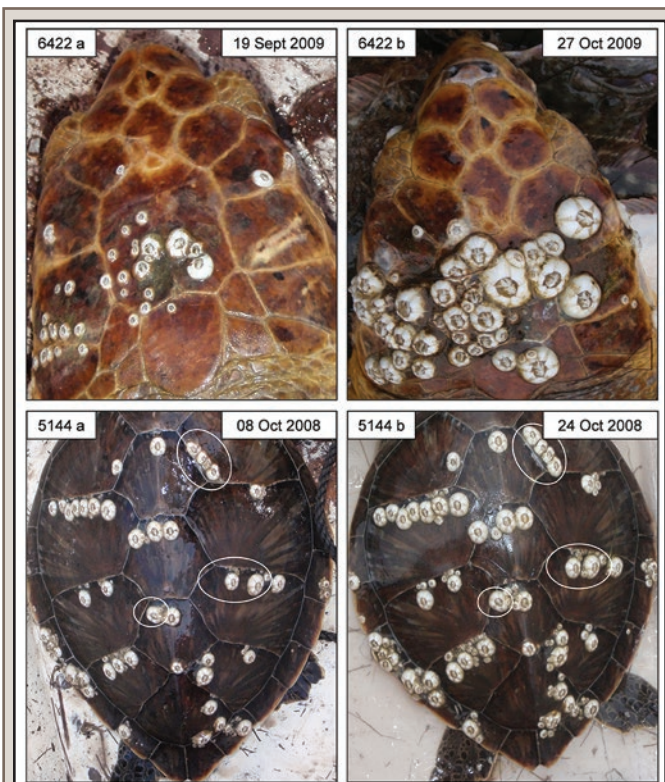


FIG. 6. Rapid growth of barnacles on the head of a loggerhead sea turtle between its initial capture (6422a) and recapture (6422b; 38 days), and movement of barnacles (circled in white) on the carapace of a green turtle between its initial capture (5144a) and recapture (5144b; 16 days).

solely with traditional tagging methods because turtles that have lost external tags or suffered PIT tag malfunctions can still be identified. However, given previous validation of the photo-ID technique for sea turtle identification (Reisser et al. 2008; Schofield et al. 2008), and because the majority of our images were of good or excellent quality (Table 3), we believe our estimate of unique individuals is an accurate representation of the sea turtle population within the estuary at this time of year.

Our estimate of turtles that may have been misidentified as unique individuals because no image was available to identify

them, or the image was of poor quality, further improves the accuracy of our estimate of unique individuals captured in 2008 and 2009. It is also probable that this estimate considerably overestimates the number of turtles that may have been misidentified as unique individuals, because it is unlikely that all individuals without images or with poor-quality images were recaptures. Finally, our estimate of the percentage of turtles that may have been misidentified as unique individuals was greatest for Kemp's Ridleys. This is likely because the facial scale outlines of Kemp's Ridleys are often less well defined by color variations between the scales, resulting in a monotonous appearance (e.g., images 5877a,b, and 6122 in Fig. 3). Thus, image quality was especially important for identifying individual Kemp's Ridleys and images that were even only slightly blurry were likely to receive a lower quality rating compared to similar images of another species.

Long-term field studies that monitor changes in demographic characteristics (i.e., survival, abundance, growth, and recruitment) of a population over time are invaluable, especially for long-lived species with complex life histories such as sea turtles (Epperly et al. 2007). However, accurate estimates of population parameters collected in long-term studies require that individuals in a population be consistently identified upon each encounter (Wursig and Jefferson 1990). To date, little is known of the stability of the shape of sea turtle facial scales and carapace scutes throughout their lifespan. Due to the short length of our study, the longest period of time over which we identified a recaptured turtle using photo-ID was a little over a year; however, longer time intervals have been reported. For instance, Reisser et al. (2008), Jean et al. (2010), and Goncalves and Loureiro (2013) identified individual cheloniid turtles by their lateral facial scales over a period just short of three years, four years, and six years, respectively. These studies, along with ours, indicate that photo-ID can serve as an accurate, low-cost, and non-invasive tool for identifying individual sea turtles from year to year; however, future studies are needed to clarify the persistence of scute and scale shapes over longer periods (e.g., decades).

Incorrectly identifying an individual as a recapture, or failing to identify an individual as a recapture, can lead to biases in estimates of population parameters (Stevick et al. 2001). Upon reviewing the turtles identified as recaptures by each observer in 2008, we did not document the occurrence of false positive errors, but O2 and O3 did not identify a number of recaptures. It is likely that some of the recaptured turtles that were not identified by O2 and O3 were overlooked because of poor image quality. Additionally, consistently identifying individuals requires a certain amount of familiarity with the key characteristics that should be examined when viewing images. Consequently, O1 and O2 discussed the characteristics that they focused on when examining images and this discussion, along with an improvement in image quality, resulted in fewer false negative errors in 2009 and when comparing the 2008 and 2009 captures. This improvement highlights the importance of ensuring that all observers are adequately trained, as well as the value of good-quality images.

Estimates of population parameters also may be influenced by tag loss because an individual that has lost all tags is likely to be misidentified as a new individual upon subsequent encounter (Seber 1982; Nichols and Hines 1993; Rivalan et al. 2005; Braun McNeill et al. 2013). Such misidentifications have the potential to negatively impact management decisions that are based on models that evaluate the status of populations. As a result, some CMR studies of sea turtles have attempted to estimate tag loss rates so a correction can be applied to estimates

of population parameters (Van Dam and Diez 1999; Rivalan et al. 2005; Reisser et al. 2008; Braun McNeill et al. 2013). Photo-ID holds great potential as a tool that can be used to estimate tag loss rates of sea turtle populations. This was demonstrated by Reisser et al. (2008), who used photo-ID to estimate Inconel tag loss in juvenile Green and Hawksbill turtles caught at Arvoredo Island, southern Brazil. They found a high rate of tag loss among turtles at their study site, prompting them to suggest that other CMR studies consider integrating photo-ID into their research programs given its potential for increasing the accuracy of data collected.

We found that all four photographic views could be used to identify turtles, but we primarily used the dorsal view because it was typically the easiest to obtain, and therefore, often the best-quality view. This was because turtles were photographed on small vessels with little space to maneuver, making it difficult to position the camera parallel with the side of the turtle's head to obtain a clear, lateral view. To take lateral photos, observers needed to kneel on the deck next to turtles, or hold the camera parallel to the turtle's head and take the image without looking through the view finder, often resulting in blurry images. Additionally, for larger turtles such as Loggerheads, observers frequently had difficulty raising the camera to sufficient height so that the field view encompassed the entire carapace. Furthermore, the carapace of some turtles, particularly Loggerheads, was also often covered in epibionts, thereby obstructing the viewing of scutes. As a result of these difficulties, when designing a photo-ID study, we suggest that researchers consider the conditions in which they will be acquiring images and the size class of the species they will be photographing to determine which photographic view is optimal for their study. For example, lateral views of the head may be easier to acquire when photographing turtles while diving, but overhead images of the head may be preferable when space is limited or turtles are too large to manipulate easily.

Although we could identify some recaptured turtles from poor-quality images, the importance of good-quality images cannot be overstated (Hammond et al. 1990; Whitehead 1990; Friday et al. 2000; Kelly 2001). We found that it was often difficult to distinguish among individuals using poor-quality images because the outlines of their scutes and scales were usually obscured. Additionally, characteristics such as scars, scute and scale colorations, and epibionts often helped with the identification of turtles from poor-quality images; however, these characteristics are likely to change over time. Therefore, while such characteristics may help with identification within a season, identifying turtles from poor-quality images among years is likely to be more challenging.

As the number of photos in an image library increases, it becomes more time consuming to manually compare images to one another (Arzoumanian et al. 2005). One option for decreasing the time it takes to compare turtle images is to divide individuals into subgroups based on scale pattern characteristics (Schofield et al. 2008) so observers only have to match images to a smaller subgroup rather than all previous captures (Bradfield 2004). Jean et al. (2010) also devised a method for cataloging individual turtles based on the location and shape of the scales on the lateral portion of the head, resulting in a unique code that allows for the quick identification of individuals. We chose not to use such identification methods, mainly because determining which group to place individuals in could be complicated by a number of factors (i.e., epibiont coverage, sloughing of scales or

poorly defined scale boundaries, unfavorable pose of the turtle, and poor image quality), and we did not want to risk misidentifying an individual because it was grouped incorrectly. In addition, we did not consider using subgroups to aid with identification until after all photographs were taken, and thus, the scale pattern characteristics that may have been chosen to group images were not always well represented. However, subgrouping and cataloging individuals is likely to prove beneficial to many photo-ID studies of sea turtles, and we recommend that the scale pattern characteristics that will be used to group images be well defined prior to the start of a project.

The identification of individual sea turtles by their natural markings served as a valuable means for examining sea turtle recapture rates during our fishery-dependent CPUE study and we suggest that other researchers consider integrating photo-ID into their CPUE and CMR studies. When used in lieu of traditional tagging methods, photo-ID can serve as a reliable, non-intrusive, and low-cost method for identifying individual turtles within a study site. However, identifying individuals using only photo-ID can be time consuming, and a turtle identified solely by photo-ID would not be identified as a recaptured animal when encountered by other researchers. The development of computer-assisted image matching software for cheloniid turtles would not only reduce the time it takes to identify individuals, but also may allow for the creation of a global database that could be used to identify individuals and track their movements (Bounantony 2008; Pauwels et al. 2008). When combined with traditional tagging methods, photo-ID can increase the accuracy of data collected by CMR studies by allowing for an estimate of tag loss (Reisser et al. 2008). Additionally, photo-ID databases collected by research groups can be used to examine a wide range of demographic characteristics (i.e., behavior, remigration estimates, sex ratios, breeding periodicity; McDonald and Dutton 1996; Schofield et al. 2007; Schofield et al. 2009; Hays et al. 2010), health (e.g., the prevalence of disease; Bennett et al. 2000), and conservation and management issues (e.g., incidence of boat strikes; Schofield et al. 2013a).

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Limestone Cave as a Cradle of the Ryukyu Ground Gecko, *Goniurosaurus kuroiwa*

Goniurosaurus kuroiwa is a eublepharid gecko distributed in the central part of the Ryukyu Archipelago, Japan (Ota 1989). Among the members of the genus *Goniurosaurus*, *G. kuroiwa* has been relatively well studied for its reproductive ecology (Tanaka and Nishihira 1987, 1989). According to these authors, gravid females possessing two eggs per clutch appear from late May to late August, and the ratio of gravid females to total females exceeds 80% at the peak. Nevertheless, the oviposition site of this gecko in the wild is unknown. Because *G. kuroiwa* and its close relatives face the risk of extinction and are designated as endangered on the IUCN Red List (Ota 2010), knowledge regarding oviposition and incubation sites in the wild is important for the planning of a habitat preservation program.

In November 2007 and 2012, we found a total of three pairs of unidentified squamate eggshells in a limestone cave in the southern part of Okinawajima Island. There are 24 native and introduced squamates recorded from this island: seven gekkotans, two iguanians, four scincomorphans, and 11 ophidians (Maenosono and Toda 2007). We presumed the eggshells to belong to *G. kuroiwa* because of their small size, parchment-shelled eggs, and local abundance of this gecko around the caves. To confirm this, we attempted to determine sequences of the residual-DNA on the eggshells and compared them with available data for other reptile taxa. We also measured several environmental parameters at and around the oviposition sites.

MATERIALS AND METHODS

Study site.—All eggshells were found in a limestone cave located in the southern part of Okinawajima Island (26°08N, 127°45E; datum WGS84); further details concerning the location are not provided in order to restrict illegal hunting by pet dealers, which is one of the serious threats to *G. kuroiwa* (Kanari and Xu 2012; Ota 2010). The cave opens southward at the midpoint of a cliff. A passage having a width for the entry of only one person runs northward, curving east at 3–4 m from the entrance, and reaches a round hall (approximately 5 m in width and depth, 3 m in height). There are many small pockets on the walls, and all eggshells were found on the surface of sediments deposited inside these pockets. The hall has another exit at the opposite end of the entrance, but it was not possible to examine the cave any further because it was too narrow (Fig. 1a).

TAKAKI KURITA*

Graduate School of Engineering and Science, University of the Ryukyus, Nishihara, Okinawa 903-0213, Japan

REMI KAWAMURA

Maehara 2-6-1-403, Ginowan, Okinawa 901-2215, Japan

MAMORU TODA

Tropical Biosphere Research Center, University of the Ryukyus, Nishihara, Okinawa 903-0213, Japan

*Corresponding author; e-mail: mofumofu_monticola@hotmail.co.jp

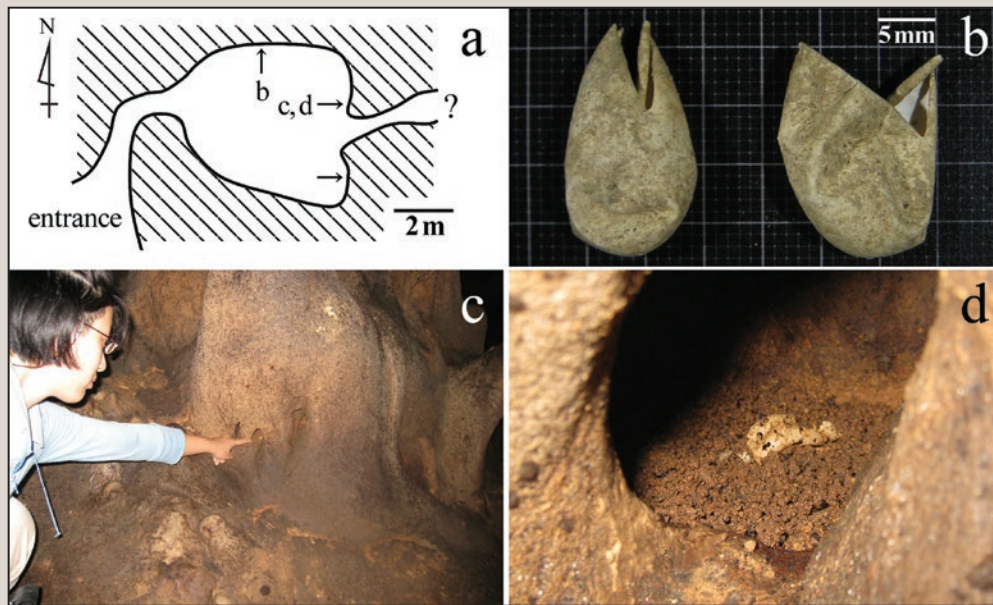


FIG. 1. a) Diagram of the study-site limestone cave in the southern part of Okinawajima Island, Japan; b) photograph of the pair of less damaged eggshells collected from the pocket on the north end wall; c) the pocket on the east end wall, in which a pair of eggshells of *Goniurosaurus kuroiwa* were found; close up view of nest cavity. Arrows in (a) indicate location of oviposition sites and the letters “b–d” correspond to the photographs.

Egg morphometry.—A well preserved pair of eggshells was used for morphological observations and three measurements of the egg were taken to the nearest 0.01 mm using a digital dial caliper: egg length along the long axis, egg breadth along the short axis, and slit length (length of the slit from which neonates emerge from the shell). Each measurement was repeated thrice to obtain a mean.

DNA analyses.—A pair of damaged eggshells was stored at -20°C until DNA extraction. The third pair of shells was heavily damaged and not used for morphological measurements or molecular analyses. A tail tip sample of an adult *G. kuroiwa* collected from the southern part of Okinawajima Island was also used for DNA analyses for comparative purposes.

Total DNA was extracted from the eggshells following the method of Oskam et al. (2010) with some modifications. Eggshells were washed in phosphate buffered saline (1.37 M NaCl, 27 mM KCl, 100 mM $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$, and 18 mM KH_2PO_4) to remove soil from the surface, and then were finely shredded. The shredded shells of the two eggs were combined in the same tube in order to yield a high concentration DNA solution. The eggshells (wet-weight 5 mg) were dissolved in 200 μl digestion buffer (0.47 M ethylenediaminetetraacetic acid pH 8.0, 20 mM Tris/HCl pH 8.0, 0.2% 2-mercaptoethanol, 0.1% sodium dodecyl sulfate, and 100 μg Proteinase K) at 56°C for 24 h. After centrifuging, the supernatant was mixed with five volumes of PB buffer from a QIAquick PCR Purification Kit (Qiagen, California, USA), followed by one tenth volumes of 3 M sodium acetate. DNA was bound to silica membrane columns and washed with 700 μl of AW1 and AW2 wash buffers included in a DNeasy Blood and Tissue Kit (Qiagen). Finally, DNA was eluted in 50 μl of EB buffer (Qiagen). We performed the DNA binding and elution step twice to maximize DNA yield by placing the flow-through back into the silica column and re-centrifugation.

We attempted to amplify short fragments of mitochondrial 12S and 16S ribosomal RNA (rRNA) and cytochrome b (cytb) genes using eight primer pairs shown in Table 1. A 20 μl PCR

mixture (0.25 mM each dNTP, 5 pmol each primer, 10x ExTaq Buffer [TaKaRa Corp., Shiga, Japan], 0.8 U ExTaq DNA polymerase [TaKaRa], and 2 μl unknown concentration of total DNA) was incubated under the conditions of an initial denaturation at 94°C for 3 min, followed by 40 cycles of denaturation at 94°C for 30 s, annealing at 50°C for 30 s, and a final extension at 72°C for 30 s. After purification of the PCR products, we conducted a cycle sequencing reaction with a BigDye 3.1 system (Applied Biosystems Inc., California, USA) according to the manufacturer’s protocol. The abovementioned primers were used for this reaction. Sequences were determined using an ABI 3730xl DNA Analyzer (Applied Biosystems).

We used negative (without any sample) and positive controls (tail tip of the adult gecko) for the DNA analyses. Sequence data are available in the DDBJ/EMBL/GenBank databases under the accession numbers AB827797–827799. Obtained sequences from the eggshell sample were BLAST-searched against the databases. For the cytb gene sequence, we used our own data obtained from the adult gecko because of lack of comparable data in the databases.

Evaluation of environmental parameters.—We recorded air temperature and relative humidity inside and outside the cave and above the oviposition sites. We collected soil samples from the oviposition sites and from 12 randomly selected points of the hall floor. We measured water-content rate (water/raw soil weight) by the heat-dry method at 105°C for 24 h, and pH after suspension in a volume of distilled water five times the weight of the air-dried soil (Rayment and Lyons 2010).

RESULTS

Identification of the eggs.—All eggs that we collected were parchment-shelled. Two of the measured eggs were elliptical and each had a slit running from one tip to the middle (Fig. 1b). The egg length, breadth, and slit length of one of the eggs were 19.63, 10.91, and 11.72 mm, respectively (Fig. 1b left). Egg ellipticity

TABLE 1. The eight primer pairs designed for amplification of short fragments of mitochondrial DNA. The filled circles indicate successful amplification and sequencing of the target fragments, and the open circles indicate that fragments were amplified but failed to sequence. Size is the expected length of the PCR products.

Primer	Sequence (5' to 3')	Locus	Size
FGss1F	CAACCTAGAGGAGCCTGTCC	12S	152 bp
FGss1R	CACCTTGACCTGACGTTTTT		●
FGss2F	CCCTACTATGCTTAGCCATTAACC	12S	191 bp
FGss2R	TGACGACGGCGGTATATAGG		●
FGls1F	GACGAGAAGACCCTGTGGAG	16S	240 bp
FGls1R	AAGAGATTGCGCTGTATC		
FGls2F	GGATAACAGCGCAATCCTCT	16S	118 bp
FGls2R	AATCGTTGAACAAACGAACC		○
FGcb1F	AAAACAACATGAAACACAGGAGT	cytb	120 bp
FGcb1R	AAGTTTGTGATTACGGTTGC		
FGcb2F	TATCATTCTGAGCGCAACC	cytb	211 bp
FGcb2R	GGATTGTTTGGCTGTTTCA		
FGcb3F	CACACATTTGCCGAGATGTA	cytb	233 bp
FGcb3R	GGTTCGCCTCAGAATGATA		●
FGcb4F	CCAGAAAACCTCATTCCAGCA	cytb	210 bp
FGcb4R	TTGGGATAAGGGTCCAAATG		

(egg breadth/egg length) was 0.60. The egg length and slit length of the other deformed egg was 19.34 and 12.52 mm, respectively (Fig. 1b right).

DNA fragments of expected lengths were successfully amplified from the eggshell extract by four of the eight primer pairs; of which three were successfully sequenced yielding 211 bp sequences of 12S rRNA (167 and 70 bp with 26 bp overlap) and 193 bp of cytb genes. Some amplification signals were detected in three out of the eight negative controls on agarose gel, but these products were not the target because of their unexpected longer lengths (>500 bp; Table 1).

A BLAST search revealed that the sequence obtained from the 12S rRNA gene matched (100%) with that of *G. kuroiwa*e from the southern part of Okinawajima Island (Accession No. AB028750), followed by the congeneric species from the Ryukyus (96–99%) and a Chinese congener (89%). In a BLAST search with our cytb gene sequence as a query, we got hits for homologous genes of some anurans and chiropterans but with very low levels of matching (79–82%). In contrast, the cytb sequence was well-matched with that of *G. kuroiwa*e determined in this study (99%), with two synonymous nucleotide substitutions in the third codon positions.

Environmental parameters.—In November 2012, daytime air temperature and relative humidity were 30.1°C and 79% at the entrance of the cave, and 23.6°C and 99% in the hall, respectively. Indirect sunlight scarcely reached the passage, and none reached the hall. There were percolating water drips falling from stalactites in the cave and no other surface water was present. The floor of the cave was extensively covered with flowstones and cohesive brownish soil. In the hall, patchy black sediments originating from bat guano were accumulated. Two of the 12 soil samples were taken from such bat guano-rich sites. Water-content rate and pH of the sediments in the hall ranged between 32.0–69.1% and 3.8–8.5, respectively.

Three pairs of eggshells were found in three different small pockets on the wall of the hall. These pockets were located

0.20–1.45 m above the hall floor. One pocket was at the north end and the other two pockets were at the east end (Fig. 1a). The north pocket and one of the east pockets were horizontally concave (Fig. 1c, d); the other east pocket was vertically concave and covered with a fallen piece of broken stalactite. Air temperature measured in front of the pockets was 21.7–22.3°C and relative humidity was 99%. A layer of small granular soil, approximately 30–100 mm in thickness, was deposited at the bottom of the pockets, but bat guano was absent. Water-content rate and pH of the soil that was used as the egg laying substrate were 33.5–46.5% and 8.1–8.2, respectively. All eggshells were exposed on the surface of the soil. The outer eggshell surfaces were entirely covered with soil particles, but no soil was found on the inner surfaces.

DISCUSSION

The results of the genetic analyses revealed that the eggshells found in the limestone cave were of *G. kuroiwa*e. Morphological features of the eggs were also consistent with captive breeding records of closely-related congeners, i.e., parchment shell and size (20 × 12 mm; Henkel and Schmidt 1995). Neonates appeared to have hatched from the eggs, confirming that environmental conditions in the cave were appropriate for incubation. Therefore, we conclude that *G. kuroiwa*e uses this limestone cave as an oviposition site.

Why is this limestone cave a suitable oviposition and incubation site for *G. kuroiwa*e? One conceivable factor is the stability of hydric conditions; parchment-shelled eggs require a certain amount of ambient air and substrate moisture level to avoid either drying out or becoming moldy (Henkel and Schmidt 1995; Werner 1972). The extreme high humidity recorded in the cave (99%) protects the substrate and eggs from dehydration. In addition, eggs in the cave are also protected from exposure to rains. Thermal conditions during the incubation period critically affect embryonic development and performance of hatchlings in many reptile species (see Du and Shine 2010 and references therein). In this respect, caves are thermally quite stable (Culver and Pipan 2009), and this may be important for this gecko.

Environmental conditions in caves are more uniform than the outside, but are still variable in a fine spatial scale. In fact, our soil samples had highly variable water-content rates and pH, representing extreme water retention and acidification in some samples most probably due to water drips from stalactites and bat excrement (Culver and Pipan 2009; Ferreira et al. 2007). Such excess water could damage eggs (Henkel and Schmidt 1995), and soil acidification can negatively affect embryonic development in some lizards with parchment-shelled eggs (Marco et al. 2005). However, it appears that the pockets on the walls offer some degree of protection from organic substances and water.

Although we lack quantitative data, soil compaction apparently differed between the oviposition sites and the hall floor. The soil particles were granular and loose in the egg laying pockets, but were tight and cohesive on the floor. In captivity, some eublepharid geckos are known to make a pit in humid ground to lay eggs and cover them with soil after oviposition (Henkel and Schmidt 1995). We observed that the outer surfaces of eggshells were entirely coated with soil particles, strongly suggesting that *G. kuroiwa*e also deposit their eggs in soil and this necessitates loose soil at oviposition sites.

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Parasitism of Reptiles by the Blacklegged Tick (*Ixodes scapularis*) and Western Blacklegged Tick (*Ixodes pacificus*) with New Records of *I. scapularis* from Arkansas and Oklahoma Lizards: Implications for Lyme Disease Epidemiology

Worldwide, at least 116 species of ticks are known to parasitize reptiles (Barnard and Durden 2000). For some of these tick species, including members of the Holarctic *Ixodes ricinus* complex (including *I. pacificus*, *I. persulcatus*, *I. ricinus*, and *I. scapularis*), the immature stages (larvae and nymphs) often feed on reptiles whereas adults mainly feed on larger mammals, including humans (Clark et al. 2013; Keirans et al. 1999). The aforementioned four species in this complex have significant medical and veterinary importance as zoonotic vectors of the causative agents of Lyme disease (= Lyme borreliosis), human babesiosis,

human granulocytic anaplasmosis, and/or tick-borne encephalitis in the northern hemisphere (Nicholson et al. 2009).

Lyme disease, caused by infection with *Borrelia burgdorferi* sensu lato spirochete bacteria, is an emerging or persistent zoonosis in much of the Northern Hemisphere (Oliver 1996; Scott et al. 2012). Presently, at least 18 distinct genomospecies are recognized within *B. burgdorferi* sensu lato and three of these, *B. burgdorferi* sensu stricto, *B. afzelii*, and *B. garinii*, are known to cause disease in humans (Nicholson et al. 2009; Scott et al. 2012). Ticks belonging to the *I. ricinus* complex are the principal vectors with different tick species being primary vectors in different regions (Oliver 1996). In North America, the Blacklegged Tick, *I. scapularis* Say, is the main vector in eastern states and provinces whereas the Western Blacklegged Tick, *I. pacificus* Cooley and Kohls, is the principal vector in far western states and a Canadian province (Burgdorfer et al. 1985; Clover and Lane 1995; Eisen et al. 2004a, b; Keirans et al. 1996; Lane and Lavoie 1988; Lane and Loye 1989). Certain species of rodents, and to a lesser extent birds, are enzootic reservoir hosts of *B. burgdorferi* sensu lato (Castro and Wright 2007; Clark et al. 2005; Clover and Lane 1995; Durden and Oliver 1999; Lane and Lavoie 1988; Scott et al. 2012). However, immature stages (larvae and nymphs) of both *I. scapularis* and *I. pacificus* not only feed on mammals and birds, but also on certain species of reptiles, especially lizards (Clark et al. 2005; Durden et al. 2002; Giery and Ostfeld 2007; Lumbad

CHRIS T. McALLISTER*

Science and Mathematics Division, Eastern Oklahoma State College,
Idabel, Oklahoma 74745, USA; e-mail: cmcallister@se.edu

LANCE A. DURDEN

Department of Biology, Georgia Southern University,
Statesboro, Georgia 30458, USA

MATTHEW B. CONNIOR

Health and Natural Sciences, South Arkansas Community College,
El Dorado, Arkansas 71730, USA

HENRY W. ROBISON

Department of Biology, Southern Arkansas University,
Magnolia, Arkansas 71754, USA

*Corresponding author

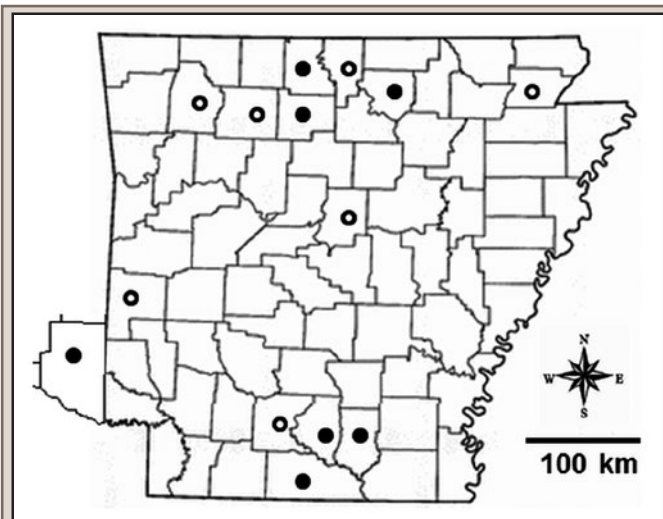


FIG. 1. Thirteen counties in Arkansas and one in southeastern Oklahoma where lizards were collected showing those infested with ticks (solid circle in county) and those without ticks (open circle in county).



FIG. 2. A nymphal *Ixodes scapularis* embedded under scales of dermis in *Plestiodon fasciatus* from McCurtain County, Oklahoma.

et al. 2011; Swanson and Norris 2007; Talleklint-Eisen and Eisen 1999). In fact, in some regions, up to 98% of nymphal *I. pacificus* in a given habitat feed on lizards (Casher et al. 2002). If these lizards are incompetent reservoir hosts of strains of *B. burgdorferi* that cause human disease, feeding of immature *I. scapularis* on lizards would serve to decrease the infection prevalence in tick populations, thereby creating a “dilution effect” (Schmidt and Ostfeld 2001) and an example of biodiversity providing “ecosystem services” to public health (Ogden and Tsao 2009).

Some researchers have reported that certain lizards may be reservoir hosts of *B. burgdorferi* in North America (Clark et al. 2005; Giery and Ostfeld 2007; Levin et al. 1996; Swanson and Norris 2007). Similarly, in Eurasia and North Africa, where immature stages of *I. ricinus* frequently parasitize lizards (Bauwens 1983; Dsolui et al. 2006; Keirans et al. 1999; Matchuschka et al. 1991), some of these reptiles have been reported to be reservoir hosts of *B. burgdorferi* sensu lato, notably of the genomospecies *B. lusitaniae* (Amore et al. 2007; Dsolui et al. 2006; Majláthová et al. 2006), which is not a human pathogen. Conversely, other researchers have shown that other species of lizards are refractory to infection by *B. burgdorferi* and have borreliacidal factors in their blood that effectively kill spirochetes (Kuo et al. 2000; Lane and Quistad 1998; Lane et al. 2006; Wright et al. 1998). In this article, we report new lizard hosts of *I. scapularis* in Arkansas and Oklahoma, list the known reptilian hosts of both *I. scapularis* and *I. pacificus* by state/province in North America, record tick stage(s) collected from each host species, and briefly consider the potential role of lizards in Lyme disease epidemiology.

Methods.—Between 2009–2013, 65 lizards (juveniles and adults) were collected by hand from various localities in upland (Ouachita and Ozark plateaus) and Gulf Coastal Plain habitat in 12 Arkansas counties (Baxter, Bradley, Calhoun, Faulkner, Greene, Iard, Madison, Newton, Ouachita, Polk, Searcy, and Union), as follows: 11 Green Anoles (*Anolis carolinensis*), eight Prairie Racerunners, (*Aspidoscelis sexlineata viridis*), four Southern Coal Skinks (*Plestiodon anthracinus pluvialis*), 20 Five-lined Skinks (*Plestiodon fasciatus*), one Broad-headed Skink (*Plestiodon laticeps*), and four Prairie Lizards (*Sceloporus consobrinus*); 12 *P. fasciatus* and five *S. consobrinus* were also collected from

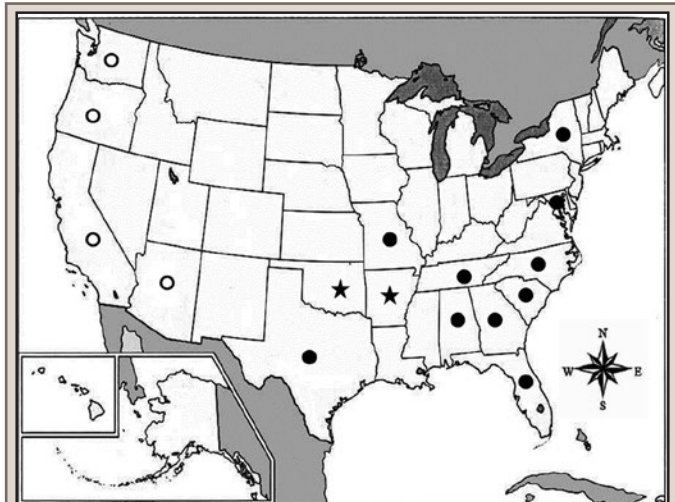


FIG. 3. Sixteen states where larvae and nymphs of *Ixodes scapularis* (solid dots) and *Ixodes pacificus* (open dots) have been reported from various lizard hosts. The latter tick is also reported from lizard hosts in British Columbia, Canada (not shown). Star = new records for *I. scapularis* from lizards.

McCurtain Co., Oklahoma. Following the guidelines for the humane treatment of research animals (HACC 2004) specimens were either examined live and released or euthanized with an intraperitoneal injection of sodium pentobarbital and their bodies examined for arthropod parasites. When ticks were found they were removed with tweezers and placed in vials containing 70% ethanol and shipped to one of us (LAD) for identification. Voucher tick specimens are deposited in the U.S. National Tick Collection, Statesboro, Georgia, under accession numbers RML 124935 (from *P. laticeps*), RML 124936–124937 (from *P. fasciatus*), and RML 124938 (from *S. consobrinus*). Host vouchers are deposited in the Arkansas State University Herpetological Collection (ASUMZ), State University, Arkansas. Previously published records of *I. scapularis* and *I. pacificus* parasitizing reptiles in the U.S. and Canada were compiled through extensive literature searches.

TABLE 1. Recorded reptilian hosts of Blacklegged Ticks (*Ixodes scapularis*) and Western Blacklegged Ticks (*Ixodes pacificus*) in North America.

Host family	Scientific name	Common name	Tick species	Tick stages collected ¹	State/Province records and citations
Anguillidae	<i>Ophisaurus attenuatus</i>	Slender Glass Lizard	<i>Ixodes scapularis</i>	L, N	(NC) Levine et al. (1997)
	<i>Ophisaurus compressus</i>	Island Glass Lizard		L, N	Unspecified (AL, FL, GA, and/or SC) Oliver et al. (1993) (GA) Durden & Oliver (1999)
	<i>Ophisaurus mimicus</i>	Mimic Glass Lizard		L	Unspecified (AL, FL, GA, and/or SC) Oliver et al. (1993)
	<i>Ophisaurus ventralis</i>	Eastern Glass Lizard		L, N	(FL) Clark et al. (2005) (GA) Durden et al. (2002)
Dactyloidae	<i>Ophisaurus</i> sp.	undetermined species		L, N	(NC) Apperson et al. (1993), Levine et al. (1997)
	<i>Anolis carolinensis</i>	Green Anole		L	(SC) Clark et al. (2005) (TX) Eads (1949) Unspecified (AL, FL, GA, and/or SC) Oliver et al. (1993)
Phrynosomatidae	<i>Sceloporus consobrinus</i>	Prairie Lizard		N	(AR) present report (FL) Rogers (1953) (NC) Levine et al. (1997)
	<i>Sceloporus olivaceus</i>	Texas Spiny Lizard		L, N	(SC) Reeves et al. (2002)
	<i>Sceloporus undulatus</i>	Eastern Fence Lizard		L, N	(AR) Lancaster (1973), present report (TX) Brennan (1945) (TX) Brennan (1945) (FL) Hixson (1941)
Scincidae	<i>Plestiodon egregius</i>	Mole Skink		N	(MD) Swanson & Norris (2007)
	<i>Plestiodon fasciatus</i>	Five-Lined Skink		L, N	(MD/NY) Giery & Ostfeld (2007) (MO) Kollars et al. (1999) Unspecified (AL, FL, GA, or SC) (Oliver et al. 1993) (AR) present report (MD) Swanson & Norris (2007)
	<i>Plestiodon inexpectatus</i>	Southeastern Five-Lined Skink		L, N	(MD/NY) Giery & Ostfeld (2007) (MO) Kollars et al. (1999) (NC) Levine et al. (1997) Unspecified (AL, FL, GA, and/or SC) Oliver et al. (1993) (FL) Clark et al. (2005)
	<i>Plestiodon laticeps</i>	Broadhead Skink		L, N	(GA) Durden & Oliver (1999), Durden et al. (2002) (NC) Apperson et al. (1993), Levine et al. (1997) (SC) Clark et al. (2005) Unspecified (AL, FL, GA, and/or SC) Oliver et al. (1993)
	<i>Scincella lateralis</i>	Ground Skink		L, N	(AR) Lancaster (1973), present report (FL) Hixson (1941), Rogers (1953) Clark et al. (2005) (GA) Keirans et al. (1996), Lavender & Oliver (1996), Durden & Oliver (1999), Durden et al. (2002) (NC) Apperson et al. (1993), Levine et al. (1997) (MD) Swanson & Norris (2007) (MD/NY) Giery & Ostfeld (2007) (SC) Clark et al. (2005) Unspecified (AL, FL, GA, and/or SC) Oliver et al. (1993) Unspecified, Bishop & Trembley (1945) (FL) Rogers (1953), Keirans et al. (1996) (GA) Lavender & Oliver (1996) (NC) Apperson et al. (1993), Keirans et al. (1996) (TX) Brennan 1945

TABLE 1. Continued.

Host family	Scientific name	Common name	Tick species	Tick stages collected ¹	State/Province records and citations
	"Skink"	undetermined species		L, N	Unspecified, Bishopp & Trembley (1945), Keirans et al. (1996)
Teiidae	<i>Aspidoscelis sexlineata</i>	Six-Lined Racerunner		L, N	(NC) Levine et al. (1997)
Emydidae	<i>Terrapene carolina</i>	Eastern Box Turtle		N	(TN) Reeves et al. (2007)
Anguidae	<i>Elgaria c. coerulea</i>	San Francisco Alligator Lizard	<i>Ixodes pacificus</i>	L, N	(CA) Jellison (1934), Mohr (1964), Arthur & Snow (1968), Furman & Loomis (1984), Eisen et al. (2004a), Castro & Wright (2007)
	<i>Elgaria coerulea principis</i>	Northwestern Alligator Lizard		L, N	(BC) Gregson (1956), Arthur & Snow (1968), Arnason (1992)
	<i>Elgaria m. multicarinata</i>	California Alligator Lizard		L, N	(CA) Cooley & Kohls (1945), Holdenried et al. (1951), Arthur & Snow (1968), Furman & Loomis (1984), Bennett (1987), Webb et al. (1990), Talleklint-Eisen and Eisen (1999), Wright et al. (2003a, b), Eisen et al. (2004a), Castro & Wright (2007)
	<i>Elgaria multicarinata scincicauda</i>	Oregon Alligator Lizard		L, N	(OR) Arthur & Snow (1968)
	<i>Elgaria</i> sp.	undetermined species		L, N, A	(WA) Arthur & Snow (1968)
Phrynosomatidae	<i>Sceloporus g. graciosus</i>	Northern Sagebrush Lizard		L, N	(CA) Jellison (1934), Cooley & Kohls (1945), Arthur & Snow (1968), Furman & Loomis (1984), Wright et al. 1998
	<i>Sceloporus occidentalis</i>	Western Fence Lizard		L, N	(CA) Mohr et al. (1964), Furman & Loomis (1984), Webb et al. (1990), Castro & Wright (2007)
		undetermined species		L, N	(CA) Arthur & Snow (1968), Furman & Loomis (1984), Webb et al. (1990), Goldberg & Bursey (1991), Wright et al. (2003a, b), Castro & Wright (2007)
		undetermined species		L, N	(CA) Jellison (1934), Cooley & Kohls (1945), Holdenried et al. (1951), Mohr et al. (1964), Arthur & Snow (1968), Furman & Loomis (1984), Manweiler et al. (1990, 1992), Webb et al. (1990), Talleklint-Eisen & Eisen (1999), Eisen et al. (2001, 2004a), Schall et al. (2000), Casher et al. (2002), Wright et al. (2003a, b), Castro & Wright (2007), Lumbad et al. (2011), and others
	<i>Sceloporus undulatus</i>	Eastern Fence Lizard ²		U	(OR) Arthur & Snow (1968)
	<i>Sceloporus</i> sp.	undetermined species		L, N	Unspecified, Bishopp & Trembley (1945)
	<i>Uta stansburiana</i>	Side-Blotched Lizard		L, N	(AZ) Olson et al. (1992)
Scincidae	<i>Plestiodon gilberti</i>	Gilbert's Skink		L, N	(CA) Furman & Loomis (1984)
	<i>Plestiodon skiltonianus</i>	Western Skink		L, N	(CA) Bennett (1987), Webb et al. (1990), Goldberg & Bursey (1991), Castro & Wright (2007)
Teiidae	<i>Aspidoscelis tessellata</i>	Common Checkered Whiptail ³		L, N	(CA) Castro & Wright (2007)
	<i>Aspidoscelis tigris</i>	Western Whiptail		L, N	(CA) Bennett (1987), Castro & Wright (2007)
	<i>Aspidoscelis</i> sp.	undetermined species		L, N	(CA) Holdenried et al. (1951)
Unknown family	"Coast Lizard"	undetermined species		U	(CA) Furman & Loomis (1984), Castro & Wright (2007)
	"Lizards"	undetermined species		U	(CA) Cooley & Kohls (1945), Arthur & Snow (1968), (BC) Arthur & Snow (1968)
Colubridae	<i>Thamnophis ordinoides</i>	Northwestern Garter Snake		U	(CA) Cooley & Kohls (1945), Arthur & Snow (1968), Furman & Loomis (1984), Webb et al. (1990)
					(OR) Cooley & Kohls (1945), Arthur & Snow (1968)

¹L = Larva(e), N = Nymph(s), A = Adult(s), U = Undetermined (not stated in original paper).²This host association was reported for Mohave County, Arizona; however, *S. undulatus* does not occur in Arizona.³This host association was reported for Alameda County, California; however, *A. tessellata* does not occur in California.

Results.—Forty-four ticks were found on 11 of 65 (17%) lizards; a total of 13 larval and 31 nymphal specimens were collected from lizards from six of 13 (46%) counties of Arkansas and a single county in Oklahoma (Fig. 1). All ticks were subsequently identified as *I. scapularis*. A single *P. laticeps* collected on 1 May 2012 from Union Co. harbored seven nymphs and 12 larvae; eight (60%) *P. fasciatus* collected on 18 March 2012 from Marion Co., 26 April 2012, 1 May 2012, 17 July 2012, 10 September 2012, and 19 May 2013 from Union Co., 19 August 2012 from Calhoun Co. and 29 March 2013 from Searcy Co. had one, one, one, six, two, two (plus one larva), one, and three nymphal specimens, respectively; a single (25%) *S. consobrinus* collected on 27 April 2012 in Izard Co. had two nymphs; and one (9%) *A. carolinensis* collected on 24 February 2013 from Union Co. had three nymphs. A single (8%) *P. fasciatus* collected on 25 May 2013 from McCurtain Co., Oklahoma had two nymphs, one of which is shown in Fig. 2.

Table 1 lists the recorded reptilian hosts by state/province of *I. scapularis* and *I. pacificus* and includes references and stages (larvae, nymphs, and/or adults) for each host species. Fig. 3 shows the 16 states from which these two tick species have currently been reported from reptilian hosts.

Discussion.—*Ixodes scapularis* has an extensive Nearctic range and has been reported previously from parts of southeastern Canada, across the eastern USA, and from the Mexican state of Coahuila (Keirans et al. 1996). In the USA, it is known from Florida to Maine in the east to central Texas and north to the Dakotas in the west (Keirans et al. 1996). There are also records of immature stages attached to migrating birds from other regions (Scott et al. 2012). Lancaster (1973) mentions that nymphs of *I. scapularis* have been found on the “common fence lizard” and “blue-tailed skink” in Arkansas but does not give a citation for this statement or list specific lizard species in his table of hosts for this tick. This species is the most common *Ixodes* in Arkansas (Lancaster 1973), where adults parasitize larger mammals (mainly deer and livestock) during the cooler months of the year while immature stages occur on a variety of smaller mammals, birds, and reptiles. However, we document the first definitive lizard host records for *I. scapularis* in Arkansas and Oklahoma, and the first voucher specimens reported from *S. consobrinus* (formerly *S. undulatus hyacinthinus*).

Various lizard species have been reported as hosts of larvae and nymphs of *I. scapularis* in the eastern U.S. including Alabama (Oliver et al. 1993), Florida (Clark et al. 2005; Oliver et al. 1993; Rogers 1953), Georgia (Durden et al. 2002; Keirans et al. 1996; Oliver et al. 1993), Maryland (Giery and Ostfeld 2007; Swanson and Norris 2007), Missouri (Kollars et al. 1999), New York (Giery and Ostfeld 2007), North Carolina (Apperson et al. 1993; Levine et al. 1997), South Carolina (Clark et al. 2005; Oliver et al. 1993), and Texas (Brennan 1945; Eads 1949) (Table 1, Fig. 1). There is also a record of nymphal *I. scapularis* parasitizing an Eastern Box Turtle (*Terrapene carolina carolina*) in Tennessee (Reeves et al. 2007). However, little is known about *I. scapularis* infesting lizards west of the Mississippi River, particularly in Arkansas and Oklahoma.

In the far western United States and parts of far western Canada, larvae and nymphs of *I. pacificus* parasitize various species of lizards (Table 1). Most of these records are from California (Arthur and Snow 1968; Casher et al. 2002; Castro and Wright 2007; Eisen et al. 2001, 2004a, b; Goldberg and Bursey 1991; Lane and Loye 1989; Lumbad et al. 2011; Manweiler et al. 1990, 1992; Schall et al. 2000; Talleklint-Eisen and Eisen 1999; Webb et al. 1990; Wright et al. 1998), but there are additional records from Arizona

(Olson et al. 1992), Oregon (Arthur and Snow 1968; Cooley and Kohls 1945; Eads 1949), Washington (Arthur and Snow 1968), and British Columbia, Canada (Arnason 1992; Arthur and Snow 1968; Gregson 1956) (Table 1, Fig. 1). There are also records of adult *I. pacificus* from undetermined alligator lizard species (*Elgaria* spp.) in California (Cooley and Kohls 1945; Mohr et al. 1964) (Table 1). Immature stages of *I. pacificus* presumably also parasitize lizards in other states where this tick is known to occur, namely Idaho, Nevada, and Utah.

Lizards can be relatively important hosts of immature *I. scapularis* and *I. pacificus*. For example, Durden and Oliver (1999) recorded 373 larvae and 21 nymphs of *I. scapularis* on a single *P. laticeps* in coastal Georgia, and Durden et al. (2002) reported a peak monthly average of 96.0 *I. scapularis* immatures/skink (*P. laticeps* and *P. inexpectatus* combined) during May 1994 in the same region. At the same site, Cotton Mice (*Peromyscus gossypinus*) were parasitized by a peak monthly average of 2.9 immature *I. scapularis* (during June 1994) with a maximum of 31 larvae on a single mouse (Durden and Oliver 1999). In one study in California, the Western Fence Lizard (*Sceloporus occidentalis*) accounted for 78% of the larval feedings and 98% of nymphal feedings for the *I. pacificus* population (Casher et al. 2002). These data suggest that in some regions up to 10x the number of immature *I. scapularis* and *I. pacificus* feed on lizards compared to the number that feed on other hosts (mammals and birds) in the same habitat. However, these numbers should be viewed with caution because infestation rates are clearly dependent on variation in host communities and because host body temperatures affect engorgement times of attached ticks. We did not record body temperature of our lizards when captured, but others have found that under laboratory conditions larvae and nymphs of *I. scapularis* remained attached to lizards for about 3x as long on skinks (*Plestiodon* spp.) as on *P. gossypinus* (Durden and Oliver 1999). Similarly, Goldberg and Bursey (1991) reported that, at 24°C, larvae and nymphs of *I. pacificus* attached to Northern Sagebrush Lizards (*Sceloporus graciosus graciosus*) for approximately eight days and to Common Side-blotched Lizards (*Uta stansburiana*) for 16 days.

Galbe and Oliver (1992) successfully fed five separate cohorts of *I. scapularis* larvae on the same individual *Plestiodon laticeps* and noted no reduction in tick engorgement prevalence or weights; additionally, antibodies against *I. scapularis* salivary gland antigens were not present in the blood of these lizards. Because of these phenomena, lizards could represent an important component in the ecology and epidemiology of any pathogens transmitted by these two tick species, in particular *B. burgdorferi*, the causative agent in Lyme disease. Because *I. scapularis* and *I. pacificus* immatures exhibit little host preference when offered laboratory mice, birds (baby chicks), or lizards as hosts (James and Oliver 1990) (larvae of both species showed a slight preference for mice, and nymphs preferred lizards and mice equally over chicks), the larger numbers of these ticks found on lizards in many regions is presumably related to the greater accessibility or availability of lizards. Slowak and Lane (2011) also tested the host preference of immature stages of *I. pacificus* under laboratory conditions but they used more natural hosts in their experiments: Deer Mouse (*Peromyscus maniculatus*), California Kangaroo Rat (*Dipodomys californicus*), California Towhee (*Pipilo crissalis*), and Western Fence Lizard. They demonstrated that both larvae and nymphs of *I. pacificus* preferred Western Fence Lizards as hosts but that rodents were also frequently parasitized and towhees were rarely parasitized.

The exact role lizard hosts play in Lyme disease ecology and epidemiology depends to a large extent on whether lizards are reservoir-competent or reservoir-incompetent hosts for genospecies of *B. burgdorferi* that can cause human disease and on the proportion of immature ticks that feed on lizards compared to alternative hosts in a given region. Early interpretations, sometimes supported by circumstantial data, suggested that lizards are refractory to infection with *B. burgdorferi* which would mean that any immatures of *I. scapularis* and *I. pacificus* feeding on lizards would not become infected with spirochetes (Durden and Oliver 1999). This would lead to a dilution effect with fewer infected ticks and fewer cases of Lyme disease in areas where most immature ticks feed on lizards rather than on reservoir-competent rodents. This seems to correlate well with the fewer cases of Lyme disease contracted in the southeastern United States where lizards are abundant and appear to feed most of the immature *I. scapularis* in the tick population (Durden and Oliver 1999; Oliver 1996). Conversely, in the northeastern and upper midwestern states, where Lyme disease is hyperendemic, lizard biodiversity and abundance is lower (compared to that in the southeastern USA) and most of the immature *I. scapularis* feed on reservoir-competent rodents (Oliver 1996).

Despite this hypothesis, Levin et al. (1996) reported prolonged (up to 5 wk) laboratory infections of both *P. inexpectatus* and *A. carolinensis* by *B. burgdorferi* sensu stricto. However, as more lizard species have been tested for their ability to maintain infections of *B. burgdorferi*-group spirochetes, the picture has become more complicated. For example, although Clark et al. (2005) used polymerase chain reaction amplification of specific primers to demonstrate the presence of *B. burgdorferi* in the blood of 86 of 160 (54%) lizards from Florida and South Carolina (representing nine species and six genera of lizards), other researchers have found other lizard species to be refractory to infection by *B. burgdorferi* sensu lato. Lane (1990) was unable to experimentally infect Western Fence Lizards with *B. burgdorferi* although one individual lizard apparently maintained a transitory spirochetemia for two days. It was later discovered that *S. occidentalis* has a borreliacidal factor in its blood that kills both *B. burgdorferi* (Lane and Quistad 1998) and the closely related *B. burgdorferi*-group spirochete *Borrelia bissettii* (Lane et al. 2006). Wright et al. (1998) similarly showed that Southern Alligator Lizard (*Elgaria multicarinata*) blood contains a borreliacidal factor. The borreliacidal factors in the blood of both *S. occidentalis* and *E. multicarinata* were shown to be proteins comprising the alternative complement pathway (Kuo et al. 2000).

In southern Maryland, Swanson and Norris (2007) detected *B. burgdorferi* markers in eight of 29 (28%) field-caught lizards (*S. undulatus* and *Plestiodon* spp.). Also, the role of lizards in the ecology of Lyme disease was examined in two endemic zones in the northeastern USA (one in New York and one in Maryland) by Giery and Ostfeld (2007). Based on very low infection prevalences (0–2%) in xenodiagnostic larval *I. scapularis* fed on field-caught *P. fasciatus* or *S. undulatus*, they devised a model to predict the ability of different vertebrate host species to influence the prevalence of *B. burgdorferi* in the tick population, which is an important component of human Lyme disease risk. They considered *P. fasciatus* to be reservoir-incompetent for *B. burgdorferi* and *S. undulatus* to be partially reservoir-competent. Combining these data with population densities of the two lizard species and their average tick burdens, they concluded that *P. fasciatus* is a dilution host for Lyme disease risk in the areas studied, meaning that its presence in the ecosystem reduces the prevalence of

B. burgdorferi-infected ticks and therefore the risk of *B. burgdorferi* transmission. Similarly, Salkeld and Lane (2010) modeled *B. burgdorferi* transmission and maintenance in hosts and vectors in oak woodlands in northwestern California and demonstrated that Western Fence Lizards are important hosts for feeding immature *I. pacificus* but reduce Lyme disease transmission risk (nymphal infection prevalence). The hypothesis that Western Fence Lizards serve as dilution hosts and reduce Lyme disease risk by diverting immature *I. pacificus* ticks away from *B. burgdorferi*-competent rodents in California was tested experimentally by Swee et al. (2011) who removed lizards from field plots and then tracked tick populations in those plots. Following lizard removal, many larval *I. pacificus* failed to find alternate hosts, resulting in lower nymphal densities the following year. Although lizard removal did not result in increased infection prevalences in *I. pacificus* nymphs, it did result in fewer infected nymphs and, therefore, decreased Lyme disease risk to humans. Nevertheless, Swee et al. (2011) argued that incompetent reservoirs (Western Fence Lizards, in this case) may actually increase disease risk by promoting higher vector density and therefore, a larger overall density of infected vectors.

Based on previous reports, the competence of lizards as reservoir hosts for *B. burgdorferi* sensu lato differs widely depending on the lizard species being studied. Some lizard hosts of Lyme disease tick vectors are reported to be reservoir-competent and appear to perpetuate the transmission of the spirochete whereas others are reservoir-incompetent and evidently serve as dilution hosts by reducing the number of ticks feeding on reservoir-competent rodents, effectively diminishing Lyme disease risk in those regions. Regardless, lizards appear to play a fundamental role in maintaining populations of *I. scapularis* and *I. pacificus* in parts of North America although tick burdens differ in different regions and are dependent on local vertebrate host communities (Apperson et al. 1993; Casher et al. 2002; Durden and Oliver 1999; Eisen et al. 2004a, b). Future studies to assess or re-assess the reservoir competence of different lizard species to strains of *B. burgdorferi* that cause human disease would shed additional light on their role as either dilution or (possibly) amplification hosts for Lyme borreliosis (see Ogden and Tsao 2009). We encourage others to report additional state and county records of lizard infestation by *Ixodes* spp. to more clearly illustrate tick-lizard associations, an important component in understanding the spread of Lyme disease.

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Ontogenetic Shift in Habitat Use in the Western Fence Lizard (*Sceloporus occidentalis*) in Northern California

Ontogenetic shifts in habitat use are obvious for many amphibian species where aquatic larvae shift to terrestrial adults. In lizards, where ontogenetic habitat shifts may not be nearly as dramatic as those that accompany amphibian metamorphosis, there is still evidence for important habitat changes during development. Two general patterns have been observed in lizards. Habitat shifts can occur either 1) horizontally, where ontogeny is associated with different habitat types across a landscape or 2) vertically, where a species remains in the same habitat type but shifts its distribution altitudinally along a substrate (e.g., rocks or trees).

Horizontal shifts have been observed in several lizard species. In *Anolis aeneus*, Stamps (1983) found that juveniles hatch in shady areas, migrate to clearings, and then move back into

shady habitat as adults. Hirth (1963) observed that *Basiliscus plumifrons* juveniles are most commonly found on beaches

MAX. R. LAMBERT*

School of Forestry and Environmental Studies, Yale University,
370 Prospect St., New Haven, Connecticut 06511, USA

CATHERINE M. YASUDA

Department of Biological Science, California State University,
Chico, California 95929-0040, USA

BRIAN D. TODD

Department of Wildlife, Fish, and Conservation Biology,
University of California, Davis, California 95616, USA

*Corresponding author; e-mail: max.lambert@yale.edu

whereas adults of the species are found almost exclusively in adjacent hedges. Baharav (1975) found that young *Phrynosoma solare* remained adjacent to ant nests whereas adult horned lizards used habitat along ant trails, farther from ant mounds and closer to large rocks used for basking. Another horizontal-type ontogenetic habitat shift has been observed in the agamid, *Amphibolurus ornatus*, where adults are predominantly found on rock outcroppings whereas juveniles are concentrated at the base of boulders adjacent to these outcroppings (Bradshaw 1971).

Vertical habitat shifts are documented in *Iguana iguana* (Henderson 1974), *Anolis cristatellus* (Kiestler et al. 1975), and *Chamaeleo chamaeleon* (Keren-Rotem et al. 2006), where adults are found higher in trees whereas juveniles use the base of trees or remain on the ground. Interestingly, *Varanus komodoensis* exhibit a similar, albeit reversed, pattern where hatchlings are arboreal whereas older animals are terrestrial (Imansyah et al. 2008). In Africa, *Pseudocordylus capensis* exhibits a vertically-stratified distribution where adult males are highest on rocks, adult females are at intermediate heights, and juveniles are found at the base of rocks (Eifler et al. 2007). Simon and Middendorf (1976) found that *Sceloporus jarrovi* shifts from using smaller, lower branches as juveniles to larger, higher branches as adults. Furthermore, although the territories of all *S. jarrovi* age classes spatially overlap, there is a temporal habitat shift where adults use the habitat in the mornings whereas juveniles do so in the afternoon (Simon and Middendorf 1976).

Stamps (1983) outlined six non-mutually exclusive factors that might explain ontogenetic habitat shifts: spatial distribution of food, suitable perches, intraspecific competition with another age class, interspecific competition, thermoregulatory constraints, and predation by conspecifics or other species. Predation pressure best supported the horizontal habitat shift seen in *A. aeneus* (Stamps 1983) and the vertical shift seen in *C. chamaeleon* (Keren-Rotem et al. 2006). There is also support for intraspecific competition (Bradshaw 1971; Schall 1974), food (Baharav 1975; Henderson 1974), and perches (Simon and Middendorf 1976) as explanations for certain ontogenetic habitat shifts in lizards. Although habitat use by different lizard age classes can be potentially complex, understanding habitat use during ontogeny is integral for studying population dynamics and processes (Lecchini and Galzhin 2005).

Our goal in the present study is to determine whether there was a difference in habitat use between two age-classes of Western Fence Lizards (*Sceloporus occidentalis*), young-of-the-year (hereafter juveniles) and adults. We used area- and time-constrained searches to measure adult and juvenile lizard densities in riparian cobble bars as well as upland, grassland habitats in northern California. In our study, riparian cobble bars and grassland habitats are particularly interesting because of their spatial juxtaposition. These cobble bars extend short distances (~2–20 m) from rivers and transition sharply into grassland habitat. The close proximity of these different environs implies that lizards should be able to readily cross between cobble bars and grassland. Given this, we were interested in whether there were differences in habitat use between age classes across relatively short distances. Because of the previously documented riverine subsidies (foreign nutrient inputs from areas of higher productivity into areas of low productivity, Sabo and Power 2002), and thermoregulatory or predatory refuge advantages (Sabo 2003) provided by riparian cobbles, we predicted that juvenile *S. occidentalis* would appear disproportionately more often in riparian

cobble bars relative to adult lizards. We further predicted that adult lizards would be more prevalent in upland habitat farther from the stream edge where they could potentially capitalize on different thermoregulatory substrate and prey resources. Although *S. occidentalis* is widespread and is heavily studied, to our knowledge there has been no evaluation of an ontogenetic habitat shift in this species. Here, we provide the first evidence of differential habitat use between juvenile and adult *S. occidentalis*. Because habitat management is key in wildlife conservation, understanding age-specific habitat use is important for management.

Materials and Methods.—Our study took place adjacent to the confluence of the South Fork Eel River and Fox Creek in the Angelo Coast Range Reserve (Mendocino Co., California, USA) during September 2010. We focused on a riparian cobble bar and its adjacent upland, grassland habitat (Fig. 1). For each habitat type (riparian and upland), we selected two habitat patches that were neighboring each other, resulting in four adjacent survey sites.

For surveys, we selected two riparian and two upland sites and conducted a half-hour time-constrained search at each location. We surveyed one pair of riparian and upland sites over two consecutive days and then surveyed the other two sites (one upland and one riparian) on the following two days. We confined our surveys visually using physiognomic delineations between the surveyed habitat and adjacent habitats (i.e., hard transitions from cobble to grassland, dirt paths, trees, etc.). The two upland habitat patches were 2,042.5 m² and 409 m², while the two riparian sites were 441 m² and 387.2 m² in size. Because the home range size of *S. occidentalis* is approximately 19–50 m² for juveniles and 51–73 m² for adults (Davis and Ford 1983), and because all sites were less than 10 m apart, we pooled the two replicate sites for both habitat types for statistical analysis, assuming some movement of lizards among habitat patches. In order to avoid straying into adjacent habitat we surveyed approximately 1 m inside of edges. Each time we spotted a lizard we would pause the search effort and capture the lizard. We captured adult lizards using a noose made from a fly-rod and dental floss and captured juveniles either by noose or a dip net. Although lizards seldom evaded capture, if a lizard escaped, we restarted the search effort. The same two surveyors were responsible for sighting and capturing all lizards. One surveyor was responsible for net captures while the other was responsible for noose captures. On the ventral side of each lizard, we used a felt-tipped pen to write a unique three-digit number and then measured its snout-vent length (SVL). As in Lambert et al. (2012), *S. occidentalis* exhibited a bimodal distribution of SVLs in which juveniles all had an SVL < 4 cm and adults had SVLs > 5 cm, with no individuals between these two size classes. After we processed and released lizards, we continued the search where we had stopped previously. On the following day, we resurveyed the same areas but in reverse order so that each location was surveyed once in the morning and once in the evening. This is important because Simon and Middendorf (1976) found that *S. jarrovi* adults and juveniles temporally segregate in the same habitat, so it is necessary to survey both in the morning and also in the afternoon to adequately assess the number of lizards present. To avoid double-counting individuals, we marked all new individuals captured on the second day of surveys.

We used a Chi-square test to determine whether densities of lizards in the two age classes were distributed non-randomly in the two habitats. We measured the area of each survey site and

calculated lizard densities as lizards/ha. Chi-square tests require integers so we rounded all densities to the nearest integer for analysis.

To characterize the habitats, we randomly oriented two 20-m line-transects that were parallel and spaced 20 m apart in each surveyed area. Every meter, we noted the substrate under the transect line. We defined cobbles as any rock < 0.5 m in length, boulders as any rock > 1 m long, and also identified the dominant substrate such as dry grass or logs.

Results.—Including search time as well as lizard processing time, we spent 73–170 minutes (mean = 109.5 min, SD \pm 42.4 min) and 65–148 minutes (mean = 109.75 min, SD \pm 35.7 min) surveying riparian and grassland habitats respectively. In total, we caught 9 adults and 18 juveniles in the riparian habitats and 16 adults and 9 juveniles in the upland habitats. The density of adults was 108.7 lizards/ha in riparian areas and 65.3 lizards/ha in upland habitat. The density of juveniles was 217.3 lizards/ha in riparian areas and 36.7 lizards/ha in upland habitat (Fig. 2). A Chi-square test on the density of lizards indicated a significantly non-random distribution of age classes among two habitat types, such that juveniles were more abundant in riparian areas whereas adults were more abundant in upland areas ($p < 0.001$). Because we marked each animal, we were able to confirm that no animals moved between any of the four study sites.

Our transects indicated that riparian habitat was composed of 48% cobble, 18% sand, 16% live grass, 9% bare ground, and < 3% each of boulders, logs, water, bedrock, and dry grass. Upland habitat was composed of 68% dry grass, 13% cobbles, 6% boulders, and 4% thistle, and < 3% each of logs, live grass, bare ground, manzanita (*Arctostaphylos* spp.), and oak (*Quercus* spp.).

Discussion.—Our data provide evidence for an ontogenetic habitat shift in *S. occidentalis*. Similar to Sabo and Power (2002), we found the densities of lizards in general were higher in riparian cobble bars; however, the distributional pattern we observed at least qualitatively shows that the relative proportions of each class was reversed between the two habitat types. Specifically, the number of juveniles was roughly twice that of adults in riparian cobble bars whereas the opposite was true in upland grassland habitat. Although we are unable to explicitly calculate detection probabilities, we are confident that the ability to detect both age classes was relatively equal in both habitat types. On the cobble bars, where juveniles were most prevalent, adults rarely fled under rocks and were readily visible. In the uplands, the grasses were relatively sparse and so juveniles tended to be easy to see. Because of this, we do not believe that our data were dramatically affected by differences in our ability to detect a particular age class in the two habitats.

Interestingly, the total number of lizards caught was similar between habitats, but the total densities of lizards were much lower in the upland habitat relative to the riparian habitat. This is likely because upland habitat was composed mainly of dry grass and was limited in the number of basking and shelter structures like boulders and logs. *S. occidentalis* in the upland habitat were found almost entirely on large basking substrates (logs and boulders), indicating that the species only uses a small fraction of the available habitat. Although the riparian habitats were also limited, and more so, in large basking objects, the main habitat characteristic were cobbles, which can act as refuges, thermoregulatory



FIG. 1. A map showing approximate locations of the riparian (solid line) and upland grassland (dashed line) patches. The study site was along the Eel River at the Angelo Coast Range Reserve, Mendocino, California, USA.

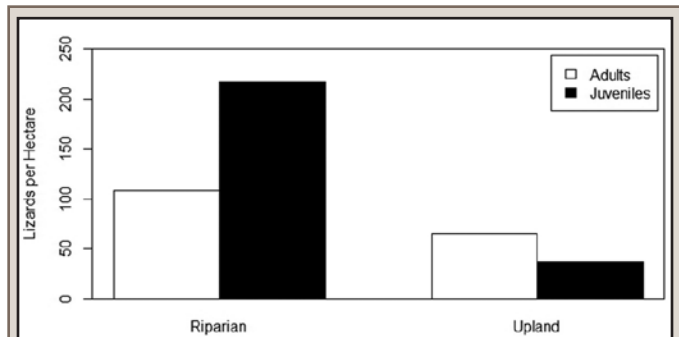


FIG. 2. The densities of adult and juvenile lizards between riparian and upland habitats.

substrate, and high ground for juvenile lizards. Cobbles are also homogeneously distributed in our riparian sites and therefore likely host more lizards for a given unit of area.

Prior work by Sabo and Power (2002) and Sabo (2003) in the same riparian cobble bar system provides inference as to the mechanisms behind this ontogenetic habitat shift. In relation to the hypotheses proposed by Stamps (1983), there is support for food availability, thermal requirements, predation, and appropriate perches. Sabo and Power (2002) found that riverine subsidies in northern California increase growth rates of subadult *S. occidentalis*, suggesting juvenile *S. occidentalis* may be capitalizing on the abundance of invertebrates along cobble bars to accelerate growth when young. Sabo (2003) found that cobbles, relative to other cover like wood or burrows, remained within a more thermally optimal zone for *S. occidentalis* and that gravid female *S. occidentalis* in cobble bars almost exclusively used cobbles for overnight refuge, whereas males were less selective in cobble bars, and upland females relied more on wood and burrows while gravid. Together with our findings, this indicates that cobble bars may provide more thermally ideal habitat for gravid lizards to lay eggs, and that juvenile lizards remain on cobble bars after hatching rather than dispersing as other species of lizards often do (Schall 1974, Stamps 1983). Sabo (2003) also reported predation by garter snakes (*Thamnophis elegans*) on adult female, but not adult male, *S.*

occidentalis, and that females choose cobbles that are slightly smaller than those most ideal thermally, suggesting that *S. occidentalis* can preferentially select certain cobbles that are less accessible to larger predators. It is thus possible that juvenile lizards may have more refuge from predators in a riparian cobble bar than in upland areas. Furthermore, larger basking surfaces were more prevalent in the upland habitat relative to riparian habitat, so there may have been inappropriate perches for adult lizards to bask upon in the cobble bars, especially given that it is common for adult lizards to bask higher up than juveniles (Bradshaw 1971; Keren-Rotem et al. 2006; Kiestler et al. 1975). Alternatively, we suggest that adults may defend perches from younger lizards, thus confining juveniles to riparian areas (*sensu* Schall 1974, Schoener 1975).

Sceloporus occidentalis is widely distributed in the western United States and occurs in an array of habitats that vary significantly from the riparian cobble bar and upland habitats we studied in northern California (Stebbins 2003). Asbury and Adolph (2007) found that *S. occidentalis* from geographically separated and distinct habitats exhibit a high degree of behavioral plasticity and tend to choose similar basking structures when placed in similar environments. We recommend future investigation as to whether *S. occidentalis* exhibits ontogenetic habitat shifts across a wider array of habitat types and, if they do, which factors (e.g., food or thermoregulation) drive this habitat shift. From an evolutionary ecology perspective, this could be particularly interesting in novel, urbanized settings where *S. occidentalis* not only occurs (Asbury and Adolph 2007), but where its physiology and ecology might have changed over time, potentially in favor of greater juvenile growth and survival.

Given how widespread, common, and heavily studied *S. occidentalis* is, it surprises us that an ontogenetic habitat shift has not yet been reported for this species. If these habitat shifts occur commonly in wildlife, as the literature indicates for lizards, then understanding such patterns may be important for managing the appropriate habitat features for species of conservation concern. We believe this study highlights the importance of studying the habitat use of different age classes across species.

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CONSERVATION

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Status and Conservation of a Gondwana Legacy: Bullock's False Toad, *Telmatobufo bullocki* (Amphibia: Anura: Calyptocephalellidae)

Lowland temperate forests often suffer from anthropogenic influences owing to their productive soils and ease of accessibility (Pérez et al. 2009). In fact, extensive alteration of Chile's lowland temperate forests has occurred for over four centuries (Armesto et al. 1994; Donoso and Lara 1996; Pérez et al. 2009). The fragmented forests that remain in Chile are sandwiched between the Andes Mountains to the east, the Pacific Ocean to the west, and the Atacama Desert to the north. A narrow strip of southern Chile and adjacent Argentina house all that remains of the temperate humid forests of the region (Aravena et al. 2002). These forests are biologically unique owing to isolation since the Tertiary Period and they host significant numbers of endemic plants and animals (Aravena et al. 2002; Armesto et al. 1996; Arroyo et al. 1996; Villagrán and Hinojosa 1997). South Chile's *Nothofagus* forests play a key role in creating the microhabitats used by some of the region's largely endemic amphibian fauna (Cuevas and Cifuentes 2009). There are minimally 37 anuran species unique to these forests, constituting no less than 85% of the regional amphibian fauna including three endemic genera (*Calyptocephalella*, *Insuetophrynus*, *Telmatobufo*) and an endemic family, the Calyptocephalellidae (Ortiz and Díaz-Páez 2006; Díaz-Páez et al. 2008; Vidal et al. 2008). The genera *Alsodes*, *Atelognathus*, *Batrachyla*, *Chaltenobatrachus*, *Eupsophus*, *Hylorina*, and *Rhinoderma* are unique to the region, some of which are found in both Chile and adjacent Argentina.

An amphibian found only in these southern forests is Bullock's False Toad, *Telmatobufo bullocki* (Figs. 1–3). It is a relict species restricted to *Nothofagus* forest fragments in south Chile (Correa et al. 2006; Donoso et al. 2010; Núñez and Formas 2000; Sánchez 2010). This frog is infrequently observed as it spends much of its time deep in forest litter. Because much of its habitat has been converted through silviculture and agriculture, and because so few specimens have been seen, the species is now listed by the IUCN as critically endangered (IUCN 2012).

TELMATOBUFO TAXONOMY

Philippi (1899) described *Bufo venustus* from four specimens collected in the Andean foothills of southern Chile. Schmidt, in 1952, erected the genus *Telmatobufo*. Formas and Veloso re-assigned *Bufo venustus* to *Telmatobufo venustus* in 1982. The

genus contains two (possibly three) other species: *T. australis* (Formas 1972), *T. bullocki* (Schmidt 1952), and, questionably,

DANTÉ B. FENOLIO*

Department of Conservation Research, Atlanta Botanical Garden, 1345 Piedmont Rd. NE, Atlanta, Georgia 30309, USA

VIRGINIA MORENO-PUIG

Ecology, Conservation & Behavior Group, Institute of Natural and Mathematical Sciences, Massey University, Auckland, New Zealand
e-mail: virginia.moreno@gmail.com

MICHAEL G. LEVY

Department of Population Health and Pathobiology, North Carolina State University College of Veterinary Medicine, 4700 Hillsborough Street, Raleigh, North Carolina 27606, USA
e-mail: Mike_levy@ncsu.edu

JOSÉ J. NÚÑEZ

Instituto de Ciencias Marinas y Limnológicas, Universidad Austral de Chile, Casilla 567, Valdivia, Chile
e-mail: jjnunezn@gmail.com

WILLIAM W. LAMAR

School of Sciences and Mathematics, The University of Texas at Tyler, 3900 University Blvd., Tyler, Texas 75799, USA
e-mail: wllamar@uttyler.edu

MAURICIO O. FABRY

Zoológico Nacional, Parque Metropolitano de Santiago, Pío Nono 450, Recoleta, Santiago, Código Postal 8420541, Chile
e-mail: mfabry@parquemt.cl

MARCELA S. TIRADO

Zoológico Nacional, Parque Metropolitano de Santiago, Pío Nono 450, Recoleta, Santiago, Código Postal 8420541, Chile
e-mail: mtirado@parquemt.cl

MARTHA L. CRUMP

Department of Biology, Utah State University, Logan, Utah 84322-5305, USA
e-mail: marty.crump@nau.edu

ANDRÉS CHARRIER**

Centro de Estudios Avanzados de Ecología y Biodiversidad, Departamento de Ecología, Facultad de Ciencias Biológicas P. Universidad Católica de Chile, Santiago, Chile

*Current address: Department of Conservation and Research, San Antonio Zoo, 3903 N. St. Mary's St., San Antonio, Texas 78212, USA
Corresponding author; e-mail: dantefenolio@sazoo.org

**Current address: Departamento de Ecología, Facultad de Ciencias Biológicas P. Universidad Católica de Chile, IEB, Santiago, Chile
e-mail: acharrier@gmail.com



FIG. 1. A female Bullock's False Toad, *Telmatobufo bullocki*, found buried 0.7 m in forest loam beneath a log.



FIG. 2. A female Bullock's False Toad, *Telmatobufo bullocki*; this is a robust species with the ability to withstand strong currents of icy water as well as range into surrounding forest under moderately dry conditions.



FIG. 3. A male Bullock's False Toad, *Telmatobufo bullocki*. Despite its large size and imposing appearance, this remains one of the least-known amphibians in the world.

T. ignotus (Cuevas 2010). Formas et al. (2001) discussed taxonomic relationships among the then-recognized three species of *Telmatobufo*. Hypothesized phylogenetic relationships between *Telmatobufo* and *Calyptocephalella* (= *Caudiverbera*) have been proposed (e.g., Correa et al. 2006; Formas and Espinoza 1975; Frost et al. 2006; Lynch 1978; Núñez et al. 2000). Correa et al. (2006) indicated that the closest living lineage of frogs to *Telmatobufo* and *Caudiverbera* (now *Calyptocephalella*) (tribe Calyptocephalellini) are Australian myobatrachids and limnodynastids. The Calyptocephalellini may be ancient; Núñez and Formas (2000) indicated that the lineage that led to the Calyptocephalellini diverged around 35 million years ago (mya) and that the lineage of *Telmatobufo* emerged approximately 20–25 mya. San Mauro et al. (2005) and Donoso et al. (2010) suggested that the Calyptocephalellidae may represent a relict lineage of Gondwanian origin.

TELMATOBUFO IS A RECLUSIVE TAXON NOW ONLY FOUND
IN FOREST FRAGMENTS

Frogs of the genus *Telmatobufo* are seldom encountered. Cuevas (2010) noted that "Since the description of this genus (Schmidt 1952), specimens of only 20 adults of the three species

have been collected. These have been from Cabrerías, Llancahue, Cerro Püschel (*T. australis*); Parque Nacional Nahuelbuta, Rucapehuen (*T. bullocki*); and Altos de Vilches (*T. venustus*).” As another example, adult *T. venustus* was recorded for the first time in 100 years in 1999 (Stuart et al. 2008; Veloso et al. 2004). The larva was not described until 1983 (Díaz et al. 1983), 84 years after the species’ description. Veloso (2006) reported that only adult specimens have been observed. Fenolio et al. (2011) reported that the only probable remaining locality for *T. venustus* is Altos de Vilches. During our recent (2011) surveys, we found several specimens of the less frequently encountered *Telmatobufo bullocki* in *Nothofagus* forests of the Butamalal River drainage system and in two more sites in the Nahuelbuta Mountains, which we report here. The tadpole of this species was not described until 1988 (Formas, 1988), 36 years after the description of the species. The numbers of specimens that have been found in this study likely exceed the total of all *Telmatobufo* in museum collections. However, *T. bullocki* remains one of the least-known amphibians in the world, and there are few images of the species available. Exceptions to this can be found at <http://ramonreyescarrasco.blogspot.com/>, at <http://www.arkive.org/telmatobufo/telmatobufo-bullocki>, and in Rabanal and Nuñez (2009) and Diez et al. (2011).

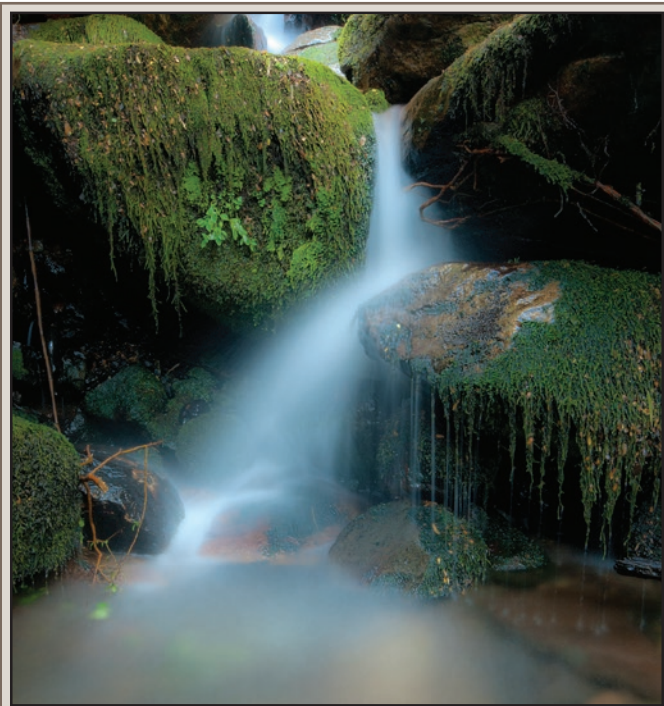


FIG. 4. False Toads of the genus *Telmatobufo* are reclusive for much of their lives. When they are active, either during nocturnal foraging or during reproductive periods, they often inhabit moist drainages and spray zones.

DISTRIBUTION AND HABITAT OF *TELMATOBUFO BULLOCKI*

All known *Telmatobufo* are endemic to southern Chile. Bullock's False Toad, *Telmatobufo bullocki*, is found in coastal range *Nothofagus* forest between 35.9794°S and 38.0000°S and between 10 and 800 m elev. (Donoso et al. 2010; Escobar et al. 2005; Formas et al. 2001). Most localities are just south of the Río Bío Bío but several new sites north of the river have also been reported (Donoso et al. 2010; Escobar et al. 2005). Smith-Ramírez (2004) cited a forest fragment (Los Queules National Reserve) as housing the northernmost population, also reported in Donoso et al. (2010). Formas et al. (2001) recognized nine localities but Veloso et al. (2004) argued that the species is known from fewer than five localities. The distribution of *Telmatobufo bullocki* has been reviewed and/or commented upon by Cei (1962), Péfaur (1971), Smith-Ramírez (2004), Escobar et al. (2005), and Donoso et al. (2010); Donoso et al. (2010) included a range map. The only two protected areas in which the species has been found are Nahuelbuta National Park and Los Queules National Reserve (Donoso et al. 2010; Escobar et al. 2005). A fourth *Telmatobufo* species, *T. ignotus* (Cuevas, 2010), has been described from Los Queules National Reserve. Donoso et al. (2010) claim genetic confirmation of their specimens from the same site as *T. bullocki*, but this has been questioned by Cuevas (2010), who further suggested that the material found by Escobar might also prove to be *T. ignotus*. So, the possibilities are that 1) *T. bullocki* exists in the Cordillera de la Costa where it 2) may or may not be syntopic with *T. ignotus*; or that 3) *T. ignotus* is conspecific with *T. bullocki*. We find the evidence in favor of recognizing *T. ignotus* as a distinct species unconvincing and thus regard the status of *Telmatobufo* in the Cordillera de la Costa as unresolved. Bullock's False Toad is found near coastal range mountain streams (Donoso et al. 2010),

yet the frogs can move considerable distances from drainage systems. Donoso et al. (2010) found individuals over 300 m from the nearest stream, and we have found them in excess of this distance. Bullock's False Toads appear to spend much of their non-reproductive time buried beneath forest debris. Favored microhabitats include areas deep below logs and rocks in *Nothofagus* forest (Formas et al. 2001; Rabanal and Nuñez 2009). Escobar et al. (2005) found an individual in a pine plantation, *Pinus radiata*, 90 meters from native forest.

CONSERVATION THREATS

All members of the family Calyptocephalellidae are threatened with extinction (IUCN 2012). Coastal range *Nothofagus* forest is declining in quality and quantity (Wolodarsky-Franke and Díaz Herrera 2011; IUCN 2012). Habitat loss, particularly conversion of *Nothofagus* forests to pine and eucalyptus, is affecting *Telmatobufo* (Cuevas 2010; Fenolio et al. 2011; Rabanal and Nuñez 2009; Stuart et al. 2008; Veloso et al. 2004). Remaining habitat has been reduced to isolated forest fragments surrounded by pine plantations and agriculture (Donoso et al. 2010; Echeverría et al. 2006; Sánchez 2010). Survey work is needed to determine the population status of all species (Stuart et al. 2008; Veloso et al. 2004) but we know that Bullock's False Toad now inhabits less than 500 km², which is spread across several forest fragments (IUCN 2009). Any use of heavy machinery in native forests, or even in silviculture areas, could disturb terrestrial habitat as these amphibians burrow in forest litter. Cuevas and Cifuentes (2009) argued that the life history of frogs like *Telmatobufo*, having a stream-adapted tadpole with specific habitat requirements, puts them at risk owing to anthropogenic environmental changes in south Chile. Heavy sediments and siltation of breeding streams from human activities in the areas where *Telmatobufo* are found could adversely affect the larval stages of these ancient amphibians (Sánchez 2010). Roads (their construction and use) and timber harvesting have been documented as a source of fine sediments washing into aquatic habitats and degrading them relative to the needs of amphibians living there (Ashton et al. 2006; Trombulak and Frissell 2000; Welsh and Oliver 1998). Hydrologic alterations (such as "run-of-the-river" hydroelectric plants) or impoundments could alter larval habitat. Hydroelectric plants in Nahuelbuta are already in place and new facilities are being constructed (e.g., on the Río Picoiquen and the Río Cayucupil, respectively). Forest fire comprises another significant threat to *T. venustus* (Veloso 2006), particularly in light of the recent conflagrations in south Chile.

There are additional threats to consider. Emergent infectious amphibian disease (amphibian chytrid fungus, *Batrachochytrium dendrobatidis*, or *Bd*) was first reported in Chile from an invasive frog, *Xenopus laevis* (Solís et al. 2010), and subsequently in native amphibian species from south Chile (Bourke et al. 2010, 2011). Emergent infectious disease has been implicated in the rapid decline of amphibian populations around the world (e.g., Berger et al. 1998; Daszak et al. 1999, 2000, 2003; Rachowicz et al. 2006). Epidemics may pose a greater extinction risk to species with reduced distributions.

Introduced and invasive species could serve as an additional threat to *Telmatobufo*. There is no question that invasive species have damaged native Chilean fauna (De Buen 1959; Jaksic 1998; Jaksic and Fuentes 1991; Jaksic et al. 2002; Lobos and Jaksic 2004; Lobos and Measey 2002; Lobos et al. 1999, 2005). The rapid expansion of salmonid fishes, post-introduction, has been

TABLE 1. Results of disease surveillance for amphibian chytrid fungus, *Batrachochytrium dendrobatidis* or *Bd*, in 45 wild Bullock's False Toads, *Telmatobufo bullocki*. Exact locality data / GPS coordinates not provided to ensure the safety of the focal populations. NMR = Nahuelbuta Mountain Range. No *Bd* was detected at NMR site No1, a 24% infection rate of *Bd* was recorded among sampled individuals at NMR site No2, and a 50% infection rate of *Bd* was recorded among sampled individuals at NMR site No3 (the exceptionally small sample size of NMR site No3 needs to be taken into consideration).

Locality	Individual number	Date	Result
NMR, site No1	Individual No.1	December 2011	<i>Bd</i> negative
NMR, site No1	Individual No.2	December 2011	<i>Bd</i> negative
NMR, site No1	Individual No.3	December 2011	<i>Bd</i> negative
NMR, site No1	Individual No.4	December 2011	<i>Bd</i> negative
NMR, site No1	Individual No.5	December 2011	<i>Bd</i> negative
NMR, site No1	Individual No.6	October 2012	<i>Bd</i> negative
NMR, site No1	Individual No.7	October 2012	<i>Bd</i> negative
NMR, site No2	Individual No.8	February 2012	<i>Bd</i> positive
NMR, site No2	Individual No.9	February 2012	<i>Bd</i> positive
NMR, site No2	Individual No.10	February 2012	<i>Bd</i> positive
NMR, site No2	Individual No.11	February 2012	<i>Bd</i> positive
NMR, site No2	Individual No.12	February 2012	<i>Bd</i> negative
NMR, site No2	Individual No.13	February 2012	<i>Bd</i> positive
NMR, site No3	Individual No.14	February 2012	<i>Bd</i> negative
NMR, site No3	Individual No.15	February 2012	<i>Bd</i> positive
NMR, site No2	Individual No.16	October 2012	<i>Bd</i> negative
NMR, site No2	Individual No.17	October 2012	<i>Bd</i> positive
NMR, site No2	Individual No.18	October 2012	<i>Bd</i> negative
NMR, site No2	Individual No.19	October 2012	<i>Bd</i> positive
NMR, site No2	Individual No.20	October 2012	<i>Bd</i> negative
NMR, site No2	Individual No.21	October 2012	<i>Bd</i> negative
NMR, site No2	Individual No.22	October 2012	<i>Bd</i> negative
NMR, site No2	Individual No.23	October 2012	<i>Bd</i> negative
NMR, site No2	Individual No.24	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.25	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.26	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.27	November 2012	<i>Bd</i> positive
NMR, site No2	Individual No.28	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.29	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.30	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.31	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.32	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.33	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.34	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.35	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.36	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.37	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.38	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.39	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.40	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.41	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.42	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.43	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.44	November 2012	<i>Bd</i> negative
NMR, site No2	Individual No.45	November 2012	<i>Bd</i> negative

well-documented, as has been the ensuing threat to native wild-life (Soto et al. 2006). We surveyed streams for three species of *Telmatobufo* and suggest that there may be a negative correlation between the presence of introduced trout (Brown Trout, *Salmo trutta*, and Rainbow Trout, *Oncorhynchus mykiss*) and *Telmatobufo* tadpoles (Fenolio et al. 2011). Field observations by one of the authors (JJN) indicate that when Brown Trout (*Salmo trutta*) are present, *Telmatobufo* tadpoles are not found; conversely, when *Telmatobufo* tadpoles are present in a given stream, there is an increased biodiversity in invertebrates and freshwater fish (i.e., the ecosystem is intact). Observations reported in Soto-Azat and Valenzuela-Sánchez (2012) support this. During some of our surveys of *Telmatobufo* breeding streams, we found that where trout are absent (one stream for *T. venustus*, one stream for *T. bullocki*, and one stream for *T. australis*), tadpoles existed. Tadpoles were not found in many streams where trout were present (> 12 streams sampled). During surveys in Altos de Lircay National Reserve, we encountered adult *T. venustus* along three streams but found tadpoles in only two of them. Rainbow Trout are common in the stream where we have been unable to locate tadpoles despite intensive searches. A local park ranger and a former landowner indicated that the trout were introduced to the first stream in the mid-1960s. However, one of us (VM) has found trout coexisting with *T. bullocki* tadpoles in many of the streams in Nahuelbuta. Observations of trout with tadpoles do not necessarily demonstrate that a negative interaction is absent and might represent a stage in the process. Trout could prey on or compete with the tadpoles; introduced fish have been implicated in other montane stream amphibian declines (e.g., Adams 1999; Collins and Storfer 2003; Kats and Ferrer 2003).

OUR DISEASE SURVEYS

Bullock's False Toad was located in a forest fragment along the Río Butamalal in January of 2011 during a frog survey organized by Felipe Rabanal and including Tomas Rivas, Edgardo Flores, Ramon Reyes, and Virginia Moreno-Puig. They found two individuals (Rabanal and Moreno-Puig, *in press*; <http://elal-madecayucupil.blogspot.co.nz/2011/01/excursion-nocturnalen-butamalal.html>). Subsequently, a group of conservationists found the species there during a field trip after an amphibian conservation symposium. We surveyed the forest fragment several times in December of 2011 and October of 2012. Over 50 person-hours were spent searching the area for *T. bullocki*. Owing to concerns about illegal collecting, the exact location is not included here. We located seven adults, all buried beneath forest debris. More adult specimens were encountered at a second and third site in the Nahuelbuta Mountain Range, during February, October, and November 2012, pursuant to a dissertation project (Moreno-Puig, *in prep.*). Skin swabs from all individuals were sent to the lab of MGL. The results for amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*), are reported in Table 1.

Methods for detecting *Bd* were as follows. Frogs were handled using a new set of vinyl gloves per specimen. Frogs were individually swabbed using sterile polyester-tipped applicators (Puritan Medical, Guilford, Maine, USA), which were gently wiped on the gular region, the flanks, the bottoms of the hands and feet, and along the ventral surface for 12 passes per body region. When dry, the tips of the swabs were transferred to individual sterile tubes and stored at 4°C until extracted and assayed. The tip of the polyester applicator was transferred to a 2 mL cryovial; 100 µl of Prepman Ultra (Applied Biosystems, Foster City, California,

USA) was added followed by 50 mg 0.5-mm glass beads for extraction. The tubes were vortexed and homogenized for 1 min in a Mini BeadBeater (Biospec Products), then placed in boiling water for 10 min, cooled for 1 min, centrifuged at 14,000 rpm for 3 min in a Marathon 16KM centrifuge (Fisher Scientific) after which the liquid was transferred using a micropipette to clean 0.6-ml microcentrifuge tubes. The recovered supernatant was then stored at 4°C until assayed using the quantitative real-time PCR protocol of Boyle et al. (2004) using 1 µl of the extract as the DNA template.

CONSERVATION ACTIONS

An unpublished conservation assessment exists for the Bullock's False Toad (Sánchez 2010). Subsequently, Soto-Azat et al. (2012) mirrored many of the recommendations made by Sánchez (2010). Although we do not agree with all of the conclusions made by Sánchez (2010), the assessment is a good starting point. The document calls for several actions: 1) historical sites should be searched for the frog during all times of the year; 2) vegetation type should be recorded across the traditional range of the species to identify specific plant communities that might be important to help identify habitat in unsurveyed areas; 3) study the condition of the water across the range of the species to identify critical hydrology for larvae; 4) evaluate the best uses of public outreach; 5) assess the impact of exotic wood culture in the region; 6) evaluate all other amphibian species across the range of *T. bullocki*; 7) tally area resource extraction; and 8) implement environmental education across the range of the frog. Sánchez (2010) calls for an order of operations that focuses on current threats once vegetation, water, and resource extraction analyses are performed. We respectfully disagree owing to the urgency of the situation with the few remaining populations of this species. Most forest fragments where this species remains are unprotected and could vanish before the proposed analyses are complete. All of the proposed analyses could be performed after critical habitat is secured and without impact on remaining populations. Sánchez and colleagues found no specimens of *T. bullocki*, and their report notes the difficulty of finding specimens and the paucity of basic information regarding biology and ecology. That study does not suggest captive reproduction as a conservation tool (presumably because they could not find frogs) despite support for assurance colonies by Conservation International, Amphibian Ark, and in published documents such as the Amphibian Conservation Action Plan. Despite their stated order of operations, Sánchez (2010) concludes by arguing for protecting remaining forest fragments as the main thrust of a conservation effort; we concur. Finally, the report notes considerable local interest in the conservation of the species during conservation workshops. A recommendation from the report calls for establishing *T. bullocki* as a flagship species for the conservation of the region. Sánchez (2010) includes several valuable conservation suggestions. We base our proposals on our field experiences, from suggestions in the literature, and from recommendations in other conservation assessments. Our recommendations also presume the ability to find live specimens and in doing so, draw from suggestions proposed in the Amphibian Conservation Action Plan (Gascone et al. 2007).

The presence of *Bd* in two of three focal populations of *T. bullocki* is alarming (Table 1); however, no mortality has been recorded. With frogs persisting at the infected sites, and in light of an infection rate of 24% and 50% of surveyed individuals at the

two sites where *Bd* has been detected, we suspect that *T. bullocki* might be a carrier of *Bd*. Continued disease surveys are under way. We caution conservation authorities against any early dismissal of the threat of *Bd* to this species based on our findings; the disease has swept through amphibian populations in Guatemala and Panama attesting to the potential speed and lethality of the pathogen (e.g., Mendelson et al. 2004). Our results require several years of verification before we can comment with authority as to the effects of *Bd* on *T. bullocki*. More intensive disease surveys across south Chile should delineate the range of the pathogen, the susceptible species, and the speed at which it is spreading.

Chilean Native Forest Law (Ministerio de Agricultura) protects vegetation surrounding drainage systems, thereby indirectly protecting amphibian species living adjacent to streams. With *T. bullocki* inhabiting sites as far away as 300 m or more from the water during their non-reproductive season, they are susceptible to commercial tree plantation activities, including the use of heavy machinery which compresses forest litter (habitat for adult animals). Silviculture activities that might threaten this species include application of herbicides and fertilizers and mechanical disturbance during harvesting and thinning operations (Donoso et al. 2010). Wider forest buffers around streams are needed to retain gallery forest that is critical to the non-reproductive habitat of Bullock's False Toad (Donoso et al. 2010).

Determining where populations of this species can be found is of critical importance (Sánchez 2010; Rabanal and Moreno-Puig, *in prep.*). Once occupied areas are identified, an intensive effort needs to be made to safeguard these forest fragments. It is not enough to know where remaining populations are; we must elevate the forest fragments to preserves because few populations are contained presently within protected lands.

Once populations are identified, long-term monitoring programs must be implemented so that we can better define the needs of the species and have an understanding of their population ecology. These efforts should be based on standardized field methods, which need to be developed based on the ecological knowledge of the species. The "rarity" of *T. bullocki* is at least partly due to inappropriate field techniques. The detection probability of the species is low, but it is also a function of other variables (observer, weather, time of the year, etc.) and this could be confounded with low abundance (or absence in some cases). Long-term monitoring of wild populations should be systematic and carefully planned. One of the authors (VM) is collecting data for her dissertation which includes habitat use and movement patterns, impact of land-use (plantations) on the species, and conservation genetics (population structure, genetic diversity, and gene flow).

Any proposed reduction or impoundment of the flow of larval streams and rivers needs to be assessed for potential impact on larvae. How are "run-of-the-river" hydroelectric plants affecting larvae? When drainage systems are reduced to the "environmental flow" (defined as 10% of the yearly average flow), how does that impact *T. bullocki*, especially the larvae?

Systematic studies need to be conducted to determine the impact of introduced salmonid fishes on the larvae of *Telmatobufo*. If introduced salmonid fishes are preying on or competing with *Telmatobufo* larvae, the interaction could remove recruitment from many, if not most, of the drainage systems across the range of all known species. If the fish are feeding on the tadpoles, salmonid abatement programs must be implemented to eliminate the predator from critical larval habitats. The resistance of

government and local authorities owing to tourism dollars generated via fishing could be considerable.

Based on the habitat loss and subsequent population fragmentation that all *Telmatobufo* species have suffered, we propose that ex-situ assurance colonies of *Telmatobufo*, including *T. bullocki*, be established immediately. The National Zoo of Chile in Santiago, the San Antonio Zoo, and the Atlanta Botanical Garden have a six-year-old partnership that developed facilities to support a captive assurance colony of Darwin's Frogs, *Rhinoderma darwinii*, at the National Zoo of Chile. That facility is now operational, amphibian keepers have been trained and are in place, and the program has reproducing groups of *R. darwinii*. The National Zoo of Chile in Santiago and the San Antonio Zoo are looking to expand their program to support other threatened amphibians of Chile. Facilities exist and permits have been obtained for the creation of assurance colonies of three species of *Telmatobufo* (*T. venustus*, *T. bullocki*, and *T. australis*). The goal is to establish the assurance colonies before wild populations drop to numbers so low that assurance colonies cannot be created. Another goal includes the development of captive care and reproduction protocols, which will be published to share methodology with all interested stakeholders. Amphibian specialists from the San Antonio Zoo's conservation program, with experience in captive breeding of endangered amphibians, will support the effort at the National Zoo of Chile in the same way that the zoo was supported while the Darwin's Frog facility was created and populated with groups of frogs. Fundraising is a joint venture. Although breeding protocols may be developed outside of Chile, involved stakeholders believe that retaining the assurance colonies within Chile encourages local enthusiasm for the conservation of native and endangered amphibians, resulting in a project that is likely to endure.

Finally, public education and outreach is a critical component of any conservation effort, particularly coming from zoos, aquariums, botanical gardens, and natural history museums (Miller et al. 2004). Our project has developed a bilingual website to promote conservation and contact with the public (www.savedarwinsfrogs.org). We have developed interpretive signage at the National Zoo of Chile around one of the amphibian breeding labs to involve the public in the project. Sánchez (2010) proposed promoting *T. bullocki* as a regional flagship species for conservation in the coastal range of south Chile. The suggestion is valuable based on local public interest in the species and its conservation; further development of the idea within regional conservation circles should be supported.

Ensuring survival of the ancient Calyptocephalellidae requires an expansion of existing partnerships to involve the zoological community, amphibian conservation-oriented programs (such as those at the San Antonio Zoo), the Chilean Forestry industry, and governmental wildlife authorities and respective agencies. Only with support from all pertinent parties can work toward a comprehensive conservation program occur. Such a program could be modeled after a collaborative effort like Partners for Amphibian and Reptile Conservation (PARC; see Gibbons 2005; <http://www.parcplace.org/>).

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Deconstructing a Southern Portuguese Monster: The Effects of a Children's Story on Children's Perceptions of Geckos

Amphibians and reptiles carry the unfortunate burden of being feared and hated throughout the world. As a result, herpetologists and others dealing directly with herpetofaunal conservation are often faced with widespread public misinformation and, in many areas, folklore-based misconceptions that depict amphibians and reptiles as evil, dangerous, or disease-carrying animals. These situations constitute a serious conservation problem, as they often result in a lack of support for conservation campaigns, a general disregard for these animals in environmental impact assessments, and even episodes of direct persecution and killing of animals (Ceríaco 2012). In the reptile world, snakes are by far the most feared and misunderstood animals globally. This may be explained by cultural interpretations and snake-related folklore in most human societies, but is also due in part to an apparent genetic aversion that primates have towards snakes (Ohman and Mineka 2003; Ohman and Soares 1994). However, snakes are not the only herpetofaunal group hated and feared by humans. Other cases are quite specific to particular

regions and historic sociocultural settings, deriving from folklore and cultural-specific interpretations (Bauer and Russell 1987; Ceríaco et al. 2011). These situations are often unknown to the majority of investigators and conservationists, contributing to a poor understanding of this phenomenon at a global level. Additionally, these specific situations are rarely brought to the attention of institutions and international agencies dedicated to the conservation of biodiversity (Mascia et al. 2003). Therefore, the importance of bridging the gap between conservation biology and the study of folklore is far more pressing than might have been imagined some years ago (Mascia et al. 2003).

Folklore can be loosely defined as a series of legends, music, oral history, proverbs, taboos, jokes, popular beliefs, and customs that are the traditions of a given culture, sub-culture, or group that have been passed from person to person or generation to generation by oral transmission or imitation (Medin and Atran 1999). Recently, Ceríaco et al. (2011) investigated folklore regarding geckos in southern Portugal and identified several resulting conservation issues. Both gecko species occurring in mainland Portugal, the Mediterranean House Gecko (*Hemidactylus turcicus*) and the Common House Gecko (*Tarentola mauritanica*), are depicted as venomous, “sticky,” and “disgusting” carriers of a dermatological disease, the “cobro,” which affects humans through direct or indirect contact by this animal (Ceríaco et al. 2011). This idea is quite prevalent throughout southern Portugal, but also extends through Arab or Arab-influenced countries such as Morocco, Egypt, and Pakistan, suggesting a common folkloric origin. However, this concept is nearly absent in other European countries where both species occur but historical Arabic influence has been less substantial (Ceríaco et al. 2011). This widespread folklore directly contributes to the killing

LUIS MIGUEL PIRES CERÍACO*

Centro de Estudos de História e Filosofia da Ciência, Universidade de Évora, Palácio do Vimioso, Largo Marques de Marialva, 8, 7000-809 Évora, Portugal and

Museu Nacional de História Natural e da Ciência, Rua da Escola Politécnica, 58, 1250 Lisboa, Portugal

MARIANA PIMENTEL MARQUES

Departamento de Biologia, Universidade de Évora, Herdade da Mitra, 7000 Évora, Portugal

e-mail: marianapimenmarques@sapo.pt

*Corresponding author; e-mail: luisceriaco@netcabo.pt

of many geckos, since both species are often found among human settlements (Cabral et al. 2006; Ceríaco et al. 2011; Mateus and Jacinto 2010). Although only *H. turcicus* is classified as Vulnerable by the Portuguese Red List of Vertebrates (Cabral et al. 2006), continuous persecution could contribute to the reduction or even extinction of local gecko populations (Ceríaco et al. 2011). This maltreatment is also ethically condemnable and forbidden by the national legislation (Cabral et al. 2006). This situation, although long since established, has not been identified or addressed until very recently, and has been virtually absent from environmental education actions that have taken place in Portugal.

In the last decade, several environmental education and awareness operations have been globally implemented in an attempt to alter these misconceptions and negative attitudes that humans have towards reptiles and amphibians. For example, efforts have been made to understand children's relationships with snakes in order to promote a positive and more comprehensive understanding of their ecology and biology (Ballouard 2012; Gangloff 2011; Gomez et al. 2004; Prokop et al. 2009; Tomazic 2011; Wojnowski 2009). Such undertakings are critical not only due to the direct influence they have on public knowledge and attitudes towards these animals, but also because they demonstrate that simple education methodologies are capable of significantly improving public opinion. Since 2010 we have been promoting a volunteer project provocatively called *Salvem as Osgas!* (Save the Geckos!). This project, funded and managed by the University of Évora's Counsel of Biology Students (Conselho de Estudantes de Biologia de Évora; CEBE), is intended to study the bio-ecological aspects of the two aforementioned gecko species occurring in southern Portugal (Ceríaco et al., *in prep.*) in order to document and understand the folklore and traditional ecological knowledge of southern Portuguese people towards these animals (Ceríaco et al. 2011). Additionally, the project promotes several environmental education activities to amiably present these animals to local populations. In this paper we present one specific case study in gecko environmental education implemented through this project involving kindergarten (ages 4–5 years) and elementary school children (ages 5–8 years).

Methods.—From May 2011 to August 2012, we conducted visits to a total of four kindergartens and two primary schools in Évora and one primary school in Beja, southern Portugal, to present a children's story about the friendship between a little boy and a gecko. This story was developed by the authors, fully illustrated with cartoons by a colleague, and published as a children's book (CEBE 2011, Box 1). Specific topics about gecko biology and ecology were addressed in the story, including food habits, diversity, habitat, anatomical characteristics, and ecosystem importance. Simultaneously, folklore-driven ideas, like supposed toxicity and disease-carrying characteristics, were refuted. These topics, both integrated into the story, were selected in order to encompass the greatest number of accurate and informative gecko characteristics, while still catering to the interests of the children.

To present this story, children were gathered into a reading location, where either an author (MM) or undergraduate volunteer read the story while the illustrations were being projected on the wall of the classroom (Fig. 1). After the story, we showed several slides presenting both cartoons and real pictures of the two relevant gecko species to better explain their morphological differences, ecology, and biology. All of this was followed by an informal chat with the children, during which they were invited



FIG. 1. General aspect of one of the storytelling sessions in Évora, Portugal, June 2011.



FIG. 2. Some drawings made by schoolchildren after one of the sessions, Évora, Portugal.

to present their ideas, doubts, and personal experiences with the animals.

We established a data collection plan with the educators and teachers in order to quantify children's opinions, ideas, and attitudes both before and after the story session. A total of 114 students participated in this survey, with similar proportions of males and females (61 girls and 53 boys), with a median age of 7 years (minimum age = 5 years, maximum age = 8). Data were collected at two separate times, with the initial session being conducted one week before the presentation of the story, and the latter session being conducted after the presentation, in the same day. For these sessions, children were asked to make a drawing of geckos and provide up to five adjectives that best described these animals in their opinion. Before and after results were then compared using a chi-squared test with a level of significance = 0.05 (Maroco 2007). For this we compared the numbers of adjectives used before and after the session, as well as the presence of the different topics and characteristics in the drawings made before the session and those in the drawing made after it.

Results and discussion.—Throughout these sessions a total of 15 adjectives were used by the children to describe geckos, with

TABLE 1. Number of times that adjectives were used by children to describe geckos in pre- and post-session inquiries. Statistically significant changes ($p < 0.0001$) denoted with an asterisk.

Adjective	# of uses before session	# of uses after session	Change
Bad	56	0	-56*
Venomous	86	0	-86*
Scary	67	2	-65*
Dangerous	90	0	-90*
Sticky	74	5	-69*
Slimy	80	16	-64*
Small	33	24	-9
Ugly	77	20	-57*
Disgusting	88	22	-66*
Friendly	0	90	+90*
Protector	2	96	+94*
Beautiful	4	76	+72*
Cute	1	70	+69*
Quick	10	7	-3
Useful	0	80	+80*

TABLE 2. Statistically significant changes ($p < 0.0001$) denoted with an asterisk.

Characteristics	# of instances before session	# of instances after session	Change
Morphological characters of the animal	33	42	+9
Ecological aspects of the animal	2	40	+38*
Presence of humans in the drawing	0	45	+45*
Presence of "happy" features	5	37	+32*
Presence of "negative" features	40	0	-40*

3 of the adjectives only being used prior to the story reading, and 2 others being only used after the session (Table 1). Statistically significant changes were detected in almost every adjective given by the children. Statistically significant increases ($p < 0.0001$) were found in children's use of the adjectives "friendly," "protector," "beautiful," "cute," and "useful." A statistically significant decrease ($p < 0.0001$) was found in the use of the adjectives "bad," "venomous," "scary," "dangerous," "sticky," "slimy," "ugly," and "disgusting." The adjectives "small" ($p < 0.2893$) and "quick" ($p < 0.6276$) did not have a statistically significant change, although their use decreased after the session (Table 1).

Some of the children did not understand the original instructions for drawing and deviated considerably from the purpose of the investigation. This resulted in the depiction of subjects clearly unrelated to geckos, such as TV shows, cartoons, etc. The possibility that some children didn't know how to draw a gecko, and therefore drew different objects instead, was also considered after discussion with educators and the children. Since we

did not have criteria to separate the initial drawings that intentionally deviated from the instructions from those that deviated due to lack of knowledge, we decided to remove both from the analysis. It is important to note that in order to prevent discrimination of any of the children, all participated in both drawing sessions, even if only a part could be used in the analysis. With these samples removed, a total of 45 drawing pairs (one made before the story sessions, the other made after it), were categorized for statistical analysis. We evaluated five different characteristics in both drawings (Fig. 2). Three of those characteristics were direct interpretations of the drawing, which we assumed reflected the most evident characteristics of the drawing, such as, "Morphological characters of the animal" (e.g., presence of distinctive traits such as coloration, skin patterns, claws), "Ecological aspects of the animal" (e.g., presence of the animal near lamps, feeding habits, habitat), and "Presence of humans in the drawing" (existence or not of human representations near the animal representation). Two were indirect interpretations of the drawing, which reflect surrounding details, such as "Presence of 'happy' features" (e.g., the animal or the human was smiling, a smiling sun/moon, flowers), and "Presence of 'negative' features" (e.g., the animal had an aggressive stance, presence of harmful objects, darker colorations).

Statistically significant changes, using a chi-squared test, were detected in most of the drawing characteristics under analysis. Statistically significant increases were found in the characteristics "Ecological aspects of the animal" ($p < 0.0001$), "Presence of humans in the drawing" ($p < 0.0001$), and "Presence of 'happy' features" ($p < 0.0001$), while statistically significant decreases were found in "Presence of 'negative' features" ($p < 0.0001$). The characteristics "Morphological characters of the animal" ($p < 0.3556$) did not have a statistically significant change (Table 2).

These results demonstrate that the use of a children's story, where bio-ecological aspects of geckos were presented, is an effective way to considerably improve children's opinion about these animals. Subsequent assessments could address whether this improvement would become permanent or long-lasting. It is interesting to note that the majority of the children, all of a very young age, already possessed a very strong and misguided opinion about these animals, suggesting that such ideas are orally transmitted between generations (see Ceriaco et al. 2011). The majority of children perceived geckos as "venomous" and "dangerous" and very few recognized any utility or beauty in the animals, reflecting the folklore-driven image of geckos held by the general southern Portuguese population. These ideas, influenced by parents and grandparents and absorbed at quite a young age, undermine the future relations between these children and the animals. Additionally, the drawing results suggest that the children's view of these animals is both incomplete and populated by negative feelings and attitudes. Many of the children possessed a poor understanding of these reptiles, lacking the majority of typical characteristics, but depicted the animal with very aggressive strokes, exaggerated dangerousness (e.g., big and sharp teeth, large claws), or dangerous objects (e.g., poison bottles).

Conservation biology is a multidisciplinary science, integrating ideas, methodologies, knowledge, and techniques from a broad range of biological and ecological fields, in addition to fields traditionally associated with the humanities (e.g., ethnography, cultural anthropology; Primack 2006). Therefore, a multidisciplinary approach is of dual importance, both because of the diversity of approaches necessary to solve such complex

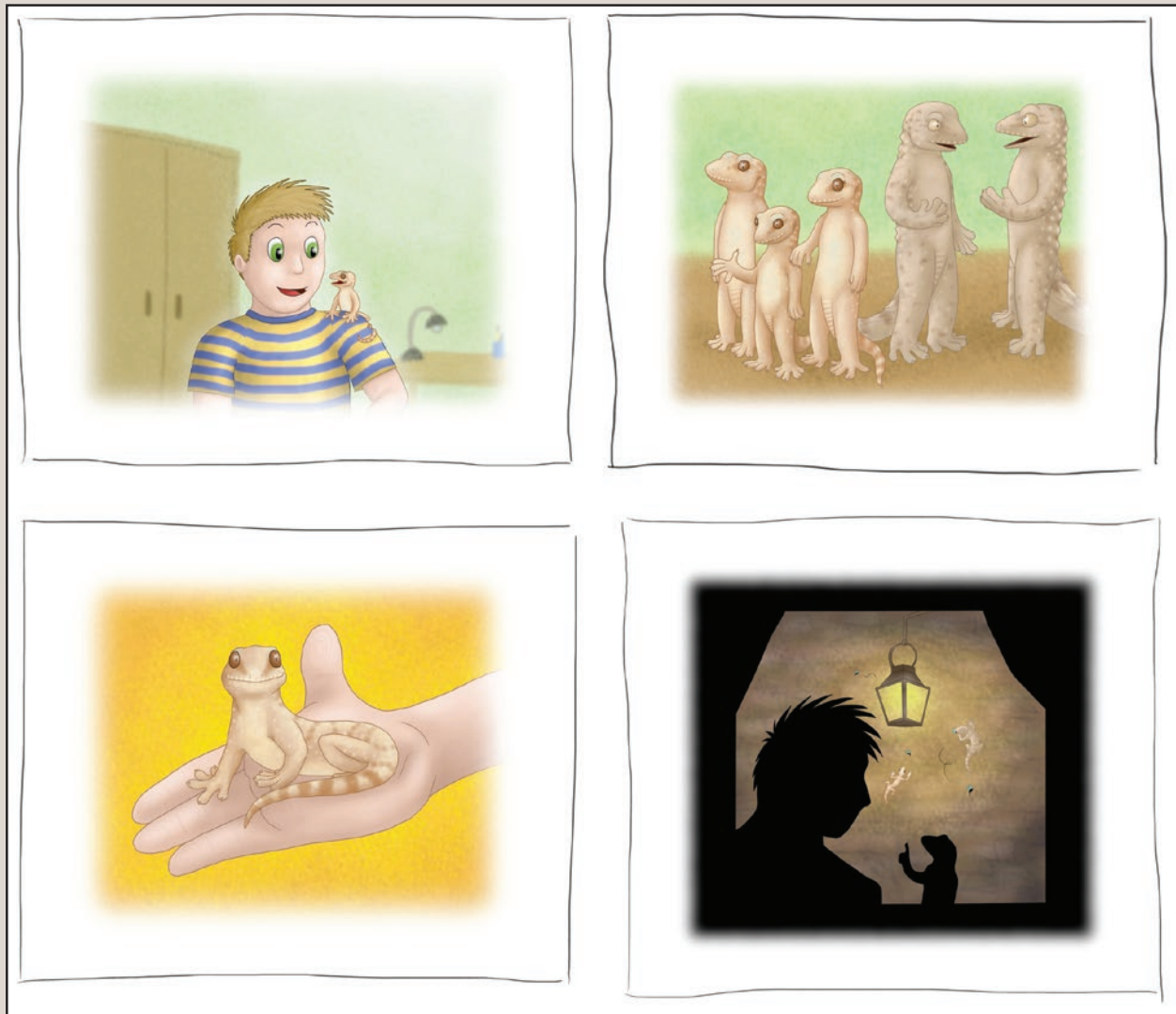


FIG. 3. Illustrations of the children's book, presenting different parts of the story where bio-ecological information or attitudes toward the geckos were implicit.

My Little Gecko Friend! The story behind the experimental children's story

"A Minha Amiga Osguita! A verdadeira história de uma amizade entre um menino e uma osga (My Gecko friend! The true story of a friendship between a boy and a gecko)" was designed to tell a story about the importance of geckos and their harmlessness to small children. The book tells the story of a little boy who meets a gecko, depicted as a *H. turcicus*, in his room. The boy was scared when he saw it, due to the stories and ideas that he had heard about the animal presenting it as poisonous and disease-carrying. After the initial shock and surpassing his fears, both became friends and the gecko promised to keep the boy safe from mosquito bites. The friendship grew and the gecko eventually presented the little boy to his family where the gecko parents were depicted as *H. turcicus* and his "cousins" as *T. mauritanica*, in an attempt to present the diversity of species occurring in Portugal. Things were good until the day the little boy's

mother found the gecko in the boy's room while he was in school and tried to kill it. Scared, the gecko ran and told all the other geckos what happened. Due to the incident the geckos decided to go on strike, eating no more mosquitoes to show to the humans how life would be without them around. After some days of the strike, most of the human population in the town was full of bites and a town hall meeting was called to deal with the plague of mosquitoes. There, the little boy presented his gecko friend and pointed to the geckos as being the responsible for his protection against mosquitoes bites. He also explained that these animals are not dangerous. From that day forward all the people started to respect geckos and stopped the persecution. The last pages of the book present a biologically accurate cartoon representing both species, showing the general morphological differences between them, as well as a summary of the project.

problems and because many conservation issues deal with anthropogenic influence as it applies to global biodiversity (Mascia et al. 2003). In the case of human attitudes towards animals, there are many different issues that clearly affect these relations which are currently being studied under the discipline of ethnozoology (Alves 2012). Despite their relevance, ethnozoological studies and data are still quite limited and mostly absent from conservation action plans. Without a fully documented picture about how people understand certain animals, any attempt to conserve or protect them may remain limited and poorly received by local people. Even documentation and knowledge of these relations is singlehandedly insufficient for resolving this persistent problem. Subsequent actions are needed to tackle the issue, with environmental education often understood as a more effective and pedagogic approach than laws and punitive actions (Ardoin and Heimlich 2013). We argue that these environmental education actions, in the form of children's stories, hands-on activities, field trips, etc., will be far more influential if they address specific concerns about discrete species, while still incorporating the cultural and ethnozoological background of the target groups.

As stated above, these school-based sessions were part of a larger project in which other approaches were implemented. Flyers and small descriptive pamphlets were distributed throughout the region, two newspapers articles were published (one in a nationally circulated paper and the other in a regional newspaper), a Facebook page was created, and participation in open-access scientific meetings was conducted. After each of the school-based sessions, a book, sticker, and information pamphlet aimed at parental education were offered to the children. This was in attempt to pass the message on to the parents by the children themselves. These types of indirect, private approaches, in combination with the other forms of public awareness described above, can facilitate the dissemination of the message, and may contribute to a more successful acceptance of these new ideas by the adults (Vaughan et al. 1999). This type of intergenerational transfer of knowledge and ideas has already been demonstrated in other environmental education activities, such as those reported by Vaughan et al. (1999), and has proved successful not only within households, but also throughout the community. Our strategy may have reversed the transfer of misinformation and folkloric concepts of geckos by leading children to deliver real bio-ecological information, such as food habits, diversity, and ecological importance, to their parents and grandparents. Considering the results obtained from these sessions, as well as the spontaneous and authentic reactions of children, we are compelled to conclude that the maintenance of these kinds of activities is an effective way to combat misconceptions, while at the same time alerting children to local biodiversity.

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TECHNIQUES

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New Experimental Method for Semen Extraction in Freshwater Turtles

Tortoises and freshwater turtles are one of the most endangered vertebrate groups, with nearly 50% of species facing the threat of extinction (Ihlow et al. 2012). Globally, they face many threats, including habitat loss and degradation, commercial harvest for food and the pet industry, road mortality, increased predation on all age classes, and the effects of pollution and climate change (Buhlmann et al. 2009). Certain life-history characteristics such as high egg mortality and delayed sexual maturity make populations of many turtle species especially vulnerable to the effects of human encroachment such that any threat can significantly reduce recruitment and survival and thus population viability (Litzgus 2006). In Nova Scotia, Canada, population declines have been observed for all four native species of freshwater turtles and accordingly, three of the four species are protected at the federal or provincial level (COSEWIC 2007, 2008; Herman et al. 1995). Reproductive dynamics of male *Emydoidea blandingii* and *Glyptemys insculpta* have not been investigated (Ernst and Lovich 2009), and previous research has suggested that in Nova Scotia, only a small proportion (5% or less) of the adult male *E. blandingii* are contributing to the gene pool (Beckett 2006). Research into the male contribution to the gene pool of each species will improve our knowledge of turtle reproductive ecology and aid in effective conservation and recovery planning to preserve these small and declining populations, based on sound scientific research.

As part of the study of male turtle reproductive dynamics, sperm samples may need to be collected and evaluated. These samples are key for investigating sperm quality and quantity and give insightful information into the reproductive stability of a turtle population. For example, to investigate the cause of the apparent low male mating success in Blanding's Turtle, sperm samples must be obtained.

To date, there are three recognized methods for sperm collection from turtles. Two of the methods are lethal and the other is highly invasive. Oviduct flushing has been used to collect sperm from inseminated female turtles. After the turtle is euthanized, typically by an intraperitoneal overdose of sodium pentobarbital, the oviduct is removed (Gist et al. 1990). The aliquot can then be observed under a microscope for presence and abundance of sperm. Although this technique has led to significant insights into sperm storage in female turtles, there are several downfalls. Aside from being lethal, this technique does not allow for identification of spermatozoa from individual males and is thus less useful when looking at reproductive deficits from a male perspective. All three species in the present study (*Chrysemys picta*, *Emydoidea*

blandingii, and *Glyptemys insculpta*) are known to be promiscuous and/or have sperm storage capacity (Banning Anthony 2012; Jenkins and Babbitt 2003; Kauffman 1992; Pearse et al. 2001), which would not allow us to isolate the actual contributing male.

Removal of the epididymis from a male turtle is another lethal method for collecting spermatozoa. Once the individual is euthanized, the organ can be removed for specific investigation (Gist and Congdon 1998; Gist et al. 2000, 2001). This technique has allowed researchers to investigate the viability and motility of turtle spermatozoa as well as the function this reproductive organ has in sperm storage (Gist et al. 2000); however, this technique is not ideal for use on threatened or endangered species.

Electroejaculation is another technique for sperm collection. Despite being non-lethal, it is highly invasive. Developed by Wood et al. (1982), electroejaculation is commonly used with domestic animals and has been successfully performed on non-anaesthetized turtles as well (Gist et al. 1990). However, according to Gist et al. (1990), it is unreliable while being both invasive and time consuming. Tanasanti et al. (2007) concurred with Wood et al. (1982) that turtles should be sedated before this technique is performed and other less invasive methods should be investigated first.

Because of the listed status of Nova Scotia species, the methods found in the literature were deemed inadequate; two require sacrifice, and electroejaculation is invasive and marginally successful. Therefore, a new technique was needed. The aim of this project was to develop and validate a new experimental method that uses vibration on the plastron and carapace to induce erection and ejaculation in male turtles. This method was tested on the three emydid species found in Nova Scotia to determine its success rate. If proven successful, this new technique for sperm collection could replace the more invasive or lethal techniques that presently exist and thus enable further research in population genetics and conservation of small and declining populations of threatened and endangered species.

Materials and Methods.—Surveys for *G. insculpta* took place at a site known for having the highest local Wood Turtle density

JOSÉ LEFEBVRE*
SHERRI-ANNE CARTER
STEPHEN W. MOCKFORD

*Department of Biology, Acadia University, 33 Westwood Ave,
Wolfville, Nova Scotia, Canada, B4P 2R6.*

*Corresponding author; e-mail: jose.lefebvre@acadiau.ca

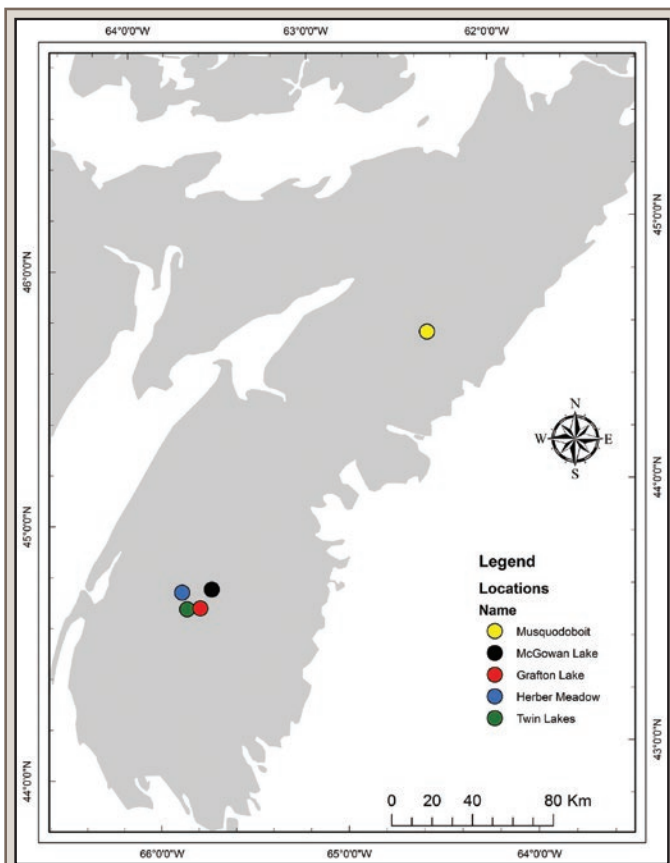


FIG. 1. Locations of spermatozoa sample collection from *Chrysemys picta*, *Glyptemys insculpta*, and *Emydoidea blandingii* in Nova Scotia, Canada.

in the Mosquodoboit watershed (Holman 2009). The sampling area was an abandoned undulating agricultural field bordering the Little River (44.9979°N, 63.1694°W; Fig. 1). The field consisted of common forbs such as goldenrod (*Solidago* sp.), with dense growth of alder (*Alnus* sp.) adjacent to the river. All *G. insculpta* were found within this site between 9 and 29 June 2011.

Emydoidea blandingii and *C. picta* were sampled from McGowan Lake (West Side Bog, 44.4366°N, 65.0751°W), Kejimikujik National Park (Grafton Lake, 44.3856°N, 65.1895°W and Heber Meadow-cove 2, 44.4084°N, 65.2636°W), and Twin Lakes (Jenny's Pond, 44.4833°N, 65.2449°W; Fig. 1). All sampling sites had extensive cover of *Sphagnum* sp. and had been previously noted to have extensive turtle activity (feeding, breeding, basking, and nesting; McNeil 2002). Sampling for both species took place periodically between 3 June and 17 August 2011.

All *G. insculpta* were collected by hand during visual surveys of the study site. Turtles were inspected for notches in the carapace indicating previous capture. Age and morphological measurements were recorded following standard protocols. Sex was determined by examining secondary sexual characteristics (Ream and Ream 1966).

Emydoidea blandingii and *C. picta* were captured either by hand or by trapping. Hoop traps 1 m in diameter with 3-cm mesh and 30-cm mouths were baited with sardines in soybean oil, set in groups of five, and checked daily for four days (20 trap-nights). Trap locations were recorded in UTM coordinates using a Garmin GPS. All *E. blandingii* captured were examined for carapacial notches indicating previous capture; individual *C.*

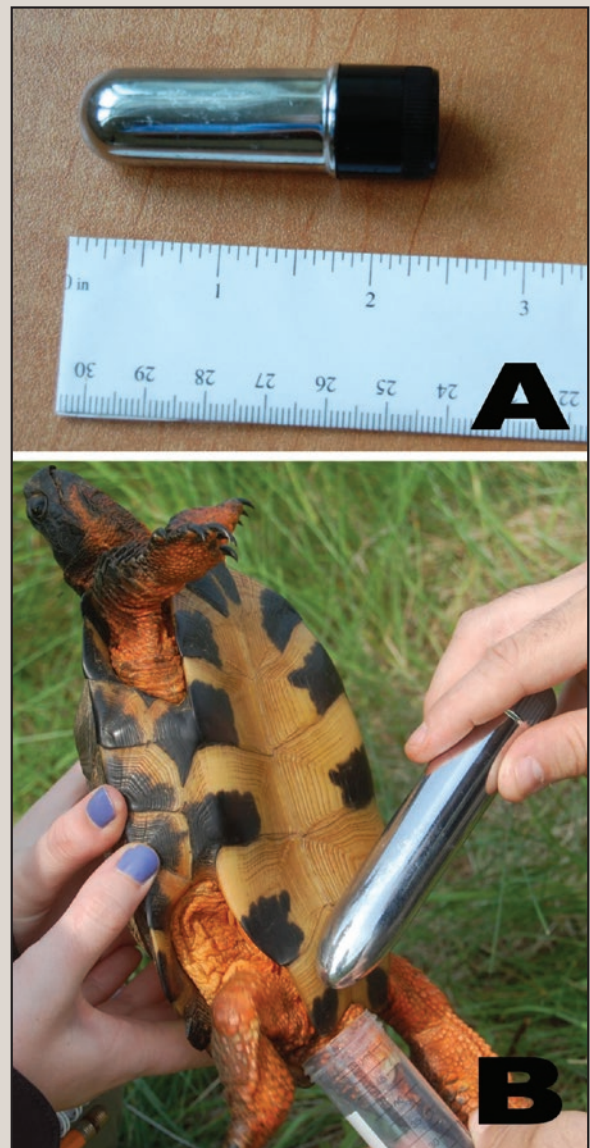


FIG. 2. A) Silver bullet-design vibrator; B) Five-inch (12.7-cm) plastic vibrator. The design was chosen depending on the size of the individual turtle.

picta were not marked and measurements were not recorded. Age and morphological measurements were recorded following standard protocols. Sex for both species was determined by examining secondary sexual characteristics (Ream and Ream 1966).

The trial began with placement of the male turtle in an upright vertical position. A vibrator (either the NMC® 5" Multi-speed, Pearlescence, Silky-Smooth plastic vibrator or a generic 2.5" battery-operated silver-bullet-design vibrator; Fig. 2), set to the highest frequency, was then firmly placed against the carapace of the turtle. Generally, the vibrator used was determined by the size of the turtle and whether the vibrator could fit between the carapace and plastron at the anterior end of the turtle.

The vibrator was then moved along the carapace in linear and circular motions (varying). If no erection was produced after covering the whole carapace, the vibrator was then placed against the plastron and the same motions were repeated. If still no erection was induced, the vibrator was first placed firmly on

TABLE 1. The number of males sampled with semen extraction technique from the three emydid species (*Chrysemys picta*, *Glyptemys insculpta*, and *Emydoidea blandingii*) in Nova Scotia.

Species	Males sampled	Successful trials	Mean attempts (max. 2)
<i>C. picta</i>	30	4	2.0
<i>G. insculpta</i>	17	2	2.0
<i>E. blandingii</i>	12	12	1.3

TABLE 2. Mean duration of all attempts made on each species (*Chrysemys picta*, *Glyptemys insculpta*, and *Emydoidea blandingii*).

Species	Average time (mins)	Standard deviation (mins)
<i>E. blandingii</i>	13.0	3.83
<i>C. picta</i>	7.7	1.64
<i>G. insculpta</i>	13.4	2.81

TABLE 3. Mean duration of successful attempts and their standard deviations for each species (*Chrysemys picta*, *Glyptemys insculpta*, and *Emydoidea blandingii*).

Species	Average time (mins)	Standard deviation (mins)
<i>E. blandingii</i>	13.0	3.83
<i>C. picta</i>	7.8	1.71
<i>G. insculpta</i>	16.0	5.65

the head of the turtle and then on the lateral region between the hind leg and tail.

If, at any point, the turtle appeared distressed (e.g., hid in shell and pulled tail or legs up and away from the vibrator), the researcher moved the vibrator to a new location. If an erection was induced, the researcher continued to vibrate that area and placed a Fisherbrand® 50-mL disposable centrifuge tube over the erect phallus to collect ejaculate. All trials were timed in seconds and are reported in minutes.

If no ejaculation was induced after a minimum of four min (maximum of eight min), the trial was terminated. The turtle was then allowed to roam freely in a contained area for up to 15 min before a second trial, with a maximum of 12 min, began. A second attempt was made only if a complete ejaculation did not occur in the first attempt.

For each species, vibration of all areas of the carapace and plastron was attempted on all turtles and some turtles appeared to have particular regions that induced an erection. These induction regions varied over all areas of the carapace and plastron. After running trials on ten *C. picta*, it was found that placing the vibrator directly on their head caused them to expose their phaluses (if only for several seconds). Stimulation of *C. picta* thereafter focused more time on the head of the turtle and less near the posterior end. Furthermore, all *E. blandingii* exposed their phallus (at least a little) upon being placed in the vertical position prior to the use of the vibrator, but no instance of ejaculation occurred with this type of manipulation in any of the three species.

All ejaculate samples collected were refrigerated within 5 h of collection. A trial was deemed successful when the presence

of spermatozoa was observed after inspection under a microscope. No previously sampled individual was subjected to the technique for more than two attempts.

To determine if there was a statistically significant difference in the number of successful attempts between each species, four Chi-square tests were performed manually (one three-way comparison, and three pair-wise comparisons). All other statistical analysis was conducted in R version 2.8.1 (R Development Core Team 2008). Four Fisher's exact tests were performed to confirm the results of the Chi-square tests (reducing concerns of inflation of results due to small sample sizes). Two ANOVAs were performed with time as the dependent variable and species as a covariate. Subsequent pairwise comparisons between each species were completed using the `glht` function in package `multcomp` in R to run Tukey's tests with Holm's adjustment, using the family-wise error rate set at $\alpha = 0.05$ (Holm 1977, 1979). Welch two-sample *t*-tests (Welch 1947) were used to compare times between successful and unsuccessful trials in *G. insculpta* and *C. picta*, with $\alpha = 0.05$.

Results.—Fifty-nine male turtles were used for the vibrational sperm extraction technique between 9 June and 17 August 2011. Ejaculate samples were obtained from 18 males in total, with samples being obtained from all three species (Table 1).

The technique was very successful in obtaining semen samples from *E. blandingii* (100%), but success rates were low for the other two species (12% for *G. insculpta* and 13% for *C. picta*). Chi-square comparison revealed a significant difference in the number of successful trials among the three species ($\chi^2 = 122.30$, $df = 2$, $P < 0.001$), with significant differences between *E. blandingii* and *G. insculpta* ($\chi^2 = 69.66$, $df = 1$, $P < 0.001$) and *E. blandingii* and *C. picta* ($\chi^2 = 66.27$, $df = 1$, $P < 0.001$), but not between *G. insculpta* and *C. picta* ($\chi^2 < 0.01$, $df = 1$, $P > 0.05$). Fisher's exact tests confirmed the Chi-square results, with significant differences in the number of successful trials among the three species ($P < 0.001$) as well as between *E. blandingii* and *G. insculpta* ($P < 0.001$) and between *E. blandingii* and *C. picta* ($P < 0.001$), but not between *G. insculpta* and *C. picta* ($P = 1$).

Comparison of the mean total trial duration for each species revealed that *G. insculpta* had, on average, the longest trial period and *C. picta* had the shortest (Table 2). There was a significant difference in trial duration among the three species (ANOVA; $F = 34.69$, $df = 2$, $P < 0.001$). Subsequent pairwise comparisons of the duration of all trials showed significant differences in trial duration between *E. blandingii* and *C. picta* ($df = 1$, $t = -6.07$, $P < 0.001$) and between *G. insculpta* and *C. picta* ($df = 1$, $t = 7.36$, $P < 0.001$), but not between *E. blandingii* and *G. insculpta* ($df = 1$, $t = 0.43$, $P = 0.67$). As for all trials, comparison of only successful trials demonstrated that it took on average the longest time to collect a sample from *G. insculpta* and the shortest time to collect a sample from *C. picta* (Table 3). A significant difference existed in the duration of successful trials among the three species ($df = 2$, $F = 4.28$, $P = 0.034$), with a significant difference existing in successful attempts between *E. blandingii* and *C. picta* ($df = 1$, $t = -2.47$, $P < 0.001$) and between *G. insculpta* and *C. picta* ($df = 1$, $t = 2.59$, $P < 0.001$) but not between *G. insculpta* and *E. blandingii* ($df = 1$, $t = 1.07$, $P = 0.30$). No significant difference was found in the duration of attempts between successful and unsuccessful attempts for *C. picta* ($t = -0.06$, $df = 28$, $P = 0.95$). Similarly, no significant difference was found between successful and unsuccessful attempts for *G. insculpta* ($t = -0.72$, $df = 15$, $P = 0.59$).

Discussion.—A new, non-invasive sperm extraction technique was tested on the three emydid species found in Nova

Scotia. The technique was significantly more successful on *E. blandingii* (100% success rate) than on the other two species; however, samples were obtained from all three.

Despite small sample sizes, the results are encouraging, particularly in the case of *E. blandingii*. The majority of the individuals sampled from each species came from single isolated populations. Sampling primarily from these specific populations could have had several effects on the success rates determined in this study (Ream and Ream 1966). First, these populations vary in their human contact. All individual *E. blandingii* sampled had previously been handled and belonged to populations subjected to extensive surveying in the past. While being handled, specifically the notching of the carapace which causes a small vibration, *E. blandingii* males typically exposed their phalluses, thus prompting the idea of using a vibrator to induce ejaculation (J. Lefebvre, unpubl. data). Consequently, these turtles, having past human contact, could have been more relaxed during application of the technique than either *G. insculpta* or *C. picta*, which had not been sampled as extensively. Nonetheless, *E. blandingii* are known for their calm disposition (Lefebvre 2009; S. Mockford, pers. obs. 2011), which may also make them good candidates for this technique.

The majority of the *G. insculpta* sampled also had been previously handled. Although the implications of prior handling for this technique are not known, at least one male sampled earlier in the summer exposed his phallus immediately when captured, a behavior not previously noted in this population (W. Holman, pers. comm. 2011). This anecdote suggests that the technique shows potential with *G. insculpta*.

Reptiles in captivity are known to be sensitive to stress from handling, and sex hormones and overall reproductive activity can be greatly impacted by stress (Mahmoud and Licht 1997). However, the overall effects of stress on turtle arousal remain unclear. Also, stress hormones such as corticosterone have been shown to increase most significantly within the first 30 minutes of handling free-living Red-eared Slider turtles (*Trachemys scripta elegans*; Cash et al. 1997). Snapping Turtles (*Chelydra serpentina*) subjected to captivity and blood sampling have been found to have significant declines in testosterone (Mahmoud and Licht 1997). Higher testosterone levels have been associated with spermatogenesis and mating activity in several species of turtles (Wibbels et al. 1987).

Conversely, some studies have indicated that exposing an erect phallus may actually be a defense mechanism for stressed turtles (McArthur 2008). Therefore, the stressful effects of handling may have decreased the sexual arousal of some of the male turtles sampled, but possibly to a lesser extent for turtles who had previously been handled. Or, the most stressed turtles may have actually been the ones to expose their phallus more quickly. The male *E. blandingii* sampled for this study all exposed their phalluses almost immediately upon being held vertically. This behavior has been noted quite commonly in this population and does not appear to be due to stress or aggression in this species (J. Lefebvre, unpubl. data).

The time of year could explain the differences in successful attempts between species. The sampling all took place within the summer months, the middle of the active season for these emydids. All three species are known to mate within these months; however, copulation is known to peak prior to and following overwintering for *E. blandingii* (Edge et al. 2010; Newton and Herman 2009), and Walde et al. (2003) reported that the majority of mating events of *G. insculpta* were observed in the fall,

almost half in October. Previous studies using electroejaculation found significant differences in the success rate of sperm obtained depending on the time of year in *C. picta* (Gist et al. 1990). Males may be more receptive to the technique if it is performed during their natural peak mating season. As Gist et al. (1990) suggested, the ability of the epididymis to transfer sperm to the sperm duct may vary temporally. This might explain the low success rate for this species; spermatogenesis might not have been completed. This might also be the case with *C. picta*, for which spermatogenesis reaches its peak in September (Ernst 1971; Gist et al. 1990; Hugues 2011; Mitchell 1988; Moll 1979).

Another possible explanation for the wide range of success rates found in this study could be physiological and anatomical differences among the species sampled. What little comparative research has been done has found significant variance in the male reproductive structures (Zug 1966). The general male turtle reproductive cycle has been studied in only a few species (Gibbons 1968; Moll 1979). Even less research has focused on comparing reproductive physiological and anatomical differences between species. It is not uncommon to observe domesticated turtles exposing their phalluses in the absence of sexual arousal or stress, although the cause remains largely unknown (McArthur 2008). Consequently, it is possible that anatomical differences may be the key to explaining some of the variation in success rates among species.

Continued testing of this technique may improve the sampling procedures used in this study and reveal variations in the process that increase sampling success for *C. picta* and *G. insculpta*. Turtles should be marked to avoid multiple sampling of individuals and sampling should be done throughout the active season, from several different populations with comparable human contact histories.

Male *C. picta* ejaculated after significantly shorter durations than the other two species. Within species, there was no significant difference in time between successful and unsuccessful trials, thus duration of the trial did not appear to play a critical role in success rates.

These results may be due to the timing methods used in this study. Setting a minimum range of duration instead of a precise time made timing results unspecific. In the future, a more quantitative scale to measure the distress of the turtle should be used. Mating behavior for turtles is a multi-stage, lengthy affair (Baker and Gilligham 1983; Ernst 1971; Kauffman 1992). Likewise, exactly when the trial was considered "complete" was difficult to define. We normally terminated a "successful" attempt when no more ejaculate fluid was being obtained or the phallus would no longer stay erect. However, it is difficult to determine whether the individual turtle had actually completed his ejaculation or simply grew stressed, timid, or uninterested. Kauffman (1992) observed that up to 85% of mating events did not result in sperm transfer. As of yet, no study has been able to determine the exact stimulus for complete ejaculation in any turtle species (Wyneken et al. 2008).

The few previous investigations into turtle ejaculations have described the action as a continuous flow of fluid over various lengths of time (Wyneken et al. 2008). It is difficult to assess the duration of copulation or ejaculation in the species studied, as most reproduction takes place under water (COSEWIC 2007; Ernst and Lovich 2009; Gilhen 1984). Studies to date have found that *E. blandingii* copulate on average for 23 minutes, *G. insculpta* between 22 and 33 minutes, and *C. picta* between 5 and 15 minutes (Ernst and Lovich 2009). Therefore, it is conceivable that

samples collected in this study were not complete ejaculates and sampling should have continued for longer durations despite the turtles' apparent responsive behaviors.

By measuring the amount of seminal fluid collected, we could have improved our confidence in the termination of the trials. Ejaculate amounts in past studies have varied in volume from 1 mL (Olive Ridley Turtles, *Lepidochelys olivacea*; Tanasanti et al. 2007) to 100 mL (Green Turtles, *Chelonia mydas*; Wood et al. 1982). Although these previous studies focus on species much larger than our three emydids, by at least knowing an expected range of semen volume for turtles in general, attempted trials made in this study could have been terminated on a more objective scale. Kimskulvech and Suttiyotin (2012) studied the Black Marsh Turtle (*Siebenrockiella crassicolis*), which is similar to emydids in size, and could not collect sufficient volume to assess quantity and quality. This basic information warrants further study based on the volume of ejaculate fluid obtained.

Conclusions.—With freshwater turtles being on the decline worldwide, it is becoming increasingly difficult to justify killing adult turtles, even for the sake of research. The present study designed and tested a new sperm extraction technique for male turtles that is minimally invasive and non-lethal. Although there was significant variation in success among species, this should not discourage the further application of this technique—other well-documented, non-lethal sperm extraction techniques also have a large range of variation in success.

The simple practicality of this technique also gives it an advantage over other sperm extraction techniques. With minimal equipment needed and the fact that it can be performed *in situ*, thereby reducing stress and handling time, it is hard to argue against its use. Encouraging results, especially for the endangered *E. blandingii*, should make it the primary option for sperm extraction in turtles, particularly when sperm is needed from threatened or endangered species.

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The Use of Photo Identification on Dickerson's Collared Lizard (*Crotaphytus dickersonae*)

Identification of individuals is important for studying the behavior and population demographics of animals. To mark individuals, several techniques can be used (reviewed in Silvy et al. 2005). In studies focusing on lizards the individuals often are marked with a painted number or symbol to allow for identification (e.g., Haenel et al. 2003; Husak et al. 2006; Kwiatkowski and Sullivan 2002). This technique is relatively non-invasive and allows identification from a distance. However, it is not permanent since lizards shed their skin. Permanent marking techniques that can be used in lizards are PIT tags (Godfrey et al. 2006; Rutherford and Gregory 2003), sewing beads in the base of the tail (Fisher and Muth 1989; Halloy and Robles 2002), branding (Hitchmough et al. 2012; Stamps 1977) and, most commonly, toe-clipping (e.g., Allsop et al. 2006; Calsbeek and Cox 2010; Chapple and Keogh 2005; Haenel et al. 2003; Sinervo et al. 2001). In toe-clipping a unique combination of digits is removed from the lizard. The advantages of this technique are that it is permanent, easy and cheap, and lizards can be easily identified and marked

in the field (Ferner 1979), although not from a large distance. The main disadvantage of toe-clipping is its invasive nature: toe-clipping may cause inflammation and infection (e.g., Golay and Durrer 1994; Lemckert 1996; Narayan et al. 2011). In addition, negative effects have been reported on mobility, survival and on the probability of recapture of the toe-clipped animal in some species (e.g., Bloch and Irschick 2005; Davis and Ovaska 2001; McCarthy et al. 2009; Schmidt and Schwarzkopf 2010), but not in others (see review in Perry et al. 2011). Natural toe loss is common in some lizard species (e.g., Freeman 1997; Hudson 1996; Kwiatkowski and Sullivan 2002; Morrison et al. 2002). In these species toe-clipping can have fewer negative effects (Hudson 1996), but makes toe-clipping less reliable as an identification technique because in some cases it cannot be determined if the toes were lost naturally or through clipping. More importantly toe-clipping can cause pain and stress according to the definition given by the International Association for the Study of Pain (IASP 1979), and might be considered unethical and should be discouraged (FDA 1989; May 2004).

An alternative to toe-clipping could be the use of photo identification. In many animal species individuals exhibit unique visual morphological characteristics, and photo identification is a non-invasive identification technique that relies on these natural markings. Photo identification is well-documented in studies on marine mammals, which have distinctive features, such as scars or the shape of the dorsal fin, allowing identification of individuals (Würsig and Jefferson 1990). On the first encounter, photos are made of distinctive markings of the animal and these photos are stored in a digital library. When the animal is seen again, subsequent photos

LIEKE FABER*

Department of Biology, Utrecht University, Padualaan 8, 3584 CH, Utrecht, The Netherlands

MELISSA PLASMAN

Instituto de Ecología, Universidad Nacional Autónoma de México, A.P. 70-275, Ciudad Universitaria, Mexico D.F., 04510, Mexico

MARIE JOSÉ DUCHATEAU

Department of Biology, Utrecht University, Padualaan 8, 3584 CH, Utrecht, The Netherlands

*Corresponding author; e-mail: liekefaber@gmail.com

will be taken to allow cross-matching with the photos in the digital library (Speed et al. 2007).

In herpetology, photo identification has been used in several studies on amphibians, using differences in individual color patterns for identification (e.g., Gamble et al. 2008; Kopp-Hamberger 1998; Kurashina et al. 2003; Streich et al. 1997; Winkler and Heunisch 1997). Surprisingly, the use of photo identification in studies on lizards is low. Differences in ventral scales have successfully been used for identification of *Podarcis muralis* and *Lacerta bilineata* (Sacchi et al. 2010). However, since ventral scales are normally not visible, lizards have to be caught and handled each time. Capture and handling is a potential stressor for lizards (e.g., Moore et al. 1991; Cabanac and Cabanac 2000), so identification by other features would be preferable when handling of the lizard is not needed.

The use of photo identification has not been documented in lizards of the family *Crotaphytidae*, although all species have a pattern of reticulations and/or spots (McGuire 1996). Toe-clipping is the most commonly used permanent marking technique in the lizards of this family (e.g., Baird and Curtis 2010; Husak et al. 2006; Husak et al. 2009; Lappin and Husak 2005; Moehn 1976; Plasman et al. 2007).

In our study on *Crotaphytus dickersonae*, we wanted to investigate whether photo identification can be used as a permanent identification technique and therefore serve as an alternative to toe-clipping. *Crotaphytus dickersonae* is a rock-dwelling species that can be found on the rocky hills of Isla Tiburón in the Sea of Cortez and the adjacent mountainous coastline of western Sonora, Mexico (McGuire 1996). These lizards have a natural pattern of dorsal and lateral white dots (McGuire 1996). We studied whether this pattern is unique and permanent for each lizard. For this purpose, we took photos of each lizard we were able to catch ($N = 38$: female = 22, male = 16), the first time they were caught (May–July 2011). Capture of the lizards was necessary for another study on this species involving body measurements. The photos were taken with a Panasonic® Lumix DMC-FS6 digital camera of both lateral sides of the lizards. The photos were printed (10 cm x 15 cm) and were carried in the field so individuals could be identified at posterior sightings. In addition, we temporarily marked each lizard with four dots on the dorsal base of the tail in a unique combination of green, red and yellow paint (non-toxic acrylic paint). This served as a way to verify identifications of the lizards based on the photos that were taken, and also allowed identification from a distance.

The 38 photographed lizards all had a unique dorsal and lateral pattern of white dots (Fig. 1). We were successfully able to identify each individual we re-encountered in the field ($N = 27$) by comparing it with the printed photos in the field. We were able to identify the lizards based on their pattern of white dots from a distance of approximately 3–5 m, which is well outside the range at which these animals allow a human to approach before they flee (Plasman et al. 2007). Photographs of lizards that were recaptured a year after this study ($N = 7$) showed no change in pattern of white spots (Fig. 2).

The identification of the 38 individuals was done by comparing the pictures visually. A larger sample size however, would require software for pattern recognizing algorithms to match images, such as I3S (Van Tienhoven et al. 2007). Pattern recognition software is available and is used for salamanders (Gamble et al. 2008), frogs (Voros et al. 2007), cheetahs (Kelly 2001), sharks (Arzoumanian et al. 2005; Van Tienhoven et al. 2007), and whales (Hiby and Lovell 2001).

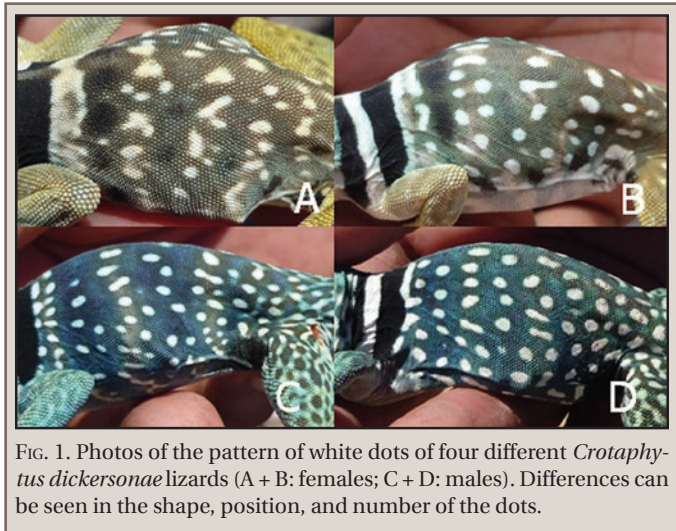


FIG. 1. Photos of the pattern of white dots of four different *Crotaphytus dickersonae* lizards (A + B: females; C + D: males). Differences can be seen in the shape, position, and number of the dots.

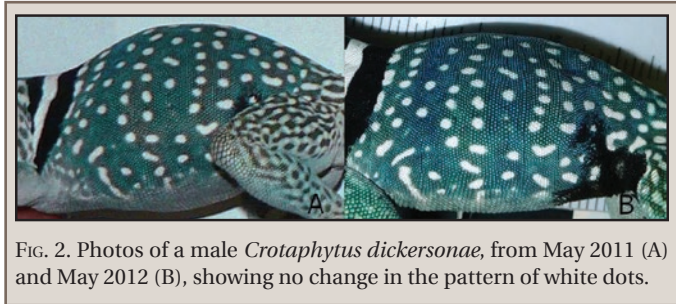


FIG. 2. Photos of a male *Crotaphytus dickersonae*, from May 2011 (A) and May 2012 (B), showing no change in the pattern of white dots.

We conclude that photo identification can be used as an alternative to the commonly used toe-clipping as a permanent identification technique in *C. dickersonae*. This method could be used for other species as well that have natural skin markings. Photo identification is a cheap, easy, and non-invasive identification technique that alleviates some of the potentially negative effects of toe-clipping.

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A Simple and Effective Technique for Demonstrating Post-prandial Metabolic Response of Snakes in the Classroom

The rapid up-regulation of snake metabolic rate following feeding has been well-documented (e.g., McCue 2006; Secor 2009; Wang et al. 2006). Although snakes are not the only animals to exhibit an increased post-prandial metabolic rate (McCue 2006; Secor 2009; Wang et al. 2006), also known as specific dynamic action, they do show an unusually large increase due in part to their low standard metabolic rate (Secor 2009). In fact, the Burmese Python (*Python molurus*), has been proposed as a model organism for studying vertebrate physiological regulation, including specific dynamic action (Secor and Diamond 1998). Because snakes, in general, exhibit dramatic metabolic responses to feeding (Secor and Diamond 2000) and many teaching faculty include the topic of snake metabolic up-regulation in courses on vertebrate biology, vertebrate physiology, and herpetology, snakes make particularly compelling subjects for classroom demonstration and experimentation. Here, a simple and inexpensive method for measuring metabolic rates in snakes to demonstrate metabolic up-regulation in the classroom is proposed.

Research questions related to metabolism typically rely on expensive respirometers wherein relative gas concentrations are measured using electronic gas analyzers (for a comprehensive overview of respirometry techniques, see Lighton 2008). While essential for obtaining research-quality data, this type of analysis is not required for classroom demonstration. Additionally, this type of equipment is not always available outside of research laboratories; consequently, undergraduate access to these instruments is typically quite limited. A simple device for measuring oxygen consumption was developed in the middle of the last century (Huber 1962; Watts and Gourley 1953). Known as a metabolism chamber (Huber 1962) or metabolism chamber (Watts and Gourley 1953), this inexpensive device gives remarkably consistent performance in the measurement of oxygen consumption of small animals (Kimbrough and Llewellyn 1973). Originally developed for use with small mammals, the manufacturer of one commercially available version of this device (Phipps & Bird, Richmond, Virginia) recommends its use for a variety of both invertebrate and vertebrate animals. In short, this type of device works as the test animal is securely housed in a sealed system. As oxygen is consumed and carbon dioxide produced, a supply of soda lime is used to remove respired carbon dioxide. Because the system is closed with a fluid bubble, the movement of the bubble within a graduated burette provides a means of measuring oxygen consumption (Fig. 1). While not the only type of system available for

measuring metabolic rate in teaching laboratories, this system was chosen for trial because of its ease and intuitiveness of use and because it can be constructed using commonly available materials (Huber 1962; Watts and Gourley 1953) if the purchase price is prohibitive.

Procedure.—Trials of the Phipps & Bird device were conducted using sub-adult African House Snakes (*Boaedon fuliginosus*) (previously included in the genus *Lamprophis*). Animals were tested pre-feeding (approximately 14 days post-feeding) and then again 48 h post-feeding in an attempt to observe the maximum change in metabolic rate (Secor and Diamond 1998). For the post-feeding trials, animals were provided with a meal approximately 6% of average snake body mass. For both pre and post-feeding trials, animals (N = 10) were weighed and then placed individually within the intra-chamber cage of the metabolism chamber (Fig. 1) to restrict movement. The bottom of the chamber was previously covered with approximately 30 g of granulated soda lime (CAS Number 8006-28-8) (color changing soda lime, to indicate CO₂ saturation, may be used if a supply of fresh material is not available for each trial). The rubber stopper and associated burette were fitted to the chamber and the chamber was allowed to equilibrate at room temperature for 15 min. Following equilibration, the inside of the burette was wetted using room temperature water to help prevent loss of bubble integrity. At the start of the trial approximately 1 mL of bubble solution (supplied by the respirometer manufacturer; however, commercial bubble solution sold as a children's toy has also been used successfully) was placed into the end of the burette using a disposable pipette.

The instruction manual for the respirometer (Kimbrough and Llewellyn 2005) suggests measuring the amount of time necessary for the test subject to consume 5 mL of oxygen. Due to the comparatively low metabolic rate of snakes (as compared to mammals), we measured the time necessary to consume 1 mL of oxygen. The measured time was used to calculate mL of oxygen consumed per hour. Because trials were conducted over several days (to allow for pre/post-feeding measurements) results were corrected to account for differences in both temperature and barometric pressure using the following equation:

$$\text{Corrected volume} = \text{observed volume} \times (\text{barometric pressure} / 760) \times (273 / [\text{temperature } (^{\circ}\text{C}) + 273])$$

This resulted in the observed volume of O₂ consumed being expressed under conditions of standard temperature (0°C) and pressure (760 mm Hg). The average of ten trials (ten snakes) was compared pre- and post-feeding using a paired t-test ($\alpha = 0.05$).

Results.—The average mass of the ten snakes was 50.2 g (SD = 10.6). The average metabolic rate pre-feeding was 3.44 mL O₂/h (SD = 0.66) and the average rate post-feeding was 7.85 mL O₂/

WILLIAM H. HEYBORNE

Southern Utah University, 351 W University Blvd.,
Cedar City, Utah 84721, USA
e-mail: williamheyborne@suu.edu

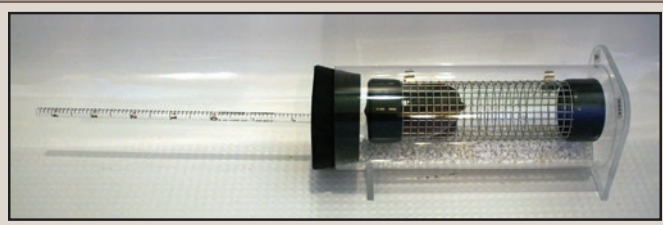


FIG. 1. Phipps & Bird (Richmond, Virginia) metabolism chamber containing a sub-adult African House Snake. Note the presence of the soda lime on the bottom of the chamber and the burette for measuring oxygen consumption.

hr (SD = 3.04). A significant difference in metabolic rate was observed for African house snakes between pre-feeding trials and post-feeding trials ($p = 0.0002$), clearly demonstrating the post-prandial up-regulation of metabolic rate.

Discussion.—A published account of African House Snake specific dynamic action (Roe et al. 2004) reported a metabolic rate of 0.68 mL O_2 /h for fasted snakes (average mass = 16.7 g) and a 3.2–5.3 times increase 24 h post-feeding. The measured metabolic rate for fasted snakes using the method described in the current report was approximately five times the rate reported by Roe et al. (2004). However, the average mass of their test animals was three times less than those used in the current study.

The classroom demonstration method described herein showed only a 2.3 times increase in metabolic rate as opposed to the 3.2–5.3 times increase reported by Roe et al. (2004). Several factors could have contributed to the observed differences. First, the meal sizes in the Roe et al. (2004) report were 10–30% of the average snake mass. The average meal size in the current study was only 6% of the average snake mass. Second, Roe et al. (2004) indicated the maximum metabolic rate of African house snakes occurs 24 h post-feeding. Our tests were conducted 48 h post-feeding, assuming the peak metabolic rate for house snakes to be similar to Burmese Pythons (Secor and Diamond 1998). Given the difference, the classroom demonstration likely missed the maximum rate window. Third, Roe et al. (2004) maintained their test animals at 25°C, while our tests were conducted at room temperature (approximately 22°C). Fourth, it should also be noted by adopters of this technique, that results would likely be more accurate if in addition to the soda lime for absorption of carbon dioxide, a desiccant such as Drierite (CAS Number 7778-18-9) would be included in the testing chamber to absorb water vapor, as accumulated water vapor will counteract some of the reduction in chamber volume due to CO_2 absorption. A desiccant was not used in the classroom demonstration reported here.

If the two groups (pre- and post-feeding) were run simultaneously for demonstration purposes, the temperature/pressure correction would not be required. In addition, to accommodate the time limitations associated with a single class/laboratory meeting, two groups of animals could be used; one group could be tested while fasting, while a second group could be tested post-feeding. Metabolic rate could be adjusted to a per-gram basis to allow for ease of comparison; however, there are issues inherent in mass-specific measurements (Beaupre 2005) that should be considered when using this approach.

Conclusion.—Despite the differences from the Roe et al. (2004) study noted above, this simple metabolism chamber method has been shown to be an inexpensive yet effective and reliable method for demonstrating snake metabolic up-regulation in a classroom setting. Although a single species

of snake was used in this trial, it is anticipated that other small snake species would work equally well. Additionally, students may readily adapt this method for testing simple hypotheses related to metabolic rate in snakes, as ambient temperature (Zaidan and Beaupre 2003), meal size (Andrade et al. 1997; Zaidan and Beaupre 2003), food type (McCue et al. 2005), snake species (Secor and Diamond 2000) and other factors (McCue 2006; Secor 2009; Wang et al. 2006) may be easily manipulated. Should the commercially available apparatuses not be of suitable size for available snake species, or should instructors desire to construct their own due to cost or other factors, both Watts and Gourley (1953) and Huber (1962) describe home-made versions of the metabolism chamber which may be easily scaled using different sizes of glassware, rubber stoppers, and burettes.

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Captive Reproduction and Husbandry of Adult Ozark Hellbenders, *Cryptobranchus alleganiensis bishopi*

Hellbenders (*Cryptobranchus alleganiensis*) are large, aquatic salamanders inhabiting cool, highly oxygenated, fast-flowing streams in sections of eastern and central North America (Conant and Collins 1998; Nickerson and Mays 1973; Petranks 1998). Currently, there are two described subspecies of Hellbenders (Crother 2012). The Eastern Hellbender (*C. a. alleganiensis*) occurs from New York south to Georgia and west to central Missouri, whereas the Ozark Hellbender (*C. a. bishopi*) is found in the Ozark Highlands of southern Missouri and northern Arkansas. Herein, we focus mainly on the Ozark Hellbender subspecies, but biology and reproductive behavior are similar for both subspecies. Currently, Ozark Hellbender populations are known to occur in the North Fork of the White River, Bryant Creek, Eleven Point River, and Current River, with some individuals possibly still present in the Jacks Fork and Spring River (Briggler et al. 2007b). Historically, Ozark Hellbenders were abundant in these rivers (Nickerson and Mays 1973; Peterson 1988; Trauth et al. 1992; USFWS 2011). Yet subsequent surveys indicate that populations have declined throughout the species' range by at least 70% since the 1970s (Trauth et al. 1992; Wheeler et al. 2003) and revealed a shift in age class structure predominated by increasingly larger individuals and diminished or absent young age classes. Wild populations of Ozark Hellbenders were estimated to be approximately 600 individuals, an extremely low number compared to an estimated carrying capacity of over 11,000 individuals (Briggler et al. 2007b). In addition, Ozark Hellbenders currently exist as small isolated populations, making them vulnerable to individual catastrophic events and reducing the likelihood of re-colonization following localized extirpations.

As a result of drastic population declines, the Ozark Hellbender was designated as critically imperiled and state endangered in Missouri in 2003 (MDC 2003). It has been protected from take or possession in Arkansas since 1990 (K. Irwin, pers. comm.), and was recently listed as federally endangered in 2011 (USFWS 2011). In 2001, the Ozark Hellbender Working Group was formed and is composed of individuals from Federal and State agencies, academia, zoos, non-governmental organizations, and individuals interested in the conservation of the Hellbender. The group has played a significant role in identifying information needs and guiding conservation and recovery efforts for Hellbenders in Missouri and Arkansas, including development of comprehensive conservation strategies (Briggler et al. 2010; Briggler et al. 2012) that addresses captive propagation, augmentation, and reintroduction goals, especially the need to captive-breed the species.

While the primary reason for population declines is unknown, several potential factors have been identified: degraded water quality, habitat alteration and degradation, disease, illegal harvest, human disturbances, and predation by non-native fish (USFWS 2011). The Ozark Hellbender population declines have necessitated the use of captive propagation efforts to ensure the long-term survival and recovery of the subspecies by maintaining/bolstering populations through augmentation and if necessary reintroduction while investigating the causes of the decline.

Herein we report our efforts on the first successful captive reproduction and husbandry of the Ozark Hellbender at the Saint Louis Zoo (STLZ). Although the reproductive biology of wild Hellbenders is well-known (Nickerson and Mays 1973; Nickerson and Tohulka 1986; Peterson 1988), there is limited information in the literature of captive-breeding of *Cryptobranchus* prior to this account. Smith (1907) was successful in artificial breeding of the Eastern Hellbender via mixing sperm and eggs obtained by sacrificing ripe females. Breeding habits of the giant cryptobranchids in Japan (*Andrias japonicus*) and China (*A. davidianus*) is relatively similar to the North American Hellbender (Okada et al. 2008; Zheng 2006). Biologists have been extremely successful in the captive-breeding of *Andrias* for several decades (Kuwabara et al. 1989; Qiang et al. 2012). However, attempts over the past decade or so by many zoos, including Saint Louis Zoo, and other institutions to naturally breed Hellbenders in captivity have been unsuccessful (Wheeler and Trauth 2002; J. Ettl

JEFFERY A. ETLING^{1*}

e-mail: ettling@stlzoo.org

MARK D. WANNER¹

e-mail: wanner@stlzoo.org

CHAWNA D. SCHUETTE¹

e-mail: schuette@stlzoo.org

SARAH L. ARMSTRONG¹

e-mail: armstrong@stlzoo.org

AMANDA S. PEDIGO¹

e-mail: pedigo@stlzoo.org

JEFFREY T. BRIGGLER²

e-mail: Jeff.Briggler@mdc.mo.gov

¹WildCare Institute, Saint Louis Zoo, One Government Drive, St. Louis, Missouri 63110, USA

²Missouri Department of Conservation, 2901 W. Truman Blvd, Jefferson City, Missouri 65109, USA

*Corresponding author

TABLE 1. Brood stock and associated data (mean, SD) for Ozark Hellbenders (*Cryptobranchus alleganiensis bishopi*) collected from the North Fork of the White River (NFWR), Current River (CR), and Eleven Point River (EPR), Missouri.

River	Artificial stream	No. males	No. females	SVL (cm)	TL (cm)	Mass (g)
NFWR	Indoor	5	3	32.1 ± 3.0	47.0 ± 4.9	631.1 ± 194.0
CR	Outdoor	5	4	28.7 ± 5.0	43.6 ± 7.0	449.9 ± 211.8
EPR	Outdoor	5	4	28.2 ± 1.9	42.8 ± 3.4	491.3 ± 125.5



FIG. 1. Indoor artificial stream at the Ron Goellner Center for Hellbender Conservation, Saint Louis Zoo, containing brood stock from the North Fork of the White River.



FIG. 2. Two outdoor artificial streams and associated life-support building at the Ron Goellner Center for Hellbender Conservation, Saint Louis Zoo, containing brood stock from the Current River and Eleven Point River.

pers. comm.). We believe the information provided herein will be useful in future efforts to captive-breed this species range-wide.

Brood stock.—Our goal was to obtain 8–10 wild, adult Ozark Hellbenders from each genetically distinct river drainage to establish breeding groups (Sabatino and Routman 2009; Crowhurst et al. 2011; Tonione et al. 2011). Therefore, breeding stock was collected from the North Fork of White River (NFWR), Eleven Point River (EPR), and Current River (CR). These animals were

collected from 2003–2007 for the NFWR, 2009–2011 for EPR, and 2010–2011 for CR. Each animal was implanted with unique identification numbers using a passive integrated transponder (PIT) tag inserted into the tail region. To date STLZ has 8 animals (5 males, 3 females) from NFWR, 9 animals (5 males, 4 females) from EPR, and 9 animals (5 males, 4 females) from CR (Table 1). The sex ratio of breeding stock was slightly skewed towards males to provide increased mate selection for females and increased genetic diversity (Table 1). Different sizes of males were targeted for collection to ensure healthy sperm. If possible, only animals that appeared healthy were collected. However, several of the animals obtained from the various rivers were compromised (e.g., missing appendages, open sores, etc.). The removal of animals was limited to only a few individuals per site to reduce effects on the resident population and to avoid inbreeding depression by collecting from several sites scattered along the river.

Quarantine.—Hellbender brood stock were quarantined and housed separately by river of origin in 151.4-liter aquariums (91.4 × 40.6 × 30.5 cm) that were part of an eight-aquarium rack system with integrated filtration system. Animals remained in quarantine until appropriate disease (e.g., amphibian chytrid fungus [*Batrachochytrium dendrobatidis*-*Bd*], bacterial, viral, etc.) and health screening (e.g., CBC blood panel, parasites, physical conditions, etc.) tests were conducted by veterinarians and animal management staff. To minimize stress, animals were placed into the stream systems as quickly as possible and in most cases less than 30 days. All animals brought into the

STLZ were treated as if they were positive for *Bd* as this fungus is already known to occur in these river systems on Hellbenders (Briggler et al. 2007a, 2008). As part of the health screening, a minimum of two time-sequenced PCR assays were conducted for each individual to determine if the animal should be treated for *Bd* or managed as a *Bd*-positive animal in breeding stock already infected with the fungus. Based on our experiences over past decade, it typically takes approximately six months for an adult Hellbender collected from the wild to adjust to captive conditions. To decrease stress and risk of mortality while the wild animals acclimate to captive conditions, abundant cover was provided for animals (e.g., multiple rocks, artificial shelters, covered tanks, etc.) and lighting was reduced during quarantine.

Artificial streams.—Adult brood stock were maintained and managed in one indoor artificial stream (NFWR brood stock) and two outdoor artificial streams (one for EPR brood stock and one for CR brood stock) once cleared from quarantine. The indoor stream, which is located in the basement of the Herpetarium, is 9.7 m long × 1.7 m wide × 0.6 m high with an average water depth of 0.3 m (Fig. 1). The indoor stream water flow (227 liters/min.) is more circular in nature due to the arrangement of a middle divider running the length of the stream and the filtration system input and output location within the stream. This indoor stream was operational since September 2002, but was not inhabited with brood stock until 2004. The two outdoor streams (11.3 m long × 1.5 m wide × 1.4 m high and 11.7 m long × 1.8 m wide × 1.4 m high) have been in operation since September 2011 (Fig. 2). The water input is located on one end of the stream and outputs are located in the middle and on the opposite end to allow water

flow (454 liters/min) across the length and width of the stream. Water depth in the outdoor streams varies considerably to mimic natural contour of river bottom. Water depths are shallow (0.6 m) on the input and output ends with a gentle sloping towards the middle of the stream, thus reaching a maximum water depth of 1.2 m. The bottom of each stream was covered with 10.2–15.2 cm of natural substrate (gravel). A variety of large flat rocks (moss rock and/or sandstone) and artificial nest boxes (Briggler and Ackerson 2012) were provided for shelter and breeding places (Fig. 3). With the success of nest boxes in the wild (Briggler and Ackerson 2012), we installed 10 nest boxes on 23 August 2011 in each of the outdoor streams prior to breeding season, and later installed six nest boxes in the indoor stream on 14 November 2011. Nest boxes can be easily accessed for observation and egg collection, as well as provide secure locations for males to defend from other Hellbenders. A minimum of two cover rocks and/or nest boxes were provided per individual to allow animals to select.

For the breeding streams and their location (i.e., indoor verses outdoor), we attempted to mimic natural conditions (e.g., photoperiod, precipitation, water temperature, water quality, etc.) of the river of origin of the brood stock to reproductively cycle the animals. Water temperature for both the indoor and outdoor streams was controlled using large multi-temperature chillers. Water temperatures for each stream were adjusted daily for the actual temperature acquired via data loggers from the respective river of origin of the brood stock. The water temperature of NFWR, EPR, and CR generally range between 4.4° and 22.2°C seasonally. Therefore, the outdoor streams also have boiler systems to prevent the streams from dropping below 4.4°C during the winter months. For the indoor stream the precipitation and photoperiod were manipulated to simulate natural cycles experienced in southern Missouri. Photoperiod was adjusted daily using a digital timer and precipitation was mimicked using a manually controlled misting system and adjusting water levels (Fig. 3). For the outdoor raceways photoperiod and precipitation conditions were provided naturally. In addition, animals in the indoor stream are closely monitored with infrared video cameras.

All artificial streams have mechanical, chemical and biological filtration as well as ultraviolet sterilization. Dedicated keeper staff and assignment of separate equipment for each stream reduces potential of disease transmission via cross-contamination. Water quality was intensively monitored to ensure animal health and encourage reproductive cycling. Water quality standards in Table 2 are based on water quality management guidelines established at STLZ staff for all hellbender streams and were recorded every two weeks or more often if warranted. A reverse osmosis filtration system was added in summer 2011 to the indoor stream and in spring 2012 for the outdoor streams to better mimic ionic compositions occurring in the rivers. Total dissolved solids (TDS) were adjusted similar to river conditions as it pertains to provide appropriate electrolyte balance, improving sperm production and defining the role of ionic composition on sperm activation. Chlorine and chloramines were removed from the water using carbon prefilters and/or dechlorinators, such as sodium thio-sulfate and/or reverse osmosis filtration.

Husbandry of brood stock.—In addition to mimicking water, substrate, and weather conditions to encourage natural breeding of the animals in the artificial streams, husbandry and health were important to ensure fitness of the animals to reproduce. A variety of foods were provided to meet the nutritional requirements of the Hellbenders (Dierenfeld et al. 2009). Adults were

TABLE 2. Water quality standards maintained in the artificial streams for Ozark Hellbenders (*Cryptobranchus alleganiensis bishopi*).

Parameter	Standard
pH	7.6–8.2
Nitrate (NO ₃)	< 10 mg/L
Nitrite (NO ₂)	< 0.2 mg/L
Nitrogen Ammonia (NH ₃)	< 0.05 mg/L
Phosphates (PO ₄)	< 0.40 mg/L
% Dissolved Oxygen (DO)	> 90%
Total Dissolved Solids (TDS)	175–300 mg/L

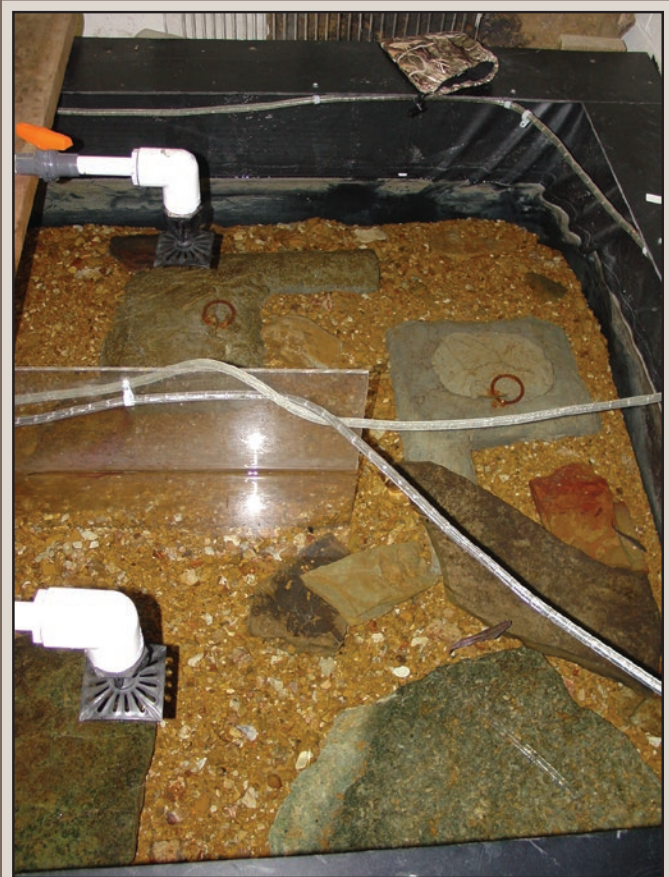


FIG. 3. Habitat (shelter rock and artificial nest boxes) utilized by Ozark Hellbenders (*Cryptobranchus alleganiensis bishopi*) in the artificial streams.

primarily fed live foods including crayfish (*Orconectes* spp., *Procambarus* spp.), sculpins (*Cottus bairdi*, *C. carolinae*), darters (*Ethoeostoma* spp.), shiners (*Notropis* spp.), and night crawlers (*Lumbricus terrestris*). The fish species listed above are collected occasionally from the wild and are augmented in the artificial streams to better represent the natural ecosystem from which the brood stock originated. Commercially obtained night crawlers were fed at a rate of two worms/Hellbender/week. Frozen-thawed fish such as Lake Smelt (*Osmerus mordax*), Rainbow Trout (*Oncorhynchus mykiss*), and Atlantic Herring (*Clupea harengus*), with Thiamin E paste supplementation, were offered once per week via tong feeding. Live food items were cleaned, quarantined, and treated prior to feeding to reduce transmission of ectoparasites, bacteria, fungus, and other pathogens.

TABLE 3. Egg-laying history and associated estimated dates for female Ozark Hellbenders (*Cryptobranchus alleganiensis bishopi*) collected for brood stock from North Fork of White River, Current River, and Eleven Point River, Missouri. * = did not lay eggs; ¹ = two females deposited eggs within one nest box for their respective stream.

PIT Tag No.	2007	2008	2009	2010	2011	2012
North Fork of White River (indoor stream)						
102-806-018	13 Oct	*	14 Oct	04 Oct	07 Oct	22 Sept ¹
066-882-540	*	9 Oct	14 Oct	08 Oct	10 Oct	25 Sept
093-624-774	18 Oct	*	*	*	18 Oct	22 Sept ¹
Current River (outdoor stream)						
051-599-288	–	–	–	–	*	28 Sept ¹
051-584-041	–	–	–	–	*	*
066-292-573	–	–	–	–	*	01 Oct
066-284-079	–	–	–	–	*	01 Oct ¹
Eleven Point River (outdoor stream)						
066-290-098	–	–	–	–	02 Oct ¹	22 Sept
094-070-830	–	–	–	–	*	*
057-810-624	–	–	–	–	10 Oct ¹	*
075-341-564	–	–	–	–	*	01 Oct



FIG. 4. A fertilized clutch of Ozark Hellbender (*Cryptobranchus alleganiensis bishopi*) eggs with attending male in an artificial nest box in an outdoor stream. Nest box lid was removed to view and photograph nest chamber.

Treatment and cleaning included: 1) soaking live crayfish for five minutes in a 50 ppt salt solution (dosed at 50 g/L), then rinsing in a fresh water solution for five minutes (Johnson et al. 2003); 2) rinsing soil from night crawlers; and 3) maintaining/isolating live fish for a three week period in a 5–7 ppt salt solution. Fish were also monitored during the quarantine period for signs of disease and/or parasites. Additional food items were provided April to June and November to January to increase the fitness of the animals prior to and immediately following the breeding season. Records were maintained for each individual Hellbender and included: 1) quarterly physical examinations, mass and length; 2) food intake, with conversion rates and graphs of weight changes over time; 3) medical; and 4) behavior.

Reproduction.—Since 2002 many actions were employed to mimic the seasonal environmental regimes (e.g., photoperiod, water temperature, and precipitation patterns) of the natural river conditions in an effort to trigger breeding activity in the artificial streams, as well as to increase fitness of the animals to produce gametes. Males developed the typical cloacal “donut” swelling and females exhibited abdominal swelling associated with egg production similar to wild animals. Between 2007 and 2011 eggs were laid every year in the indoor stream for a total of 10 clutches (Table 3), which all proved to be infertile. However, on 18 October 2011 two clutches of fertilized eggs with different stages of development were discovered in one of the nest boxes in the outdoor stream housing the EPR Ozark Hellbender population (Fig. 4), eventually yielding 151 larval Hellbenders. As noted earlier, this population is comprised of five males and four females. These animals were removed from the wild from 2009 to 2011 and were augmented into the outdoor stream on 20 September 2011. The two females that deposited eggs were recently collected from the wild (August and September 2011). However, the male that fertilized the eggs and guarded the nest was housed and environmentally cycled indoors since 25 August 2009.

In 2012, natural reproduction occurred in both outdoor streams (EPR and CR brood stock) and finally the indoor stream (NFWR brood stock) resulting in eight fertilized egg clutches and the sequential hatching of over 2500 embryos. All three females deposited eggs in the indoor stream with the NFWR brood stock, two females in the EPR brood stock in one outdoor stream, and three females in the CR brood stock in the other outdoor stream (Table 3). Dates of egg laying in 2012 were earlier than previous years with eggs being laid from 22 September to 01 October (Table 3). All eggs were laid in nest boxes, and in two instances (NFWR and CR) two different females laid eggs within one nest box. In all cases, males guarded the nest site by protecting the nest box entrance tunnel from conspecifics. The male that successfully guarded the first fertilized clutch in the EPR outdoor stream in 2011 was not the guardian of either fertilized clutch in 2012.

While checking nest boxes on 01 October 2012, we witnessed one male and one female in the act of spawning in EPR outdoor stream. The two animals were in a circular position with heads and tails overlapping. There were three visible eggs protruding from her cloaca, and the inside of the nest box chamber was foaming with seminal fluid in a cloudy mass or stringy threads. Immediately the lid of the nest box was put into place to decrease disturbance, and on the following morning the nest chamber was full of fertilized (cleavage furrows visible) eggs.

In the artificial streams it is typical for animals to share cover rocks and nest boxes outside of the breeding season. This changes in late summer however, as males become increasingly aggressive and establish themselves in certain nest boxes or cover rocks as the spawning season approaches in late-September to mid-October. Prior to the 2012 breeding season, aggression among the animals was relatively minor; however, during the major breeding event that occurred in 2012 several animals (males and females) had lost limbs, severe lacerations on the limbs, and bite marks along the lateral folds.

Discussion.— Intensive captive propagation efforts for the Ozark Hellbender have been pursued at the Saint Louis Zoo

since 2002. Seasonal changes in photoperiod, water temperature, and precipitation patterns are thought to trigger breeding activity (Nickerson and Mays 1973). Through seasonal manipulation of the water temperature, photoperiod, precipitation, and feeding regime, Hellbenders housed in the indoor stream consistently cycled at exactly the same time as their wild counterparts (JTB, unpubl. data). For example, when eggs were being laid in the wild on the NFWR, the NFWR brood stock at the STLZ would be laying either on the same day or within a day or two. Even with consistent egg-laying in the indoor stream since 2007, fertilization did not occur until 2012 in the indoor stream. Further investigation revealed that the males comprising our breeding group were producing sperm with deformities and/or low motility. Based on a review of the literature the ionic composition of the water appears to affect sperm development and activation during spawning for fishes (Yeung et al. 2006). With that in mind, the use of reverse osmosis filtration was put into place in August 2011 for the indoor stream and May 2012 for the outdoor streams to adjust the ionic composition (e.g., TDS) of water used in our Hellbender streams in an effort to closely match that of river water. An evaluation of sperm quality on 08 October 2011 for males housed in the indoor raceway indicated motility of 85%, the highest recorded for these animals to date (T. Crabill, pers. comm.). Follow-up sperm assessments in 2012 showed increased sperm quality for animals in all three streams, thus resulting in successful fertilization of all eight clutches deposited by females.

In addition to adjusting the ionic composition of the streams, the nest boxes also played a significant role in the increased level of success occurring in 2011 and 2012. The first fertilized clutch of eggs occurred in a nest box installed in summer 2011 in the outdoor streams. With the success of this fertilized clutch at the STLZ and in the wild (Briggler and Ackerson 2012), nest boxes were later installed in the indoor stream for the upcoming 2012 breeding season, thus resulting in eight fertilized clutches in six nest boxes in both the indoor and outdoor streams. In previous years, it was not uncommon for both male and female Hellbenders in the indoor stream to consume conspecifics eggs under cover rocks provided. Although cannibalism of eggs is known to occur in wild populations (Bishop 1941; Smith 1907), it seemed difficult for males in the streams at the STLZ to protect nests under cover rocks from conspecifics due to many animals that would dig their way into the nest chamber from various sides of the cover rock to consume or remove eggs. Therefore, we believe the nest boxes not only provided ideal conditions for successful spawning, but also provided a long, narrow, single-entrance tunnel from which males could protect nests from conspecifics. Success towards achieving our goal to naturally breed Hellbenders in captivity was steady in the earlier years; however, we believe the addition of nest boxes and mimicking ionic compositions of the river water paved the way to the remarkable breeding successes that occurred in the past two years.

Considerable Hellbender life history data were observed during the process to achieve captive-breeding of the species. It is unclear if female Hellbenders in the wild lay eggs annually. However, Topping and Ingersol (1981) and Peterson et al. (1989) data suggest that not all gravid females lay their eggs during the same season. For the NFWR brood stock, two females consistently laid eggs annually while the third female rarely laid eggs; however, the health of this animal was compromised in 2009 and 2010 (Table 3). We have limited egg-laying history for CR and EPR brood stock, but one female deposited eggs in both 2011

and 2012 (Table 3). Similar to wild Hellbenders, there appears to be variation among captive-held females for their egg laying history, but it is not uncommon for females to lay eggs annually.

In all cases of successful fertilization of eggs in 2011 and 2012, an individual male protected and remained with his respective clutches by defending the nest box entrance tunnel similar to natural nests found in the wild (Nickerson and Mays 1973; JTB, pers. obs.). However, this does not preclude males foraging on their own eggs as documented via ultrasound by EPR male in 2011. Based on our observation of all streams and video evidences of the indoor stream, it appeared that guardian males were the sole gamete contributors to their respective clutches. However, multiple paternity has been reported within a nest cavity for the related *Andrias* species (Kawamichi and Ueda 1998), and several male Hellbenders have been observed within a nest cavity in the wild in Missouri (JTB, pers. obs.), but only one male attends the nest. To further examine whether multiple paternity has occurred within these artificial streams, we plan to conduct genetic parenting of fertilized clutches. Also, on three occasions multiple maternity was witnessed within a given nest box in each of the streams (Table 3); this is further supported in the literature that males will accept several females into the nest cavity (Bishop 1941; Crowhurst et al. 2009; Smith 1907). Hellbender behavior and reproduction (e.g., multi-parenting, egg laying history, nest box selection, etc.) observed in captivity will likely provide additional insight into the breeding activities of wild populations.

Conclusion.—The first successful captive reproduction of Ozark Hellbenders in 2011, repeated in 2012, at the STLZ was believed to be the result of a combination of six factors: 1) Space—providing ample space allows individual animals the opportunity to establish their own home territory. With this in mind, the streams were designed and constructed to be as large as possible. 2) Cover rocks and nesting sites—a combination of large rocks and nest boxes were provided in both the indoor and outdoor streams. Appropriate nesting sites are ones that can be easily defended by the attending male. 3) Environmental cycling—simulation of seasonal photoperiod, water temperature, and precipitation changes resulted in the Hellbenders becoming reproductive at the same time as their wild counterparts. 4) Water quality—maintenance of high water quality standards, including adjustments to ionic composition, dissolved solids, etc., was vital to overall health including sperm development and activation. 5) Sex ratio—a good ratio of both sexes simulates natural breeding dynamics and provides females with mate selection opportunities. 6) Animal health—increase food availability during late winter and early spring to improve fitness of animals to produce gametes. The factors described above could be applied to other *ex situ* management plans in zoos and conservation organizations in need of propagating the species range-wide. Through the significant achievement of the successful captive-breeding of the Ozark Hellbender in the past two years at the STLZ, many of these offspring will be released into the wild to bolster populations.

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AMPHIBIAN DISEASES

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Detection of *Batrachochytrium dendrobatidis* in River Frogs (Genus *Amietia*) on Mount Kilimanjaro, Tanzania

Within Africa, the amphibian chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) has been reported from southern, eastern, and central parts of the continent, whereas it is currently undetected in West Africa (Penner et al. 2013 and citations therein). Although *Bd* has been found in some African species without aquatic larval stages (Bell et al. 2011; Conradie et al. 2011a; Gower et al. 2012), the majority of species affected by the fungus are from high altitude and inhabit mostly flowing streams (Murray and Skerratt 2012). River frogs of the genus *Amietia* seem to be particularly susceptible, showing the highest zoospore loads known among African frogs in Kenya (Kielgast et al. 2010), Malawi (Conradie et al. 2011a), South Africa, and Lesotho (Weldon 2005). *Bd* infection also has been detected in Uganda (Viertel et al. 2012), yet records from the Udzungwa Mountains in Tanzania have not detected *Bd* (Moyer and Weldon 2006). Here, we report the occurrence of *Bd* in *Amietia angolensis* and *A. wittei* from Mt. Kilimanjaro, northern Tanzania.

Mount Kilimanjaro is the remnant of a large volcano located on the border with Kenya (3.07583°S, 37.35333°E; Fig. 1). It rises from a hot and dry savanna plain at 700 m to an ice-clad summit of 5895 m, thereby encompassing several different bioclimatic zones. At 1700 m, the borders of the Kilimanjaro National Park delimit the montane forest, whereas the lower part of the slope has been almost entirely converted into a traditional agroforestry system (mainly banana and coffee trees) and monocultures (mainly maize, sunflowers, and beans). *Amietia angolensis* inhabits the lowland (1000–1700 m), whereas *A. wittei* occurs from 1700 m to 3500 m on the Shira Plateau (GZ, unpubl. data).

Samples for *Bd* analysis were collected in 2011 (from March to June—long rains; October and November—short rains) during surveys of *Amietia* tadpoles for other research purposes. Because we observed tadpoles with jaw sheaths and tooth rows completely colorless (Fig. 2d), we gently brushed the mouthparts with common cotton swabs and stored them dry in safe-lock tubes. Diagnostic analysis was performed in October 2012 at the Amphibian Disease Diagnostic Center at Washington State University (Pullman, Washington, USA). Fungal DNA was extracted using DNeasy extraction kits (Qiagen). Detection and quantification of *Bd* was performed using standards (1000, 100, 10, 1, and 0.1) from serial dilutions by means of RT-qPCR according to Boyle et al. (2004).

Although sample size was low ($N = 17$), we detected *Bd* in at least 40% of the specimens for both species (Table 1). Overall, the *Bd* infection levels appeared low in individual samples (< 5 zoospore equivalents). We believe these results do not reflect

realistic levels of pathogen load, but they are very likely due to a combination of technical factors. First, this non-lethal technique for detecting *Bd* on tadpoles is less effective than histological diagnosis (Retallick et al. 2006). In their research, the authors scraped the tadpoles' mouthparts with wooden toothpicks whereas we used swabs which are less invasive (i.e., they are less likely to damage mouthparts and influence the ability of tadpoles to feed). However, swabs may not collect *Bd* DNA as effectively as toothpicks, which regularly break pieces of labial teeth (Retallick et al. 2006). Second, during field work, samples were stored in a freezer to avoid high temperatures, but the power supply at the field station was irregular, resulting in frequent blackouts and consequent thawing of the freezer's contents. High temperatures and long storage periods can result in reduced recovery of *Bd* DNA from swabs (van Sluys et al. 2008). These factors likely induced degradation of DNA in our samples; still, we were able to detect *Bd*, suggesting that the pathogen load may have been high originally.

This is the first record of *Bd*-positive *Amietia* from Tanzania. All specimens presenting depigmentation of keratinized mouthparts were *Bd*-positive; however, the sample size was too low for a statistically significant correlation between oral deformity and *Bd* presence. During the whole field season, we observed larval deformities with similar gross morphology at other sites, but we never encountered dead or moribund adults of *Amietia* or of other species occurring in the area. Similar observations of a general lack of mortality among *Bd*-infected animals have been reported in other studies from Africa, including Kenya (Kielgast et al. 2010), Uganda (Goldberg et al. 2007), and South Africa (Conradie et al. 2011b). The high prevalence of *Bd* and apparent low virulence may suggest that the pathogen is enzootic within those regions, thereby providing support for the "out of Africa" hypothesis (Weldon et al. 2004). However, a lack of connection

GIULIA ZANCOLLI*

Department of Animal Ecology and Tropical Biology, Biocentre, University of Würzburg, Am Hubland, 97074 Würzburg, Germany

ANDREW STORFER

School of Biological Sciences, Washington State University, Pullman, Washington 99164, USA

MARK-OLIVER RÖDEL

Museum für Naturkunde, Leibniz Institute for Research on Evolution and Biodiversity, Invalidenstr. 43 10115 Berlin, Germany

*Corresponding author; e-mail: giulia.zancolli@gmail.com



FIG. 1. Mount Kilimanjaro, Tanzania, where *Batrachochytrium dendrobatidis* (*Bd*) was detected. Records of *Bd* infections from the Eastern Arc Mountains are still poor (www.bd-maps.net, accessed 16 April 2013).

between *Bd* presence and population decline has been reported elsewhere, for instance in eastern North America (Longcore et al. 2007). The question about the origin of *Bd* remains open.

Kielgast et al. (2010) suggested a taxonomic basis for variation in apparent *Bd* susceptibility among host species, and the genus *Amietia*, in particular, showed the highest pathogen load and prevalence in their study. Other studies have also provided support for aquatic life histories contributing to *Bd* occurrence patterns (e.g., Bancroft et al. 2011; Olson et al. 2013). During our surveys, we regularly observed tadpoles of both species in the water. *Amietia angolensis* adults are semi-aquatic and active throughout the year (Channing and Howell 2006); the tadpoles have a prolonged development and may take up to two years to complete metamorphosis (Channing 2004). Thus, river frogs can act as reservoirs for *Bd* and facilitate disease persistence in the system. Moreover, *Amietia* species cover most of the elevational range of Mt. Kilimanjaro, and this might allow *Bd* to survive during unfavorable conditions within spatially disparate microhabitats (e.g., by persisting at higher elevations during summer and at lower elevations during winter).

Local dispersal of *Bd* may be facilitated by humans. Kilimanjaro National Park is a tourist attraction with over 35,000 climbers a year (Peaty 2012), and each climber has at least three porters to conform with park regulations. The first campsites encountered along the climbing routes are usually allocated at the upper ridge of the forest (ca. 3000 m) and close to ponds or streams which are used by *A. wittei* for breeding (GZ, unpubl. data). We observed porters collecting water (e.g., for cooking and human



FIG. 2. Typical creek within the subalpine zone at ca. 3000 m, Kilimanjaro National Park, Tanzania; a) breeding site of *Amietia wittei* close to the Machame Huts campsite where porters collect water; b) larvae of *Amietia wittei*; c) oral disc with unchanged morphology; d) mouthparts with depigmentation of jaw sheaths and labial teeth.

consumption) at the same water bodies where tadpoles tested *Bd*-positive. Porters are able to walk through the mountain for long distances within a day, and this may translocate zoospores from one site to another. Below the national park borders, the slope is characterized by an extensive network of water canals built by the local human population for irrigation, and by which *Bd* may disperse, or river frogs or other transmission vectors may spread the pathogen (Morgan et al. 2007; Johnson and Speare 2005).

Our results showed the presence of *Bd* infection in river frog populations on Mt. Kilimanjaro. Considering the high susceptibility of *Amietia* species and their potential to serve both as *Bd* reservoirs and vectors to nearby areas (especially the lowland *A. angolensis*), it would be beneficial to intensify surveys for *Bd* detection in the East African highlands and in particular in the Eastern Arc Mountains. The few data available to date are from the southern Udzungwa Mountains, where *Bd* has been detected in 12 species (Moyer and Weldon 2006; www.Bd-maps.net, accessed 16 April 2013), and from the northern East Usambara Mountains with negative records dated 2006 (www.Bd-maps.net). This hotspot of biodiversity harbors an outstanding number of endemic species (Burgess et al. 2007) that may still be naïve to the fungus and thus will suffer population declines if the infection reaches those forests.

TABLE 1. *Batrachochytrium dendrobatidis* infection data for *Amietia angolensis* and *A. wittei* from Mount Kilimanjaro, Tanzania. All samples are from larvae. Because of the extremely low amount of *Bd* DNA, it was not possible to determine *Bd* presence with absolute certainty for some samples. Uncertain results are reported as suspect positive (susp.pos.) or negative (susp.neg.).

Species	Dates	Localities	Coordinates	Elevation (m)	Water bodies and habitat	N <i>Bd</i> -positive samples	N samples	Zoospore equivalents (min-max)	Mouthparts
<i>A. angolensis</i>	18 Oct 2011	Waramu river	3.1959°S 37.2555°E	1532	stream cultivated area	0	1		normal
<i>A. angolensis</i>	18 Oct 2011	Nkuu	3.1808°S 37.2511°E	1692	creek cultivated area	4 (2 susp.neg.)	5	0.001–2.621	depigmented
<i>A. angolensis</i> <i>A. wittei</i>	29 Oct 2011	Umbwe route	3.1845°S 37.2789°E	1705	stream disturbed forest	0	1		normal
<i>A. wittei</i>	05 May 2011	Mweka route	3.2038°S 37.3485°E	1992	creek montane forest	0	1		normal
<i>A. wittei</i>	26 Oct 2011	Marangu route	3.2018°S 37.5175°E	2359	stream montane forest	1 (susp.pos.)	1	0.087	depigmented
<i>A. wittei</i>	03 Nov 2011	Machame huts	3.0940°S 37.2657°E	2978	stream moorland	3 (1 susp.pos.)	3	0.014–1.656	depigmented
<i>A. wittei</i>	01 Nov 2011	Machame huts	3.0967°S 37.2667°E	3023	creek moorland	2 (1 susp.neg.)	5	0.004–1.526	depigmented

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Batrachochytrium dendrobatidis in Amphibians of Northern Calhoun County, Illinois, USA

We assessed *Batrachochytrium dendrobatidis* (*Bd*) infection rates among amphibian species occupying aquatic ecosystems (lake, wetland, and creek) within the Great Rivers region, Illinois, USA. Our data provide a baseline for future research to determine how *Bd* is affecting amphibians in this area.

We surveyed for amphibians by nocturnal and diurnal visual encounter surveys throughout all habitats on the McCully Heritage Project from 14 to 19 July 2008. The study area is located in northeastern Calhoun County, Illinois along the Illinois River, approximately 1.6 km south of Kampsville, Illinois (www.mccullyheritage.org). The site consists of approximately 3.8 km² of upland and lowland forest, forest edge, and hill prairie habitat, as well as a lake, wetland, and creeks. We swabbed the ventral surface and inside surface of the legs of each amphibian encountered using sterile technique (Livo 2004). We stored swabs individually in 70% EtOH. All swabs were analyzed by either Pisces Molecular LLC (Boulder, CO, USA) within 3 mo of collection or the Amphibian Disease Laboratory, San Diego Zoo Institute for Conservation Research within 3 yr of collection. There were no differences between the methods used in the two different laboratories, hence we pooled all data for statistical analysis.

PETER J. MUELLEMAN

Biology Department, Truman State University,
Kirksville, Missouri 63501, USA

CHAD E. MONTGOMERY*

Biology Department, Truman State University,
Kirksville, Missouri 63501, USA

*Corresponding author; e-mail: chadmont@truman.edu

TABLE 1. Amphibians tested for *Batrachochytrium dendrobatidis* (*Bd*) at McCully Heritage Project, Calhoun Co., Illinois, USA.

Species	Common name	No. <i>Bd</i> -positive/ Total sampled (%)
<i>Acris crepitans</i>	Northern Cricket Frog	25/52 (48.1%)
<i>Hyla crucifer</i>	Spring Peeper	1/1 (100%)
<i>Hyla versicolor</i>	Grey Treefrog	3/13 (23.1%)
<i>Lithobates clamitans</i>	Green Frog	0/1
<i>Lithobates palustris</i>	Pickerel Frog	0/1
<i>Lithobates catesbeianus</i>	American Bullfrog	2/2 (100%)
<i>Lithobates sphenoccephalus</i>	Southern Leopard Frog	8/13 (61.5%)
<i>Anaxyrus americanus</i>	American Toad	1/3 (33.3%)
<i>Eurycea longicauda</i>	Long-tailed Salamander	2/19 (10.5%)

We detected *Bd* in 42 of 105 (40%) amphibians, in 7 of 9 (78%) species sampled (Table 1). No animals were observed showing symptoms of the disease chytridiomycosis. Although there was variation in infection level among species (χ^2 test of independence; $\chi^2 = 18.2$, $p = 0.019$), our low sample sizes likely precluded detection if *Bd* prevalence was low (Skerratt et al. 2008). Nevertheless, infection levels were similar to reports of 31% infection level from Sparta Training Center, Randolph County, Illinois (Lannoo et al. 2011). Among species in our sample with relatively greater sample sizes ($N > 10$), *Eurycea longicauda* and *Hyla versicolor* may have had lower infection levels due their terrestrial habitat use (Phillips et al. 1999). *Bd* has been reported to affect amphibians that are dependent on aquatic ecosystems more severely than those species that are more terrestrial (Lips et al. 2003). *Lithobates sphenoccephalus* showed the highest level of infection, which is interesting considering anti-microbial skin

peptides that inhibit *Bd* growth have been shown to occur in ranid frogs (Rollins-Smith et al. 2002). However, *L. sphenoccephalus* is highly aquatic and therefore may be more exposed to *Bd*.

Although examination of seasonal patterns of infection is limited by our low sample sizes and haphazard sampling design, of the two species (*A. crepitans* and *L. sphenoccephalus*) that were sampled during both spring (May) and summer (July), *L. sphenoccephalus* sampled in May (N = 8) were all *Bd*-positive whereas those sampled in July (N = 5) were all *Bd*-negative. Seasonal variation in infection level has been reported previously, and may be due to the more unfavorable conditions (decreased humidity, increased temperature) for *Bd* or the potential for individual amphibians to increase their body temperature to clear themselves of the infection during the summer (Berger et al. 2004; Ribas et al. 2009; Richards-Zawacki 2010).

When all individuals were pooled for analysis by habitat type, there tended to be a difference in infection rate among animals captured in different habitats (lake, wetland, creek: χ^2 test of independence; $\chi^2 = 0.49$, $p = 0.058$). Amphibians captured in wetlands showed the highest infection rate (49.1%). Wetland habitat was used for breeding by all anurans within the community, likely increasing the chance for both *Bd* occurrence and transmission (Kriger and Hero 2007). Although our sample sizes were relatively low, restricting comparisons among habitats within species, the species with the greatest sample in multiple habitats, *A. crepitans*, showed no difference in infection level between habitats (χ^2 test of independence; $\chi^2 = 4.91$, $p = 0.18$).

Our data represent a baseline starting point for understanding *Bd* infection levels in this area. Increased sampling and both seasonal and annual monitoring is needed to better understand patterns of infection.

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Detection of Ranavirus in Ohio, USA

Of the many proximal factors that potentially contribute alone or in combination to the global concern about amphibian population declines (e.g., Stuart et al. 2004), habitat conversion (e.g., Homan et al. 2004) and infectious diseases (e.g., Daszak et al. 2003; Miller et al. 2011) are dominant concerns. To examine the differential patterns of habitat use for adult amphibians, the amphibian community of Taylor-Ochs Pond, Ohio, USA (40.0538°N, 82.3105°W) has been extensively studied since Spring 2005 (Homan et al. 2008, 2010). This 0.1-ha temporary pond supports breeding populations of *Ambystoma maculatum* (Spotted Salamanders), *Lithobates sylvaticus* (Wood Frogs), and *Anaxyrus americanus* (American Toads). As part of our long-term study, we have surveyed the pond by dip-netting weekly each summer since 2005. Prior to the summer of 2012, the only mass mortality of larval amphibians witnessed was clearly associated with early drying of the pond. However, in late May 2012,

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a time in which the pond had a suitably high water level, routine dip-netting of Taylor-Ochs Pond revealed evidence of mass mortality among larval amphibians. Larval individuals of four species, *A. maculatum*, *L. sylvaticus*, *A. americanus*, and, uncharacteristically, *Lithobates clamitans* (Green Frogs), were present in the pond at that time. Although we did not attempt to formally

REBECCA N. HOMAN*

JUSTINA R. BARTLING

ROBERT J. STENGER

Denison University, Department of Biology, Granville, Ohio 43023, USA

JESSE L. BRUNNER

Washington State University, School of Biological Sciences,

Pullman, Washington 99164, USA

*Corresponding author; e-mail: homanr@denison.edu



FIG. 1. Ponds sampled for larval amphibians in Granville, Ohio, USA. No larval amphibians were found in either Gurvis Pond or Wood Duck Pond; a recent metamorph was sampled from Wood Duck Pond. Griesse Pond is upstream of Taylor-Ochs Pond, while Gurvis, Olde Minnow, Spring Peeper, and Wood Duck Ponds are downstream.

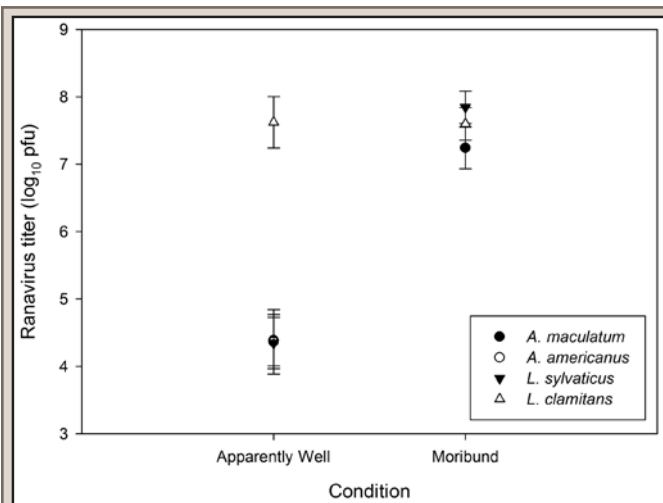


FIG. 2. Log₁₀ virus titer (mean ± SE) of apparently well and moribund larval samples collected from Taylor-Ochs Pond, Ohio, USA. For apparently well *Ambystoma maculatum* (N = 2), *Anaxyrus americanus* (N = 5), *Lithobates clamitans* (N = 2), *L. sylvaticus* (N = 2). For moribund *A. maculatum* (N = 3), *A. americanus* (N = 0), *L. clamitans* (N = 5), *L. sylvaticus* (N = 5).

quantify the magnitude of mortality in the pond, we estimate that hundreds of *A. maculatum*, *L. clamitans*, and *L. sylvaticus* showed signs of illness in the field; only *A. americanus* seemed unaffected.

We suspected ranavirus might have been associated with and contributed to the high mortality based on the signs of individuals, which included hemorrhaging, swelling, erythema, and lethargy (Miller et al. 2011). To determine whether ranavirus was present, on 24 May 2012 we haphazardly collected five each of *A. maculatum* and *A. americanus* larvae, and seven each of *L. clamitans* and *L. sylvaticus* larvae from Taylor-Ochs Pond using dip-nets. Each animal was classified as either moribund (presence of any gross signs consistent with ranavirus infection, as described above) or apparently well (no signs present) at the time of capture. Each animal was bagged individually at the pond, euthanized using MS-222 (2.5g/L buffered to a pH of 7), frozen individually at -80°C, and screened for ranavirus as described below.

Additionally, on 29 and 30 May 2012, we haphazardly collected 49 apparently healthy *A. americanus* larvae from Taylor-Ochs

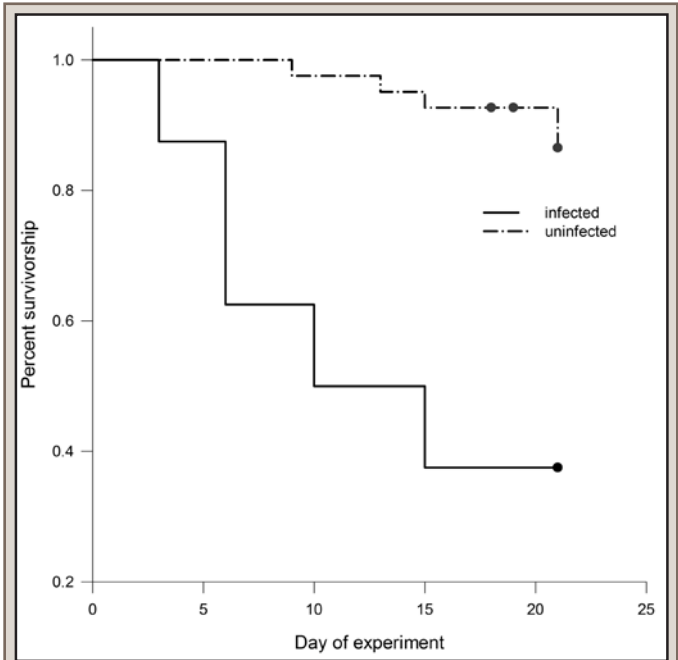


FIG. 3. Kaplan-Meier survival curves for infected (N = 8) and uninfected (N = 41) *Anaxyrus americanus* larvae from Taylor-Ochs Pond, Ohio, USA. Dots represent individuals that were removed during or at the end of the experiment, but were alive at the time of removal.

Pond with dip-nets and brought them back to the laboratory. Given their apparent health in the field, we were interested in carefully monitoring individuals over time to document whether they experienced mortality and whether or not that mortality was associated with ranavirus infection. Larvae were housed individually in 500-mL plastic cups with approximately 300 mL of water. Water, either aged tap water or a blend of aged tap and Taylor-Ochs Pond water, was changed every three days. We varied the water source because we originally intended to look for effects of continued exposure to pond water on the mortality and infection status of the larvae; however, the infection rates were the same among the treatments, so we pooled the data to look only at infection and survival. Larvae were fed Tetra fish food every three days *ad libitum*, and were kept in the laboratory at room temperature (21–24°C) in a natural light:dark cycle. Larvae were kept for a period of 21 days. If an animal metamorphosed before the end of that period, it was euthanized and frozen as described above. If a pre-metamorphic animal died before the end of the study, it was bagged individually and frozen at -80°C. All surviving animals at day 21 were euthanized and frozen as above. At the completion of the study, all animals were tested for ranavirus infection, as described below.

In late June, after the confirmation of ranavirus in Taylor-Ochs Pond (see below), we sampled one pond directly upstream of Taylor-Ochs Pond (Griesse Pond) and four ponds downstream of Taylor-Ochs Pond (Gurvis, Olde Minnow, Spring Peeper, and Wood Duck Ponds, Fig. 1). Griesse Pond is a permanent pond that directly feeds Taylor-Ochs Pond via a single stream channel. It has a surface area of ~1.5 ha, and is 200 m upstream of Taylor-Ochs Pond. Gurvis Pond is a permanent pond with an area of ~1.3 ha and is 487 m downstream of Taylor-Ochs Pond; Olde Minnow Pond is a permanent pond with an area of ~0.1 ha and is 684 m downstream of Taylor-Ochs Pond; Spring Peeper Pond is a temporary pond with an area of ~0.1 ha and is 783 m

TABLE 1. Summary of ranavirus infection in *Ambystoma maculatum*, *Lithobates catesbeianus*, *Hyla versicolor*, *L. clamitans*, and *Anaxyrus americanus* in ponds upstream (Griesse) and downstream (Olde Minnow, Spring Peeper and Wood Duck) of Taylor-Ochs Pond, in central Ohio, USA. The 95% confidence interval in the proportion infected is calculated using the method of Wilson (1927) with a correction for continuity (Newcombe 1988).

Site	Date	Coordinates	Species	Infected/Tested	95% CI
Griesse Pond	21 June 2012	40.0546°N, 82.3102°W	<i>A. maculatum</i>	0/4	0–0.604
Olde Minnow Pond	21 & 25 June 2012	40.0506°N, 82.3057°W	<i>L. catesbeianus</i>	3/3	0.310–1
Spring Peeper Pond	21 & 25 June 2012	40.0501°N, 82.3055°W	<i>A. maculatum</i>	1/1	0.055–1
			<i>H. versicolor</i>	0/4	0–0.604
			<i>L. clamitans</i>	1/2	0.027–0.973
Wood Duck Pond	21 June 2012	40.0500°N, 82.3057°W	<i>A. americanus</i>	0/1	0.055–1

downstream; Wood Duck Pond is a semi-permanent pond with an area of ~0.2 ha and is 806 m downstream of Taylor-Ochs pond (Fig. 1). Surface areas of ponds and distances between ponds were determined using ImageJ software and satellite photos (Schneider et al. 2012). To avoid potential cross-contamination among ponds, equipment was disinfected with a 10% bleach solution between ponds. In all cases, larvae in these ponds were sampled haphazardly (see Table 1 for sample sizes). We could not find any amphibian larvae in either Gurvis Pond or Wood Duck Pond, but one recent *A. americanus* metamorph was collected from the shore of Wood Duck Pond. All animals were euthanized and frozen as described above and tested for ranavirus. Individuals were kept isolated from one another throughout all procedures.

To screen for ranavirus, we extracted DNA from a combination of tissues from each animal (liver, interrenal glands, and the upper intestine, dissected with sterilized forceps and scissors) using the Qiagen DNeasy Blood and Tissue kit following the manufacturer's instructions (QIAGEN Inc, Valencia, California, USA). We ground up the entirety of very small individuals in 2-mL screw cap tubes filled with a small volume of 1.0-mm diameter silicon-carbide sharp particles (BioSpec Products, Bartlesville, Oklahoma, USA), and then topped up with tissue lysis buffer. These individuals were then homogenized for 45 s using a Mini-BeadBeater-16 (BioSpec Products, Bartlesville, Oklahoma) and DNA was extracted from a 200- μ L aliquot of the homogenate. The concentration of extracted DNA was measured using a NanoDrop-2000 (Thermo-Scientific) and, if necessary, diluted to approximately 20ng DNA/ μ L with elution buffer.

Extracted DNA from each sample was screened for ranavirus in triplicate 20- μ L reactions on 96-well plates on a StepOne-Plus (Applied Biosystems, Foster City, California, USA) with 5 μ L of DNA template (~100ng) using a Taqman realtime polymerase chain reaction (qPCR) with primers and probe that amplify a 70-bp region within the major capsid protein of all known ranaviruses (Brunner and Collins 2009). The unknown samples were quantified by comparing against DNA extracted from a frog virus 3-like ranavirus grown in *Epithelium papilloma cyprinia* cells and serially diluted from 10^2 to 10^7 plaque-forming units (pfu). Each plate also had two no-template controls. Samples with amplification in two or three wells within 35 cycles were scored as positive. Those without amplification in any of the wells were scored as negative. Ambiguous samples were re-run and if at least one well showed amplification the sample was scored as

positive. Viral quantities for positive samples are reported as the mean of the \log_{10} (pfu) across all wells of the sample.

In addition, virus isolation was attempted from two moribund, ranavirus-positive animals, one *L. sylvaticus* and one *L. clamitans*. For each animal, the sample was homogenized in 2% fetal bovine serum in minimum essential medium with Hanks salts (HMEM; HyClone, Ottawa, Ontario, Canada) with the Mini-Beadbeater-16 as described above. The homogenates were then filtered through a 0.45- μ m filter and 1 mL inoculated onto 90% confluence monolayers of fathead minnow (FHM) cells in 6-well plates for 1 h before being overlaid with 3 mL of 5% FBS-HMEM growth media. Samples were passed two to three times and observed for signs of cytopathic effects using an inverted light microscope. Isolation of ranavirus was verified using conventional PCR with primers 4 & 5 for the major capsid protein (MCP) gene (Mao et al. 1996). The ~500 pb product was sequenced with an ABI 3730 (Applied Biosystems, Foster City, California, USA) and compared with published ranavirus sequences on GenBank using a BLAST search.

We found that all 24 specimens initially collected from Taylor-Ochs Pond were infected with ranavirus (Fig. 2). We successfully isolated a *Ranavirus* from two moribund frogs. The sequence of the MCP gene of these viruses was >99% identical to the type ranavirus frog virus 3 (FV3). To examine the patterns of \log_{10} viral quantities among the four amphibian species in Taylor-Ochs Pond, we ran a two-factor ANOVA to look for effects of species, condition, and any interaction between the two (JMP 10.0, 2012). Excluding *A. americanus*, none of which were moribund, moribund tadpoles had a much higher titer than those that were apparently well ($F_{1,17} = 17.5$, $P < 0.001$). Although sample sizes were small, *L. clamitans* had a significantly higher mean virus titer than *A. maculatum*, *A. americanus*, and *L. sylvaticus* among apparently well individuals ($F_{3,7} = 13.5$, $P = 0.003$; Tukey HSD, $P < 0.05$), whereas there was no significant difference in virus titers among moribund individuals of different species ($F_{2,10} = 1.8$, $P = 0.22$, Fig. 2).

Among the 49 *A. americanus* larvae that were maintained in the laboratory, ranavirus DNA was detected in eight. We generated Kaplan-Meier Survival Curves and used log-rank tests (JMP 10.0, 2012) to look for differences in survivorship between infected and uninfected animals, as well as ANOVA to look for differences in the \log_{10} viral titers among those that died or survived. Infected individuals had significantly lower survivorship than uninfected individuals ($\chi^2_1 = 15.2$, $P < 0.0001$; Fig. 3). Three of the

eight infected larvae survived to the end of the 21-day experiment; two of these survivors metamorphosed during the study. Among the larvae that were infected, there was no difference in virus titer between those that died during the study (mean \pm SD = $3.67 \pm 3.45 \log_{10}$ pfu) and those that survived (mean \pm SD = $0.90 \pm 0.53 \log_{10}$ pfu; $t_6 = -1.76$, $P = 0.22$), nor was there a difference in virus titer between the surviving metamorphs (mean \pm SD = $1.0 \pm 0.66 \log_{10}$ pfu) and the others (mean \pm SD = $3.16 \pm 3.34 \log_{10}$ pfu; $t_6 = -0.85$, $P = 0.43$). However, our statistical power was low for both tests (Power = 0.21 and 0.11, respectively).

In our upstream and downstream sampling, we did not detect ranavirus in the four *A. maculatum* larvae found in Griesse Pond, upstream of Taylor-Ochs, but we did find ranavirus downstream, in *L. catesbeianus* from Olde Minnow Pond and in *A. maculatum* and *L. clamitans*, but not *Hyla versicolor*, from Spring Peeper Pond (Table 1). Given our small sample sizes it is not possible to exclude ranavirus occurrence from any site or make meaningful comparisons in prevalence among ponds or species.

In the summer of 2012, Taylor-Ochs Pond in Granville, Ohio experienced a mass die-off event concurrent with the confirmed presence of an FV3-like ranavirus. To our knowledge, this is the first published report of ranavirus in Ohio although ranaviruses have been confirmed in other nearby states, including Illinois and Wisconsin (J. Sekowska, pers. comm.), New York (Brunner et al. 2011), Pennsylvania (Glennay et al. 2010), and Tennessee (Gray et al. 2009; Green et al. 2002). While we cannot be sure that ranavirus caused the observed mortality event, the prevalence of infection among *A. maculatum*, *L. sylvaticus*, and *L. clamitans*, each of which experienced high levels of mortality, as well as the positive relationship between infection and mortality in the laboratory-housed *A. americanus*, suggest that ranavirus likely played a role. In addition to finding ranavirus in our focal pond, we also confirmed its presence in two downstream ponds. Across these three ponds, we identified ranavirus infection among *A. maculatum*, *L. catesbeianus*, *L. clamitans*, *L. sylvaticus*, and *A. americanus*, all of which have had documented ranavirus infections previously (as reviewed by Miller et al. 2011). Whether *H. versicolor* was infected and we simply did not have the sample size to detect it remains unknown, although ranavirus infection in this species has been documented elsewhere (Duffus et al. 2008).

Among the larvae initially sampled from Taylor-Ochs Pond, ranavirus titers were higher in moribund animals than in apparently healthy animals, which is consistent with the finding of Brunner et al. (2005) that higher viral doses are associated with more rapid expression of symptoms. Interestingly, apparently well *L. clamitans*, a species not found in Taylor-Ochs in the preceding seven years, had viral titers that were higher than those of the other species. We hypothesize that a large spring rain event that occurred in 2012 brought the *L. clamitans* larvae to Taylor-Ochs from the upstream Griesse Pond. Although we cannot confirm that *L. clamitans* larvae were the source of the Taylor-Ochs infection, their unusual presence in the community as well as their relatively high viral loads are consistent with this hypothesis. We plan to continue monitoring Taylor-Ochs Pond, as well as the upstream and downstream ponds to document further occurrence and potential impacts of continuing ranavirus presence. Understanding the role of potential co-infection of *Batrachochytrium dendrobatidis*, or another pathogen, in larval health is a secondary objective for future monitoring.

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GEOGRAPHIC DISTRIBUTION

CAUDATA — SALAMANDERS

AMBYSTOMA MACRODACTYLUM (Long-toed Salamander). USA: ALASKA: KETCHIKAN GATEWAY BOROUGH: Revillagigedo Island: Ward Lake Area (55.41°N, 131.70°W; WGS84). 19 July 2010. Joshua T. Ream, Verified by J. Andres Lopez. UAM Herpetology 367. Southernmost record of species in Alaska and first record of the species from Revillagigedo Island (Norman and Hassler 1995. Field investigations of the herpetological taxa in southeast Alaska. California Cooperative Fishery Unit, Humboldt State University. Report 29-95). Previous southernmost record in Alaska at Sokolof Island, approximately 130 km N (Norman and Hassler, *op. cit.*). Adult specimen (60 mm SVL; 4.65 g) found under rock on side of trail from Frog Pond to Ward Lake. Collection was made under Alaska Department of Fish and Game Fish Resource Permit # SF2010-0004.

JOSHUA TAYLOR REAM, 7620 Pleasure View Circle, Anchorage, Alaska 99515, USA; e-mail: jtream@alaska.edu.

HEMIDACTYLUM SCUTATUM (Four-toed Salamander). USA: MICHIGAN: HURON Co.: Albert E. Sleeper State Park (43.973611°N, 83.210611°W; WGS84). 6 May 2013. David A. Mifsud and Sean Zera. Verified by Gregory Schneider. UMMZ image database 973–975. First record for county (Holman 2012. The Amphibians and Reptiles of Michigan. Wayne State University Press, Detroit. xix+291 pp.). Extends the range into “thumb” region of state, approximately 90 km from nearest known record. Two individuals found under logs at water’s edge along a forested interdunal swale 0.9 km inland from Lake Huron. One individual also observed 4 May 2011 at same locality.

DAVID A. MIFSUD, P.O. Box 110, Chelsea, Michigan 48118, USA (e-mail: DMifsud@HerpRMan.com); **SEAN ZERA**, 5635 Thomas Road, Ann Arbor, Michigan, USA (e-mail: sean.zera@gmail.com).

NECTURUS MACULOSUS (Mudpuppy). USA: GEORGIA: FANNIN Co.: Fightingtown Creek, tributary of the Toccoa River. Accessed from Highway 2, approximately 6 miles NW of Blue Ridge, Georgia (34.893919°N, 84.4157°W; WGS 84). 26 May 2011. Verified J. T. Briggler. Georgia Museum of Natural History (GMNH 50332). New county record (Jensen et al. 2008. Amphibians and Reptiles of Georgia. Univ. of Georgia Press, Athens. 575 pp.). This record fills gap within the predicted range. Egg mass found under large rock in river below a small man-made dam.

SHEM D. UNGER, Savannah River Ecology Laboratory, University of Georgia, Drawer E, Aiken, South Carolina 29802, USA (e-mail: unger@srel.edu); **BART T. KRAUS**, Forestry & Natural Resources, Purdue University, 715 West State Street, West Lafayette, Indiana 47907, USA (e-mail: bkraus@purdue.edu); **THOMAS FLOYD**, Georgia Department of Natural Resources, 116 Rum Creek Drive, Forsyth, Georgia 31029, USA (e-mail: thomas.floyd@dnr.state.ga.us).

NOTOPHTHALMUS VIRIDESCENS PIAROPICOLA (Peninsula Newt). USA: FLORIDA: LEE Co.: Florida Gulf Coast University (FGCU) campus (26.461406°N, 81.777247°W; WGS 84). 18 May 2011. Verified by K. L. Krysko. Florida Museum of Natural History (FLMNH 170244 photo voucher). New county record (Krysko et al. 2011. Atlas of Amphibians and Reptiles in Florida. Final Report, Project Agreement 08013, Florida Fish and Wildlife Conservation Commission, Tallahassee. 524 pp.). Fills a gap among Charlotte, Collier, Glades, and Hendry counties. Several adult individuals have been captured with minnow and Breder traps in multiple wetlands on the FGCU campus, both before and after university construction began in 1995 (DAC and DWC, unpubl. data).

DEAN A. CROSHAW, Department of Biological Sciences, Florida Gulf Coast University, Fort Myers, Florida 33965, USA (e-mail: dcroshaw@fgcu.edu); **DAVID W. CEILLEY**, Department of Marine and Ecological Sciences, Florida Gulf Coast University, Fort Myers, Florida 33965, USA (e-mail: dceilley@fgcu.edu).

PLETHODON GLUTINOSUS (Northern Slimy Salamander). USA: TENNESSEE: MARSHALL Co.: Hickory Ridge Trail near River Road at Henry Horton State Park, Chapel Hill, Tennessee, (35.5935397°N, 86.7067119°W; WGS 84). 15 March 2013. Nicole Foster and Colleen Conway. Verified by A. Floyd Scott. Austin Peay State University (APSUMZ 19414). New county record (Scott and Redmond 2008 [latest update: 1 August 2013]). Atlas of Amphibians in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. Available at <http://apsu.edu/amatlas/> [accessed 1 August 2013]). Found under a moss-covered rock near a tree.

NICOLE FOSTER, Department of Science Math and Technology (e-mail: nfoster2@Columbiastate.edu); **COLLEEN CONWAY**, Columbia State Community College, Columbia, Tennessee 38401, USA (e-mail: cconway@Columbiastate.edu).

PSEUDOTRITON RUBER (Red Salamander). USA: TENNESSEE: DAVIDSON Co.: Beaman Park Nature Center, Nashville, Tennessee (36.2522°N, 86.8944°W; WGS 84). 23 March 2013. Cynthia Routledge. Verified by A. Floyd Scott. Austin Peay State University (APSU 19407, color photo). First vouchered record for Davidson Co. (Scott and Redmond 2008 [latest update: 30 May 2013]. Atlas of Reptiles in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. Available at <http://apsu.edu/reptatlas/>). Specimen found under rotting log in deciduous woods, approximately 1 m off the main paved hiking trail. A second specimen was observed under another rotting log in the immediate area. This species was mentioned by Ashton (1966. J. Tennessee Acad. Sci. 41:106–111) as occurring within Davidson Co. but remained unvouchered.

CYNTHIA ROUTLEDGE, 1515 N. Willow Bend Court, Clarksville, Tennessee 37043, USA; e-mail: routledges@bellsouth.net.

ANURA — FROGS

ALLOBATES CAERULEODACTYLUS. BRAZIL: AMAZONAS: MANICORÉ MUNICIPALITY: 05.47756°S, 61.57783°W (datum WGS 84, 56 m elev.). 18 January 2005. T. M. Sanaiotti. Amphibian and Reptile Collection, Instituto Nacional de Pesquisas da Amazônia - INPA, Manaus, Brazil, (INPA-H 31437, 31438, two males; Permit Number IBAMA 06/2005/NUFAS/RAN/AM). Verified by A. P. Lima. The specimens were found calling during a diurnal survey in the reserve RDS Rio Amapá, only in the leaf litter in mainland forest, with presence of Brazil nuts trees, about 100 m from a periodically flooded forest at left margin of Amapá River. This endemic species was previously known from three localities in Amazonas State, Brazil: the type locality (40 km S of Manaus, at Km12 on the road to Autazes), municipality of Castanho (03.46742°S, 59.81919°W, datum WGS 84, coordinates corrected from the original paper according to information by the author A. P. Lima); municipality of Borba about 102 km to the SE of type locality (04.43417°S, 59.62361°W, datum WGS 84), and Canutama municipality about 665 km SW of type locality (06.9468333°S, 64.2003611°W, datum WGS 84) (Lima and Caldwell 2001. *Herpetologica* 57[2]:180–189; Simões 2007. *Herpetol. Rev.* 38[4]:473; Cordeiro et al. 2009. *Herpetol. Rev.* 40[2]:233). The new record extends the distribution 230 km SW of Castanho and 340 km NE from Canutama and is the first record within a protected area.

TÂNIA M. SANAIOTTI, Instituto Nacional de Pesquisas da Amazônia - INPA, Coordenação de Biodiversidade, Av. André Araújo, nº. 2936, Manaus, Amazonas, Brazil, CEP 69060-001; e-mail: tania.sanaiotti@gmail.com.

ELEUTHERODACTYLUS PLANIROSTRIS (Greenhouse Frog). USA: FLORIDA: GULF Co.: 1913 Cypress Ave, Port St. Joe (29.799053°N, 85.293014°W; WGS 84). 13 December 2011. Matt Greene. Verified by Craig Guyer. Auburn University Museum (AHAP-D 687-688). New county record (Krysko et al. 2011. *Atlas of Amphibians and Reptiles in Florida. Final Report, Project Agreement 08013, Florida Fish and Wildlife Conservation Commission, Tallahassee. 524 pp.*), and has been documented in neighboring counties (Bay, Franklin) and five other Panhandle counties. Several adult individuals observed on nearby conservation lands 6 miles to the south (St. Joseph Bay State Buffer Preserve). Individuals also observed on 22 July 2012.

MATT GREENE, National Forests in Alabama, The Nature Conservancy, 2946 Chestnut Street, Montgomery, Alabama 36107, USA; e-mail mgreene@tnc.org.

EXERODONTA JUANITAE (Juanita's Earless Treefrog). MÉXICO: GUERRERO: ILIATENCO MUNICIPALITY: Cruztomahuac (17.043179°N, 98.62038°W; WGS84), 1450 m elev. 12 January 2005. E. Beltrán-Sánchez. MZFC 17903, 17906, 17909. METLATONOC MUNICIPALITY: Zitlaltepec, Sierra de Malinaltepec (17.1192°N, 98.4385°W; WGS 84), 1550 m elev. 21 December 2009. E. Pérez-Ramos. MZFC 27023, 27024. All verified by Luis Canseco Márquez. New municipality records fill a ca. 364 km distributional gap between San Vicente de Benitez and San Andrés de la Cruz in the Sierra Madre del Sur, Guerrero, and San Gabriel Mixtepec and Pluma Hidalgo in the Sierra Madre del Sur, Oaxaca (Duellman 2001. *Hylid Frogs of Middle America, Vol. 2 [Supplement]. SSAR Contrib. Herpetol.* 18: 916, 926–928, 1126). The Zitlaltepec locality is higher than the previously known localities for this species in Guerrero and Oaxaca (1080 and 1530 m, respectively) (Duellman 2001, *op. cit.*).

Frogs from both localities were found calling in remnant patches of cloud forest.

EDMUNDO PÉREZ-RAMOS (e-mail: munditastres@yahoo.com.mx) and **ITZUE WENDOLIN CAVIEDES-SOLIS** (e-mail: euzti@yahoo.com.mx), Facultad de Ciencias, Universidad Nacional Autónoma de México, A.P. 70-399, México, DF 04510; **ELIZABETH BELTRÁN-SÁNCHEZ**, Instituto de Investigación Científica, Área de Ciencias Naturales, Universidad Autónoma de Guerrero. Av Lázaro Cardenas S/N, Ciudad Universitaria, Interior del Jardín Botánico CP 39000, Chilpancingo, Guerrero, México (e-mail: ebeltran@guerrero.uagro.mx).

FEJERVARYA PIERREI (Pierre's Cricket Frog). INDIA: HARYANA: Kalesar National Park and Wildlife Sanctuary (01.482030°N, 09.16377°E; 597 m elev.; WGS 84). 22 May 2008. A. Bahuguna. Northern Regional Centre, Zoological Survey of India (ZSI NRC 779). Verified by Karan Bahadur Shah, Natural History Museum, Kathmandu, Nepal. Previously known from central and eastern midlands of Nepal; and in India, from Arunachal Pradesh, Assam, and Nagaland States (Ao et al. 2003. *Zoos' Print J.* 18[6]:1117–1125; Mathew and Sen 2010. *Pictorial Guide to the Amphibians of North East India. Zoological Survey of India, Kolkata. 144 pp.*). First record for Haryana State.

ARCHANA BAHUGUNA, Northern Regional Centre, Zoological Survey of India, 218 Kaulagarh Road, Dehradun 248 195, Uttarakhand, India; e-mail: archana.bahuguna65@gmail.com.

HYLA CINEREA (Green Treefrog). USA: INDIANA: SPENCER Co.: Unnamed bottomland slough on Ohio River floodplain, Ohio Township (37.814056°N, 87.110167°W; WGS 84) 11 June 2013. Michael J. Lodato and Noah M. Gordon. Verified by Chris Phillips. Illinois Natural History Survey (INHS 2013b, photo voucher). New county record (Minton 2001. *Amphibians and Reptiles of Indiana, 2nd ed., revised. Indiana Academy of Science. vii + 404 pp.*; Lodato et al. 2004. *Herpetol. Rev.* 35:281). Chorus of singing males audio-recorded and archived with photo voucher. This new locality lies about 23 km SE of the nearest known Indiana population in Warrick Co. and is immediately north of confirmed populations in adjacent Daviess Co., Kentucky (John MacGregor, pers. comm.). Two additional choruses of this treefrog heard on 11 June 2013 in wetlands to the south and southwest of the recorded population.

MICHAEL J. LODATO, 925 Park Plaza Drive, Evansville, Indiana 47715, USA (e-mail: mikelodato@wowway.com); **NOAH M. GORDON**, Department of Biology, University of Evansville, 1800 Lincoln Avenue, Evansville, Indiana 47722, USA (e-mail: ng62@evansville.edu).

HYLA SQUIRELLA (Squirrel Treefrog). USA: ARKANSAS: UNION Co.: 4.5 km NE of El Dorado (33.230°N, 92.620°W; WGS 84). 21 May 2013. Tobin Fulmer, Kim Fulmer, and Matthew Connior. Verified by Renn Tumilson. Henderson State University Museum of Zoology (HSU 1645, adult male). Extends the known range 79.5 km NW from nearest known location in Ouachita Parish, Louisiana (Dundee and Rossman 1989. *The Amphibians and Reptiles of Louisiana. Louisiana State University Press, Baton Rouge. 316 pp.*). New state record. This population was discovered after a small chorus of males was heard in a flooded grassy area following heavy thunderstorms. Several males and two females were observed. This is most likely a naturally occurring population, due to the number of individuals discovered and the contiguous potential habitat between this location and the nearest known population in Louisiana.

TOBIN FULMER, 1033 Magnolia Drive, El Dorado, Arkansas 71730, USA (e-mail: frogman1975@yahoo.com); **MATTHEW B. CONNIOR**, Health

and Natural Sciences, South Arkansas Community College, 300 S. West Ave., El Dorado, Arkansas 71730, USA (e-mail: mconnior@southark.edu).

HYLAVERSICOLOR (Gray Treefrog). USA: PENNSYLVANIA: CENTRE CO.: Forest edge 650 m S of PA State Route 45 (40.70995°N, 77.94130°W; WGS 84). 11 May 2012. B. Carlson. Verified by David Laurencio, AUM AHAP-D 678 (digital photograph file). New county record (Hulse et al., 2001. *Amphibians and Reptiles of Pennsylvania and the Northeast*. Cornell University Press, Ithaca, New York.; Meshaka and Collins 2010. *A Pocket Guide to Pennsylvania Frogs & Toads*. The Commonwealth of Pennsylvania). Audio recordings taken at the same site on 20 May 2013 confirm the identification as *H. versicolor*. Recording verified by S. Graham, AUM AHAP-C 0020 (digital sound file). This record extends the distribution of *H. versicolor* in central Pennsylvania north from the nearest records approximately 39 km SW in Blair County and 55 km S in Huntingdon County.

CHRISTOPHER J. THAWLEY (e-mail: cthawley@gmail.com) and **BRADLEY E. CARLSON** (e-mail: bec169@psu.edu), Department of Biology, Pennsylvania State University, 208 Mueller Laboratory, University Park, Pennsylvania 16802, USA.

HYLARANA TYTLERI (Yellow-striped Frog). BANGLADESH: DINAJPUR DISTRICT: Singra National Park (25.882139°N, 88.564028°E, WGS 84; 52 m elev.). 28 June 2013. Md. Abdur Razzaque Sarker and Md Momin Mehedi Selim. Verified by Saibal Sengupta. Museum of Herpetology Laboratory, Ichamati College, Dinajpur, Bangladesh (MHLB-HT02). Adult beside a *Saccharum* plantation field at 1700 h. First record for Dinajpur District, northern Bangladesh; described from Dhaka District (Theobald 1868. *J. Asiatic Soc. Bengal* 37:i-vi, 7-88, i-iii), and rediscovered at type locality (Mahony et al. 2009. *Hamadryad* 34:80-94); also recorded from Nilphamari District (Sarker and Howlader 2011. *Herpetol. Rev.* 43:299), Chittagong District (Asmat et al. 2003. *Univ. Rajshahi J. Zool.* 22:141-143), and Barisal District (Howlader 2010. *Russian J. Herpetol.* 17:255-256).

MD. MOMIN MEHEDI SELIM (e-mail: selim2801@yahoo.com), **SULTANA NACIRA DITI** (e-mail: sultana07211@yahoo.com), and **MD ABDUR RAZZAQUE SARKER**, Department of Zoology, University of Dhaka, and Herpetology Laboratory Bangladesh, Society for Research and Development, House No. E-23, Floor-5A, Road-02, Block-D, Bashundhara R/A, Dhaka 1229, Bangladesh (e-mail: razzaqsciencebd@gmail.com).

INCILIUS NEBULIFER (Gulf Coast Toad). USA: MISSISSIPPI: LAMAR CO.: residential neighborhood in West Hattiesburg, ca. 450 ft SSE of intersection of West 4th Street and Pecan Grove Drive (31.33535°N, 89.36198°W; WGS 84). 30 July 2013. Brandon C. Morris and Jennifer Y. Lamb. Verified by Carl P. Qualls. MMNS 19380. New county record (Mendelson III 2005. *In* M. Lannoo [ed.], *Amphibian Declines: The Conservation Status of United States Species*, pp. 424-427. Univ. California Press, Berkeley; Robert L. Jones, pers. comm.).

A second specimen (MMNS 19381) was collected on 12 August 2013. These are the second and third of this species found at this location. An earlier specimen was captured, photographed, and released on 8 July 2013. Closest known locality is 19 miles W of Wiggins, Mississippi, off Hwy 26 in Pearl River County (MMNS 8560). The differences in age suggest that breeding may be occurring in the area, but calling has not been heard.

These specimens were collected under Mississippi Department of Wildlife Fisheries and Parks Permit #0422131.

JENNIFER Y. LAMB, Department of Biological Sciences, The University of Southern Mississippi, Hattiesburg, Mississippi 39406, USA; e-mail: Jennifer.Lamb@eagles.usm.edu.

KALOULA PULCHRA (Asiatic Painted Frog). PHILIPPINES: Mindanao Island, Davao del Norte Province, Panabo City, Barangay San Francisco (07.306389°N, 125.676389°E; WGS 84). Emerson Y. Sy. 16 August 2013. Photographic voucher, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC [IMG] 1.44a-b). Verified by Indraneil Das. Observed in residential area. SVL 39.5 mm. First record from Mindanao Island. An introduced species in the Philippines, previously recorded on Luzon (Aurora, Bulacan, Cagayan, Ilocos Norte, Isabela, Laguna, and National Capital Region) and Palawan (Puerto Princesa) (Brown et al. 2013. *ZooKeys* 266:1-120; Brown et al. 2012. *Check List* 8:469-490; Diesmos et al. 2006. *J. Env. Sci. Manage.* 9:41-53; Fidenci 2009. *Herpetol. Rev.* 40:446; Siler et al. 2011. *Check List* 7:182-195). Pathway may be through accidental introduction with agricultural and horticultural products.

EMERSON Y. SY, Philippine Center for Terrestrial and Aquatic Research, 1198 Benavidez St., Unit 1202, Tondo, Manila, Philippines; e-mail: emersonsy@gmail.com.

LITHOBATES CAPITO (Gopher Frog). USA: FLORIDA: LIBERTY CO.: Apalachicola National Forest, Little Camel Pond (30.2920°N, 84.9942°W; WGS84). 30 April 2013. Kevin M. Enge. Verified by Kenneth L. Krysko. Florida Museum of Natural History, UF 169926. New county record (Krysko et al. 2011. *Atlas of Amphibians and Reptiles in Florida*. Final report, Florida Fish and Wildlife Conservation Commission, Tallahassee. 524 pp.). The only other record from between the Apalachicola and Ochlockonee rivers is ca. 57 km SE near Carrabelle, Franklin Co., in 1948 (UIMH 25907). The nearest records are ca. 26 km SW in Wewahitchka, Gulf Co., in 1946 (FMNH 48210-48229).

SUWANNEE CO.: 0.25 km SE jct 196th Terrace and 35th Drive, Wellborn (30.0924°N, 82.8153°W; WGS84). 30 May 2013. Kevin M. Enge. Verified by Kenneth L. Krysko. UF 170295 (color photo). First voucher record for the county (Krysko et al. 2011, *op. cit.*). Collected tadpole (108 mm TL) with hind legs while dipnetting a depression marsh in xeric hammock habitat.

KEVIN M. ENGE (e-mail: kevin.enge@myfwc.com) and **CAROLYN M. ENLOE**, Florida Fish and Wildlife Conservation Commission, 1105 S.W. Wiliston Road, Gainesville, Florida 32601, USA.

LITHOBATES MAGNAOCULARIS (Northwest Mexico Leopard Frog). MÉXICO: JALISCO: MUNICIPALITY OF CAÑADAS DE OBREGÓN: Temacapulín, 88 km NE from Guadalajara (21.187605°N, 102.70635°W; WGS84), 1628 m elev. 30 November 2010. Jesús M. Rodríguez-Canseco, Krystal L. González-Estupiñán, and Luand E. López-Rodríguez. Verified by Jacobo Reyes Velasco. UTADC 7614, 7615. First municipality record and a 175 km E range extension from its nearest known locality at Huajimic, Nayarit (Pfeiler and Markow 2008. *Mol. Phylogenet. Evol.* 49:343-348). The photographed frog and several others were found in a thermal water pool inside the town, and more were observed nearby in Arroyo Colorado and Río Verde, which is lined by gallery forest.

JESÚS MAURICIO RODRÍGUEZ-CANSECO (e-mail: jmrc2603@hotmail.com), **KRYSTAL LUCÍA GONZÁLEZ-ESTUPIÑÁN** (e-mail: krystal_mclean@hotmail.com), and **LUAND ELIUD LÓPEZ-RODRÍGUEZ** (e-mail: luandaja@hotmail.com), Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara, Zapopan, Jalisco, 45110, México.

LITHOBATES SPECTABILIS (Showy Leopard Frog). MÉXICO: JALISCO: MUNICIPALITY OF TECOLOTLÁN: Sierra de Quila, near Tecolotlán, 100 km SW of Guadalajara (20.24833°N, 104.0566°W; WGS 84), 1326 m elev. 19 February 2011. Jesus Rodriguez-Canseco and Alberto Ayon Escobedo. Verified by Jacobo Reyes-Velasco. UTADC 7616. First municipality record and only second for Jalisco, representing a 100 km E range extension from the only other Jalisco record from Tuxcueca; the next closest locality is from 312 km SE at Morelia, Michoacán (Santos-Barrera and Flores-Villela 2004. *In* IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1; Hillis and Frost 1985. *Occas. Pap. Mus. Nat. Hist. Univ. Kansas* 117:1–14). The frog was active at night in a permanent stream surrounded by tropical deciduous forest, along with individuals of *L. neovolcanica*, *L. psilonota*, and *L. forreri*.

JESÚS MAURICIO RODRÍGUEZ-CANSECO (e-mail: jmrc2603@hotmail.com), **ALBERTO AYÓN-ESCOBEDO** (e-mail: albertoayon_cucba@hotmail.com), and **KRYSTAL LUCÍA GONZÁLEZ-ESTUPIÑÁN** (e-mail: krystal_mclean@hotmail.com), Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara, Zapopan, Jalisco, 45110, México.

LITHOBATES SPECTABILIS (Showy Leopard Frog). MÉXICO: JALISCO: MUNICIPALITY OF TUXCUECA: near Tuxcueca, 61 km SE of Guadalajara (20.139777°N, 103.151444°W; WGS84), 1635 m elev. 12 August 2011. Jesús Rodríguez-Canseco and Rodrigo Quiroz. Verified by Jacobo Reyes-Velasco. UTADC 7617. First record for Jalisco, extending its range 213 km NW from its nearest locality in Morelia, Michoacán (Santos-Barrera and Flores-Villela 2004. *In* IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1; Hillis and Frost 1985. *Occas. Pap. Mus. Nat. Hist. Univ. Kansas* 117:1–14). The frog was found active during daytime in a streambed with a few small pools surrounded by tropical deciduous forest.

JESÚS MAURICIO RODRÍGUEZ-CANSECO (e-mail: jmrc2603@hotmail.com) and **RODRIGO QUIROZ** (e-mail: rodrigo_ocelotl@hotmail.com), Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara, Zapopan, Jalisco, 45110, México.

LITHOBATES SPHENOCEPHALUS (Southern Leopard Frog). USA: TEXAS: KLEBERG CO.: North Padre Island, within the Padre Island National Seashore, 0.48 km W of the intersection of Bird Island Basin Road and Park Road 22 (27.465447°N, 97.295205°W; NAD 83, elev. 1.2 m). 25 May 2005. David Hall. Verified by Travis LaDuc. Texas Natural History Collection (TNHC 65562). New county record (Dixon 2013. *Amphibians and Reptiles of Texas*, 3rd ed. Texas A&M University Press, College Station. 447 pp.). *L. sphenocephala* occurs sympatrically with *L. berlandieri* at this locality, and some specimens are intermediate in appearance between the two species (TCWC 93885–93887). The two species were audio-recorded calling simultaneously from a pond near this locality.

C. MIKE DURAN, The Nature Conservancy, 200 E. Grayson, Suite 202, San Antonio, Texas 78215, USA (e-mail: mduran@tnc.org); **DAVID W. HALL**, Department of Genetics, the University of Georgia, Fred C. Davison Life Sciences Complex, Athens, Georgia 30602, USA (e-mail: davehall@uga.edu).

PSEUDACRIS CRUCIFER (Spring Peeper). USA: MISSOURI: STE. GENEVIEVE CO.: Weingarten. 0.5 km SE of Miller Switch and 1 km N of Jonca Creek at Horton Farm Conservation Area (37.8551°N, 90.2650°W; WGS84). 15 June 2013. Andrew P. Braun. Verified by Dustin S. Siegel. University of Missouri-Columbia (UMC 2381P). Juvenile specimen. Replaces missing county record (Edmond

and Daniel 2013 [latest update: 5 April 2013], Missouri Herpetological Atlas Project. Available at <http://atlas.moherp.org/>; accessed 27 June 2013). Found on bank of fishless artificial pond.

ANDREW P. BRAUN, Department of Biology, Southeast Missouri State University, Cape Girardeau, Missouri 63701, USA; e-mail: apbraun1s@gmail.com.

RHINOPHRYNUS DORSALIS (Sapo Borracho). HONDURAS: OLANCHO: Juticalpa, Barrio el Portillo (14.673056°N, 86.221389°W, WGS84), 504 m elev. 10 September 2010. Victor Eduardo Henríquez Aguilar. Verified by Larry David Wilson. USNM 579869. This locality fills a wide gap in the known distribution of the species, extending the range ca. 240 km SE from the nearest Honduras locality, 2 km W of Tegucigalpa, Cortés (McCranie 2006. *Smithson. Herpetol. Infor. Serv.* 137:224–232), and ca. 245 km W from the nearest Nicaraguan locality at Waspam (Köhler 2001. *Anfibios y Reptiles de Nicaragua*. Herpeton, Verlag Elke Köhler, Offenbach, Germany. 208 pp.). The specimen was caught at the edge of town while active behind a house after a heavy rain, at the base of small mountain supporting secondary xeric forest.

VICTOR E. HENRRIQUEZ AGUILAR, Escuela de Biología, Universidad Nacional Autónoma de Honduras, Departamento de Francisco Morazán, Honduras (e-mail: vick_futbol@yahoo.com); **JOSIAH H. TOWNSEND**, Department of Biology, Indiana University of Pennsylvania, Indiana, Pennsylvania 15705-1081, USA (e-mail: josiah.townsend@iup.edu).

SCAPHIOPUS HOLBROOKII (Eastern Spadefoot). USA: TENNESSEE: HICKMAN CO.: 6132 Parker Road, Lyles (35.838446°N, 87.341899°W; WGS 84). 4 May 2013. Nicole Foster and Mary Christensen. Verified by A. Floyd Scott. Austin Peay State University (APSUMZ 19416). Found in the road. New county record (Scott and Redmond 2008 [latest update: 1 August 2013]. *Atlas of Amphibians in Tennessee*. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. Available at <http://apsu.edu/amatlas/> [accessed 1 August 2013]).

NICOLE FOSTER, Department of Science, Math and Technology, Columbia State Community College, Columbia, Tennessee 38401, USA (e-mail: nfooster2@Columbiastate.edu); **MARY CHRISTENSEN**, Columbia State Community College, Columbia, Tennessee 38401, USA.

TESTUDINES — TURTLES

CHRYSEMYS PICTA (Painted Turtle). USA: GEORGIA: CHEROKEE CO.: Waleska, Reinhardt University campus, 0.25 km SE of intersection of State Route 108 and Grady Street (34.31884°N, 84.54663°W; WGS 84). 21 April 2013. Z. Felix. UF 170290. Digital photograph. Verified by Kenneth Krysko. New county record (Jensen et al. [eds.], 2008. *Amphibians and Reptiles of Georgia*, University of Georgia Press, Athens. 575 pp.). One adult female captured in hoop trap in shrubby marsh.

SUSAN SCRIVNER, TERRAN LEWIS, and ZACH I. FELIX, Biology Department, Reinhardt University, Waleska, Georgia, USA (e-mail: zif@reinhardt.edu).

CHRYSEMYS PICTA (Painted Turtle). USA: TENNESSEE: BLEDSOE CO.: on SR 30, 350 m NW of junction with SR 101 (35.67114°N, 85.24368°W; WGS 84). 18 July 2013. C. Thawley. Verified by David Laurencio. AUM AHAP-D 708 (digital photograph). New county record (Scott and Redmond 2008. *Atlas of Reptiles in Tennessee*. Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. <http://www.apsu.edu/reptatlas> [updated 1 August 2013; accessed 2 August 2013]). Adult male found alive on road.

C. picta is presumably distributed statewide in Tennessee, but records in the central portion of the state are lacking. This record fills a distributional gap between the nearest records approximately 35 km ESE in Rhea Co. and 9 km W in Van Buren Co. This specimen showed characteristics of both *C. picta picta* (a carapace with aligned, as opposed to alternate scutes) and *C. picta marginata* (a plastron with characteristic splotching); as such, it was entered into AUM as a *C. picta picta* × *marginata* intergrade.

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CHRISTOPHER J. THAWLEY, Department of Biology, Pennsylvania State University, 208 Mueller Laboratory, University Park, Pennsylvania 16802, USA; e-mail: cthawley@gmail.com.

DERMOCHELYS CORIACEA (Leatherback Sea Turtle). BRAZIL: AMAPÁ: MUNICIPALITY OF CALÇOENE: Praia do Goiabal (2.633333°N, 50.816667°W; datum WGS84). 17 April 2012. Verified by C. Bellini. Photographic voucher deposited in the Coleção Científica Fauna do Amapá of Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá, Brazil (IEPA 000254). The species is known from Atlantic, Pacific, and Indian oceans, and from the Mediterranean Sea. In the American coasts of the Atlantic ocean, it is known from Canada to Argentina, and the main spawning areas are located in Suriname and French Guiana (Girondo et al. 2007. *Chelon. Conserv. Biol.* 6[1]:37–46; Fossette et al. 2008. *J. Exp. Mar. Biol. Ecol.* 356:69–82). In Brazil, the range of the species includes the states of Rio de Janeiro, Santa Catarina, and Rio Grande do Sul, and the only recurrent breeding sites are located along the northern coast of the state of Espírito Santo although spawning has been occasionally recorded in other states (Loebmann et al. 2008. *Herpetol. Rev.* 39[1]:81–81). New state record, filling a gap of 365 km from French Guiana and 1225 km from Piauí state. The occurrence of *Dermochelys coriacea* in Amapá may be an indication of the resumption of an old migration route or use of new territory due to ideal conditions of food supply or possible new breeding areas.

CARLOS EDUARDO COSTA-CAMPOS, Universidade Federal do Amapá, Departamento de Ciências Biológicas e da Saúde, Laboratório de Herpetologia, CEP 68903-499, Macapá, AP, Brazil (e-mail: eduardocampos@unifap.br); **JANAINA REIS FERREIRA LIMA**, Divisão de Zoologia - Centro de Pesquisas Zoológicas e Geológicas - CPZG do Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá - IEPA, Campus da Fazendinha, Brazil (e-mail: janareis@yahoo.com); **JUCIVALDO DIAS LIMA**, Divisão de Zoologia, Centro de Pesquisas Zoológicas e Geológicas - CPZG do Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá - IEPA, Campus da Fazendinha, Brazil (e-mail: jucivaldo@yahoo.com); **ROBERTA SÁ LEITÃO BARBOZA**, Universidade Federal do Amapá, Departamento de Meio Ambiente e Desenvolvimento, CEP 68903-499, Macapá, AP, Brazil (e-mail: betabarboza@gmail.com).

EMYDOIDEA BLANDINGII (Blanding's Turtle). USA: MICHIGAN: BENZIE CO.: west edge of shrub swamp, Upper Herring Lake Nature Preserve, east of M-22, 5.6 km SE of Elberta, Blaine Twp (T25N R16W) Section 13 SW1/4 (44.565647°N, 86.193547°W; WGS84; elev. 182 m). 21 April 2012. Thomas F. Beauvais. Verified by Chris Phillips. Illinois Natural History (2012g Survey digital color photo voucher). New county record (Casper and Anton 2008. An Amphibian and Reptile Inventory of Sleeping Bear Dunes National Lakeshore. Natural Resource Technical Report NPS/GLKN/NRTR--2008/147. 47 pp.; Holman 2012. The Amphibians and Reptiles of Michigan. Wayne State Univ. Press, Detroit, Michigan. 291 pp.).

THOMAS F. BEAUVAIS, P.O. Box 130137, Ann Arbor, Michigan 48113, USA; e-mail: t7f3b8@fastmail.fm.

GOPHERUS MORAFKAI (Sonoran Desert Tortoise). USA: ARIZONA: SANTA CRUZ CO.: Coronado National Forest, Atascosa and Pajarito Mountains. Forest Road 39 (31.401933°N, 111.144819°W; WGS 84; elev. 1401 m), 22 September 2006. R. D. Babb. UAZ 57470-PSV, photo voucher. Verified by George Bradley. New county record (Brennan and Holycross 2009. Amphibians and Reptiles in Arizona. Arizona Game and Fish Department, Phoenix, Arizona, 150 pp.), an adult female ca. 228 mm straightline carapace. Three other specimens were found (UAZ 57471-PSV) on 11 August 2007, (UAZ 57166-PSV) on 26 July 2008, and (UAZ 57566-PSV) on 24 July 2013.

Current eastern distributional limits of *Gopherus morafkai* in Arizona are delineated as extending southward through central Gila Co., eastern Graham Co., to northeastern Cochise Co. and falling westward through southern Pima County into the Altar Valley to the international boundary on the Buenos Aires National Wildlife Refuge (Brennan and Holycross 2009, *op. cit.*). Closest known record is UAZ 56244 southwest of the town of Arivaca, Pima Co. These records represent an extension of the known range of *G. morafkai* ca. 23 km to the east and a ca. 40 km extension to the south, and places them in another major drainage, Sycamore Creek, which drains into the Río de la Concepcion in Sonora, Mexico.

All tortoises were associated with the more xeric, rocky south and southwest facing slopes of the Atascosa and Pajarito Mountains. Although the habitat could be considered an ecotone between Sonoran desert scrub, Chihuahuan desert scrub, and Madrean evergreen woodland in places (Brown 1994. Biotic Communities: Southwestern United States and Northwestern Mexico. University of Utah Press, Salt Lake City. 342 pp.) it is predominately Madrean evergreen woodland, atypical habitat for this species in Arizona.

RANDALL D. BABB, Arizona Game and Fish Department, Region VI Office, 7200 E. University Dr., Mesa, Arizona 85207, USA (e-mail: rbabb@azgfd.gov); **THOMAS C. BRENNAN**, 8445 E. Natal Circle, Mesa, Arizona 85209, USA (e-mail: t_c_brennan@yahoo.com); **DAVID D. KANDIYELI**, 10747 E. Enid Ave., Mesa, Arizona 85208, USA (e-mail: david.kandiyeli@gmail.com); **CHRISTINA M. AKINS** (e-mail: cakins@azgfd.gov) and **THOMAS R. JONES**, Arizona Game and Fish Department, Nongame Branch, 500 W. Carefree Highway, Phoenix, Arizona 85086, USA (e-mail: tjones@azgfd.gov).

GRAPTEMYS PSEUDOGEOGRAPHICA (False Map Turtle). USA: MISSOURI: PERRY CO.: Brazeau Township, near bank of Mississippi River on northwest corner of Cottonwood Island, 0.8 km W of Grand Tower Island and 2.5 km S of Tower Rock (37.6094°N, 89.5128°W; WGS84). 2 July 2013. Andrew P. Braun and John West. Verified by Richard E. Daniel. University of Missouri-Columbia (UMC 2391P). New county record (Edmond and Daniel 2013 [latest update: 5 April 2013]). Missouri Herpetological Atlas Project. Available at <http://atlas.moherp.org/>; accessed 9 July 2013). Female specimen, captured in fyke net.

ANDREW P. BRAUN, Department of Biology, Southeast Missouri State University, Cape Girardeau, Missouri 63701, USA; e-mail: apbraun1s@gmail.com.

GRAPTEMYS PSEUDOGEOGRAPHICA PSEUDOGEOGRAPHICA (False Map Turtle). USA: TENNESSEE: LAUDERDALE CO.: Chickasaw National Wildlife Refuge, 30 m S boat ramp on Barr Road

(35.878611°N, 89.70583°W; WGS 84). Michael C. Fulbright and James P. Flaherty. Verified by A. Floyd Scott. Austin Peay State University Museum of Zoology (APSU 19408). New county record (Scott and Redmond 2008 [latest update: 01 August 2013]). Atlas of Reptiles in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. Available at <http://apsu.edu/reptatlas/> [accessed 15 July 2013]). Captured by hand while basking on log, both eyes were injured.

MICHAEL C. FULBRIGHT (e-mail: mfulbright@my.apsu.edu), **JAMES P. FLAHERTY** and **C. M. GIENGER**, Center of Excellence for Field Biology/ Department of Biology, Austin Peay State University, Clarksville, Tennessee 37040, USA.

KINOSTERNON SUBRUBRUM (Eastern Mud Turtle). USA: GEORGIA: CHEROKEE Co.: Ball Ground, Flatbottom Trail 0.11 km S of intersection with State Route 372 (34.327324°N, 84.366347°W; WGS 84). 7 July 2013. Z. Felix. UGA 50356; digital photograph. Verified by Nikole Castleberry. New county record (Jensen et al. [eds.] 2008. Amphibians and Reptiles of Georgia, University of Georgia Press, Athens. 575 pp.). One adult found dead on road.

ZACH I. FELIX, Biology Department, Reinhardt University, Waleska, Georgia, USA; e-mail: zif@reinhardt.edu.

MACROCHELYS TEMMINCKII (Alligator Snapping Turtle). USA: ALABAMA: HALE Co.: Individual found in a shallow stream 40 m N of Hale County Road 28 and 8.2 km W of Greensboro (32.707624°N, 87.683859°W; WGS84). 26 March 2013. Will Selman and Al Cherry. Verified by Jim Godwin. Florida Museum of Natural History Herpetology Department (UF 170047 photo voucher). New county record (Mount 1975. The Reptiles and Amphibians of Alabama. University of Alabama Press, Tuscaloosa. 270 pp.; Alabama Natural Heritage Program Database, <http://www.alnhp.org/>). This record fills a large distributional gap between southern Clark and southern Tuscaloosa counties (approximately 215 river miles along the Black Warrior River).

WILL SELMAN, Rockefeller Wildlife Refuge, Louisiana Department of Wildlife and Fisheries, 5476 Grand Chenier Hwy, Grand Chenier, Louisiana 70643, USA (e-mail: wselman@wlf.la.gov); **AL CHERRY**, Greensboro, Alabama 36744, USA.

STERNOTHERUS ODORATUS (Eastern Musk Turtle). USA: TENNESSEE: DYER Co.: Tigrett Wildlife Management Area (35.994874°N, 89.263393°W; WGS 84). 3 November 2012. James P. Flaherty. Verified by A. Floyd Scott. Austin Peay State University Museum of Zoology (APSU 19418). New county record (Scott and Redmond. 2008 [latest update: 30 May 2013]). Atlas of Reptiles in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. Available at <http://apsu.edu/reptatlas/> [accessed 9 July 2013]). Nearest record ca. 21 km SE in Crockett Co. Desiccated shell found in mostly dry cypress slough.

JAMES P. FLAHERTY (e-mail: jflaherty1@my.apsu.edu), **MICHAEL C. FULBRIGHT**, and **C. M. GIENGER**, Center of Excellence for Field Biology/ Department of Biology, Austin Peay State University, Clarksville, Tennessee 37040, USA.

TERRAPENE CAROLINA (Eastern Box Turtle). USA: ALABAMA: RANDOLPH Co.: Found dead on road, along Hwy 22 near the town of Dickert (33.13285°N, 85.47071°W; WGS84/NAD83). 25 July 2013. R. Birkhead, M. Birkhead, and S. Birkhead. AHAP-D-716 (Digital photo). HALE Co.: Found dead on road, on Hwy 69 south of Havana (32.82587°N, 87.6028°W; WGS84/NAD83). 8 August 2013. R. Birkhead. AHAP-D-719 (Digital photos). All specimens

verified by David Laurencio. New county records (Mount 1996. The Reptiles and Amphibians of Alabama. University of Alabama Press, Tuscaloosa. xi+347 pp.). *T. carolina* is assumed to occur statewide; however, verified records are lacking for many Alabama counties.

ROGER D. BIRKHEAD, Alabama Science In Motion, Auburn University, Alabama 36849-5414, USA; e-mail: birkhrd@auburn.edu

SQUAMATA — LIZARDS

ABRONIA LYTHROCHILA (Red-lipped Arboreal Alligator Lizard): GUATEMALA: HUEHUETENANGO: humid Caribbean slope of Sierra de Cuchumatanes, 2862 m elev. 2 October 2010. Monica Torres. Verified by Ted Papenfuss. USAC 3335. First record for Guatemala, extending the range 31 km from the nearest known locality in the Municipality of Comitán de Domínguez, Chiapas, México (MVZ 57170; Global Biodiversity Information Facility, Univ. California, Berkeley. Electronic data accessed 21 August 2011 at <http://data.gbif.org/occurrences/201617419/>). USAC 3335 and three other adult individuals placed into the breeding collection of Guatemalan NGO Zootropic were found in a remnant pine-oak cloud forest inside a felled pine tree covered with epiphytes. The area also contains the recently rediscovered *A. frosti* (Ariano et al. 2011. Herpetol. Rev. 42:196–198), which represents the first case of sympatry between subgenera *Lissabronia* (*A. frosti*) and *Auriculabronia* (*A. lithrochila*). As in other cases of sympatry between related species, there seems to be niche partitioning within the shared habitat; *A. lithrochila* appears to be restricted to conifer patches within the pine-oak forest, while *A. frosti* seems to be limited to oak patches.

MONICA TORRES (e-mail: monica@zootropic.com) and **ANTONIO URBINA** (e-mail: aurbina@zootropic.com), Zootropic, 12 calle 1-25 zona 10, edificio Geminis 10, torre sur, nivel 18, oficina 1801A, Guatemala City, Guatemala; **CARLOS VÁSQUEZ-ALMAZÁN**, Museo de Historia Natural, Universidad de San Carlos de Guatemala (e-mail: crvasal@yahoo.com.mx); **TODD PIERSON**, Odum School of Ecology, University of Georgia, Athens, Georgia, USA; **DANIEL ARIANO-SÁNCHEZ**, Escuela de Biología, Universidad del Valle de Guatemala, Ciudad Universitaria zona 12, Guatemala, Guatemala (e-mail: dariano@zootropic.com).

ANOLIS ALLISONI (Allison's Anole). HONDURAS: ISLAS DE LA BAHÍA: Utila, Mango Inn (16.083602°N, 86.883486°W; WGS84), 12 m elev. 25 February 2012. Andrea M. Martinez and Steven M. Clayson. Verified by James R. McCranie. MPM P766. First record for Isla de Utila (McCranie et al. 2005. Amphibians & Reptiles of the Bay Islands and Cayos Cochinos, Honduras. Bibliomania, Salt Lake City, Utah. xii + 210 pp.) and likely represents a contemporary introduction from Islas de Roatán, which lies ca. 33.3 km NE of Isla de Utila. The anole was active above a roof gutter at Mango Inn.

ANDREA M. MARTINEZ, Kanahau Utila Research and Conservation Facility, Pumpkin Hill, Utila, Bay Islands, Honduras (e-mail: andrea@kanahau.com); **STEVEN M. CLAYSON**, Kanahau Utila Research and Conservation Facility, Pumpkin Hill, Utila, Bay Islands, Honduras (e-mail: steve@kanahau.com)

ANOLIS SAGREI (Brown Anole). USA: FLORIDA: GULF Co.: St. Joseph Bay State Buffer Preserve office (29.717942°N, 85.304058°W; WGS 84). 1 April 2012. Matt Greene. Verified by Craig Guyer. Auburn University Museum (AHAP-D 689–690). New county record (Krysko et al. 2011. Atlas of Amphibians and Reptiles in Florida. Final report, Project Agreement 08013, Florida Fish and Wildlife

Conservation Commission, Tallahassee, Florida. 524 pp.). Has been documented in neighboring Bay and Franklin counties and four other Panhandle counties. Several adult and juvenile individuals observed on Preserve's office deck. Dozens of individuals were also observed at the author's residence and in downtown, both in Port St. Joe (6 and 8 miles N of Buffer Preserve, respectively), indicating an established population with widespread distribution in southern Gulf Co. Brown Anoles appeared more numerous in residential areas than in the Buffer Preserve and surrounding natural areas.

MATT GREENE, National Forests in Alabama, The Nature Conservancy, 2946 Chestnut Street, Montgomery, Alabama 36107, USA; e-mail: mgreene@tnc.org.

CALOTES VERSICOLOR (Common Garden Lizard). PHILIPPINES: NATIONAL CAPITAL REGION: Luzon Island, Parañaque City, Barangay Don Bosco (14.485833°N, 121.016389°E; WGS 84). Emerson Y. Sy. 3 August 2013. Photographic voucher, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC [IMG] 2.181a–d). Verified by I. Das. Five juveniles and two adults observed perched on ornamental shrubs and bamboo fences within 500 m² in residential area between 1230–1400 h. SVL 49–101 mm. First country record; possible introduction pathway as cargo stowaways due to close proximity to international airport. Native of Iran, Afghanistan, Pakistan, Nepal, Bhutan, Bangladesh, India, Sri Lanka, southern China including Hainan, Cambodia, Peninsular Malaysia, Myanmar, Thailand, and Vietnam (Auffenberg and Rehman 1993. *Asiatic Herpetol.* Res. 5:14–30; Hallermann 2000. *Bonner zool. Beitr.* 49:155–163; Radder 2006. *Curr. Sci.* 91:1354–1363). Introduced on Borneo (Brunei Darussalam), Sumatra (Indonesia), Maldives, Mauritius, Réunion, Seychelles, Singapore, and Florida (USA) (Chou 1994. *Herpetol. Rev.* 25:75–76; Das et al. 2008. *Curr. Herpetol.* 27:109–112; Enge and Krysko 2004. *Biol. Sci.* 67:226–230; Hasen Didi 1993. *Hamadryad* 18:42; Henkel and Schmidt 2000. *Amphibians and Reptiles of Madagascar and the Mascarene, Seychelles, and Comoro Islands*. Krieger Publ. Co., Malabar, Florida. 316 pp.).

EMERSON Y. SY, Philippine Center for Terrestrial and Aquatic Research, 1198 Benavidez Street, Unit 1202, Tondo, Manila, Philippines; e-mail: emersonsy@gmail.com.

COLOPTYCHON RHOMBIFER (Isthmian Alligator Lizard). COSTA RICA: PUNTARENAS: Cantón Aguirre, San Andres de Matapalo (09.350025°N, 83.950002°N; WGS84), 515 m elev. 7 October 2012. Juan Andres Lopez. Verified by Jonathan A. Campbell and William W. Lamar. UTADC 7635–7636. Northwestern most record for this species, extending the range by ca. 70 km NW from the closest known locality plotted on the map in Savage (2002. *The Amphibians and Reptiles of Costa Rica: A Herpetofauna between Two Continents, between Two Seas*. Univ. Chicago Press, Chicago, Illinois. xx + 934 pp.). The lizard was found on the ground at the edge of a clearing in tropical humid forest.

QUETZAL DWYER (e-mail: reptilandia.cr@gmail.com) and **ROEL DE PLECKER** (e-mail: rulito76@yahoo.com), Parque Reptilandia, Platanillo de Perez Zeledon, San José, Costa Rica.

DAREVSKIA ALPINA (Alpine Lizard). RUSSIA: KABARDINO-BALKARIA: Zolsky District, upper reaches of the Malka River, terrain Dzhily-Su (= Castle Valley) (43.4329771°N, 42.5333118°E), 2400 m elev. 22 July 2013. It is a new extreme northwestern point of species distribution range (Darewskij 1984. *Lacerta caucasica* Méhely, 1909 – Kaukasische Felseidechse // Böhme W. [Hrsg.].

Handbuch der Reptilien und Amphibien Europas. Band 2/I. Echsen II [Lacerta]. Wiesbaden: AULA-Verlag. S. 225–238). The new record extends the range of this species by 20 km to the northwest. This is the first record of *D. alpina* on the northern slopes of Mount Elbrus, the highest mountain in the Caucasus, where it was previously recorded on the southern and western slopes. This suggests that this species is more widespread on Mount Elbrus than previously thought. At the Sultan Waterfall, we observed 10 adult specimens and one juvenile per 300 m of the route (a width of about 2 m). We also observed an adult male and a juvenile specimen at a site more distant from the waterfall at a distance of 60 m, where the humidity was lower; the fewer individuals farther from the waterfall may be due to fewer insect prey on the sparse vegetation distant from the water. These new records are within 15 km of populations of *D. saxicola* and we assume that these species are sympatric in the upper part of the valley of the River Malka.

IGOR V. DORONIN, Department of Herpetology, Zoological Institute of Russian Academy of Sciences, St. Petersburg 199034, Russia (e-mail: ivdoronin@mail.ru); **KONSTANTIN J. LOTIEV**, Sochi National Park, Sochi 354000, Russia (e-mail: k_lotiev@mail.ru).

ECHINANTHERA AMOENA (Corredeira-do-mato). BRAZIL: MINAS GERAIS: ALTO CAPARAÓ MUNICIPALITY: Parque Nacional do Caparaó: Vale Verde (20.419164°S, 41.846123°W, datum WGS 84; elev. ca. 1330 elev.). 8 November 2008. M. T. Rodrigues. Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZUSP 17986, adult male; M. T. Rodrigues field number MTR 15853). Verified by F. F. Curcio. Found at 1400 h in an area of dense and preserved forest. *E. amoena* is extremely rare in collections, and known only from a few records. It is known from the Atlantic Rainforest areas in Paraná, São Paulo, Rio de Janeiro, and Minas Gerais states (Di-Bernardo 1992. *Comun. Mus. Cienc. PUCRS, sér. Zool. Porto Alegre* 5:225–256; Silveira et al. 2010. *Herpetol. Rev.* 41:108). This new record extends the known distribution ca. 235 km NE of Reserva Ecológica de Guapiçu, in Rio de Janeiro state (Silveira et al., *op. cit.*), the nearest documented locality, and ca. 250 km NE of Parque Estadual do Ibitipoca, the nearest locality in Minas Gerais state.

JOSÉ CASSIMIRO (e-mail: geckoides@gmail.com), **MAURO TEIXEIRA JR.** (e-mail: mteixeirajr@usp.br), **RENATO SOUSA RECODER** (e-mail: renatorecoder@gmail.com), and **MIGUEL TREFAUT RODRIGUES**, Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, Caixa Postal 11.461, CEP 05422-970, São Paulo, SP, Brazil (e-mail: mturodri@usp.br).

HEMIDACTYLUS FRENATUS (Common House Gecko). MÉXICO: OAXACA: MUNICIPALITY OF OAXACA DE JUÁREZ: Oaxaca City (17.063326°N, 96.706898°W; WGS84), 1545 m elev. 18 June 2013. Vicente Mata-Silva. Verified by Aurelio Ramírez-Bautista. Photographic voucher, UTEP G 2013.1. First municipality record. The distribution of this species in southern Mexico includes lowland regions on the Pacific and Gulf versants (mapped in Farr 2011. *Southwest. Nat.* 56:265–273) and in Oaxaca within the floristic-faunistic regions 8 (Planicie Costera del Pacífico) and 9 (Istmo de Tehuantepec), from 0 to 1000 m elev. (Casas-Andreu et al. 1996. *Acta Zool. Mex.* 69:1–35; Casas-Andreu et al. 2004. *In* Garcia-Mendoza et al. [eds.], *Biodiversidad de Oaxaca*, pp. 375–390. *Inst. Biol. UNAM, Mexico D.F.*). The record reported herein is from a higher elevation within floristic-faunistic region 6 (Valles Centrales) (Casas-Andreu et al. 1996, *op. cit.*). The gecko was observed on the outside brick wall of a house; additional individuals were observed by VMS and ARB on walls at other locations

within the city. We assume that successful colonization of Oaxaca City by *H. frenatus* was likely due to passive dispersal by vehicles traveling from coastal regions.

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VICENTE MATA-SILVA (e-mail: vmata@utep.edu) and **JERRY D. JOHNSON** (e-mail: jjohnson@utep.edu), Department of Biological Sciences, The University of Texas at El Paso, El Paso, Texas 79968, USA; **LARRY DAVID WILSON**, 16010 S. W. 207th Avenue, Miami, Florida 33187, USA, and Centro Zamorano de Biodiversidad, Escuela Agrícola Panamericana Zamorano, Depto. Francisco Morazán, Honduras (e-mail: bufodoc@aol.com); **ARTURO ROCHA**, Department of Biology, El Paso Community College, El Paso, Texas 79998, USA; **JESÚS GARCÍA-GRAJALES**, Instituto de Recursos, Universidad del Mar, Campus Puerto Escondido, Oaxaca, México (e-mail: archosaurio@yahoo.com.mx).

HEMIDACTYLUS TURCICUS (Mediterranean Gecko). MÉXICO: CHIHUAHUA: MUNICIPALITY OF CHIHUAHUA: Ciudad Chihuahua (28.637965°N, 106.075392°W; WGS84), 1425 m elev. 28 September 2012. Rubén Alonso Carbajal Márquez and Martín Lara. Verified by Luis Canseco Márquez (UAA-CV 0354). First municipality record, third record for the Chihuahua, extending the known distributional range of the species in the state ca. 153.7 km (airline) NW from the closest known locality, La Perla, Municipality of Camargo, Chihuahua (Lemos-Espinal et al. 2009. Anfibios y Reptiles del Estado de Chihuahua. UNAM, Tlalnepantla, México, México; Univ. Colorado, Boulder; CONABIO, México, D.F. 613 pp.), and ca. 346.6 km (airline) S from Ciudad Juárez (Gatica-Colima et al. 2009. Herpetol. Rev. 40:452). This exotic gecko was found on a downtown street.

RUBÉN ALONSO CARBAJAL-MÁRQUEZ (e-mail: redman031@hotmail.com), Centro de Investigaciones Biológicas del Noroeste, Instituto Politécnico Nacional No.195 Col. Playa Palo de Santa Rita Sur, C.P. 23096, La Paz, Baja California Sur, México; **GUSTAVO E. QUINTERO-DÍAZ**, Universidad Autónoma de Aguascalientes, Centro de Ciencias Básicas, Departamento de Biología, Avenida Universidad No. 940, Aguascalientes, Ags. 20131, México; **ZAIRA YANETH GONZÁLEZ-SAUCEDO**, Universidad Autónoma de Querétaro, Facultad de Ciencias, Av. de la Ciencias S/N, Col. Juriquilla, C.P. 76230, Querétaro, Qro., México; **MARTÍN LARA**, Juan Mata Ortiz, #4042, C.P. 32230, Ciudad Juárez, Chihuahua, México.

PHELSUMA GRANDIS (Madagascar Day Gecko). USA: FLORIDA: MONROE Co.: Key Largo, near Bass Avenue and Kingfish Street (25.13713°N, 80.39987°W; WGS84; elev. 2 m). 28 May 2013. Elizabeth Frampton and James G. Duquesnel. Verified by Laurence L. Connor. Florida Museum of Natural History (UF-Herpetology 170288). New island record and tenth known island in the Florida Keys to which this species has been introduced (Krysko and Sheehy 2005. Carib. J. Sci. 41:169–172, Krysko and Hooper 2007. Gekko 5:33–38). This specimen was reported by Key Largo resident Elizabeth Frampton via the State's Invasive Species Hotline and collected within an hour by JGD. When found, the gecko was alive and mobile but exhibited a penetrating injury with entry and exit wounds on opposite sides of the body. Several maggots were observed emerging from the wounds, and the gecko died soon after capture. Based on the diameter of the wounds, we suspect that the gecko had been shot with a pellet rifle or similar weapon. Additional *P. grandis* have been observed on Key Largo, one (UF-Herpetology 170996) of which was collected on 22 July 2013 near Oceanview Drive, ca. 0.51 km SW of our first record above. This is from the southern end of the same neighborhood

suggesting a more widespread population than currently known. Several residents reported that *P. grandis* had been more abundant locally in the Keys prior to record-setting cold weather of January and February 2010. Our new vouchers are also ca. 22.5 km NE of the closest known verified voucher (UF-Herpetology 135121) from Plantation Key.

KENNETH L. KRYSKO, Division of Herpetology, Florida Museum of Natural History, Dickinson Hall, University of Florida, Gainesville, Florida 32611, USA (e-mail: kenneyk@ufl.edu); **JAMES G. DUQUESNEL**, 385 Pompano Drive, Key Largo, Florida 33037, USA (e-mail: park_bio@yahoo.com); **ROBERT N. REED**, U.S. Geological Survey, 2150 Centre Ave, Bldg C, Ft. Collins, Colorado 80526, USA (e-mail: reedr@usgs.gov).

PLESTIODON FASCIATUS (Common Five-lined Skink). USA: TENNESSEE: VAN BUREN Co.: Fall Creek Falls State Park (35.65663°N, 85.37927°W; WGS 84). 24 June 2013. C. Thawley. Verified by David Laurencio, AUM AHAP-D 685 (digital photograph file). New county record (Scott and Redmond 2008. Atlas of Reptiles in Tennessee. Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. <http://www.apsu.edu/reptatlas> (updated 30 May 2013; accessed 25 June 2013). *P. fasciatus* is presumably distributed statewide in Tennessee, and this record fills a distributional gap between the nearest records approximately 33 km WSW in Warren Co., 20 km N in White Co., and 12 km E in Bledsoe Co. Funding for this research was provided by IOS-1051367 to T. Langkilde.

CHRISTOPHER J. THAWLEY, Department of Biology, Pennsylvania State University, 208 Mueller Laboratory, University Park, Pennsylvania 16802, USA; e-mail: cthawley@gmail.com.

PLESTIODON LATICEPS (Broad-headed Skink). USA: GEORGIA: CHEROKEE Co.: Ball Ground, Flatbottom Road, 0.56 km S of Northridge Road (34.30526°N, 84.38816°W; WGS 84). 10 May 2013. Z. Felix and K. Bonno. (UF 170289 digital image). Verified by Kenneth Krysko. New county record (Jensen et al. [eds.] 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.). One adult male found dead on road near thinned pine stand.

ZACH I. FELIX, Biology Department, Reinhardt University, Waleska, Georgia USA; e-mail: zif@reinhardt.edu.

SCOLOPORUS LUNDELLI (Lundell's Spiny Lizard). MÉXICO: QUINTANA ROO: MUNICIPIO BENITO JUÁREZ: Puerto Morelos, Crocun Zoo (20.88°N, 86.89°W; WGS84), 15 m elev. 16 July 2012. P. Charruau and R. F. Rojo García. Verified by F. R. Méndez de la Cruz and N. Martínez Méndez. CNAR-IBH-RF 40 (a–b). MUNICIPIO SOLIDARIDAD: Playa del Carmen, Río Secreto, Carretera Federal Libre Chetumal - Puerto Juárez, km 283.5 Col. Ejido Sur (20.62°N, 87.14°W; WGS84), 19 m elev. 2 November 2012, P. Charruau and R. F. Rojo García. Verified by F. R. Méndez de la Cruz and N. Martínez Méndez. CNAR IBH-RF 41 (a–b). New municipality records for the species in Quintana Roo, extending the range ca. 74 km E (Puerto Morelos record) of the nearest locality at Nuevo X-Can, Quintana Roo (Lee 1996. The Amphibians and Reptiles of the Yucatán Peninsula. Cornell Univ. Press, Ithaca, New York. 500 pp.). These records are also located ca. 160 and 120 km NE, respectively, from a supposedly isolated record at Santa Teresa Station, Sian Ka'an Biosphere Reserve, Quintana Roo (Calderón-Mandujano and Mora-Tembre 2004. Herpetol. Rev. 35:295–296). Both localities were composed of medium semi-evergreen forest. Other populations of the species have been recorded from central Belize, northeastern Guatemala, and northcentral portions

of the Yucatan Peninsula in Mexico (Lee 1996, *op. cit.*), Calakmul Biosphere Reserve, Campeche (Calderon et al. 2003. *Herpetol. Rev.* 34:269–272), near Tenosique, Tabasco (Barragán et al. 2004. *Herpetol. Rev.* 35:188), and Bahía de Chetumal, Quintana Roo (Cedeño-Vázquez et al. 2003 *Herpetol. Rev.* 34:393–395). Present records confirm that *S. lundelli* is endemic to the Yucatan Peninsula. However, more field work is needed from the central and southern portions of the Peninsula to determine if its range is continuous or fragmented.

PIERRE CHARRUAU, Laboratorio de Herpetología, Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México, A.P. 70163 México 04510, Distrito Federal, México (e-mail: charruau_pierre@yahoo.fr); **ROBERTO F. ROJO GARCÍA**, Río Secreto, Carretera federal libre Chetumal - Puerto Juárez, km. 283.5 Col. Ejido Sur, Playa del Carmen, Quintana Roo, México (e-mail: chibebo@yahoo.com).

TROPIDOPHORUS LAOTUS (Laotian Water Skink). THAILAND: UTTARADIT PROVINCE: NAM PAAD DISTRICT: Nam Paad Wildlife Sanctuary, Huay Sum Ma Kow (17.781340°N, 100.886650°E; ca. 350 m elev.; WGS 84). At night, on small stream bank (water depth 2–3 cm) in mixed deciduous forest and released after photography. Thiti Sorsa. 7 September 2013. Khon Kaen University Vertebrate Collection (KKUD 2013.4a–e). Verified by Sunchai Makchai. First record for Uttaradit Province, ca. 300 km NW of nearest locality (Phu Kradueng National Park, Loei Province; Taylor 1963. *Univ. Kansas Sci. Bull.* 44:687–1077). Previously known only from northeast Thailand, in Loei and Nong Khai provinces (Chuaykern and Chuaykern. 2012. *J. Wildl. Thailand* 19:75–162).

YODCHAIY CHUAYKERN (e-mail: yodchaiy@kku.ac.th) and **CHANTIP CHUAYKERN**, Department of Biology, Faculty of Science, Khon Kaen University, Muang, Khon Kaen 40002, Thailand; **KRAIRAT EIAMAMPAL**, **THITI SORNSA**, **KUNTIDA ITTIPORN**, **CHALERMCHAI OUCHAN**, Bungboraphet Wildlife Research Station, Pranon, Nakhon Sawan, 60000, Thailand; and **PRATEEP DUENGKAE**, Department of Forest Biology, Faculty of Forestry, Kasetsart University, Jatujak, Bangkok 10900, Thailand, and Center for Advanced Studies in Tropical Natural Resource, Kasetsart University, Jatujak, Bangkok, Thailand.

TROPIDURUS JAGUARIBANUS. BRAZIL: CEARÁ: Castanhão Ecological Station, municipality of Nova Jaguaribara (5.593701°S, 38.485622°W, datum SAD69; 108 m elev.). 19 March 2004. I. J. Roberto and T. Pinto, Coleção Herpetológica da Universidade de Brasília (UNB), Brasília, Distrito Federal, Brazil (CHUNB 56546); Aiauba Ecological Station, municipality of Aiuaba (6.650833°S, 40.135000°W, datum SAD69; 466 m elev.). 1 September 2007. S. Cardozo Ribeiro. Coleção Herpetológica da Universidade Regional do Cariri (URCA) Crato, Ceará, Brazil (URCA-H 1915). PIAUÍ: APA Chapada do Araripe, Municipality of Caldeirão Grande do Piauí: (7.3449°S, 40.6033°W, datum SAD69; 737 m elev.). 25 June 2013. I. J. Roberto, S. Cardozo Ribeiro and J. A. Araujo Filho. (URCA-H 5935, adult male 7.3 cm SVL). Verified by R. W. Ávila. This species was previously known only for the state of Ceará, at Jaguaribe River Valley, municipalities of São João do Jaguaribe (type locality) and Banabuiú (Passos et al. 2011. *Zootaxa* 2930:60–68). These new records show a wider occurrence for *T. jaguaribanus*, outside the Jaguaribe River Valley, occurring at elevations of 100–740 m. Also this is the first record for the state of Piauí, extending the known distribution of the species ca. 288 km SW from the municipality of Banabuiú, state of Ceará, Brazil (Passos et al., *op. cit.*).

IGOR JOVENTINO ROBERTO, **JOÃO ANTÔNIO ARAUJO FILHO**, Departamento de Ciências Físicas e Biológicas, Laboratório de Zoologia, Uni-

versidade Regional do Cariri (URCA), Rua Cel. Antônio Luiz Pimenta, 1161, CEP 63105-000, Crato, Ceará, Brazil (e-mail: igorjoventino@yahoo.com.br); **SAMUEL CARDOZO RIBEIRO**, Programa de Pós-Graduação em Ciências Biológicas, Departamento de Sistemática e Ecologia, Laboratório/Coleção de Herpetologia, Universidade Federal da Paraíba – UFPB, Cidade Universitária, Campus I, CEP 58059-900, João Pessoa, Paraíba, Brazil (e-mail: ribeiroherpeto@gmail.com).

UROSAURUS ORNATUS (Ornate Tree Lizard). USA: CALIFORNIA: IMPERIAL CO.: Property at 2110 W Holt Avenue, El Centro (32.7881°N, 115.5797°W; WGS 84; elev. -10 m) 19 Mar 2008. Tyler J. Grant. Verified by Bradford D. Hollingsworth. San Diego Natural History Museum (SDNHM 72855–72857). First record from the Imperial Valley (Peralta 2009. Historical demography and lineage diversification of the ornate tree lizard *Urosaurus ornatus*. M.S. Thesis, San Diego State University). The specimens were collected in the yard of a house. One specimen was collected on a wood fence; two were collected on the house. Several other specimens were observed. This species was also observed in two other locations in El Centro where they seem to be rather common in the artificial landscapes. The nearest vouchered population is 65 km NNE at Beal Well in the Chocolate Mountains (SDNHM 13545).

It seems possible that *U. ornatus* colonized the Imperial Valley through anthropogenic features such as vegetation along the All-American canal. It seems equally likely it was introduced as a hitchhiker, in a manner similar to a population of *U. ornatus* in San Bernardino, California (Bass and Hakim 2010. *Herpetol. Rev.* 41:515). To determine the origin of the Imperial Co. population, the collected specimens were included in a phylogeographic analysis (Peralta 2009, *op. cit.*). The results were inconclusive. The El Centro specimens occurred in clades with southwestern Arizona specimens as might be expected if they were colonizers. However, they were not very differentiated from Maricopa Co., Arizona specimens. If they were naturally occurring in the Imperial Valley, they might be expected to be more differentiated. Therefore it seems likely that they were introduced.

TYLER J. GRANT, Department of Natural Resource Ecology and Management, Iowa State University, Ames, Iowa 50011, USA; e-mail: tgrant@iastate.edu.

VARANUS NUHALIS (White-headed Water Monitor Lizard). PHILIPPINES: ROMBLON PROVINCE: Tablas Island, Municipality of Ferrol, Barangay Tubigon (12.360833°N, 121.949444°E; WGS 84). Ernest Kurt Tan. 22 August 2013. Photographic voucher, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC[IMG] 2.182 a–c). Verified by Rafe M. Brown. Dead on road. SVL 24.8 cm; TL 63.2 cm. First record from Tablas Island. Species known from Panay, Negros, Cebu, Masbate, Ticao, and Sibuyan (Koch et al. 2007. *In* Horn et al. [eds.], *Advances in Monitor Research III*, pp. 109–180. Mertensiella 16, Rheinbach; Siler et al. 2012. *Check List* 8[3]:443–462).

EMERSON Y. SY, Philippine Center for Terrestrial and Aquatic Research, 1198 Benavidez St., Unit 1202, Tondo, Manila, Philippines (e-mail: emersonsy@gmail.com); **ERNEST KURT TAN**, Philippine Native Plants Conservation Society Incorporated, 11 Ipo St., Salvacion, Quezon City, Philippines (e-mail: tablasisland@gmail.com).

SQUAMATA — SNAKES

COLUBER (=MASTICOPHIS) FLAGELLUM FLAGELLUM (Eastern Coachwhip) USA: ALABAMA: CRENSHAW CO.: US Route 331, 200 m S of Johnson Rd. intersection (31.78786°N 86.30514°W;

WGS 84). 2 July 2013. M. Herr and S. Graham. Verified by David Laurencio. AUM 40267. New county record (Mount 1975. The Reptiles and Amphibians of Alabama. Auburn Printing Co., Auburn, 347 pp.). Collected DOR.

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MARK W. HERR (e-mail: mwh5426@psu.edu) and **SEAN P. GRAHAM**, Department of Biology, Pennsylvania State University, 208 Mueller Laboratory, University Park, Pennsylvania 16802, USA (e-mail: szg170@psu.edu).

CROTALIS HORRIDUS (Timber Rattlesnake). USA: ALABAMA: JEFFERSON Co.: Leeds, 2.1 km SE of I20/I459 interchange, 600 m due S of Cahaba River on a ridgetop (33.534548°N, 86.623225°W; WGS 84). 1 May 2013. Kristin A. Bakkegard and Zachery L. Napier. Verified by David Laurencio. AUM AHAP-D 706 (photo voucher). New county record (Mount 1975, Amphibians and Reptiles of Alabama. Auburn University Agricultural Experiment Station, Auburn, Alabama. 347 pp.). Search of 61 museum databases (HerpNet2, <http://www.herpNet2.org/> accessed 23 July 2013) and the AUM database show no voucher specimens for Jefferson Co. even though this species is found nearly state-wide in Alabama.

KRISTIN A. BAKKEGARD, Department of Biological and Environmental Sciences, Samford University, Birmingham, Alabama 35229, USA (e-mail: kbakkega@samford.edu); **ZACHERY L. NAPIER**, Freshwater Land Trust, Birmingham, Alabama 35203, USA (e-mail: zlnapier@gmail.com).

CROTALUS HORRIDUS (Timber Rattlesnake). USA: ARKANSAS: LEE Co.: 100 m E of County Rd. 222 (34.71366°N 90.72717°W; WGS 84). 13 May 2013. S. Graham, C. Thawley, and G. McCormick. Verified by David Laurencio. AUM AHAP-D 677 (digital photograph file). New county record (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. University of Arkansas Press, Fayetteville, Arkansas. 421 pp.). Adult specimen found in ambush posture in slash pile at edge of private agricultural field. This record fills a distributional gap between the nearest records approximately 48 km N in Cross Co. and 11 km SE in Phillips Co..

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CHRISTOPHER J. THAWLEY (e-mail: cthawley@gmail.com), **GAIL L. MCCORMICK** (e-mail: glm173@psu.edu), and **SEAN P. GRAHAM**, Department of Biology, Pennsylvania State University, 208 Mueller Laboratory, University Park, Pennsylvania 16802, USA (e-mail: szg170@psu.edu).

CROTALUS HORRIDUS (Timber Rattlesnake). USA: OKLAHOMA: CHOCTAW Co.: off St. Hwy. 93 just N of county road E2040 in Messer (34.056280°N, 95.469327°W, WGS 84). 17 August 2013. C. Courtwright. Verified by S. E. Trauth. Arkansas State University Museum of Zoology, Herpetological Collection (photographic voucher, ASUMZ 32768). New county record (Oklahoma Biological Survey, Distribution of Oklahoma Amphibians and Reptiles by Recorded Sightings [DOKARRS Search], <http://www/snomnh.ou.edu>; Sam Noble Oklahoma Museum of Natural History Reptile Database [SNOMNH Search], <http://www.snomnh.ou.edu>). Specimen is a large adult (total length = 1880 mm); several *C. horridus* from the state are housed in the SNOMNH from adjacent Bryan and McCurtain counties, and McAllister (2012. Herpetol. Rev. 43:620) recently reported a specimen from nearby Pushmataha Co. Interestingly, Mahaffey (1954. Oklahoma Game Fish News 10:10–11) reported a rattlesnake from Choctaw Co.

(near the Red River bottoms) that Webb (1970. Reptiles of Oklahoma. University of Oklahoma Press, Norman. 370 pp.) listed as “probably *horridus*” but there is apparently no voucher specimen. In addition, there are records of *C. horridus* from just south of Choctaw Co. across the Red River in Fannin, Lamar, and Red River counties, Texas (Dixon 2000. Amphibians and Reptiles of Texas. Texas A&M University Press, College Station. 421 pp.).

CHRIS T. McALLISTER, Science and Mathematics Division, Eastern Oklahoma State College, Idabel, Oklahoma 74745, USA; e-mail: cmcallister@se.edu.

DRYMARCHON COUPERI (Eastern Indigo Snake). USA: GEORGIA: PIERCE Co.: Blackshear (31.300588°N, 82.246831°W; WGS 84). 17 May 2013. Alexander D. McKelvy. Verified by Nicole Castleberry (GMNH 5033 photo voucher and tissue). New county record (Jensen et al. 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.). Field series record # ADM559. Male measuring ~1.9 m found DOR in urban area on State Hwy 84/38. Potentially suitable indigo habitat is located ~2.8 km E of this location along the NE bank of the Satilla River.

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ALEXANDER D. MCKELVY, Department of Biology, The Graduate School, City University of New York, New York, New York 10016, USA; and Department of Biology, 65-143, College of Staten Island, 2800 Victory Blvd., Staten Island, New York 10314, USA (e-mail: amckelvy@gc.cuny.edu); **DIRK J. STEVENSON**, The Orianna Society, Indigo Snake Initiative, 414 Club Drive, Hinesville, Georgia 31313, USA (e-mail: dstevenson@oriannasociety.org); **MATT ELLIOTT**, Georgia Department of Natural Resources, Wildlife Resources Division, 2065 U.S. Hwy 278, SE, Social Circle, Georgia 30025, USA (e-mail: matt.elliott@dnr.state.ga.us).

FARANCIA ABACURA (Red-bellied Mudsnake). USA: TENNESSEE: CARROLL Co.: U.S. Route 79 ca. 6.5 km SW of McKenzie (36.073982°N, 88.564575°W; NAD 83). 8 August 2013. James Flaherty, Michael Fulbright, Aaron Ross, and Shawn Settle. Verified by A. Floyd Scott. Austin Peay State University Museum of Zoology (APSU 19424). New county record (Scott and Redmond. 2008 [latest update: 1 August 2013]. Atlas of Reptiles in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. Available at <http://apsu.edu/reptatlas/> [accessed 14 August 2013]). A second specimen (APSU 19425) was found within 1 km of the first, just two days later. Both specimens were found dead on a heavily trafficked road that bisects a large, vegetated wetland.

JAMES P. FLAHERTY (e-mail: jflaherty1@my.apsu.edu), **MICHAEL C. FULBRIGHT**, **AARON ROSS**, **SHAWN SETTLE**, and **C. M. GIENGER**, Center of Excellence for Field Biology/Department of Biology, Austin Peay State University, Clarksville, Tennessee 37040, USA

HETERODON SIMUS (Southern Hog-nosed Snake). USA: FLORIDA: BAY Co: Pine Log State Forest, 0.45 km N jct. State Road 79 and Gumlock Cemetery Road (30.3955°N, 85.8732°W; WGS84). 16 June 2008. Andrea N. Drayer. Verified by Kevin M. Enge. Florida Museum of Natural History, UF 170589 (photo voucher). New county record (Krysko et al. 2011. Atlas of Amphibians and Reptiles in Florida. Final report, Florida Fish and Wildlife Conservation Commission, Tallahassee. 524 pp.). Gravid female captured in sandhill habitat.

ANDREA N. DRAYER, Department of Forestry, 105 T. P. Cooper Building, University of Kentucky, Lexington, Kentucky 40546, USA; e-mail: andrea.drayer@uky.edu.

IMANTODES GEMMISTRATUS (Central American Tree Snake). MÉXICO: QUINTANA ROO: MUNICIPALITY OF BACALAR: Sitio Experimental San Felipe Bacalar, Zona 1 (18.748253°N, 88.327936°W; WGS84), 30 m elev. 19 November 1981. Juan Nava-Solorio. Verified by Luis Canseco-Márquez. Herpetological Collection, Museo de Fauna Silvestre Juan Nava Solorio, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Sitio Experimental San Felipe Bacalar, Quintana Roo (SESB-H-058). New municipality record, extending known range ca. 70 km S from the closest known locality, 16.9 mi (ca. 27 km) S Felipe Carrillo Puerto (Lee 1996. *The Amphibians and Reptiles of the Yucatán Peninsula*. Cornell Univ. Press, Ithaca, New York. xii + 500 pp.). Additionally, this record extends the range ca. 103 km E from the closest locality in Campeche (Calderón-Mandujano et al. 2003. *Herpetol. Rev.* 34:269–272) and closes the gap between the northeastern and southwestern populations on the Yucatán Peninsula. The specimen is a juvenile found in tropical deciduous forest.

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SERGIO A. TERÁN-JUÁREZ, Instituto Tecnológico de Ciudad Victoria, Blvd. Emilio Portes Gil No. 1301, C.P. 87010, Cd. Victoria, Tamaulipas, México (e-mail: sergioatj@gmail.com); **TERESA ALFARO-REYNA**, Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, Campo Experimental Chetumal, C.P. 77000, Chetumal, Quintana Roo, México (e-mail: alfaro.teresa@inifap.gob.mx); **R. GERARDO CÁMARA-CASTILLO**, Benemérita Universidad Autónoma de Puebla, C.P. 75482, Tecamachalco, Puebla, México (e-mail: kimbalnukuch@gmail.com); **MIGUEL TUN-XIS**, Instituto Tecnológico de Chetumal, Av. Insurgentes No. 330, A.P. 267, C.P. 77013, Chetumal, Quintana Roo, México.

LAMPROPELTIS NIGRA (Black Kingsnake). USA: TENNESSEE: LAWRENCE CO.: Front yard of 106 Hunter Road, Summertown, Tennessee (35.388345°N, 87.396551°W; WGS 84). 6 April 2013. Kayla Clark and Nicole Foster. Verified by A. Floyd Scott. Austin Peay State University (APSUMZ 19415). New county record (Scott and Redmond 2008 [latest update: 1 August 2013]). *Atlas of Reptiles in Tennessee*. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. Available at <http://apsu.edu/reptatlas/> [accessed 1 August 2013]).

KAYLA CLARK, Columbia State Community College, Columbia, Tennessee 38401, USA (e-mail: kclark1@columbiastate.edu); **NICOLE FOSTER**, Department of Science, Math and Technology, Columbia State Community College, Columbia, Tennessee 38401, USA (e-mail: nfoster2@columbiastate.edu).

OPHEODRYS AESTIVUS AESTIVUS (Northern Rough Greensnake) USA: ALABAMA: ESCAMBIA CO.: DOR on Escambia County Rd. 4, 25 m E of Escambia County Rd. 11, Conecuh National Forest (31.06919°N, 86.79368°W; WGS 84). 27 June 2013. S. Graham, M. Herr, J. Williams, and M. Goldy-Brown. Verified by David Laurencio (AUM 40269). New county record (Mount 1975. *The Reptiles and Amphibians of Alabama*. Auburn Printing Co., Auburn. 347 pp.).

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MARK W. HERR (e-mail: mwh5426@psu.edu), **SEAN P. GRAHAM** (e-mail: szg170@psu.edu), and **MARK GOLDY-BROWN** (e-mail: mjpg5402@

psu.edu), Department of Biology, Pennsylvania State University, 208 Mueller Laboratory, University Park, Pennsylvania 16802, USA; **JENNIE WILLIAMS**, Department of Biology, Northeastern University, 413 Mugar Life Science, 360 Huntington Avenue, Boston, Massachusetts 02115, USA (e-mail: williams.jennie@husky.neu.edu).

OPHEODRYS AESTIVUS AESTIVUS (Northern Rough Greensnake). USA: ARKANSAS: POPE CO.: Dover city limits. (35.401471°N, 93.114341°W, WGS 84). 17 May 2013. J. Kremers. Verified by S. E. Trauth. Arkansas State University Museum of Zoology, Herpetological Collection (ASUMZ 32751). New county record; fills gap among previous records in Johnson (Trauth et al. 2004. *Amphibians and Reptiles of Arkansas*. Univ. Arkansas Press, Fayetteville. 421 pp.), Van Buren (Engelbert et al. 2007. *Herpetol. Rev.* 38:221), and Yell counties (Robison and McAllister 2008. *Herpetol. Rev.* 39:244–245).

CHRIS T. McALLISTER, Science and Mathematics Division, Eastern Oklahoma State College, Idabel, Oklahoma 74745, USA (e-mail: cmcallister@se.edu); **HENRY W. ROBISON**, Department of Biology, Southern Arkansas University, Magnolia, Arkansas 71754, USA (e-mail: hwrobison@yahoo.com).

PANTHEROPHIS SPILOIDES (Gray Ratsnake). USA: TENNESSEE: CARROLL CO.: Milan Army Ammunition Plant (35.85388°N, 88.67111°W; WGS 84). 14 May 2013. Michael C. Fulbright and James P. Flaherty. Verified by A. Floyd Scott. Austin Peay State University Museum of Zoology (APSU 19428). New county record (Scott and Redmond 2008 [latest update: 01 August 2013]). *Atlas of Reptiles in Tennessee*. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. Available at <http://apsu.edu/reptatlas/> [accessed 10 August 2013]).

MICHAEL C. FULBRIGHT (e-mail: mfulbright@my.apsu.edu), **JAMES P. FLAHERTY**, and **C. M. GIENGER**, Center of Excellence for Field Biology/Department of Biology, Austin Peay State University, Clarksville, Tennessee 37040, USA.

PANTHEROPHIS VULPINUS (Eastern Foxsnake). USA: WISCONSIN: ROCK CO.: Town of Avon, Avon Bottoms Wildlife Area (42.53693°N, 89.30708°W; WGS 84). 1 July 2013. Karl M. Rutzen and Joshua M. Kapfer. Verified by Erik Wild. University of Wisconsin-Whitewater Collections (UWHERP 0043 photo voucher). New county record (Casper 1996. *Geographic Distributions of the Amphibians and Reptiles of Wisconsin*. Milwaukee Public Museum, 87 pp.; Casper 1999. *Herpetol. Rev.* 30:181–182). Fills the gap in the currently known range of this species in Wisconsin. A juvenile individual was captured under an artificial cover object. Surrounding habitat was primarily open prairie with sandy soils (associated plant species observed include *Tradescantia* sp., *Lupinus* sp.) with adjacent sedge meadow wetland. A second road-killed juvenile was obtained on 8 July 2013. Most land parcels in the immediate vicinity appeared to be active agriculture.

KARL M. RUTZEN, S. 67 W. 26030 Benson Ave., Waukesha, Wisconsin 53189, USA; **PHILIP K. PIEPER**, W3831 Elmwood Rd., Hustisford, Wisconsin 53034, USA; **JOSHUA M. KAPFER**, Department of Biological Sciences, University of Wisconsin-Whitewater, Whitewater, Wisconsin 53190, USA (e-mail: kapferj@uww.edu).

PITUOPHIS CATENIFER SAYI (Bullsnake). USA: ILLINOIS: LEE CO.: Nachusa Grasslands, 5.9 km NW Franklin Grove (41.88511°N, 89.34151°W; WGS 84). 15 August 2013. T. G. Anton and D. Mauger. Verified by Chris Phillips at the Illinois Natural History Survey

(Unvouch 42959, digital image). New county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Natural History Survey, Urbana, Illinois. 282pp). Adult male, 154 cm S-VL, found alive on the shoulder of Lowden Rd. at 1459 h. Grassland-dominated habitat was present on both sides of the road. The species has been documented from adjacent Ogle County and reported from Nachusa Grasslands without prior documentation with photos or specimens.

The 2013 Herpetofaunal Survey was funded by a grant from The Friends of Nachusa Grasslands with access and support provided by The Nature Conservancy.

THOMAS G. ANTON, Division of Amphibians and Reptiles, The Field Museum, Roosevelt Road at Lakeshore Drive, Chicago, Illinois 60614, USA (e-mail TomAnton@comcast.net); **DAVID MAUGER**, Forest Preserve District of Will County (retired), 17029 Henry Street, Lansing, Illinois 60438, USA; **BILL KLEIMAN**, The Nature Conservancy, 8772 South Lowden Rd., Franklin Grove, Illinois 61031, USA.

RENA DULCIS (Texas Threadsnake). USA: COLORADO: BACA Co.: Two Buttes SWA, 0.5 mi S of Prowers Co. line (37.6364778°N, 102.53639167°W; WGS84). 14 May 2012. Verified by J. Hobert. University of Northern Colorado Museum of Natural History (UNC-MNH 4685). The specimen represents a roughly 80 km northward range extension in Colorado (Hammerson 1999. Amphibians and Reptiles in Colorado: A Colorado Field Guide, 2nd ed. University Press of Colorado and Colorado Division of Wildlife, Niwot, Colorado. 484 pp.). Single adult female (2.63 g; 21.9 cm SVL; 1.1 cm TL) encountered alive under rock in sand sage prairie. A species of special concern known from only a few specimens in Colorado.

Specimen was collected under Colorado Division of Wildlife Scientific Collection license (#12HP950) issued to SPM.

CONNOR P. MONTGOMERY and **CHAD E. MONTGOMERY**, Department of Biology, Truman State University, Kirksville, Missouri 63501, USA (e-mail: chadmont@truman.edu); **STEPHEN P. MACKESSY**, School of Biological Sciences, University of Northern Colorado, Greeley, Colorado 80639-0017, USA (e-mail: stephen.mackessy@unco.edu).

STORERIA DEKAYI (Dekay's Brownsnake). USA: GEORGIA: HENRY Co.: on private residence off of Hearthstone Drive (33.560223°N, 84.16194°W; WGS 84) May 2013. J. Agan. Verified by Nikki Castleberry. UGA 50352. New county record (Jensen et al. [eds.] 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens. 575 pp.). Adult under leaf debris in Ocmulgee River floodplain.

JUSTIN AGAN, Clayton State University, 2000 Clayton State Blvd., Morrow, Georgia 30260, USA; e-mail: jagan@student.clayton.edu.

STORERIA OCCIPITOMACULATA (Red-bellied Snake). USA: ALABAMA: LAUDERDALE Co.: Shoal Creek Preserve Forever Wild Tract (34.916437°N, 87.618602°W; WGS84). 27 July 2010. Ashley S. Peters and Brian D. Holt. Photographic voucher (AUM AHAP-D 645). Verified by Craig Guyer. New county record (Mount 1975. Reptiles and Amphibians of Alabama. Agricultural Experiment Station, Auburn University, Alabama. 347 pp.). Hand captured juvenile on predominantly hardwood slope with sandy soils. An adult (AUM AHAP-D 646 photo voucher) was observed under a cover board on 23 September 2010.

We thank Craig Guyer for verifying these records and Eric Soehren for reviewing this note.

ASHLEY S. PETERS (e-mail:ashley.peters@dcnr.alabama.gov) and **BRIAN D. HOLT**, Alabama Department of Conservation and Natural Re-

sources, State Lands Division, Natural Heritage Section, 64 N. Union Street, Suite 464, Montgomery, Alabama 36130, USA.

STORERIA STORERIOIDES (Mexican Brownsnake). MÉXICO: GUANAJUATO: MUNICIPALITY OF CORTAZAR: Cerro El Culiacán, 6 km ENE of Victoria de Cortazar (20.345000°N, 100.976028°W; WGS84), 2646 m elev. 26 July 2009. José Carlos Arenas and Christian Martín García Balderas. Verified by Edmundo Pérez Ramos. MZFC 27073. New municipality record and third locality from Guanajuato, bridging a gap between Sierra de Santa Rosa, Guanajuato populations (Ernst 2008. Cat. Amer. Amphib. Rept. 860:1–4) and Tzitzio, Michoacán populations (Duellman 1961. Univ. Kansas Publ. Mus. Nat. His. 15:1–148). The snake was found under a rock in oak forest.

JOSÉ CARLOS ARENAS-MONROY, Universidad Autónoma de Aguascalientes, Ciudad Universitaria, C.P. 20100, Aguascalientes, Ags., México (e-mail: jca_exe@yahoo.com.mx); **RUBÉN ALONSO CARBAJAL-MÁRQUEZ**, Centro de Investigaciones Biológicas del Noroeste, Instituto Politécnico Nacional No. 195 Col. Playa Palo de Santa Rita Sur, C.P. 23096, La Paz, Baja California Sur, México.

TANTILLA BOCOURTI (Bocourt's Black-headed Snake). MEXICO: OAXACA: MUNICIPALITY OF OAXACA DE JUÁREZ: Agencia San Luis Beltrán (17.095514°N, 96.688878°W; WGS84), 1550 m elev. 30 June 2013. Elí García-Padilla. Verified by Larry D. Wilson. Photographic voucher, UTEP G 2013.2. This individual represents a new municipality record, the second report for Oaxaca, and a range extension of ca. 160 km SSE from the nearest known locality in the vicinity of Santiago Chazumba (Canséco-Márquez and Gutiérrez-Mayén 2010. Anfibios y Reptiles del Valle de Tehuacán-Cuicatlán. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Fundación para la Reserva de la Biósfera Cuicatlán A.C., Benemérita Universidad Autónoma de Puebla, México, D.F. xvi + 302 pp.). The snake was found in an empty lot surrounded by an urban housing development.

ELÍ GARCÍA-PADILLA, Oaxaca de Juárez, Oaxaca 68023, México (e-mail: eligarcia_18@hotmail.com); **VICENTE MATA-SILVA**, Department of Biological Sciences, The University of Texas at El Paso, El Paso, Texas 79968, USA (e-mail: vmata@utep.edu).

THAMNOPHIS RADIX (Plains Gartersnake). USA: ILLINOIS: OGLE Co.: Nachusa Grasslands, 5.9 km NW Franklin Grove (41.9045°N, 89.3281°W; WGS 84). 2 September 2010. M. King and R. B. King. Verified by Chris Phillips. Illinois Natural History Survey (Unvouch 42967 digital image). New county record (Phillips et al. 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Natural History Survey, Urbana, Illinois. 282 pp.). Fills gap among Stephenson, Winnebago, and Lee counties. Juvenile found under cover board in Clear Creek Unit between Lowden and Carthage roads in grassland-dominated habitat. Nine additional individuals have been observed at the Clear Creek and Holland Prairie units in Ogle County managed by Nachusa Grasslands.

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THOMAS G. ANTON, Division of Amphibians and Reptiles, The Field Museum, Roosevelt Road at Lakeshore Drive, Chicago, Illinois 60614, USA (e-mail TomAnton@comcast.net); **RICHARD B. KING**, Department of Biological Sciences, Northern Illinois University, DeKalb, Illinois 60115, USA; **BILL KLEIMAN**, The Nature Conservancy, 8772 South Lowden Rd., Franklin Grove, Illinois 61031, USA.

THAMNOPHIS SIRTALIS PARIETALIS (Red-sided Garter-snake). USA: ARKANSAS: MARION Co.: Yellville (36.226182°N, 92.684888°W; WGS 84). August 2005. Unknown collector. Verified by S. E. Trauth. Arkansas State University Museum of Zoology, Herpetological Collection (ASUMZ 32764, photo voucher of 26 July 2013). First definitive record from the state; previous record for this subspecies from Lawrence Co. (McDaniel and Byrd 1975. Herpetol. Rev. 6:116) is not valid given the variation in “red” specimens from eastern Arkansas (S. E. Trauth, pers. comm.). Specimen is an adult female that gave birth to a litter of 20 live young in 2005 and was subsequently donated to the Arkansas Game and Fish Commission Fred Berry Conservation Education Center (CEC) in Yellville, where it remains for viewing. Trauth et al. (2004. Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, Fayetteville. 421 pp.) noted that Conant and Collins (1998. Amphibians and Reptiles of Eastern and Central North America. 3rd ed. expanded, Houghton Mifflin Co., Boston, Massachusetts. 450 pp.) indicated the presence of *T. s. parietalis* in western Benton Co., Arkansas. However, Trauth et al. (*op. cit.*) further mentioned they were unaware of any voucher specimens for this subspecies in the state; thus, we report the first one.

We thank M. Doran, Facility Manager for the Fred Berry CEC, for collection data on this snake, and S. E. Trauth (ASUMZ) for information on previous specimens.

CHRIS T. McALLISTER, Science and Mathematics Division, Eastern Oklahoma State College, Idabel, Oklahoma 74745, USA (e-mail: cmcallister@se.edu); **HENRY W. ROBISON**, Department of Biology, Southern Arkansas University, Magnolia, Arkansas 71754, USA (e-mail: hwrobison@yahoo.com).

THAMNOPHIS SIRTALIS SIRTALIS (Eastern Gartersnake). USA: ALABAMA: ESCAMBIA Co.: Escambia County Rd. 4, 10 m E of Escambia County Rd. 11, Conecuh National Forest (31.06922°N

86.79408°W; WGS 84). 25 June 2013. S. Graham and M. Herr. Verified by David Laurencio. AUM AHAP-D 683 (digital photo voucher). New county record (Mount 1975. The Reptiles and Amphibians of Alabama. Auburn Printing Co., Auburn, Alabama. 347 pp.).

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MARK W. HERR (e-mail: mwh5426@psu.edu), **SEAN P. GRAHAM** (e-mail: szg170@psu.edu), and **MARK GOLDY-BROWN** (e-mail: mjg5402@psu.edu), Department of Biology, The Pennsylvania State University, 208 Mueller Laboratory, University Park, Pennsylvania 16802, USA; **JENNIE WILLIAMS**, Department of Biology, Northeastern University, 413 Mugar Life Science, 360 Huntington Avenue, Boston, Massachusetts 02115, USA (e-mail: williams.jennie@husky.neu.edu).

VIPERA AMMODYTES (Long-nosed or Nose-horned Viper). GREECE: CYCLADES PREF.: Rhinia Island (37.384338°N, 25.246775°E; WGS 84; 39 m elev.). 23 June 2011. Stephanos A. Roussos and Llewellyn D. Densmore III. Verified by M. Dimaki and J. Foufopoulos. University of Michigan Museum of Zoology, Division of Reptiles and Amphibians (Digital Image Collection number 1230, photographic voucher, one individual). New island record (Chondropoulos 1989. Herpetozoa 2:3–36). This record fills a gap in the viper's distribution of the northern islands in the Cyclades among the most proximal islands: Delos, Mykonos, and Tinos. Three individuals were found on the southern part of the island; two females under rocks and one male in a rock wall.

STEPHANOS A. ROUSSOS, Department of Biological Sciences, MS 43131, Texas Tech University, Lubbock, Texas 79409-3131, USA; e-mail: sa.roussos@ttu.edu.

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New Distributional Records for Amphibians and Reptiles from the State of Tamaulipas, México III

This is the third and final contribution to a series of articles reporting new distributional information on the herpetofauna of Tamaulipas, Mexico (Farr et al. 2007, 2009). Twenty-nine species are reported herein, including two new state records. In addition to noting range extensions discovered in the course of conducting fieldwork and examining museum specimens, we include notes on several species previously reported from Tamaulipas in the literature, sometimes from a single specimen or locality, or from a very limited number of localities in outdated sources (e.g., Amaral 1930 (1929); Duellman 1958; Martin 1955, 1958; Oliver 1948; Peters 1951; Smith 1947; Stuart 1941). Although the occurrence of these species in Tamaulipas is widely accepted and reflected in contemporary literature, their exact distributions within the state have never been examined or clearly defined, despite the accumulation of additional museum vouchers over the last half century. We update and clarify the distributions of a number of such species by reporting a single record from each municipality the species is known to occur in (although

some are known from several localities in each given municipality), including records that delineate the distributional limits and maximum elevations within the state known to us. Also included are notes on three species that have been inferred to occur in Tamaulipas in previous literature and websites based on records from adjacent areas of neighboring

WILLIAM L. FARR

11019 Wainfleet Lane, Houston, Texas 77096, USA;
e-mail: williamfarr@sbcglobal.net

DAVID LAZCANO

Universidad Autónoma de Nuevo León, Facultad de Ciencias Biológicas,
Laboratorio de Herpetología, Apartado Postal 513,
San Nicolás de los Garza, Nuevo León, C.P. 66450, México;
e-mail: imantodes52@hotmail.com

PABLO A. LAVÍN MURCIO

Laboratorio de Biodiversidad, ICB, Universidad Autónoma de Ciudad Juárez,
Ciudad Juárez, Chihuahua, C.P. 32310, México;
e-mail: atropoides@hotmail.com

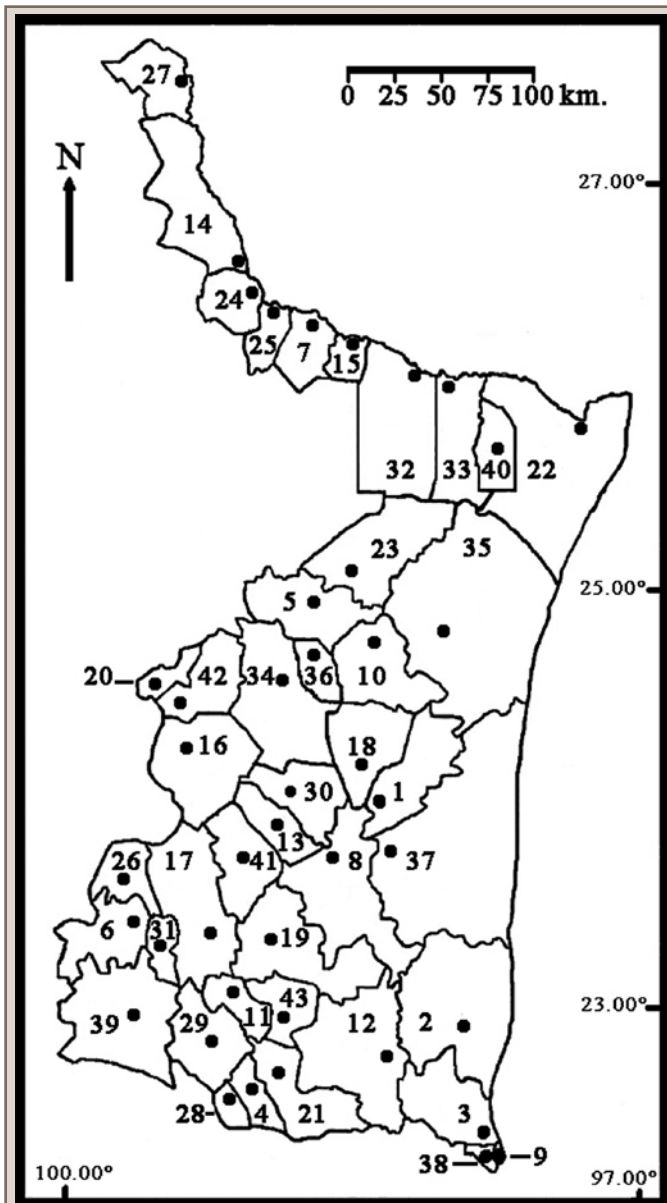


FIG. 1. Map of Tamaulipas, México showing the generalized distribution of its 43 municipalities (equivalent to U.S. counties) and the capital city or town (= •) of each bearing the same name: 1. Abasolo; 2. Aldama; 3. Altamira; 4. Antiguo Morelos; 5. Burgos; 6. Bustamante; 7. Camargo; 8. Casas; 9. Ciudad Madero; 10. Cruillas; 11. Gómez Farías; 12. González; 13. Güémez; 14. Guerrero; 15. Gustavo Díaz Ordaz; 16. Hidalgo; 17. Jaumave; 18. Jiménez; 19. Llera; 20. Mainero; 21. Mante, El; 22. Matamoros; 23. Méndez; 24. Mier; 25. Miguel Alemán; 26. Miquihuana; 27. Nuevo Laredo; 28. Nuevo Morelos; 29. Ocampo; 30. Padilla; 31. Palmillas; 32. Reynosa; 33. Río Bravo; 34. San Carlos; 35. San Fernando; 36. San Nicolás; 37. Soto La Marina; 38. Tampico; 39. Tula; 40. Valle Hermoso; 41. Victoria; 42. Villagrán; 43. Xicoténcatl.

states; even though those species might occur in the state, we are unaware of any confirmed records. Comments on some problematic taxonomic issues involving Tamaulipas species that are in need of status updates are also noted.

The following accounts are based on a review of the literature: 16,133 museum voucher specimens from the subsequent institutions (abbreviations follow Sabaj Pérez 2013), including 11,071 examined by WLF from: AMNH, ANSP, BYU, CAS, CM, FMNH,

INHS, KU, LACM, LSUMZ, LSUS, MPM, MVZ, OMNH, OSUS, ROM, SDSNH, SRSU, TCWC, TNHC, TU, UANL, UCM, UF, UIMNH, UMMZ, USNM, UTA, and UTEP; and additional unexamined museum records from: FWM, JFBM, MCZ, MSUM, NMSU, SMBU, UAZ. An additional 2735 field records and photo vouchers were collected during fieldwork by WLF during 2003–2009 (316 field days). DL conducted statewide surveys of the Tamaulipas herpetofauna during 1996–1997 and made additional irregular fieldtrips in the state during 1977–2009 (118 field days). PALM lived in Tamaulipas for 24 years (1978–2002), and conducted statewide surveys while working from 1996 to 2002 at ITCV (Instituto Tecnológico de Ciudad Victoria), during which time he assembled a collection of ca. 950 specimens from the state that was subsequently transferred to UANL in 2009; the UANL collection currently holds 2377 voucher specimens from Tamaulipas. All museum specimens referenced below were verified by Javier Banda-Leal and UTADC photo vouchers by Jonathan A. Campbell, unless stated otherwise. Distances are expressed in air (not road) km, unless otherwise noted. Locality coordinates and elevations of original field data were determined using a GPS device using map datum WGS84. For older museum and literature locality records that did not include coordinates and elevations we have supplemented these data using topographic maps and Google Earth (map datum WGS84) and present those here in brackets []. The supplemental data in brackets should be regarded as approximate collecting localities. For a few particularly vague localities requiring some speculation, coordinates are preceded by “ca.” Martin (1958), which to this day is probably the single most significant publication on the Tamaulipas herpetofauna, referenced Aserradero del Paraíso, Aserradero del Refugio I, and Aserradero del Refugio II, long abandoned lumber camps and sawmills that were active in the region from 1951 to the early 1970s, but have since been reclaimed by the forest; we were unable to identify them with exact coordinates. Also, many of the elevations for localities given by Martin (1958) were imprecise or generalized and do not always agree with elevations provided by current topographic maps, GPS units, and Google Earth. Elevations that differ significantly are also presented in brackets [] following the original elevations. Common names follow Liner and Casas-Andreu (2008), with one exception: we follow Keiser (1982), who noted in his review of *Oxybelis aeneus* that it is highly variable in color and pattern and preferred the name Neotropical Vinesnake over Brown Vinesnake. In the following text, when referring to municipalities, they are specified as such (e.g., Municipality of Tula) and the capital community is referred to only by its name (e.g., Tula) (Fig. 1).

CAUDATA — SALAMANDERS

AMBYSTOMA (Mole Salamanders). The following are comments on what is known about the distributions of *Ambystoma mavortium* (Barred Tiger Salamander) and *Ambystoma velasci* (Plateau Tiger Salamander) in Tamaulipas. Despite several records of *A. mavortium* in adjacent counties of Texas (Dixon 2013), and records of *A. velasci* in the vicinity of Doctor Arroyo in neighboring Nuevo León (Irschick and Shaffer 1997; Liner et al. 1976; Reese 1971), and San Luis Potosí (Lemos Espinal and Dixon 2013; Taylor 1952, 1953), as well as implications that both species occur in the state (AmphibiaWeb 2013; Gehlbach 1967; Hammerson et al. 2004; Shaffer et al. 2010), we are unaware of any verifying literature records, museum records, or field records for any *Ambystoma* from Tamaulipas. Although speculative, the southern

distributional limit of *A. mavortium* in Texas—occurring exactly at the USA-Mexican boundary (Irschick and Shaffer 1997; Morafka 1977; Petranka 1998)—could be explained if *Ambystoma* was introduced into the region by Texas fishermen as commercially available bait. We are unaware if *Ambystoma* was ever commercially distributed or customarily used as bait in Tamaulipas.

ANURA — FROGS

ANAXYRUS SPECIOSUS (Texas Toad). MUNICIPALITY OF CASAS: On Hwy 75 (Soto La Marina-Casas), 11 km. NW of Soto La Marina (23.8318°N, 98.3077°W), 42.6 m elev. 10 October 2005. William L. Farr. UANL 6445. MUNICIPALITY OF EL MANTE: Mante, southern city limits, irrigation canal [ca. 22.7184°N, 98.9805°W, 88 m elev.]. Edmund D. Keiser, Jr., Don E. Ashurst, and Robert A. Thomas. 21 August 1967. LSUMZ 63523. MUNICIPALITY OF GONZÁLEZ: Magiscatzin [22.800°N, 98.700°W, 51 m elev.]. 6 July 1951. E. R. Burdine. TCWC 6992. MUNICIPALITY OF SAN CARLOS: Hwy 89, 10 km. SE of San Carlos (24.4930°N, 98.8900°W), 362 m elev. 7 August 2005. William L. Farr. UTADC 7576. MUNICIPALITY OF SOTO LA MARINA: Rancho La Rosita, 10 km E of Soto La Marina [23.7978°N, 98.0621°W, 37 m elev.]. 11 March 2000. Angel D. Hernández García. UANL 7408. We have not found any detailed reviews that included specific localities and museum records for this species in Tamaulipas and available maps provide only generalized ranges in the state (Conant and Collins 1998; Morafka 1977; Smith 1947; Stebbins 2003). The above localities define its southern distributional limit on the coastal plain of Tamaulipas and UTADC 7576 is from the highest elevation reported from the state. We have available 351 museum records (326 examined) for this species from 19 municipalities (Burgos, Camargo, Casas, Cruillas, El Mante, González, Güémez, Jiménez, Llera, Matamoros, Méndez, Mier, Miguel Alemán, Padilla, Reynosa, San Carlos, San Fernando, Soto la Marina, Victoria), and our field records include observations from three additional municipalities (Guerrero, Gustavo Díaz Ordaz, Hidalgo). A museum specimen (TCWC 9261) with an imprecise locality, “25 mi N Ciudad Mante” [40.22 road km N on Hwy 85, ca. 23.076°N, 99.1066°W, 113 m elev.], likely originated from the municipality of Xicoténcatl, or possibly Gomez Farías or Llera. *Anaxyrus speciosus* appears to be absent from the Sierra de Tamaulipas, and has not been recorded significantly south of the Río Soto La Marina to the northeast of that mountain range. However, southwest of the Sierra de Tamaulipas it occurs as far as Ciudad Mante and Magiscatzin, but no records are available east of Magiscatzin on the southern coastal plain. Even though the maximum elevation recorded from Tamaulipas was in the foothills of the Sierra San Carlos at 362 m, it reaches higher elevations in Chihuahuan Desert environments in SE New Mexico (900–1300 m, Degenhardt et al. 1996) and a little higher (1314 m) on the Indio Mountains in Trans-Pecos, Texas (Couvillon 2011).

INCILIUS NEBULIFER (Gulf Coast Toad). MUNICIPALITY OF TULA: Tula [23.0000°N, 99.7104°W, 1183 m elev.]. 20 July 1996. David Lazcano, Alan Kardon, Mike Bishop, David Jacobo Galván. UANL 4117–4118. Carretera Tula-Ocampo en Sierra de Tula [state Hwy 66, 22.9508°N, 99.6062°W, 1461 m elev.]. 7 September 1996. David Lazcano and David Jacobo Galván. UANL 4218. 14 km NE of Tula in the Sierra Mocha (23.0311°N, 99.5841°W), 1740 m elev. 16 September 2009. William L. Farr. UTADC 7593. Near Ejido San Pablo, 15 km SW of Tula (22.8972°N, 99.8236°W), 1064 m elev. 12 October 2007. William L. Farr. UTADC 7592. Respective range extensions of 37 km W, 26.5 km WSW, 24.5 km WNW, and 49.5 km SW

from the nearest record “near Aserradero del Refugio No 1, 1050 m elev.” Municipality of Ocampo [ca. 22.9833°N, 99.3499°W, 971 m elev.] (Martin 1958). These are first municipality records, westernmost localities for the state, and first records from the arid interior of the plateau region of Tamaulipas (Mendelson 1998; Mulcahy and Mendelson 2000; Porter 1964). Additional field observations include a few from the Municipality of Miquihuana on the night of 11 August 2003 on the road from La Peña [23.5584°N, 99.6962°W, 1807 m elev.] SE toward Hwy 101 [ca. 23.4936°N, 99.6423°W, 1724 m elev.] in Chihuahua Desert scrub. We have 1140 museum records (921 examined) including verified records from 32 municipalities (Abasolo, Aldama, Altamira, Antigua Morelos, Camargo, Casas, Cruillas, El Mante, Gómez Farías, González, Güémez, Guerrero, Hidalgo, Jaumave, Jiménez, Llera, Ciudad Madero, Mainero, Matamoros, Méndez, Miguel Alemán, Nuevo Morelos, Ocampo, Padilla, San Carlos, San Fernando, Soto la Marina, Tampico, Tula, Victoria, Villagrán, Xicoténcatl) and our field records include observations from three additional municipalities (Miquihuana, Reynosa, San Nicolás). Among the remaining municipalities of Tamaulipas, it should be anticipated with near certainty in Burgos, Gustavo Díaz Ordaz, Mier, Nuevo Laredo, Río Bravo, and Villa Hermoso; its occurrence in Palmillas is likely, but its presence in Bustamante is questionable. Martin (1958) reported the maximum elevations in Tamaulipas at 1520–1550 m from La Joya de Salas [23.1722°N, 99.3000°W]. In field surveys, *I. nebulifer* was common in the Sierra Madre Oriental between 400–1250 m elevations, significantly less common from 1250–1500 m, and only observed twice between 1500–1800 m. *Incilius nebulifer* is one of the most abundant species of the herpetofauna and nearly ubiquitous in Tamaulipas, being absent only from areas above ca. 1800 m elevation in the Sierra Madre. We have observed it near sea level no more than 45 m from coastal mangrove lagoons, and in thorn scrub, tropical deciduous forest, cloud forest, Chihuahuan Desert flats, and other vegetation zones and ecotones, as well as urban environments and agricultural areas. It is possible that recent changes in land use, such as construction of manmade water tanks and irrigation practices associated with commercial agriculture have facilitated the dispersal and bolstered populations of *I. nebulifer* in the desert flats of Tula Valley. However, those elements would seem less likely to be factors regarding their occurrences in the relatively undisturbed Miquihuana Valley, and the species is known to occur in other eastern regions of the Chihuahua Desert (Flores-Villela 1993; Lemos-Espinal and Smith 2007; Morafka 1977; Schmidt and Owen 1944)

ELEUTHERODACTYLUS DENNISI (Dennis's Chirping Frog). MUNICIPALITY OF EL MANTE: Grutas de Quintero, 1.5 mi [2.4 km] SW Quintero [22.6486°N, 99.0416°W, 201 m. elev.]. 13 July 1964. Sherman A. and Madge R. Minton. AMNH 182639. MUNICIPALITY OF GÓMEZ FARIAS: Río Frío Dulgés, cueva del nacimiento del río [ca. 22.9876°N, 99.1525°W, 205 m. elev.]. 16 February 1970. V. Wade, TNHC 83571. In a cave a near Gómez Farías (23.0411°N, 99.1333°W), 270 m. elev. 9 August 2004. William L. Farr and Tim Burkhardt. UANL 6739. First municipality records for each and range extensions of five, 43.5, and 47 km N, respectively, from the only other known locality for the species at its type locality, Municipality of Antigua Morelos at “a cave near El Pachón 8 km. N. Antigua Morelos, Tamaulipas, México, 250 m” (Frost 2013; Lynch 1970). El Pachón is now officially recognized by both state and federal governments as Praxedis Guerrero and depicted by that name on current maps. Reddell and Mitchell (1971) identified

and mapped five caves in the area, and in our field surveys we explored four caves within 2.5 km of Praxedis Guerrero, and locals informed us of more. Presumably the cave referred to by Reddell and Mitchell (1971) as Cueva de el Pachón [22.6070°N, 99.0487°W], which is closest to the town, is the type locality although this was not made explicitly clear by Lynch (1970). We did not observe *E. dennisi* in this cave in our field surveys, but did find them in other caves nearby. Five *E. dennisi* were found beneath rocks on the floor and on walls within nooks and crannies less than 1 m above floor in a cave near Gómez Farías, of which only one was retained as a voucher specimen. The surrounding vegetation there was tropical deciduous forest. *Eleutherodactylus dennisi* occur in caves in the Tamaulipas section of the Sierra Cucharas (= Sierra de El Abra in Reddell and Mitchell 1971) and adjacent areas of the Sierra de Guatemala between 201–270 m elevation. Its occurrence is anticipated in the Sierra Cucharas of San Luis Potosí if its distribution mirrors that of *Lepidophyma micropholis*, a species that shares the type locality and seemingly the same microhabitat (Bezy and Camarillo 2002).

There is a profound need for a review, at the species level, of *Eleutherodactylus* previously assigned to the genus *Syrhophus* (Lynch 1970) and subgenus *Syrhophus* (Hedges 1989). We tentatively follow Lynch's (1970) characters of color pattern and small tympanum size in recognizing *E. dennisi* herein, although there are some indications that *E. dennisi* might represent a clinal variant in lower elevational populations of *E. longipes*.

LEPTODACTYLUS MELANONOTUS (Sabinal Frog). MUNICIPALITY OF ALDAMA: on road to El Sabino 2 mi. E of Aldama [22.915°N, 98.047°W, 80 m elev.]. 8 April 1949. Paul Martin, Richard Robins, and William Heed. UMMZ 101187 A-I. MUNICIPALITY OF ALTAMIRA: 8 mi N Tampico [ca. 22.406°N, 97.931°W, 20 m elev.]. 27 June 1953. J. W. Graber. OMNH 26476, 26477, 26478. MUNICIPALITY OF EL MANTE: Approx. 5 rd. mi. SW. Cd. Mante, El Nacimiento Rd. [22.69344°N, 99.0291°W, 94 m elev.]. 8 July 1965. Douglas A. Rossman, Edmond D. Keiser Jr. and R. Earl Olson. LSUMZ 11087. MUNICIPALITY OF GÓMEZ FARIAS: Km 610, 7 km. E. Gómez Farías [23.031°N, 99.093°W, 99 m elev.]. 2 July 1961. Ernest A. Liner. UIMNH 64617. MUNICIPALITY OF GONZÁLEZ: Río Guayalejo near Magiscatzin [22.7972°N, 98.7121°W, 38 m elev.]. 22 December 1939. Archie F. Carr, Jr. UMMZ 88243. MUNICIPALITY OF OCAMPO: In the town of Ocampo (22.8522°N, 99.3363°W), 347 m elev. 22 September 2006. William L. Farr, James R. Dixon, and Toby J. Hibbitts. UTADC 7577. MUNICIPALITY OF SOTO LA MARINA: Los Ébanos Rancho; 6.0 km SW, 4.8 km S Tepehuajes [23.477°N, 97.800°W, 19 m elev.]. 8 January 1992. James R. Dixon. TCWC 70394. MUNICIPALITY OF XICOTÉNCATL: El Encino, 6 mi S of El Encino at Los Kikos [= Los Kikos, 9 km S of El Encino, 23.0830°N, 99.1103°W, 118 m elev.]. 4 July 1966. Ernest A. Liner and Larry D. Wilson. CM 63953 and AMNH 177381–177383. An additional museum record (JFBM 4617) from the Municipality of Tampico, at Tampico [22.240°N, 97.857°W, 5 m elev.] collected 26 July 1957 by J. H. Campbell has not been examined by us. Martin (1958) reported *L. melanonotus* from the Gómez Farías region and correctly speculated that it occurred throughout the coastal plain of southern Tamaulipas south of the Tropic of Cancer, but presented no specific data. Heyer (1970) only included Tamaulipas specimens in his review that were collected by Paul Martin and associates from the Gómez Farías area and considered locality data for a specimen (UIMNH 29817), allegedly from Star County, Texas, to be in error. Some internet accounts underestimate the distribution in Tamaulipas (e.g., AmphibiaWeb 2013; Solís et al. 2010). We have 84 museum

vouchers (72 examined) including eight verified municipality records (Aldama, Altamira, El Mante, Gómez Farías, González, Ocampo, Soto La Marina, Xicoténcatl) and one unexamined record from the Municipality of Tampico. *Leptodactylus melanonotus* typically occurs in tropical deciduous forest and in riparian areas on the coastal plain of southern Tamaulipas at elevations below 347 m, including the Chamal Valley west of the Sierra Cucharas and the Ocampo Valley west of the Sierra Tamalave. It appears to be absent from the Sierra de Tamaulipas. In field surveys we found it to be locally abundant in Tamaulipas, but unevenly distributed and apparently absent from many areas supporting appropriate habitat. On the night of 10 September 2007 one of us (WLF), accompanied by Tim Burkhardt, heard a chorus calling from a flooded field near the intersection of Hwy 180 and Hwy 70 (23.7318°N, 98.2205°W), 17 m elev., which represented the northernmost locality for the species, although no voucher specimens or photographs were taken. We are of the opinion that locality data for a specimen (LSUMZ 11060) allegedly collected at Rancho del Cielo [23.1°N, 99.1925°W, 1190 m elev., in cloud forest] is in error and that it was probably found at a lower elevation in tropical deciduous forest a few km to the east.

PSEUDACRIS CLARKII (Spotted Chorus Frog). MUNICIPALITY OF MATAMOROS: km 10, Camino El Refugio-La Burrita [25.8989°N, 97.3378°W, 6 m elev.]. June 2000. Pablo A. Lavín Murcio. UANL 7333–7334. This is only the second locality recorded for the species in Mexico and a range extension of ca. 22 km E of the other Mexican records (CAS-SUR 315449–450) from 5 km W of Matamoros, Tamaulipas [ca. 25.8693°N, 97.5530°W, 10 m elev.] (Duellman 2001; Lynch 1965), published as 5 mi W of Matamoros by Lynch (1965). The ITCV catalogue had four specimens listed from this locality (ITCV 417, 605–607), however when the collection was transferred and re-catalogued at the UANL only two specimens were found and examined. The locality is in the vicinity of a Resaca in the flood plain of the Río Grande, which supports grassland and thorn scrub vegetation. Additional material (not examined) includes a lot of tadpoles (OMNH 26519) collected by O. Sanders with no date or locality other than Tamaulipas, Mexico.

SQUAMATA — LIZARDS

COPHOSAURUS TEXANUS (Greater Earless Lizard). MUNICIPALITY OF CASAS: Cd. Victoria, 33 mi [53 km] E Soto La Marina Rd. [Mexican Hwy 70, 23.6448°N, 98.6460°W, 233 m elev.]. 6 July 1963. Sabath McKinney. TNHC 30326. MUNICIPALITY OF GÜÉMEZ: 25 km N Ciudad Victoria [ca. 23.9604°N, 99.1145°W, 187 m elev.]. 13 August 1965. A. C. Echternacht. KU 95534. MUNICIPALITY OF HIDALGO: [Santa] La Cruz, 66 km N Ciudad Victoria, 1 km W Hwy 1 [24.1860°N, 99.3650°W, 275 m elev.]. 5 August 1950. Collector unknown. UIMNH 19267. MUNICIPALITY OF JIMÉNEZ: 44 mi [70.7 km] S jct. De las Conchas River [= Río San Juan, = Río San Fernando] on Rt. 101 [24.2815°N, 98.4580°W, 191 m elev.]. 22 February 1971. J. Barry Kirby. LSUMZ 70677. MUNICIPALITY OF PADILLA: [Antigua] Padilla, 1 mi [1.6 km] S of [23.993°N, 98.7772°W, 127 m elev.]. 26 August 1963. Sherman A. and Madge B. Minton. UMMZ 125710. MUNICIPALITY OF VICTORIA: 5 mi [8 km] S Ciudad Victoria [ca. 23.6642°N, 99.1009°W, 326 m elev.]. 23 July 1950. A. W. Jackson. TCWC 7011. New municipality records and range extensions of 114 km SSE, 74 km SSW, 61 km SW, 67 km SE, 66 km SSW, and 107 km S, respectively, from the nearest published locality in the Municipality of San Carlos at Marmolejo [24.6258°N, 99.0031°W,

550 m elev.] (UMMZ 69216–17; Gaige, 1937; Peters, 1951). Each of these six localities represents significant extensions of the species on the Gulf coastal plain of Tamaulipas (Conant and Collins 1998; Morafka 1977; Peters 1951; Stebbins 2003). All localities for the species in Tamaulipas are west of the Bordas Escarpment as illustrated by Johnston (1963). We did not encounter *C. texanus* in any of the municipalities reported above in our field surveys or in any of the localities reported by Martin (1958) in the municipalities of Gómez Farías, Jaumave, and Ocampo in the south of the state, all of which are over 40 years old, which suggests the species is either rare, declining in numbers, or receding in distribution in those areas of the state. In field surveys we found *C. texanus* to be abundant on the plateau in the Municipality of Tula and occasionally observed in the Municipality of Miquihuana at 1038–1900 m. elev.; along the coastal plain and in the Sierra San Carlos we found the species to be abundant in the Municipality of San Carlos and occasionally observed it in the Municipalities of Hidalgo, Mainero, and Villagrán between 344–601 m elev. We observed *C. texanus* in a variety of arid and semiarid vegetation zones including rocky stream beds within oak forest of the Sierra San Carlos and well into the canyons on the eastern versant of the Sierra Madre Oriental draining onto the Gulf coastal plain.

HOLBROOKIA LACERATA (Spot-tailed Earless Lizard). Although the literature implies this species occurs in the far northwestern “pan handle” region of Tamaulipas (Axtell 1956, 1968, 1998; Conant and Collins 1998; Morafka 1977), we are unaware of any museum vouchers or specific literature records from the state. Due to records in adjacent areas of Texas and Coahuila (Axtell 1968; Dixon 2013; Lemos-Espinal and Smith 2007), particularly Falcon Heights, near Falcon Dam, in Star County, Texas [26.565°N, 99.125°W, 98 m elev.] (Axtell 1998), *H. lacerata* most likely occurs in Tamaulipas. On 6 October 2007, in the Municipality of Miguel Aleman, 16 km SSW of Miguel Aleman (26.2556°N, 99.0604°W, 100 m elev.), one of us (WLF) observed a lizard that appeared to be *H. lacerata*, but it eluded capture, so its identification is not unequivocal or verifiable. This species has recently been reported to be in serious decline and extirpated from some areas of its historic range in Texas (Duran and Axtell 2010).

HEMIDACTYLUS TURCICUS (Mediterranean House Gecko). MUNICIPALITY OF TULA: Hotel Jorge in Tula (22.9900°N, 99.7206°W), 1156 m elev. 19 September 2009. William L. Farr. UANL 7094. This is the first record of this exotic species from the plateau region of Tamaulipas west of the Sierra Madre Oriental (Conant and Collins 1998; McCoy 1970), first municipality record, and a range extension of 75 km WNW at El Limón, in the Municipality of El Mante [22.83°N, 99.012°W, 73 m elev.], UMMZ 104077 (Martin 1958).

SCINCELLA SILVICOLA (Taylor's Ground Skink). MUNICIPALITY OF ANTIGUO MORELOS: 10.9 mi [17.5 km] S. Mante on Hwy 85 [22.6086°N, 99.0236°W, 272 m elev.]. 31 March 1972. P. J. Conzelmann. LSUMZ 72299. MUNICIPALITY OF BUSTAMANTE: 7.5 mi [12 km] W Palmillas, Hwy 101 [23.2921°N, 99.6638°W, 1726 m elev.]. 26 June 1976. James R. Dixon and Carl S. Lieb. TCWC 52506. MUNICIPALITY OF JAUMAVE: On the road to Avila y Urbina, 31 km NW of Jaumave (23.6019°N, 99.6025°W, 1703.1 m elev.). 15 October 2006. William L. Farr and Andrew Godambe. UTADC 7578. MUNICIPALITY OF PALMILLAS (very near Tula boundary): 21 km S of Palmillas on the road through San Vicente (23.1105°N, 99.5497°W), 1425 m elev. 9 July 2005. William L. Farr and José Cortés Larriva. UTADC

7578. MUNICIPALITY OF TULA: On the road to Lagunas Las Hondas, 24 km SE of Tula (22.8125°N, 99.5583°W), 1229 m elev. 24 August 2006. William L. Farr. UANL 6494. MUNICIPALITY OF VICTORIA: Altas Cumbres Carr. Victoria km 157 [23.6067°N, 99.2055°W, 1270 m elev.]. 24 November 1996. David Lazcano. UANL 4305. We were unable to find a comprehensive or detailed review on the distribution of *S. silvicola* in Tamaulipas. We have 39 museum records (35 examined) available from 20 localities in eight municipalities in the state and an additional 33 field records from 11 localities in five municipalities. Previous records include Martin (1958) who reported a number of records from the Gómez Farías region where several municipality boundaries converge, including: Municipality of Gómez Farías, Rancho del Cielo [23.1°N, 99.1925°W], 1050 [1177] m elev. and 6 km N Gomez Farías [ca. 23.1079°N, 99.1538°W], 120 [135] m elev.; Municipality of Jaumave, La Joya de Salas [23.1666°N, 99.2999°W], 1500 m elev.; Municipality of Ocampo, slopes N of El Tigre [ca. 22.9785°N, 99.3603°W], 1000–1050 m elev.; Municipality of Tula, Sierra de Tula at 1260 elev. [ca. 22.9602°N, 99.6501°W, 1363 m elev.]; Municipality of Xicoténcatl, Mesa Josefeña, 120–300 m elev. [23.1083°N, 99.0851°W, 217 m elev.]. Two additional literature records include SMBU 8594-6 (not examined) from Municipality of Ocampo, 5 mi W Chamal [22.8170°N, 99.2666°W, 462 m elev.] (Auth et al. 2000) and MZFC 8514 (not examined) from Municipality of Gómez Farías, Gómez Farías [23.0472°N, 99.1551°W, 390 m elev.] (García-Vázquez et al. 2010). We have thus verified records of *S. silvicola* from nine municipalities in Tamaulipas (Antiguo Morelos, Bustamante, Gómez Farías, Jaumave, Ocampo, Palmillas, Tula, Victoria, Xicoténcatl), from low to moderate elevations (ca. 135–1726 m) in the Sierra Madre Oriental. Museum records and field surveys suggest it is absent from higher elevations in these mountains, which reach over 3400 m in Tamaulipas, and the arid interior ranges west of the Tula Valley. Canseco-Márquez et al. (2004) previously reported a range of 300–1800 m elev. throughout the Sierra Madre Oriental.

SQUAMATA — SNAKES

RAMPHOTYPHLOPS BRAMINUS (Brahminy Blindsnake). MUNICIPALITY OF EL MANTE: Hwy 85, ca. 4 km S of Ciudad Mante (22.7108°N, 98.9900°W), 82 m elev. 10 June 2004. 2004 UTA Mexico field Trip. UTA 53054. First record for Tamaulipas. *Ramphotyphlops braminus* is an introduced species and a comprehensive review detailing its distribution in Mexico has not been published. It has been reported from adjacent Texas (Cameron and Hidalgo counties, Merino et al. 2009) and from other states in northeastern Mexico, including: Nuevo León (Nevárez 1999), Veracruz (Mendoza-Quijano et al. 1993), Hidalgo (Hernández-Salinas and Ramírez-Bautista 2010), and Querétaro (Dixon and Hendricks 1979). This snake was found under a cinder block at a gas station and it is unknown if it represents an established population.

ADELPHICOS NEWMANORUM (Newman's Earth Snake). MUNICIPALITY OF GÓMEZ FARIÁS: Gómez Farías, ca. 1 mi [1.6 km] NW of, on Road to Rancho del Cielo [ca. 23.0769°N, 99.1768°W, 791 m elev.]. 26 August 1972. Jeremy F. Jacobs and George J. Jacobs. USNM 244768. First municipality record and a range extension of 23 km NE from the nearest locality, 13 km N of Ocampo [22.9659°N, 99.3654°W, 1000 m elev.] in the Municipality of Ocampo (Martin, 1955, 1958). Martin (1955, 1958) reported the only published records for *A. quadrivirgatus newmanorum* in

Tamaulipas based on a series of 11 specimens collected in a day and a half in April 1953 with help from a 30 man road-building crew. *Adelphicos newmanorum* was not encountered in our state surveys and the lack of additional museum records from the heavily surveyed Gómez Farías region suggests this species is highly secretive or rare in Tamaulipas.

The genus *Adelphicos* is in need of an updated systematic review. A number of authors appear to have missed Martin's records, and the northern distributional limit of the genus on the eastern versant of Mexico has often been reported in the literature as central Veracruz (e.g., Campbell and Ford 1982; Köhler 2003; Lee 1996, 2000; Peters and Orejas-Miranda 1970). Contreras-Arquieta (1989) and Lazcano et al. (2004, 2005) reported records of *A. q. newmanorum* in the neighboring state of Nuevo Leon. Additionally, five variants or combinations of names have been applied to populations from Tamaulipas and adjacent areas of NE Mexico in past and recent years: *A. quadrivirgatus newmanorum* (Martin 1955, 1958; Smith et al. 2001; Lazcano et al. 2004, 2005); *A. quadrivirgatus* (Canseco-Márquez et al. 2004; Dixon and Lemos-Espinal 2010; Lavin-Murcio, et al. 2005a; Murillo et al. 2003); *A. quadrivirgatum* (LaDuc 1995; Lemos-Espinal and Dixon 2013; Ramírez-Bautista et al. 2010); *A. quadrivirgatum newmanorum* (Liner and Casas-Andreu 2008); and *A. newmanorum* (Taylor 1950; LaDuc 1996; Wilson and Johnson 2010; Wilson et al. 2013). Wilson and Johnson (2010) and Wilson et al. (2013) recognized *A. newmanorum* (Taylor 1950) as a full species without comment, although this was based largely on LaDuc (1996; unpubl. thesis) who indicated this population was diagnosable and allopatric (a separate evolutionary lineage) from *A. quadrivirgatum* that ranges from central Veracruz southeastward into Central America. Murillo et al. (2003) and Ramírez-Bautista et al. (2010) reported *A. quadrivirgatum* from NE Hidalgo in areas adjacent to LaDuc's (1996) records for *A. newmanorum* in SE San Luis Potosí and NE Querétaro, and although they did not describe morphological characters, based on distribution we tentatively regard them as *A. newmanorum* here. Future collecting could produce more specimens within the hiatus between the Hidalgo and Veracruz records, but we tentatively follow Taylor (1950), LaDuc (1996), Wilson and Johnson (2010), and Wilson et al. (2013) in recognizing *A. newmanorum* as a distinct species pending new information resolving the issue.

FICIMIA HARDYI (Hardy's Hook-nosed Snake). MUNICIPALITY OF BUSTAMANTE: Near La Joya de Herrera, 7 km W of Bustamante (23.4225°N, 99.8211°W), 1947 m elev. 19 September 2007. Tim Burkhardt and William L. Farr. UANL 6480. MUNICIPALITY OF JAUMAVE: On the road to Avila y Urbina, 33 km NW of Jaumave (23.6017°N, 99.6023°W), 1738 m elev. 5 September 2005. William L. Farr. UANL 6427. First state and municipality records, northernmost localities from throughout the species range, and extensions of 95.5 km and 125 km, respectively, NE from the nearest record at San José de las Flores, Municipality of Guadalcázar, San Luis Potosí (22.7380°N, 100.3900°W), 1850 m elev. (Hernandez-Ibarra et al. 1999; Ramírez-Bautista et al. 1999). The Bustamante specimen was found in high elevation Chihuahuan Desert scrub where adjacent slopes supported stands of juniper trees (*Juniperus angosturana*, *J. flaccida*). The Jaumave snake was found in moderately open dry pine-oak forest; both were found under rocks. This species was described by Mendoza-Quijano and Smith (1993) and is known from only a few specimens, all found on the semiarid interior western slopes and ranges of the Sierra Madre Oriental in Hidalgo, San Luis Potosí, and

Tamaulipas (Hernandez-Ibarra et al. 1999; Mendoza-Quijano and Smith 1993).

HETERODON KENNERLYI (Mexican Hog-nosed Snake). MUNICIPALITY OF MATAMOROS: Matamoros [ca. 25.8860°N, 97.5010°W, 9 m elev. January–February, 1853 *vide* Conant (1968)]. Lieut. Darius Nash Couch. USNM 1282 [two specimens]. 5 mi [8.04 km] S Matamoros [25.8025°N, 97.5235°W, 9 m elev.]. 11 June 1958. J. Shaffner, D.A. Langebartel, and J. Winkelmann. UIMNH 42848. MUNICIPALITY OF PADILLA: 6 mi [9.65 km] W Padilla [24.0739°N, 98.9826°W, 166 m elev.]. 12 June 1950. A. F. Dittman and W. P. Kerr. TCWC 7001–7002. MUNICIPALITY OF REYNOSA: On Hwy 97, 7 mi [11.26 km] S jct. Hwys 97 and 2 (40) S of Reynosa [25.9357°N, 98.2697°W, 60 m elev.]. 19 July 1970. R. W. McDiarmid. LACM 114105. MUNICIPALITY OF SAN FERNANDO: 41.2 mi [66.29 km] S Matamoros [25.3669°N, 97.8721°W, 10 m elev.]. 30 June 1963. Ernest A. Liner and Richard Whitten. AMNH 158668. An additional specimen is from Rancho Santa Ana, 8 mi [12.87 km] SE of [Antiguo] Padilla [23.9768°N, 98.7246°W, 126 m elev.]. 27 December 1941. Archie F. Carr Jr., MCZ R-46335 (not examined). These eight specimens from four Tamaulipan municipalities include all museum and literature records known to us and we did not encounter *H. kennerlyi* in field surveys. The distribution of *H. kennerlyi* in Tamaulipas has been overestimated in previous literature (Conant and Collins 1998; Platt 1969; Stebbins 2003; Walley and Eckerman 1999; Werler and Dixon 2000). In the state, we have no records of the species occurring within the Sierra Madre Oriental, on the interior plateau, or south of 23.97°N on the Gulf coastal plain. In Tamaulipas, *H. kennerlyi* is known from four records within 12 km of the Río Grande, three isolated records along the Río Purificación in the Municipality of Padilla, and one record from 66 km S of Matamoros. The most recent museum record known to us was collected 42 years ago, although we have viewed photographs of *H. kennerlyi* informally circulated on the internet, purportedly taken during the last five years in the vicinity of Antiguo Padilla [24.0096°N, 98.7762°W, 136 m elev.]. All localities except Reynosa (LACM 114105) were from the general vicinity of riparian habitats on the coastal plain from near sea level to 166 m elev. All those habitats have been severely degraded or entirely altered by urbanization, agriculture, or in one instance submerged after the construction of Presa Vicente Guerrero.

IMANTODES CENCHOA (Blunt-headed Tree Snake). MUNICIPALITY OF ALDAMA: 9.5 mi [15.28 km] N Aldama [23.0505°N, 98.0322°W, 237 m elev.]. June 1975. L. Landry. LACM 119185. MUNICIPALITY OF ANTIGUO MORELOS: Carretera Nuevo Morelos-Antiguo Morelos [Hwy 80], 20.32 km al E de Nuevo Morelos (22.5518°N, 99.1376°W) [303 m elev.]. 28 March 1997. Ramiro David Jacobo-Galván. UANL 4474. MUNICIPALITY OF CASAS: On the "old" highway from Victoria to Soto La Marina (23.5725°N, 98.5227°W), 441.9 m elev. 24 October 2004. William L. Farr. UANL 6383. MUNICIPALITY OF LERA: Hwy 85, 6 km N of El Encino (23.1902°N, 99.0980°W), 238.8 m elev. 9 August 2004. William L. Farr and Tim Burkhardt. UANL 6362. MUNICIPALITY OF NUEVO MORELOS: Hwy 80, 1 mi [1.6 km] E Nuevo Morelos [22.5437°N, 99.2026°W, 272 m elev.]. 7 August 1975. Jonathan A. Campbell et al. UTA 4672. MUNICIPALITY OF OCAMPO: Hwy between Santa María de Guadalupe and Ocampo (22.8707°N, 99.3927°W), 382 m elev. 19 September 2004. William L. Farr. UANL 6366. MUNICIPALITY OF SOTO LA MARINA: Carretera 180 Aldama-Soto La Marina, km 61 [23.4719°N, 98.0102°W, 74 m elev.]. 20 July 1996. David Lazcano Villarreal and "Brown Tracks" (Alan Kardon, Mike Bishop, David Jacobo Galván and

students). UANL 4116. All first municipality records. A complete range-wide review of this species is needed (*fide* McCranie 2011), and although its occurrence in southern Tamaulipas is widely reported in the literature, its distribution within the entire state has never been addressed. Martín (1955, 1958) reported two localities in the municipality of Gómez Farías: source of the Río Frío ca. 5 km [6.2 km] SSE of Gómez Farías [22.9927°N, 99.1444°W, ca. 150 m (95 m) elev.]; Pano Ayuctle (= El Azteca) [23.1130°N, 99.1434°W], 100 m elev. [123 m]. The latter is located on the Río Sabinas, which forms the border of the municipalities of Gómez Farías and Xicoténcatl. We have records of 22 specimens (19 examined) from 21 localities, including verified records from eight municipalities (Aldama, Antiguo Morelos, Casas, Gómez Farías, Llera, Nuevo Morelos, Ocampo, Soto La Marina). *Imantodes cenchoa* most often inhabits tropical deciduous forest associated with the foothills and lower elevations of the Sierra Madre Oriental, Sierra de Tamaulipas, and adjacent areas of the Gulf coastal plain at elevations up to 441 m in southern Tamaulipas. It is less commonly found in tropical thorn forest and occasionally in coastal plain grasslands.

LAMPROPELTIS SPLENDIDA (Desert Kingsnake). MUNICIPALITY OF GUERRERO: 10 road mi [16.09 km] S Laredo on Route 85 [27.3211°N, 99.5874°W, 150 m elev.]. 30 August 1968. E. D. Keiser, Jr. and P. A. Keiser. LSUMZ 76222. 21 km S Nuevo Laredo on Mexican Hwy 85 [27.2940°N, 99.6026°W, 143 m elev.]. 30 June 1986. D. G. Barker and J. R. Forester UTA 17793. MUNICIPALITY OF NUEVO LAREDO: 8 mi [12.87 km] S Nuevo Laredo [27.3480°N, 99.5734°W, 120 m elev.]. 7 May 1967. James R. McCranie and L. Porras. UCM 50387. This species was not encountered in our field surveys and the three localities listed above include every museum record from Tamaulipas known to us, all of which are from the same stretch (ca. 40 km) on Hwy 85 S of Nuevo Laredo, in the extreme NW panhandle region. Blaney (1977) accurately mapped the distribution of *L. getula splendida* in Tamaulipas, including an additional record unknown to us from the vicinity of Ciudad Camargo or Gustavo Díaz Ordaz. However, subsequent literature has significantly overestimated its range on the Gulf coastal plain of Tamaulipas (Conant and Collins 1998; Morafka 1977; Pyron and Burbrink 2009a, 2009b; Stebbins 2003), including all areas between “dots” in S Texas and extreme NW Tamaulipas as well as records to the south from San Luis Potosí on the Mexican plateau, apparently with little consideration for the lack of any records and the geographic features (Sierra Madre Oriental) separating these localities. We have no evidence suggesting that *L. splendida* occurs in Tamaulipas south of the above records and consider that maps in Blaney (1977), Werler and Dixon (2000) and Dixon and Werler (2005) illustrate its distribution in south Texas and Tamaulipas most accurately.

In their review of *L. getula*, Pyron and Burbrink (2009a,b), who elevated *L. g. splendida* and *L. g. holbrooki* to full species, did not include samples from S Texas or NE Mexico, but predicted *Lampropeltis holbrooki* would occur there based on ecological niche models, even though the precise western extent of the range was unclear and a question mark was included on their map in the vicinity of the Tamaulipas populations referred to herein. Historically the populations occurring in S Texas and Tamaulipas have been considered *L. g. splendida* based on morphological characters, including dorsal scale counts and color patterns (Blaney 1977; Conant and Collins 1998; Dixon 2000; Stebbins 2003; Werler and Dixon 2000). In their species diagnosis, Pyron and Burbrink (2009a) cite Blaney (1977) as having defined *L. holbrooki*

with 19–25 midbody scale rows and *L. splendida* typically with 23–25, indicating an overlap in that character between the two taxa. In our reading of Blaney (1977), the definitions indicated *L. g. splendida* with 23 or 25 dorsal scale rows and 21 in *L. g. holbrooki*; individuals in a putative intergrade zone had 23 dorsal scale rows. Based on our examination of morphological characters of the Tamaulipan material (mid-body dorsal scale rows >23, dorsal patterns with head and neck predominantly black followed by a row of distinct and well defined black body blotches from neck to tail, and ventral patterns predominantly black from the posterior neck region to the tail with lighter colors encroaching on the lateral edges, although lighter colors occasionally traverse the ventral surface [on UCM 50387]), these specimens are unambiguously consistent with *L. splendida*.

LEPTODEIRA MACULATA (Southwestern Cat-eyed Snake). MUNICIPALITY OF LLERA: 37 rd. mi [59.5 km] S Victoria, 0.6 mi [0.96 km] S jct. with Llera rd. on Rt. 85 [23.3156°N, 98.9888°W, 257 m elev.]. 18 August 1971. Edmund D. Keiser, Pat A. Keiser, and Mark Keiser. LSUMZ 76307. MUNICIPALITY OF OCAMPO: On Hwy between Nicolás Bravo and Ocampo (22.8705°N, 99.3919°W), 385.8 m elev. 20 September 2004. William L. Farr. UANL 6367. MUNICIPALITY OF SOTO LA MARINA: Río Soto la Marina, Rancho la Rosita 127 km NE of Ciudad Victoria (23.7738°N, 98.2166°W), 12 m elev. 11 October 2000. Angel D. Hernández García. UANL 7976. The Soto La Marina specimen is the northernmost record from throughout the species distribution, including the Gulf coastal plain, extending the range 174 km N from Tampico [22.240°N, 97.857°W, 5 m elev.] (Duellman 1958). The Llera specimen is the northernmost interior record in the state, extending the range 15.75 km NW from Hacienda La Clementina, near Forlón [23.2642°N, 98.8453°W, 200 m elev.] (Duellman 1958). The Ocampo specimen is the westernmost record in Tamaulipas, extending the range 17 km W over the Sierra de Tamalave into the Ocampo Valley from 4 km NW of Chamal [22.8614°N, 99.2261°W, 174 m elev.] in the Chamal Valley (Duellman 1958). Duellman (1958) is the most recent publication to report any localities from Tamaulipas.

There has been some confusion regarding the status of this taxon in recent literature. Duellman (1958) described *L. annulata cussiliris* and 50 years of subsequent literature referred to the Tamaulipas population by that name. Duellman (1958) also recognized *L. maculata* as a distinct species from the west coast of Mexico. Recent molecular-based studies of phylogenetic relationships within *Leptodeira* have demonstrated that *L. annulata* and *L. septentrionalis* are polyphyletic (Daza et al. 2009; Mulcahy 2007) and elevated the former subspecies *L. a. cussiliris* to full species, *L. cussiliris*. Daza et al. (2009) established that *L. maculata* was nested within *L. a. cussiliris* and concluded that *L. maculata* “should therefore be synonymized” with *L. cussiliris*; then stated that “Species delimitation and description is, however, outside the scope of this study, and taxonomic changes will be treated elsewhere,” in opposition to their earlier assessment, leaving the status somewhat unstable. Wilson et al. (2013) and Uetz (2013) pointed out that *L. maculata* (Hallowell, 1861; as *Megalops maculatus*) has priority over *L. cussiliris*, although we note the type locality of *L. maculata* has a convoluted history (Duellman 1958); until future taxonomic analyses counter the patterns supported by Mulcahy (2007) and Daza (2009), the correct name should be *L. maculata*. There is an increasingly common practice of systematic reviews identifying polyphyletic species and other incongruous taxonomy, but concluding without a clear arrangement and updated nomenclature (see *Rhadinaea* below).

Sixty-six museum specimens (60 examined) are known to us from the state, including verified records from ten municipalities (Aldama, Antiguo Morelos, El Mante, Gómez Farías, González, Llera, Ocampo, Soto la Marina, Tampico, Xicoténcatl). *Leptodeira maculata* occurs on the southern Gulf coastal plain of Tamaulipas from near sea level to 510 m elev. including the Chamal Valley and the Ocampo Valley in tropical deciduous forest, thorn scrub, and thorn forest. Martin (1958) stated *Leptodeira maculata* invariably occurred near water; however we have found them on several occasions well over a kilometer from any known source of permanent water.

LEPTODEIRA SEPTENTRIONALIS (Northern Cat-eyed Snake).

MUNICIPALITY OF MIQUIHUANA: 14.5 km SE of Miquihuana (23.4975°N, 99.6422°W), 1724 m elev. 14 October 2006. William L. Farr and Andrew Godambe. UANL 6504. MUNICIPALITY OF PALMILLAS: 15 km south of Palmillas, on the dirt road through San Vicente and on to Tula. (23.1672°N, 99.5538°W), 1506.6 m elev. 11 July 2004. William L. Farr, James R. Dixon, Ricardo Enrique-Núñez, Mike Forstner, Gilberto Herrera-Patiño, Oscar M. Hinojosa-Falcón, Pablo A. Lavín-Murcio, Armando Martínez. UTADC 7580. MUNICIPALITY OF TULA: 3 km N of El Refugio, 18.5 km NE of Tula (23.0472°N, 99.545°W), 1137.3 [1175] m elev. 16 October 2006. William L. Farr and Andrew Godambe. UTADC 7581. In the forest on the north side of Hwy 66, 15 air km E of Tula (22.9308°N, 99.5861°W), 1376 m elev. 18 September 2009. William L. Farr. UTADC 7582. First municipality records for each, westernmost localities for the species in Tamaulipas, and westward range extensions of 50 km NW, 26 km W, 28 km SW, and 39.5 km SW, respectively, from the nearest locality at La Joya de Salas [23.1722°N, 99.3000°W, 1540 m elev.] (Duellman 1958; Martin 1958). These records effectively extend the distribution westward from the Gulf coastal plain and humid eastern slopes of the Sierra Madre Oriental, into the arid interior western slopes and onto the threshold of the Mexican plateau where the Sierra Madre transitions into the Chihuahuan Desert. We have 125 museum vouchers (106 examined), including verified records from 23 municipalities (Aldama, Altamira, Burgos, Casas, Cruillas, Gómez Farías, González, Güemez, Jau-mave, Jiménez, Llera, Matamoros, Miquihuana, Nuevo Morelos, Ocampo, Padilla, Palmillas, San Carlos, San Fernando, Soto La Marina, Tula, Victoria, and Xicoténcatl). An additional unexamined specimen (UAZ 27016) from the municipality of Antiguo Morelos, collected 6 August 1967 by Robert Bezy and Charles J. Cole at “El Pachon (cave at), 8 km. (road) NNE of Antiguo Morelos” [22.6070°N, 99.0487°W] is likely valid; however, due to the remarkable resemblance between *L. septentrionalis* and the sympatric *L. maculata* we regard this unexamined record with slight caution. *Leptodeira septentrionalis* occurs in a wide spectrum of vegetation zones in Tamaulipas (Martin 1958) from near sea level up to 1724 m elev. The specimen from Miquihuana was found DOR in Chihuahuan Desert scrub characterized by *Agave lechuguilla*, scattered juniper trees (*Juniperus angosturana*, *J. flaccida*), and barrel cactus (*Ferocactus* sp.) in the adjacent foothills.

LEPTOPHIS MEXICANUS (Mexican Parrot Snake). MUNICIPALITY OF ALDAMA: Aldama, NE of Rancho Nuevo, 9 mi [14.48 km.] N of Barra del Tordo [23.1843°N, 97.7790°W, 11 m elev.]. 17 May 1978. Diderot Gicca. USNM 209853. MUNICIPALITY OF ALTAMIRA: Altamira [22.4023°N, 97.9330°W, 24 m elev.]. 14 April 1898. Edward A. Goldman USNM 046524. MUNICIPALITY OF ANTIGUO MORELOS: On the dirt road from Adolfo López Mateos (aka Chamal) to Hwy 85 just N of Antiguo Morelos (22.6072°N, 99.0847°W), 170.7 m elev. 24

September 2004. William L. Farr. UANL 6370. MUNICIPALITY OF EL MANTE: Mexico Route 85, 0.8 mi N El Abra [22.6330°N, 99.0225°W, 119 m elev.]. 4 July 1977. John E. Cadle. MVZ 146962. MUNICIPALITY OF LLERA: El Guayabo, Carr. Ciudad Victoria-Mante [23.1980°N, 99.0988°W, 271 m elev.]. 15 October 1989. Pablo A. Lavín-Murcio. UANL 7982. MUNICIPALITY OF OCAMPO: Chamal Tamps, 2 mi [3.22 km] N [22.8766°N, 99.1942°W, 151 m elev.]. 18 July 1965. Harrison Gilbert. TNHC 32772. MUNICIPALITY OF SOTO LA MARINA: km 14.5, Carr. La Pesca-Soto la Marina at naval base, rumbo a Soto la Marina (23.8113°N, 97.9380°W), [12 m elev.]. 19 July 1997. David Lazcano and students. UANL 4886. On “new” highway 70, 3 km W of Soto La Marina (23.7644°N, 98.2405°W), 37.2 m elev. 16 May 2007. William L. Farr and Oscar Gallardo. UANL 6525. Km 60, Carr. Casas-Soto la Marina, rumbo a Soto la Marina [ca. 23.6600°N, 98.3416°W, 245 m elev.]. 18 July 1997. David Lazcano and students. UANL 4871. MUNICIPALITY OF TULA: On Hwy 66, 15 air km E of Tula (22.9308°N, 99.5861°W), 1376.4 m elev. 18 September 2009. William L. Farr. UANL 7093. MUNICIPALITY OF VICTORIA: Cañón de Las Burras [within Cañón del Novillo, ca. 23.7142°N, 99.2769°W, 600–900 m elev.]. 23 March 2001. Teresa Alfaro. UANL 7984. We have found no comprehensive review or map detailing the distribution of *Leptophis mexicanus* in Tamaulipas more recent than Oliver (1948), who stated *L. mexicanus* occurred in extreme southern Tamaulipas and included two dots on his map from the vicinity of Altamira and Tampico. Oliver (1948) also listed two examined specimens, one from Altamira (oddly none from Tampico), and another from central Tamaulipas in the Municipality of Padilla but that was not mapped or discussed, at “La Laguna, Doña [Santa] Ana, Mexico” [23.9768°N, 98.7246°W, 126 m elev.] [submerged by Presa Vicente Guerrero in the late 1970s], collected 22 December 1941 by Archie Carr Jr. MCZ R-46372 (not examined). Martin (1958) reported 21 records, mostly from the Municipality of Gómez Farías, although six records were from Pano Ayuctle [= El Azteca, 23.1130°N, 99.1434°W, 123 m elev.], located on the Xicoténcatl-Gómez Farías border, and four others from the Municipality of Ocampo. Mertens (1973) only included records from Tampico. We have records for 55 museum specimens (48 examined) from Tamaulipas, including verified records from 10 municipalities (Aldama, Altamira, Antiguo Morelos, El Mante, Gómez Farías, Llera, Ocampo, Soto la Marina, Tula, Victoria), and an unexamined literature record from the Municipality of Padilla (northernmost record). Its occurrence in the Municipality of Xicoténcatl should be anticipated with near certainty. Martin (1958) stated the species was limited to tropical deciduous forest and lower sections of the cloud forest. However, it is obvious from museum records and our field observations that the species inhabits more than those two vegetation zones in Tamaulipas. *Leptophis mexicanus* occurs throughout the Gulf coastal plain south of 23.9768°N where it has been found in grasslands, tropical thorn forest, tropical deciduous forest, tropical evergreen forest, lower sections of cloud forest, and pine-oak forests of the Sierra de Tamaulipas and eastern slopes of Sierra Madre Oriental at elevations up to 1376 m.

MASTIGODRYAS MELANOLOMUS (COMMON LIZARD EATER).

MUNICIPALITY OF ANTIGUO MORELOS: 10 km N Antiguo Morelos [22.6083°N, 99.0241°W, very near El Mante border, 274 m elev.]. 28 May 1966. E. L. Roth. TCWC 76954. 7.4 km W Antigua Morelos on Mex. Hwy 80 [22.5517°N, 99.1463°W, very near Nuevo Morelos municipality border, 382 m elev.]. 22 August 1985. Steve Hammack and others. UTA 16124. MUNICIPALITY OF GÓMEZ FARIÁS: Ej. Alta Cima [23.0588°N, 99.1967°W, 903 m elev.]. 25 May 1995. Oscar

Hinojosa-Falcón. UANL 8000. 1.9 mi [3 km] E Gómez Farías town square by Gómez Farías Rd. [23.0257°N, 99.1396°W, 292 m elev.]. 3 July 1977. John E. Cadle. MVZ 146965. MUNICIPALITY OF LLERA: Galeana, 34 mi [54.7 km] N Ciudad Mante on Hwy 85 [23.2066°N, 99.1020°W, 296 m elev.]. 20 July 1970. R. W. McDiarmid. LACM 114115. MUNICIPALITY OF OCAMPO: 2 km W Chamal [22.8328°N, 99.2147°W, 158 m elev.]. 30 July 1976. Sherman A. Minton and Madge R. Minton. AMNH 162221. First municipality records for each except Gómez Farías and range extensions of 45.4 km SE for TCWC 76954; 47 km SSE for UTA 16124; 15.2 km S for AMNH 162221, from the nearest record at Aserradero del Paraíso (Martin 1958); and 11.2 km NW for LACM 114115 from the nearest record at Pano Ayuctle (Martin 1958). The Llera record (LACM 114115) is the northernmost record from throughout the species range and the Gómez Farías locality (UANL 8000) is the highest confirmed elevation in Tamaulipas. Although the distribution of *M. melanolomus* is widely reported to include southern Tamaulipas, we are unaware of any detailed review or map of its distribution there. Stuart (1941) included Tamaulipas in the distribution of *M. melanolomus*, but he did not list or map any localities from the state. Previous records include Auth et al. (2000), from 5 mi [8.04 km] E of Gómez Farías [23.0184°N, 99.1187°W, 122 m elev.] (SMBU BCBF 67-1204, not examined) and Martin (1958) from Pano Ayuctle [23.1127°N, 99.1433°W], 100 m elev. (UMMZ 101231–101232); Gómez Farías [23.0471°N, 99.1552°W], 350 m elev. (UMMZ 110832); 3 km WNW of Pano Ayuctle [23.1054°N, 99.1567°W], 300 [148] m elev. (UMMZ 111253); Aserradero del Paraíso [ca. 22.9688°N, 99.2352°W], 450 (765) m elev. (UMMZ 111101); and Rancho del Cielo [23.1°N, 99.1925°W], 1050 [1176] m elev. (UMMZ 112911). All of those records could have originated from the Municipality of Gómez Farías, although Pano Ayuctle [= El Azteca] is located on the Xicoténcatl-Gómez Farías boundary. Also, Aserradero del Paraíso, the site of a sawmill abandoned in the mid-1960s, could have been in either the Municipality of Ocampo or Gómez Farías. Martin (1958) doubted the validity of the locality for UMMZ 112911 from Rancho del Cielo in cloud forest. The Alta Cima record (UANL 8000) reported here, at 903 m elevation, is just below the lower limit of the cloud forest and likely represents the elevation limit in the state. In Costa Rica, Savage (2002) reported it ranging from 4–1760 m elevation, but we are unaware of any records below 122 m elev. in Tamaulipas. All totaled, we have only 13 museum records available from Tamaulipas (12 examined), with confirmed occurrences in four municipalities (Antiguo Morelos, Gómez Farías, Llera, Ocampo), although it is to be anticipated in the Municipalities of El Mante, Nuevo Morelos, and Xicoténcatl. In Tamaulipas, *M. melanolomus* has only been recorded in a remarkably narrow longitudinal zone (99.0241°W–99.2352°W) in the south central region of the state, S of Llera, at elevations between 122–903 m on the eastern slopes of the Sierra Madre Oriental and in the Chamal Valley in tropical deciduous forest and evergreen forest.

OXYBELIS AENEUS (Neotropical Vinesnake). MUNICIPALITY OF CASAS: On “old” highway 70, 37 km SE of Casas (23.6044°N, 98.3986°W), 455 m elev. 25 October 2006. William L. Farr. UANL 6517. MUNICIPALITY OF CASAS OR SOTO LA MARINA: very near their borders on Hwy 70 (the old southern Casas-Soto Marina road), 26 km SW of Soto La Marina (23.6104°N, 98.3911°W), 447 m elev. 5 August 2005. William L. Farr. UANL 6420. MUNICIPALITY OF OCAMPO: 21 km NW of Ocampo (22.9919°N, 99.4711°W), 663 m elev. 16 October 2006. William L. Farr and Andrew Godambe. UANL 6505. First municipality records for Casas and Ocampo (and possibly

for Soto La Marina). Northernmost records for Tamaulipas and range extensions of 48.9 and 49.1 km N, respectively, for the Casas and Casas/Soto La Marina records from the nearest record (MCZ 55821, not examined) at Las Yucas, Aldama [23.2291°N, 98.1448°W, 332 m elev.] (Keiser 1974). Westernmost record from Tamaulipas and a range extension of 33 km W for the Ocampo record from the nearest locality at Gómez Farías [ca. 23.0471°N, 99.1552°W, 390 m elev.] (Martin 1958). Keiser (1974) reviewed the range-wide distribution of *O. aeneus* and although listing collections utilized, he did not identify specimens examined or specific localities, and included no records north of the Tropic of Cancer on the eastern versant of Mexico. Keiser (1982) included one record from the vicinity of Monterrey, Nuevo León. A specimen listed in the ITCV (601) catalogue from the Municipality of Victoria, Cañón del La Peregrina, Ej. La Libertad [ca. 23.7769°N, 99.2090°W, 390 m elev.] collected on 16 March 2000 by Arnulfo Moreno was not found when that collection was transferred to UANL and is presumed lost. However, that locality seems plausible considering the record from Monterrey, Nuevo León. We have 18 records (16 examined) from Tamaulipas, including 14 verified records from five municipalities (Aldama, Casas, Gómez Farías, Llera, Ocampo), four records from localities very near municipality boundary lines (1 Casas-Soto La Marina, 1 Gómez Farías-Xicoténcatl, 2 El Mante-Antiguo Morelos), and one additional unverifiable record from the Municipality of Victoria. In Tamaulipas, *O. aeneus* occurs mostly in the lower foothills of the Sierra Madre Oriental and the Sierra de Tamaulipas and adjacent areas supporting tropical deciduous forest, and less frequently in thorn forest and riparian areas on the Gulf coastal plain at elevations from near sea level to 663 m.

PLIOCERCUS BICOLOR (Northern False Coral Snake). MUNICIPALITY OF OCAMPO: in the forest just E of the road to Emperadores Aztecas (Lagunas Las Hondas), 24 km SE of Tula (22.8036°N, 99.5530°W), 1213 m elev. 6 October 2008. William L. Farr. UTADC 7583. MUNICIPALITY OF TULA: In forest S of Hwy 66, 15 km E of Tula (22.9419°N, 99.5933°W), 1456 m elev. 24 September 2006. James R. Dixon, William L. Farr, and Toby J. Hibbitts. UANL 6621. First municipality records for each and southwestward range extensions of 43.5 and 39.5 km, respectively, from the nearest locality at Rancho Viejo, Municipality of Gomez Farías [23.0571°N, 99.2288°W, 1330 m elev.] [UMMZ 111036] (Martin 1958). These records also fill a gap between previously reported Tamaulipas localities in the cloud forest of the Sierra de Guatemala and records to the S at El Salto Falls, San Luis Potosí [22.5864°N, 99.3823°W, 425 m elev.], which is the type locality of *Pliocercus bicolor hobartsmithi* (Liner 1960). Although both Savage and Crother (1989) and Smith and Chiszar (2001b) provided maps that illustrated the species distribution in Tamaulipas, neither provided a list of specimens examined or data, and both maps include dots that appear to represent the type locality of *Pliocercus elapoides celatus* (Smith 1943), a junior synonym of *P. b. bicolor*, at “Ciudad Victoria.” Ciudad Victoria would represent the northernmost record for the genus, although locality data for this record were noted to be in error (Martin 1958; Smith and Chiszar 2001b), a conclusion with which we agree. However, Martin’s (1958) speculation that the specimen probably originated from the mountains immediately west of Ciudad Victoria is currently not supported by over half a century of additional museum records and field collections, no *Pliocercus* records have been reported from that far north or from anywhere on the lowland Gulf coastal plain of Tamaulipas. We have 64 museum

records (59 examined) and one additional field voucher. Among those 65 records, 62 are from the Municipality of Gómez Farías, one each from Ocampo and Tula, and one doubtful record from Victoria. Both of the snakes reported here were found inside rotten logs on the floor of humid oak forest.

Curiously, Martin (1958) noted that the distributions of *Micrurus* and its mimic *Pliocercus* did not overlap in the Gómez Farías region and in our statewide analysis of 54 years of additional records, we have no evidence to counter that observation. In Tamaulipas, *P. bicolor* has only been recorded in the Sierra Madre Oriental between 1000–1456 m elev. in cloud forest and humid pine-oak forest (Martin 1958). *Micrurus tener* has recently been recorded at elevations of 1066 and 1120 m in the state (Farr et al. 2009), but only in arid and semiarid environments. *Micrurus tamaulipensis* occurs in humid pine-oak forest in the Sierra de Tamaulipas between 750–1000 m (Lavín-Murcio and Dixon 2004), but no *Pliocercus* have been recorded from that isolated mountain range.

The systematics of the *Pliocercus elapoides* complex is highly contentious and many follow Savage and Crother (1989) in recognizing *Pliocercus elapoides* as monotypic, but which is highly variable in color and pattern. The arrangements of Smith and Chiszar (1996, 2001a,b), recognizing several species and subspecies in the complex, is based solely on color pattern variations correlated with geographic distributions and has been criticized (Wilson and Johnson 2010; Wilson and McCranie, 1997). Our recognition of *P. bicolor* should not be interpreted as support for Smith and Chiszar's arrangement of southern populations of the complex or for recognition of subspecies. However, Smith and Chiszar (2001a,b) demonstrated that *P. bicolor* is uniquely characterized among the complex, in addition to color pattern, by a distinguishing feature of scutellation (posterior infralabial fused with the second labiogenial) and a relatively isolated distribution, if not entirely allopatric in the Sierra Madre Oriental.

RHADINAEA GAIGEA (**Gaige's Pine Forest Snake**). MUNICIPALITY OF TULA: 13.5 km ENE of Tula in the Sierra Mocha, on the road to El Refugio (La Unión) (23.0216°N, 99.5847°W), 1700 m elev. 16 September 2009. William L. Farr. UANL 7092. Carr. Tula-Ocampo entronque a terracería km 20 [22.9407°N, 99.5921°W, 1486 m elev.]. 7 September 1996. David Lazcano. UANL 4221. Westward range extensions of ca. 28 and 30 km, respectively, from "Aserradero del Refugio No. 2." [Municipality of Ocampo, ca. 23.0137°N, 99.3092°W, 1662 m elev.]. First municipality records (Dixon et al., 2011 referenced UANL 4221, but did not include data) and westernmost locality within the state (Martin 1958). Two additional records from the Municipality of Victoria, which would represent the northernmost records in the state, are problematic. One specimen (UANL 6802) lacks any data other than the locality "Cañón del Novillo" [ca. 23.6991°N, 99.2615°W, 1001 m elev.]. A second unverified specimen (ITCV 687) listed as *R. montana* from La Reja, found on 1 August 2001 by Oscar Manuel Hinojosa Falcón, Gilberto Herrera Patiño, and Ricardo Enrique Nuñez, was not located when the ITCV collection was transferred and re-catalogued at UANL, and is presumed lost. Previously published records include Martin (1958) who reported what he considered *R. crassa* (see below) from a number of localities in the Gómez Farías region near the borders of five municipalities, including indisputable localities in the Municipalities of Gómez Farías (Rancho del Cielo) and Ocampo (see above), and other imprecise localities along trails through the Sierra de Guatemala that likely encompassed the Municipality of Jaumave, "La Joya

de Salas, 4 km SE" [ca. 23.1433°N, 99.2746°W, 1683 m elev.], and the Municipality of Llera "ca. 4 km N of Rancho del Cielo, 1380 m" [23.1355°N, 99.2002°W, 1380 m elev.]. Myers (1974) included an additional locality from the Municipality of Antigua Morelos "cave at El Pachón, 8 rd. km. NNE Antigua Morelos" (the type locality of *Eleutherodactylus dennisi* (see note in that account above) and Farr et al. (2009) reported a record from the Sierra de Tamaulipas in the Municipality of Casas. We have 109 museum records (102 examined) of *Rhadinaea* from Tamaulipas, including five verified municipality records (Antigua Morelos, Casas, Gómez Farías, Ocampo, Tula) and additional imprecise localities and unverifiable specimens that likely include three more municipalities (Jaumave, Llera, Victoria). Members of the genus occur in cloud forest and both humid and subhumid pine-oak forests in the Sierra Madre Oriental E and S of the Jaumave Valley, and in the Sierra de Tamaulipas between 1000–1829 m elev. The Antigua Morelos (UAZ 26582) record is notably unusual, originating from tropical deciduous forest in the Sierra Cucharas at 250 m elev. and the data for this specimen is not explicitly clear if it was found in the general vicinity of the cave, or inside the cave, which would also be notable.

Lavín-Murcio et al. (2005a,b) first included *Rhadinaea montana* among the herpetofauna of Tamaulipas based on an unexamined museum specimen (KU 129234), for which no data were provided. García-Vázquez (2012) incorrectly reported *R. montana* for the first time from Tamaulipas (Municipality of Gómez Farías, rd. from La Gloria-Las Palmas; 23.0710°N, 99.1420°W, 1900 m elev.). One of us (WLF) subsequently examined KU 129234 from Agua Linda, Sierra de Guatemala [ca. 23.0888°N, 99.2611°W, 2034 m elev., Municipality of Gómez Farías] and the vertebral stripe precisely fits the pattern illustrated by Myers (1974). However, we are reluctant to include *R. montana* among the herpetofauna of Tamaulipas in light of the discussion below. The taxonomic status of populations of *Rhadinaea* in Tamaulipas is problematic. Martin (1958) reported 78 *R. crassa* from the Gómez Farías region and suggested that both *R. montana* and *R. crassa* were conspecific with *R. gaigeae*. Myers' (1974) systematic review of the genus synonymized *R. crassa* with *R. gaigeae*, but he continued to recognize as valid *R. montana* from Nuevo Leon, known from only four individuals. Myers (1974) also recognized as valid *R. quinquelineata*, known from one specimen, and also reported that scutellation of *R. montana* fell within the range of *R. gaigeae*, so the two species were distinguishable only by subtle variations in vertebral and paravertebral stripes. Recently Dixon et al. (2011), in a non-peer reviewed journal, and McCoid and Dixon (1981) reviewed the relationship of *R. quinquelineata*, *R. gaigeae*, and *R. montana* based on morphology using a substantially larger series of 27 specimens from Nuevo Leon (*R. montana* by inference), two *R. quinquelineata*, and additional new *R. gaigeae* from a number of states including Tamaulipas. They demonstrated that the variation in color patterns used to separate *R. montana* from *R. gaigeae* were more variable in both species than was evident to Myers (1974), and noted a generalized cline from south to north of increased numbers of ventrals and subcaudals in all three species, although the counts still largely overlapped. Dixon et al. (2011) were also indecisive in their final arrangement, presenting two possible scenarios for the taxonomic status of the three species: they could be regarded as distinct species or all three could be regarded subspecies of *R. quinquelineata*; they also concluded that "a genetic comparison could prove we were wrong." Despite these shortcomings, Dixon et al. (2011) did find color pattern types used to distinguish the

three species were more variable among the various populations than previously known, and the apparent allopatric distributions among them have left their taxonomic status problematic and somewhat unstable. We concur with the allopatric distribution hypothesis based on our extensive time on the ground in the region, although this might ultimately prove to be wrong with future collecting, especially in light of the one record noted above from 250 m elev. in tropical deciduous forest. We tentatively follow the full species scenario of Myers (1974) and Dixon et al. (2011) in referring to Tamaulipas populations of *R. gaigeae* based on the likelihood of allopatry with Nuevo Leon populations of *R. montana*. However, this only highlights the critical need for further review of *Rhadinaea* from the Sierra Madre Oriental of northeastern Mexico.

SPILOTES PULLATUS (Tropical Tree Snake). MUNICIPALITY OF ALDAMA: Rancho Nuevo [23.1935°N, 97.7961°W, 34 m elev.]. May 1978. Diderot F. Gicca. UF 49504 and 49506. MUNICIPALITY OF CASAS: 54.3 mi [87.3 km] E of Jct. of Hwy 70 and 85 in Victoria on hwy70 [23.5934°N, 98.4173°W, 483 m elev.]. 28 July 1982. H. K. McCrystal. TCWC 61135. 0.45 km N of El Piruli, on “old” Hwy 70, 26 km SE of Casas (23.5766°N, 98.5347°W), 375 m elev. 18 October 2005. William L. Farr and Tiffany Kosch. UANL 6454. MUNICIPALITY OF LLERA: El Encino, 2 mi [3.2 km] W of at Río Sabinas [23.1360°N, 99.1488°W, 139 m elev.]. 13 November 1960. James Edward Heath. LACM 20255. First municipality records for each, a range extension of 88.7 km N for the Aldama locality from Altamira [Municipality of Altamira, 22.4030°N, 97.9369°W, 13 m elev.] (Smith and Taylor 1945), and range extensions of 91 km, 80 km, and 2.6 km NE, respectively, from Pano Ayuctle (= El Azteca), Municipality of Gómez Farías [23.1130°N, 99.1434°W, 123 m elev.] (Martin 1958). The records from the Municipality of Casas represent the northernmost verifiable accounts within the entire species range (but see below). *Spilotes pullatus* has not been the subject of a range-wide review since Amaral 1930 (1929), which has since been described as inadequate (McCranie 2011; Stuart 1948), and did not include any Tamaulipas material. Velasco (1892) included *S. pullatus* in his list of Tamaulipas herpetofauna but did not provide any locality information. Martin (1958) reported 10 specimens from three localities in the Municipalities of Gómez Farías, Ocampo, and Xicoténcatl. We have 22 museum records (19 examined) composed of seven verified municipality records (Aldama, Altamira, Casas, Gómez Farías, Llera, Ocampo, Xicoténcatl). Our field accounts include an observation at the maximum elevation of 551 m for the state from W of Gómez Farías (23.0452°N, 99.1693°W), 25 September 2004, although Johnson et al. (2010) listed a maximum of 1500 m elev. in SE Mexico. One of us (PALM) observed an individual at the top of a small tree in the Municipality of Soto La Marina, 19 km W of La Pesca [23.8222°N, 97.9500°W, 57 m elev.], in July 1985, representing the northernmost observation for the species throughout its range. In Tamaulipas, *S. pullatus* occurs most often in tropical deciduous forest and tropical semi-evergreen forest, but also occasionally in thorn scrub and thorn forest.

STORERIA HIDALGOENSIS (Mexican Yellow-bellied Brown-snake). MUNICIPALITY OF MIQUIHUANA: 11 km La Peña-Joya Pelona [23.6027°N, 99.7072°W, 2648 m elev.]. 11 April 1996. Xochitl M. Sampablo Angel. UANL 8077. First verified municipality record and a range extension of ca. 72 km from the nearest known locality in the state, “on the trail from R. El Cielo to Laguna Zarca” [ca. 23.1484°N, 99.2013°W, 1450 m elev.], 23 August 1950, William B.

Heed. UMMZ 102986 (Martin 1958). This trail passes through the Municipalities of Gómez Farías and Llera; records from Nuevo Leon might be closer. Martin (1958) reported additional records in the state, all from the Municipality of Gómez Farías, although its occurrence should be anticipated with near certainty in adjacent areas in the Municipalities of Jaumave, Llera, and Ocampo in the Sierra de Guatemala. Martin (1958) had doubts about their occurrence in cloud forest, but a series of 10 specimens from La Gloria (23.04657°N, 99.25188°W, 1631 m elev.), 13 September 1975, R. McCranie and L. Porras, LACM 122912–122921, as well as our field records, confirm its occurrence in that vegetation zone. Ernst (2008) reviewed *S. hidalgoensis*, which included western Tamaulipas (citing Martin 1958) in the description of distribution section, and included photographs of a specimen and habitat from Municipality of Miquihuana, although there are no dots on his map for the state. We confirm the occurrence in Tamaulipas with 38 museum vouchers (37 examined). It has been found in Madrean pine-oak woodlands, humid pine-oak forest, and cloud forest from ca. 900–3203 m elev. in the municipalities of Gómez Farías, Miquihuana, and probably Llera.

TANTILLA NIGRICEPS (Plains Black-headed Snake). MUNICIPALITY OF CAMARGO: 12 km S of Camargo, on the road to Comales (26.2072°N, 98.8897°W), 53.4 m elev. 8 July 2007. William L. Farr. UANL 6536. MUNICIPALITY OF GUERRERO: 16.7 mi [26.87 km] S Nuevo Laredo on Mex. Hwy 85 [27.2517°N, 99.6245°W, 130 m elev.]. 2 June 1979. Darrel R. Frost. UTA 8829. MUNICIPALITY OF LLERA: ca. 196 on Carr. 85 between Ciudad Victoria-Ciudad Mante (23.5036°N, 98.9783°W), [301 m elev.]. 27 March 1997. Terry A. Hammes. UANL 4443. MUNICIPALITY OF VICTORIA: Cañón del Novillo [ca. 23.6958°N, 99.2049°W, 435 m elev.]. August 1997. Oscar M. Hinojosa-Falcón. UANL 8086. First municipality records for all. The Guerrero record is also a range extension of 102.5 km NW from the nearest Tamaulipas records at Mier, Municipality of Mier [26.4303°N, 99.1482°W, 65 m elev.], USNM 46584–46585 (Smith 1938); literature records from Texas are closer (Werler and Dixon 2000). The Camargo record fills a gap between the preceding Mier locality and 16.3 km SW of Reynosa on Mex. Hwy 40 [26.0173°N, 98.4661°W, 118 m elev.], AMNH 160359 (Liner and Dundee 1977) in the Municipality of Reynosa. The Llera and Victoria records are the southernmost records from throughout the species’ entire range, and southward range extensions of 122 km and 103 km, respectively, from 2.6 mi (4.18 km) WNW San Carlos [24.6053°N, 98.9782°W, 1600 ft (488 m) elev.], TCWC 48204 (Cole and Hardy 1981). These eight records all represent verifiable *T. nigriceps* museum vouchers known to us from Tamaulipas, and include seven municipality records (Camargo, Guerrero, Llera, Mier, Reynosa, San Carlos, Victoria). Two additional specimens (TCWC 58114, 58120) from San Carlos could not be located and another (UANL 8087) lacked any data. All records are from areas W of Bordas Escarpment on the Gulf coastal plain and adjacent canyons and foot hills of the Sierra Madre Oriental and the Sierra San Carlos from 53 to 488 m elev. *Tantilla nigriceps* occurs in three seemingly disjunct regions of Tamaulipas, in the far northwest panhandle region, in the Sierra San Carlos, and in the general region around Ciudad Victoria. Nevertheless, the intervening habitats between those areas present no obvious barriers and future fieldwork might fill these gaps.

AGKISTRODON TAYLORI (Taylor’s Cantil). MUNICIPALITY OF SAN FERNANDO: Near Carboneras, Carr. Estatal No. 340 [24.6294°N, 97.7222°W, 5 m elev.]. 18 January 2000. Fernando Jiménez

Guzmán. UANL 5622. First municipality record, northeastern most record from throughout the species range, and a range extension of 94 km N of the nearest literature record, 8 km west of La Pesca [23.788°N, 97.851°W, 5 m elev.] (Burchfield 1982) and 117 km N from the nearest museum record (UTA 8117) from 12.4 mi [19.95 km] S of Soto la Marina [23.6283°N, 98.12361°W, 40 m elev.] (Burchfield 1982; Campbell and Lamar 2004; Gloyd and Conant 1990). The vegetation in the area is Tamaulipan thorn scrub. Burchfield (1982) reported “problematic localities” from the San Carlos Mountains based solely on information from local inhabitants and Campbell and Lamar (2004) explicitly included the Sierra San Carlos in the distribution of the species. Although its occurrence there seems plausible, the Sierra San Carlos has been well surveyed by us and others (Gauge 1937; Hendricks and Landry 1976), and we are unaware at this time of any confirmed literature, museum, or field records from that mountain range. We have 27 museum specimens (25 examined, including 5 from zoo collections without detailed locality data), with confirmed records from seven municipalities (Aldama, Casas, Llera, Mainero, Ocampo, San Fernando, and Soto La Marina). A specimen from the Municipality of Victoria (ITCV 561) Cañón del Novillo, collected by Aldo A. Guevara Camzales and Gevson Herrera Rivera in October 1999 was not found when the ITCV collection was transferred and re-catalogued in the UANL collection and is presumed lost. There are numerous and significant gaps within the known distribution of the species. Confirmed elevations in Tamaulipas range from near sea level to ca. 500 m. although a maximum elevation of 914 m has been reported from neighboring areas of San Luis Potosí at 18 km W of El Naranjo, [ca. 22.4956°N, 99.4171°W], TAIC 2684 (now AMNH) collected by Allan Chaney 11 August 1971 (Gloyd and Conant 1990).

CROTALUS MOLOSSUS (Black-tailed Rattlesnake). MUNICIPALITY OF BUSTAMANTE: On the road to La Taponá, 29 km SW of Bustamante (23.12319°N, 99.99118°W), 1869 m elev. 9 October 2008. William L. Farr. UANL 6612. This specimen is the head from a badly damaged snake found DOR. Additional records include a skin and tail without a head (UANL 4832) and three field records. MUNICIPALITY OF MIQUIHUANA: 5 km. NE of Miquihuana (23.59980°N, 99.71370°W), 2573 m elev. 14 October 2006. William L. Farr and Andrew Godambe. UANL 6499. First record from the Municipality of Bustamante and range extension of 48 km SW from the closest known locality, a literature record at 7 km N of Pamillias at 1280 m [municipality of Pamillias ca. 23.34537°N, 99.58489°W, 1385 m elev.] collected 7 August 1979 (Burchfield et al. 1982). Also, first museum record with published data for Miquihuana and a range extension of 31 km NW, from the above literature record (Burchfield et al. 1982).

Early accounts of *C. molossus* distribution did not include Tamaulipas (Klauber 1972; Price 1980) and more recent ones did not include specific locality data (Anderson and Greenbaum 2012; Campbell and Lamar 2004), but were likely based on a record from Sierra El Macho, rd from La Peña to Valle Hermoso, 3.9 mi N of La Peña-Miquihuana rd jct. (Municipality of Miquihuana: ca. 23.5803°N, 99.7132°W, 2245 m elev.), 31 August 1986, J. E. Copp, D. E. Breedlove, R. R. Riviere, and B. R. Anderson, CAS 165227. Burchfield et al. (1982) reported collecting additional specimens (presumably for zoo display; no museum numbers given) on 8 August 1979, at 2286 m elev. and 9 August 1979 at 2377 m elev., from unspecified localities in the vicinity of Miquihuana. Burchfield et al. (1982), based on personal communications of observations by others, speculated that *C. molossus* occurred in

the Sierra de Guatemala in areas where Martin (1958) had previously reported *C. totonacus*. Confusion between the two species is understandable, as Campbell and Lamar (2004) indicated the *C. molossus* (as understood at that time) and *C. totonacus* appeared very similar morphologically and recent molecular research (Anderson and Greenbaum 2012; Wüster et al. 2005) has shown *C. totonacus* to be the sister taxon of populations located in the northeastern part of the range of the *C. molossus* complex; these were previously considered by Campbell and Lamar (2004) to be subspecies of *C. molossus* (*C. m. molossus* and *C. m. nigrescens*). Wüster et al (2005) were the first to show that northern *C. m. molossus* was paraphyletic, with the eastern (northern Chihuahuan Desert) populations being sister to *C. totonacus*, while the western populations (northern Sonoran Desert) were sister to *C. basiliscus*. Anderson and Greenbaum (2012) resurrected the name *C. ornatus* for the northern Chihuahuan Desert populations. Data presented by both Wüster et al (2005) and Anderson and Greenbaum (2012) indicate that *C. m. nigrescens* is basal to the *C. ornatus*-*C. totonacus* clade, and to the *C. m. molossus*-*C. basiliscus* clade. To date, only *C. m. nigrescens* has been reported from Tamaulipas and a few specimens were used in the two molecular studies noted above. According to Campbell and Lamar (2004), *C. m. nigrescens* is the only *C. molossus* occurring in southern Chihuahuan Desert areas.

All available museum records and our field accounts from Sierra de Guatemala are *C. totonacus*. Based on eight museum records (1 CAS, 7 UANL) and additional literature and field records, *C. molossus* can be confirmed from the municipalities of Bustamante, Miquihuana, and Palmillas between 1385–2573 m elev. in Madrean pine-oak woodlands, Chihuahuan Desert mountains, and juniper-chaparral ecotone zones. During our field surveys we anticipated it occurring in the adjacent municipalities of Jaumave and Tula based on available habitat, but we are unable to confirm its presence there, suggesting the possibility that the two taxa are allopatric in Tamaulipas, although no obvious barriers are apparent in the Tula and the Jaumave Valleys.

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New Distributional Records for Amphibians from Durango, Mexico

Durango, located in the northwestern portion of Mexico, is the fourth largest state in the country (Álvarez 1987), and contains a wide variety of natural habitats and associated biodiversity (González-Elizondo et al. 2007). Knowledge about Durango's herpetofauna has been progressing at a slow rate. The number of amphibian species currently known to occur in Durango is 33 (Valdez-Lares et al. 2013), some of which are based on only one or two specimens, or from records made over 50 years ago. However, a substantial amount of information exists in scientific collections, both within Mexico and in other countries. One example in Mexico is the Herpetological Collection of the Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Instituto Politécnico Nacional, Durango, Durango, which is the institution where all voucher specimens reported herein were deposited (CIIDIR-DGO; Sabaj-Pérez 2013). We report on 18 species of amphibians (two salamanders and 16 anurans), all assembled between 1984 and 2009 by a group of collectors whose names are indicated in the text. Accounts include a new addition to the herpetofauna of Durango (*Hyla wrightorum*), confirmation of a historical record for *Smilisca baudinii* (Günther 1885–1902), and a list of 48 new records from 15 municipalities within the state (Fig. 1). Determination of the new geographic distribution records (e.g., new state and municipality accounts) is based on the lack of substantiating evidence in the literature. We also record new elevational records for two anuran species and discuss systematic relationships between *Hyla eximia* and *H. wrightorum*. Locality coordinates were taken with a GPS device using map datum WGS84 and standard English names follow Liner and Casas-Andreu (2008). In many cases, we collected more individuals from different localities within identified municipalities, but only listed the oldest record in the accounts; data for the others are available through CIIDIR-DGO. Vegetation types in areas surrounding collecting sites were identified, if known. We take all responsibility for accurately verifying the identification of the species. All specimens were collected under SEMARNAT permits issued to Raúl Muñiz-Martínez (FAUT 0003).

CAUDATA — SALAMANDERS

AMBYSTOMA ROSACEUM (Tarahumara Salamander). MUNICIPALITY OF DURANGO: 48.71 km SE El Salto, Salto de Agua llovida

ROSAURA VALDEZ-LARES*

GERARDO A. MARTÍN-MUÑOZ DE COTE
RAÚL MUÑOZ-MARTÍNEZ

Laboratorio de Fauna Silvestre, Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional-Unidad Durango, Sigma 119, Fracc, 20 de Noviembre II, C.P. 34220, Durango, Dgo, México

GEORGINA SANTOS-BARRERA

Departamento de Biología Evolutiva, Facultad de Ciencias, UNAM, Av. Universidad 3000, Ciudad Universitaria, Delegación Coyoacán, C.P. 04510, D.F., México

*Corresponding author; e-mail: biorosaura@gmail.com

(23.53913°N, 104.95685°W), 2308 m elev. 31 August 2005. Rolando González-Trápaga. CIIDIR-DGO 1230. MUNICIPALITY OF NUEVO IDEAL: 4.4 km WSW Pinos Altos (24.93761°N, 105.20472°W), 2690 m elev. 26 August 1999. Rolando González-Trápaga. CIIDIR-DGO 766. MUNICIPALITY OF TEPEHUANES: 11.8 km S, 37.2 km W Los Herreras (25.05233°N, 105.86916°W), 2530 m elev. 31 October 1995. Raúl Muñiz-Martínez. CIIDIR-DGO 505. The three localities reflect new municipality records. All salamanders were found in pine forest.

AMBYSTOMA SUBSALSUM (Alchichica Salamander). MUNICIPALITY OF NUEVO IDEAL: 4.75 km N, 5.6 km E Guatimape (24.85081°N, 104.86673°W), 2040 m elev. 13 November 1999. Rolando González-Trápaga. CIIDIR-DGO 712. MUNICIPALITY OF TAMAZULA: 10.8 km N, 11.7 km E El Durazno (25.57116°N, 106.80646°W), 1923 m elev. October 2004. Raúl Muñiz-Martínez. CIIDIR-DGO 1049-1050. Both localities are new municipality records. Even though the taxonomic status of some populations of the *Ambystoma tigrinum* complex in Durango is questionable, we provisionally follow Webb (2004) for assigning these specimens to *A. subsalsum*.

ANURA — FROGS

ANAXYRUS COGNATUS (Great Plains Toad). MUNICIPALITY OF MEZQUITAL: 4.75 km N, 5.6 km E Guatimape (24.85081°N, 104.86673°W), 2040 m elev. 27 August 1999. Rolando González-Trápaga CIIDIR-DGO 761. MUNICIPALITY OF NUEVO IDEAL: 0.6 km ENE Miguel Negrete (25.01558°N, 105.15566°W), 1994 m elev. 26 August 2000. Rolando González-Trápaga. CIIDIR-DGO 664. MUNICIPALITY OF POANAS: La Joya (23.8375°N, 103.99916°W), 1890 m elev. 30 October 1984. Raúl Muñiz-Martínez. CIIDIR-DGO 07. All three localities represent new municipality records. The Mezquital toad was found in disturbed oak forest, and the one from Poanas was captured within desert shrubland.

ANAXYRUS COMPACTILIS (Plateau Toad). MUNICIPALITY OF CANATLÁN: Rancho El Durangueno, 17.29 km SW Canatlán (24.45861°N, 104.93194°W), 2396 m elev. 2 October 2005. Rolando González-Trápaga. CIIDIR-DGO 1238. MUNICIPALITY OF PÁNUCO DE CORONADO: 22.31 km N, 9.75 km W Francisco I. Madero, H. Galeana (24.59944°N, 104.42138°W), 1953 m elev. 12 September 2008. Raúl Muñiz-Martínez. CIIDIR-DGO 1365. Both localities represent new municipality records. No information on vegetation type is available.

ANAXYRUS MEXICANUS (Mexican Madre Toad). MUNICIPALITY OF SANTIAGO PAPASQUIARO: 14.2 km S, 22.8 km W Los Herreras (25.03025°N, 105.72309°W), 2430 m elev. October 1995. Raúl Muñiz-Martínez. CIIDIR-DGO 517–518. New municipality record. An additional toad from San Juan de Camarones, Santiago Papasquiario (24.92716°N, 106.41147°W; 580 m elev.) (CIIDIR-DGO 538) was caught by Raúl Muñiz-Martínez on 28 June 1997 in subtropical deciduous forest at an elevation 1000 m lower than previously reported for the species (Oliver-López et al. 2009, Wilson and Johnson 2010).

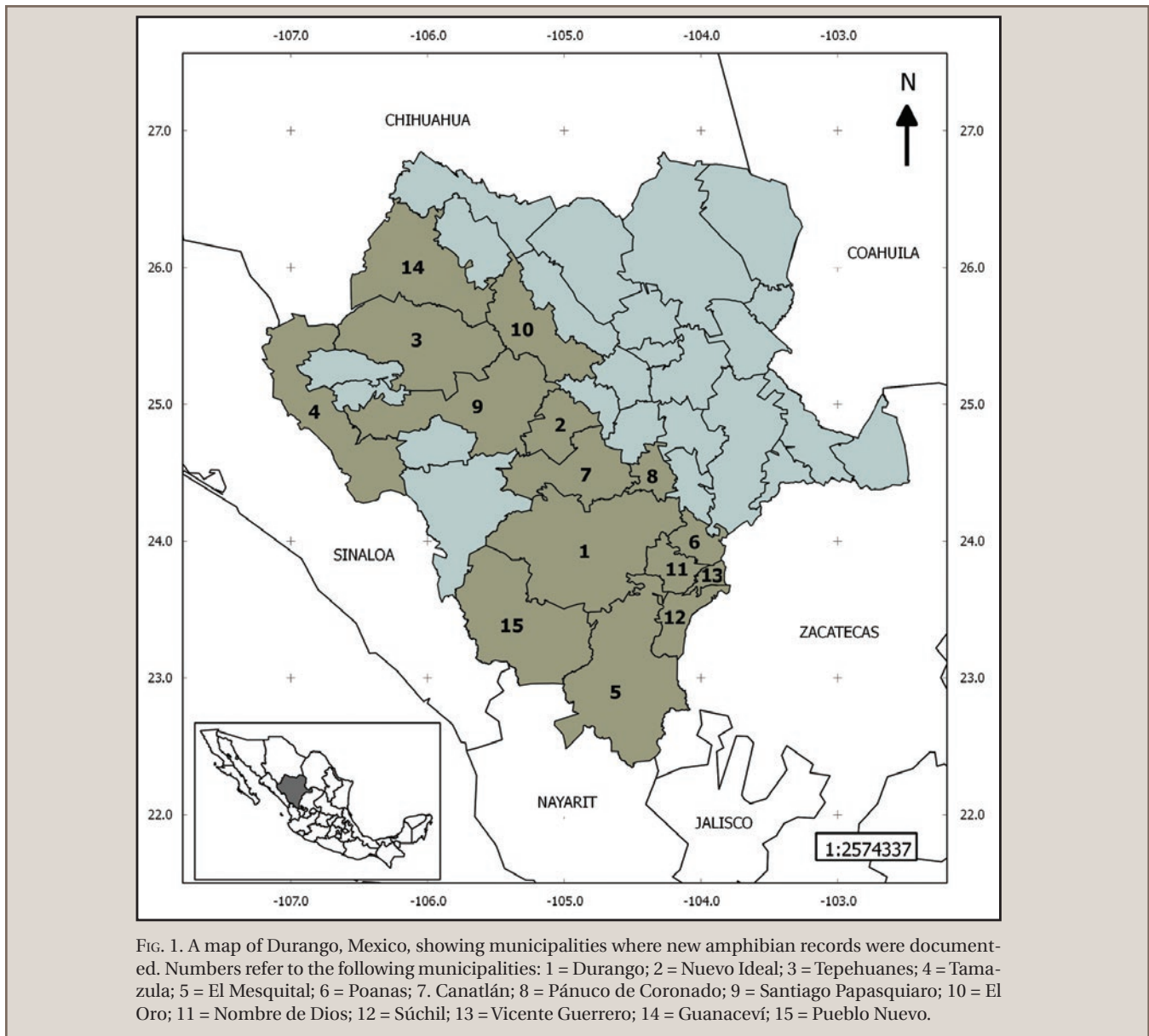


FIG. 1. A map of Durango, Mexico, showing municipalities where new amphibian records were documented. Numbers refer to the following municipalities: 1 = Durango; 2 = Nuevo Ideal; 3 = Tepehuanes; 4 = Tamazula; 5 = El Mesquital; 6 = Poanas; 7. Canatlán; 8 = Pánuco de Coronado; 9 = Santiago Papasquiario; 10 = El Oro; 11 = Nombre de Dios; 12 = Súchil; 13 = Vicente Guerrero; 14 = Guanaceví; 15 = Pueblo Nuevo.

ANAXYRUS PUNCTATUS (Red Spotted Toad). MUNICIPALITY OF CANATLÁN: Rancho El Duranguero 17.29 km SW Canatlán (24.45861°N, 104.93194°W), 2396 m elev. 14 October 2005. Rolando González-Trápaga. CIIDIR-DGO 1188. MUNICIPALITY OF EL ORO: 1 km S, 18 km E Emiliano Martínez (25.44727°N, 105.0082°W), 1980 m elev. 18 August 2005. Rosaura Valdez-Lares. CIIDIR-DGO 1079–1083. MUNICIPALITY OF NOMBRE DE DIOS: 5 km S, 4.1 km W Nombre de Dios (23.80194°N, 104.28611°W), 1720 m elev. 28 September 1987. Raúl Muñiz-Martínez. MUNICIPALITY OF SÚCHIL: 0.7 km S, 4.6 km W San Miguel de la Michilfa (23.58638°N, 104.10805°W), 2020 m elev. 12 July 1985. Raúl Muñiz-Martínez. CIIDIR-DGO 112. MUNICIPALITY OF TEPEHUANES: 11.8 km S, 37.2 km W Los Hererras (25.05233°N, 105.86916°W), 2530 m elev. 1 November 1995. Raúl Muñiz-Martínez. CIIDIR-DGO 508–509. MUNICIPALITY OF VICENTE GUERRERO: 1.8 km N, 9.9 km E Vicente Guerrero (23.74861°N, 103.89027°W), 2070 m elev. 13 September 1983. Raúl Muñiz-Martínez. CIIDIR-DGO 28–29. All six localities represent new municipality records. The toads were found in pine forest and desert scrubland.

INCILIUS MAZATLANENSIS (Sinaloa Toad). MUNICIPALITY OF MEZQUITAL: 12.1 km S, 2.0 km E Huazamota (22.41222°N, 104.47361°W), 700 m elev. 4 June 1992. Raúl Muñiz-Martínez. CIIDIR-DGO 280. MUNICIPALITY OF SANTIAGO PAPASQUIARO: San Juan de Camarones (24.92716°N, 106.41147°W), 580 m elev. 26 June 1997. Raúl Muñiz-Martínez. CIIDIR-DGO 540–542, 544–545. Both localities represent new municipality records and only the second and third known from Durango. The previously listed locality is from Municipality of Pueblo Nuevo, 6 miles (9.6 km) S of Pueblo Nuevo (Webb and Baker 1962). All toads were captured in tropical deciduous forest.

INCILIUS OCCIDENTALIS (Pine Toad). MUNICIPALITY OF VICENTE GUERRERO: 2.0 km S, 1.5 km W Vicente Guerrero (23.71361°N, 104.00055°W), 1920 m elev. 28 July 1989. Raúl Muñiz-Martínez. CIIDIR-DGO 246. New municipality record. The toad was found in an agricultural field.

RHINELLA MARINA (Cane Toad). MUNICIPALITY OF SANTIAGO PAPASQUIARO: San Juan de Camarones (24.92717°N, 106.41147°W), 580

m elev. 27 June 1997. Raúl Muñiz- Martínez. CIIDIR-DGO 539, 546. MUNICIPALITY OF TEPEHUANES: 11.8 km S, 37.2 km W Los Herreras (25.05233°N, 105.86917°W), 2530 m elev. Raúl Muñiz-Martínez. CIIDIR-DGO 507. Both localities represent new municipality records. This species was previously known in the state only from the Municipalities of Mezquitlan (Kellogg 1932) and San Dimas (Günther 1885–1902). The Tepehuanes toad sets a record for highest elevation reported for this wide-ranging species (Oliver-López et al. 2009; Wilson and Johnson 2010).

CRAUGASTOR VOCALIS (Pacific Stream Frog). MUNICIPALITY OF SANTIAGO PAPANASQUIARO: 0.4 km S, 0.35 km W San Juan de Camarones (24.92277°N, 106.41711°W), 590 m elev. 12 September 2000. Raúl Muñiz-Martínez. CIIDIR-DGO 626. New municipality record, and only the second from the state. The other known locality in Durango is from Municipality of Pueblo Nuevo, 6 mi (9.6 km) S of Pueblo Nuevo (Webb and Baker 1962). The frog was found in tropical deciduous forest.

HYLA ARENICOLOR (Canyon Treefrog). MUNICIPALITY OF CANATLÁN: Rancho El Durangueno, 17.29 km SW Canatlán, (24.45861°N, 104.93194°W), 2396 m elev. 14 October 2005. Rolando González-Trápaga. CIIDIR-DGO 1242–1243. MUNICIPALITY OF NOMBRE DE DIOS: 10.5 km N, 7.0 km W Nombre de Dios (23.94083°N, 104.300°W), 1800 m elev. 15 June 1984. Raúl Muñiz-Martínez. CIIDIR-DGO 03. MUNICIPALITY OF NUEVO IDEAL: 4.4 km SWW Pinos Altos (24.93761°N, 105.20472°W), 2690 m elev. 26 August 1999. Rolando González-Trápaga. CIIDIR-DGO 762, 764–765. MUNICIPALITY OF POANAS: 4 km N, 7.8 km E La Joya (23.87638°N, 103.92111°W), 2017 m elev. March 1995. Raúl Muñiz-Martínez. CIIDIR-DGO 521–523. MUNICIPALITY OF SANTIAGO PAPANASQUIARO: 0.7 km S, 2.95 km E Los Herreras (25.15388°N, 105.47083°W), 1964 m elev. 17 April 1995. Raúl Muñiz-Martínez. CIIDIR-DGO 504. MUNICIPALITY OF SÚCHIL: 0.7 km S, 4.6 km W San Miguel de la Michilfa (23.58638°N, 104.10805°W), 2020 m elev. 17–19 July 1985. Raúl Muñiz-Martínez. CIIDIR-DGO 100–106. MUNICIPALITY OF TAMAZULA: 11.1 km S, 2.9 km W Durazno (25.36672°N, 106.94055°W), 1506 m elev. 27 May 2002. Raúl Muñiz-Martínez. CIIDIR-DGO 638. MUNICIPALITY OF VICENTE GUERRERO: 2.0 km S, 1.5 km W Vicente Guerrero (23.71361°N, 104.00055°W), 1920 m elev. 28 July 1989. Raúl Muñiz-Martínez. CIIDIR-DGO 247. All eight localities are new municipality records. Frogs were found in a variety of habitats, including desert scrub, oak forest, subtropical deciduous forest, and coniferous forest.

HYLA EXIMIA (Mountain Treefrog). MUNICIPALITY OF GUANACEVÍ: Ciénega de la Vaca (25.92205°N, 106.16444°W), 3000 m elev. 29 September 2001. Karina Grajales-Tam. CIIDIR-DGO 648–649. MUNICIPALITY OF MEZQUITLAN: 1.5 km N, 3.8 km E Charcos (23.02222°N, 104.26611°W), 2900 m elev. 25 September 1985. Raúl Muñiz-Martínez. CIIDIR-DGO 107. MUNICIPALITY OF NOMBRE DE DIOS: 2.8 km S, 4.0 km W San Isidro de Morillos (23.69611°N, 104.08277°W), 2080 m elev. 16 July 1985. Raúl Muñiz-Martínez. CIIDIR-DGO 99. MUNICIPALITY OF NUEVO IDEAL: 4.75 km N, 5.6 km E Guatimapé (24.85081°N, 104.86673°W), 2040 m elev. 20 October 2000. Rolando González-Trápaga. CIIDIR-DGO 710. MUNICIPALITY OF POANAS: San Atenógenes (23.99139°N, 104.01806°W), 1910 m elev. 12 October 1984. Raúl Muñiz-Martínez. CIIDIR-DGO 01–02. MUNICIPALITY OF SANTIAGO PAPANASQUIARO: 14.5 km N, 81.7 km W Santiago Papanasquiario (25.17522°N, 106.23432°W), 2350 m elev. 25 June 1997. Raúl Muñiz-Martínez. CIIDIR-DGO 565. MUNICIPALITY OF TEPEHUANES: 11.8 km S, 37.2 km W Los Herreras (25.05233°N, 105.86916°W), 2530 m elev. 01 November 1995.

Raúl Muñiz-Martínez. CIIDIR-DGO 514. MUNICIPALITY OF VICENTE GUERRERO: 3.7 km S, 3.45 km W Vicente Guerrero (23.69877°N, 104.02142°W), 1950 m elev. July 2004. Raúl Muñiz-Martínez. CIIDIR-DGO 1062. All eight municipality records are new for Durango, and the Guanaceví locality is the northernmost record for *Hyla eximia* in Mexico, narrowing the range to 90 km NE of our first reported record of *H. wrightorum* for Durango (see below) and 63 km SE for that species from El Vergel, Chihuahua (Lemos-Espinal and Smith 2007). Frogs were found in a variety of habitats including pine forest, oak forest, grasslands, and desert scrub edges.

It should be noted that our identification of *H. eximia* and *H. wrightorum* were based on morphology, primarily size difference between those two previously synonymized species. *Hyla wrightorum* is considered to be larger than *H. eximia* and is reported to have different mating calls and distinctive molecular qualities (Duellman 2001). Duellman (2001) also considered that the southern distributional limit of *H. wrightorum* was located in the Sierra Madre Occidental of SW Chihuahua, but Frost's (2013) amphibian website, apparently based on personal communication with E. Gergus, indicated that its range continues southeastward along the Sierra Madre Occidental almost to the state of México. That pattern specifies that *H. eximia* and *H. wrightorum* have a substantial zone of overlapping ranges from northern Durango (records reported herein) to the southeast as determined by Duellman's (2001) depiction of the distribution of *H. eximia*. Therefore, additional data on mating calls, molecular features, and other systematic characters from the perceived overlapping zones might well alter the taxonomy and established geographic ranges of the two species.

HYLA WRIGHTORUM (Arizona Treefrog). MUNICIPALITY OF TAMAZULA: 1 km N San Juan de Tecuan (25.56972°N, 106.98472°W), 2457 m elev. 22 August 2008. Raúl Muñiz-Martínez. CIIDIR-DGO 1106–1107. First published record for Durango, extending the known range 99.77 km SW from the nearest known locality, 12.3 km SW of El Vergel, Municipality of Balleza, Chihuahua (Lemos-Espinal and Smith 2007). However, see the *Hyla eximia* account above.

SMILSICA BAUDINII (Mexican Treefrog). MUNICIPALITY OF SANTIAGO PAPANASQUIARO: San Juan de Camarones (24.92716°N, 106.41147°W), 580 m elev. 26 June 1997, 12 September 2000. Raúl Muñiz-Martínez. CIIDIR-DGO 547–548, 628. First municipality records and first for Durango since Günther (1885–1902) reported that Forrer collected *Hyla baudinii* in the Municipality of San Dimas near Ventanas; Duellman (2001) did not depict this record on his distribution map. The Santiago Papanasquiario records result in a 58.5 km NNE range extension from the closest known locality, 51 km SSE of Culiacán, Municipality of Cosalá, Sinaloa (Duellman 2001), and 133 km NW from the locality mentioned by Günther (1885–1902). CIIDIR-DGO 547–548 (numbers 1969 and 1970 in Muñiz-Martínez 2000) were previously misidentified as *Pachymedusa dacnicolor*. All specimens were found in tropical deciduous forest.

LITHOBATES BERLANDIERI (Rio Grande Leopard Frog). MUNICIPALITY OF TAMAZULA: Los Frailes (25.64347°N, 106.90050°W), 2527 m elev. October 2003. Raúl Muñiz-Martínez. CIIDIR-DGO 1045–1048. First confirmed records from the municipality. Webb and Baker (1984) reported ranid frogs from this and adjacent localities in Chihuahua as belonging to the *Rana pipiens* group.

Lemos-Espinal and Smith (2007) tentatively assigned some frogs from the eastern slopes of central and southern Sierra Madre Occidental, including those from the localities mentioned by Webb and Baker (1984), to *L. berlandieri*, although they also mentioned the possibility that the frogs belonged to a distinct species. *Lithobates berlandieri* had previously been recorded definitely from the eastern portion of the state (Castañeda-Gaytan et al. 2005; Gadsden et al. 2006).

LITHOBATES CHIRICAHUENSIS (Chiricahua Leopard Frog). MUNICIPALITY OF CANATLÁN: 17.29 km SW Canatlán, Rancho El Duranguero (24.45861°N, 104.93194°W), 2396 m elev. 9 July 2005. Rolando González-Trápaga. CIIDIR-DGO 1234–1235. MUNICIPALITY OF NUEVO IDEAL: 7.8 km N, 3.1 km E Guatimapé (24.87623°N, 104.8912°W), 1940 m elev. 25 November 1995. Rolando González-Trápaga. CIIDIR-DGO 727–729. The two localities represent new municipality records for Durango. No vegetation information is available for these records.

LITHOBATES MAGNAOCULARIS (Northwest Mexico Leopard Frog). MUNICIPALITY OF SANTIAGO PAPASQUIARO: San Juan de Camarones (24.92717°N, 106.41147°W), 580 m elev. 26–27 June 1997, 3 February 2000, 12–13 September 2000. Raúl Muñoz-Martínez. CIIDIR-DGO 555–564, 597–599, 612, 629. New municipality records and only the third locality known from Durango (Webb 1991). The other two records are both from the Municipality of Mezquital: Paso de Sihucori, ca. 46 km S, 25 km W of Teneraca, 6 km S, 4 km W of Mezquital (Webb 1991). All frogs were found in tropical deciduous forest.

SPEA MULTIPLICATA (Mexican Spadefoot). MUNICIPALITY OF MEZQUITAL: 18.25 km S, 0.9 km W Canoas (22.44972°N, 104.30556°W), 2420 m elev. 6 June 1992. Raúl Muñoz-Martínez. CIIDIR-DGO 284–286. MUNICIPALITY OF NUEVO IDEAL: 4.75 km N, 5.6 km E Guatimapé (24.85082°N, 104.86673°W), 2040 m elev. 2 June 2002, 24 August 2000, 20 October 2000. Rolando González-Trápaga. CIIDIR-DGO 703–705, 708–709. MUNICIPALITY OF PUEBLO NUEVO: 6.5 km S, 0.2 km W Pueblo Nuevo (23.32389°N, 105.37250°W), 1560 m elev. 18 November 1993. Raúl Muñoz-Martínez. CIIDIR-DGO 331–333. MUNICIPALITY OF TEPEHUANES: 11.8 km S, 37.2 km W Los Herreras (25.05233°N, 105.86917°W), 2530 m elev. 1 November 1995. Raúl Muñoz-Martínez. CIIDIR-DGO 506. MUNICIPALITY OF VICENTE GUERRERO: 1.0 km N, 1.5 km E Gabriel Hernández (23.82056°N, 104.00833°W), 1900 m elev. 11 August 1984. Raúl Muñoz-Martínez. CIIDIR-DGO 08. Mexican Spadefoots were found in a variety of habitats, including desert shrubland, pine-oak forest, pine forest, and subtropical deciduous forest.

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NATURAL HISTORY NOTES

CAUDATA — SALAMANDERS

AMBYSTOMA JEFFERSONIANUM (Jefferson Salamander). **PREDATION BY THAMNOPHIS SIRTALIS.** *Ambystoma jeffersonianum* is primarily a fossorial species, seldom seen outside of a brief spring breeding season (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Inst. Press, Washington, DC. 587 pp.). Most knowledge of their predators concerns the developing larvae; there is limited documentation of predation upon juveniles and adults (Petranka 1998, *op. cit.*). They are particularly vulnerable when migrating to and from the ponds in which they breed (Petranka 1998, *op. cit.*). The Eastern Garter-snake (*Thamnophis sirtalis sirtalis*) is a generalist predator that would be expected to commonly co-occur with these salamanders, based upon geographic range and habitat preference (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Books, Washington, DC. 668 pp.; Petranka 1998, *op. cit.*). They are known to feed on other ambystomatids, including *A. opacum*, *A. laterale*, and *A. maculatum* (Ernst and Ernst 2003, *op. cit.*). At 2100 h on 10 April 2013 in the State Game Lands No. 176, Centre Co., Pennsylvania, USA (40.77170°N, 77.95856°W; WGS 84) a *T. s. sirtalis* was observed in the process of swallowing an adult *A. jeffersonianum* tail first, which it ultimately completely consumed (Fig. 1). This occurred within 1 m of a vernal pool breeding pond used by *A. jeffersonianum*. To our knowledge, this is the first record of predation by *T. s. sirtalis* on *A. jeffersonianum*.

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JENNIE WILLIAMS (e-mail: williams.jennie@husky.neu.edu) and **JASON LANGSHAW**, Department of Biology, Northeastern University, 413

Mugar Life Science, 360 Huntington Avenue, Boston, Massachusetts 02115, USA (e-mail: langshaw.j@husky.neu.edu); **SEAN P. GRAHAM**, Department of Biology, 508 Mueller Lab, The Pennsylvania State University, University Park, Pennsylvania 16868, USA (e-mail: szg170@psu.edu).

AMBYSTOMA OPACUM (Marbled Salamander). **LARVAL AGGREGATION.** Over several years and at several small-pond breeding sites in Wayne and Jennings counties, Indiana, USA, we observed larval Marbled Salamanders associated with recently laid egg masses of Wood Frogs (*Lithobates sylvaticus*) during March (Fig. 1). Although larval Marbled Salamanders are known to feed on embryos and tadpoles of Wood Frogs in the laboratory and the field (Cortwright and Nelson 1990. Oecologia 83:123–131; Walters 1975. J. Herpetol. 9:267–279), the only published statement intimating aggregation behavior in Marbled Salamander larvae is that by Walters (1975, *op. cit.*) who observed that a “clump of about 30 freshly laid masses [of *sylvaticus*] was surrounded by over 50 larval *A. opacum*.”

On the night of 19 March 2013, nine days after the local peak of Wood Frog breeding at an ephemeral pond in old-growth forest (ca. 38.96555°N, 85.62527°W) on the Crosley Wildlife Management Area, Jennings Co., Indiana, USA, we undertook visual surveys around the entire pond margin to test the hypothesis that Marbled Salamander larvae in this pond were concentrated at the site of Wood Frog egg deposition. With only a single LED headlight, we identified two adjacent clusters of Wood Frog egg masses centered about 0.75 m from the shore. We turned on the light for about 15 seconds at the first cluster and quickly counted the number of larvae in a quadrat area of ca. 0.75 m x 0.75 m. In the dark we moved clockwise around the pond, stopping every



FIG. 1. *Thamnophis sirtalis sirtalis* ingesting an adult *Ambystoma jeffersonianum* tail first, Centre Co., Pennsylvania.



FIG. 1. Larval *Ambystoma opacum* (white circles) in association with egg masses of *Lithobates sylvaticus*, Jennings Co., Indiana.

ca. 2 m (about three paces) to repeat the count, centered on the same distance from the shoreline. All sample sites were similar in microhabitat, but varied in depth from ca. 5 to 15 cm. The second count was located over the second Wood Frog egg cluster, but eggs were found at no other site around the pond. Our larval counts were 25, 25, 2, 0, 0, 0, 4, 3, 3, 5, 9, and 7. The mean larval count away from the egg masses (3.3; $N = 10$) was nearly an order of magnitude fewer than at the egg masses, confirming that Marbled Salamander larvae were strongly associated with Wood Frog eggs. Although we did not sample quantitatively the distribution of Marbled Salamander larvae before Wood Frogs began laying eggs, during our general amphibian surveys at this pond (and others) during November, December, and early March over more than a decade we never found Marbled Salamander larvae concentrated at particular sites along the shoreline prior to Wood Frog breeding. We presume that this larval concentration is facilitated by olfactory cues, and that the association is diet related (references above).

JOHN B. IVERSON (e-mail: johni@earlham.edu) and **MATTHEW P. LACHUISA**, Department of Biology, Earlham College, Richmond, Indiana 47374, USA.

CRYPTOBRANCHUS ALLEGANIENSIS ALLEGANIENSIS (Eastern Hellbender). TERRESTRIAL MOVEMENT. In the Toccoa River (Ocoee River) drainage, a tributary to Blue Ridge Lake, Fannin Co., Georgia, USA, a larval hellbender (evident external gills present; 7 cm TL) was observed moving terrestrially over fine sand and gravel substrate along the margin of a stream ca. one hour before sunset on 16 July 2012. This individual appeared to be emerging from a cover rock (55 cm x 25 cm) with a small, shallow (barely deep enough for submergence) puddle underneath. The cover rock was located adjacent to a riffle of a 5-m-wide stream and was 50 cm from flowing water and 30 cm from open standing water. Terrestrial movement of adult hellbenders has been observed in captivity and in the wild, but to our knowledge this is the first observation of the terrestrial movement of a larval hellbender. Diurnal terrestrial movements have been observed by captive hellbenders at Riverbanks Zoo and Gardens (Columbia, South Carolina) on several occasions, where hellbenders are maintained in captivity within a 2.5 m x 1.5 m x 3 m exhibit that contains a coldwater-flowing stream as well as planted, dry land areas with a soil and leaf litter substrate. Multiple individual hellbenders have been observed exiting the stream and walking along the rear wall of the exhibit and then reentering the water. All of these observations have been made during daylight hours and the hellbenders could be moving on land at night without being observed. In North Carolina, local fishermen have reported observing hellbenders moving on land some distance from the water. Beck (1965, *Field and Stream* 69:64–66, 109–113.) reported catching hellbenders < 1 m from the water's edge with meat-baited mammal traps on more than one occasion along the Allegheny River in Pennsylvania. Terrestrial movement may support biogeographic theory in explaining the distribution of hellbender populations within portions of drainages upstream of apparent barriers to movement (e.g., a hellbender population found upstream of a ca. 35 m waterfall within the Nottely River watershed in Georgia).

Species identification of the larval specimen from this observation was verified from a voucher photograph (K. Krysko and M. Nickerson, University of Florida, Florida Museum of Natural History).

THOMAS M. FLOYD, Georgia Department of Natural Resources, Non-game Conservation Section, 116 Rum Creek Drive, Forsyth, Georgia 31029,

USA (e-mail: Thomas.Floyd@dnr.state.ga.us); **THERESA S. M. STRATMANN**, 125 Trent House Road, Irmo, South Carolina 29063, USA; **GROVER J. BROWN, III**, 14 McKelvey Court, NW, Cartersville, Georgia 30121, USA; **C. SCOTT PFAFF**, Riverbanks Zoo and Garden, 500 Wildlife Parkway, Columbia, South Carolina 29210, USA.

CRYPTOBRANCHUS ALLEGANIENSIS ALLEGANIENSIS (Eastern Hellbender). CANNIBALISM. Although cannibalism in *Cryptobranchus alleganiensis* has been previously reported (Nickerson and Mays 1973. *The Hellbenders: North American Giant Salamanders*. Milwaukee Public Mus. Press; 106 pp.; Petranks 1998. *Salamanders of the United States and Canada*. Smithsonian Institution Press, Washington, D.C. 587 pp.; Phillips and Humphries 2005. *In Lannoo [ed.], Amphibian Declines: The Conservation Status of United States Species*, pp 648–651. Univ. California Press, Berkeley, California), additional cases are worthy of note, since only a few specific reports of this behavior have been recorded from wild caught hellbenders, and there has been no discussion on the possible causes of this behavior. Cannibalism was first reported in *C. a. alleganiensis* by Reese (1903. *Sci. Monthly* 62:526–531). In captivity, he observed a larger hellbender consuming a smaller conspecific. He was able to remove the ingested smaller specimen with forceps, and it swam away unharmed when released in its enclosure. Smith (1907. *Biol. Bull.* 13:5–39) reported a two year-old hellbender in northwestern Pennsylvania, that when placed in quiet water after capture, regurgitated a partly digested 6-cm larval conspecific. The size of the larger specimen was between 12.0 cm and 12.3 cm. The only other reported observation of cannibalism in this species from a wild specimen is that of Humphries et al. (2005. *Herpetol. Rev.* 36:428) who reported that a larger, wild caught, adult male *C. a. alleganiensis* (37.2 cm TL) regurgitated a smaller individual (18.5 cm TL) in the field. The North Carolina population where this occurred is very dense and comprised of all size classes (J. Humphries, pers. comm. and L. Williams, pers. obs.). Here we report another field case of cannibalism from a North Carolina population.

On 29 June 2010, an adult female (39 cm TL) *Cryptobranchus a. alleganiensis* was collected from a fast riffle, in a section of the French Broad River, Transylvania Co., North Carolina, USA (specific locality is recorded with the North Carolina Wildlife Resources Commission and is withheld to protect the population). After data collection, the specimen was held in a mesh bag and lowered into the water in strong, swift current in preparation for its release. During this process and after being subjected to the strong current, it regurgitated a smaller hellbender (21 cm TL) while still in the mesh bag. The consumed hellbender was decaying, and there was a strong odor of rotten flesh (Fig. 1). From our observations and photographs of the carcass, it appears that the adult hellbender grasped the smaller hellbender laterally on its right side (tooth marks identified on dorso-lateral surface of body confirmed by North Carolina Zoo pathologist, Brigid Trovan). Unfortunately, this regurgitated hellbender was not saved due to its advanced state of decay. The locality where this observation was made contains a robust, reproductively active population of hellbenders of all age classes.

In a similar example, Max A. Nickerson (pers. comm. 2012) informed us of wild-caught Ozark Hellbenders (*C. alleganiensis bishopi*) eating smaller conspecifics from the North Fork of the White River in Missouri when they were placed in coolers under crowded conditions. On 12 March 1972, two Ozark Hellbender gilled larvae (9.5 and 13.0 cm TL) were cannibalized when placed



FIG. 1. Cannibalized juvenile *Cryptobranchus alleganiensis*, Transylvania Co., North Carolina.

and pers. obs.). Hellbenders are opportunistic foragers and scavengers and are attracted to food by visual, chemical, and tactile stimuli (Nickerson and Mays 1973, *op. cit.*). It is possible that cannibalism in this species is a density-dependent behavior, primarily related to population size. Denser populations may provide adults with more opportunity to find younger, smaller hellbenders during foraging activities. All reported cases of hellbender cannibalism have come from dense populations (Smith 1907, *op. cit.*; Humphries et al. 2005, *op. cit.*) or in the confines of captivity. Another possible contributing factor to hellbender cannibalism is that in denser populations less food may be available and cannibalism may increase due to fewer or more dispersed food resources. A similar explanation of this behavior has been suggested for other salamanders (Duellman and Trueb 1986. *Biology of Amphibians*. McGraw Hill, New York. 670 pp.). Our observations and reports from other field biologists working with hellbenders suggest that crayfish are less abundant in denser hellbender populations than in smaller or possibly declining hellbender populations.

We thank Max Nickerson for sharing his observations of cannibalism in hellbenders and for allowing us to publish them. Thanks to Brigid Trovan for examining our photographs. We also thank the many volunteers who worked with us throughout our hellbender surveys for their time and efforts.

JOHN D. GROVES, North Carolina Zoological Park, 4401 Zoo Parkway, Asheboro, North Carolina 27205, USA (e-mail: john.groves@nczoo.org); **LORI A. WILLIAMS**, North Carolina Wildlife Resources Commission, 177 Mountain Laurel Lane, Fletcher, North Carolina 28732, USA (e-mail: lori.williams@ncwildlife.org).

PLETHODON CINEREUS (Eastern Red-backed Salamander). **MORPHOLOGY.** *Plethodon cinereus* is the most common woodland salamander in the northeastern United States (Conant and Collins 1998. *A Field Guide to Reptiles and Amphibians of Eastern and Central North America*. Houghton Mifflin Co., Boston, Massachusetts. 616 pp.) This species is polymorphic, and three color variations are commonly recognized and described. The striped or “red-backed” morph is black with a deep red dorsal stripe, the unstriped or “lead-backed” morph is black and lacks a dorsal stripe, and the “erythristic” morph is red with varying degrees of dark mottling. There is also a “leucistic” morph, which is far less common across the range of *P. cinereus*. This morph has general reduction in pigmentation, but retains regular black



FIG. 1. Leucistic individuals of the Eastern Red-backed Salamander, *Plethodon cinereus*, from Geauga Co., Ohio. A) Adult female (33.9 mm SVL) observed 14 Sept 2011. B) Subadult (sex unrecorded; 25.9 mm SVL) observed 14 October 2012.

eyes and is not considered albino. Across the range of *P. cinereus*, three leucistic individuals have been reported from Maryland (Mitchell and Mazur 1998. *Northeast. Nat.* 5[4]:367–369), two individuals from Nova Scotia (Moore and Gilhen 2011. *Can. Field Nat.* 125:58–60) and Massachusetts (Lotter and Scott 1977. *Copeia* 1977:681–690; Mendyk et al. 2010 *Herpetol. Rev.* 41[2]:189–190), and one individual each from West Virginia (Pauley 1974. *The Restart* 42:104), Ontario (Rye 1991. *Can. Field Nat.* 10:573–574), New York (Mendyk et al. 2010, *op. cit.*), Quebec (Moore and Gilhen 2011, *op. cit.*), and New Brunswick (Jongsma 2012. *Herpetol. Rev.* 43[3]:460). Two leucistic individuals from Ohio were discovered on 14 Sept 2011 and 14 October 2012 at the West Woods in Russell Township, Geauga Co. The first individual, an adult female, was found under a partially decomposed hardwood log fragment and the second individual, a subadult, was found under an artificial cover object (slate floor tile). Striped and erythristic phenotypes have also been observed at this site.

These are the first two confirmed records of leucistic *P. cinereus* for Ohio and it is notable that both specimens were observed at the same locality. These individuals were not collected; however photo vouchers (Fig. 1) were deposited in the herpetology collection of the Cleveland Museum of Natural History (CMNH 14071, 14072).

DANIEL J. PALUH (e-mail: dpaluh14@jcu.edu), **CARL D. ANTHONY** (e-mail: canthony@jcu.edu), and **CARI-ANN M. HICKERSON**, Department of Biology, John Carroll University, University Heights, Ohio 44118, USA (e-mail: chickerson@jcu.edu).

ANURA — FROGS

CRAUGASTOR LATICEPS. POSSIBLE OVOVIVIPARITY. All species of *Craugastor* (Craugastoridae) are thought to be direct developers (Hedges et al. 2008. *Zootaxa* 1737:1–182). However, we report an instance in which indirect evidence suggests that *C. laticeps* is ovoviviparous. We collected an adult female *C. laticeps* (MVZ 269388) on the ground about 1–2 h after nightfall on 25 April 2011 in the vicinity of San Isidro (15.11666°N, 88.93333°W, datum WGS 84; elev. 1350 m), Copán, Honduras. The frog was placed alone in a plastic collecting bag. The next morning, upon inspection, the female, together with 44 eggs, each of which included a froglet in an advanced stage of development (tails nearly completely resorbed, limbs well developed, etc.), but still within the egg membranes (with the exception of one, which had emerged from its still present membranes), were present in the bag (Fig. 1A).

The female measures 66 mm SVL. The oviducts of the female are highly contracted and only slightly convoluted, rather than dilated and flaccid as we had anticipated (based on the MHW's experience with recently post parturient viviparous caecilians). The ovaries are contracted and compressed dorsally. A large compacted dark gray mass of presumably undigested dirt in the terminal part of the intestine suggests that the female had been feeding; her stomach was compressed dorsally and the large coelomic space is open and evacuated.

The froglet that had emerged from its egg membrane (MVZ 269391; not illustrated owing to positional distortion) is 14.0 mm SVL. A tiny egg tooth is present; it is bifid, each side terminating as a black tip. Its tail is fully resorbed. The SVL of a froglet freed from its membrane (MVZ 269390) is 13.5 mm; that of two slightly smaller ones (included in MVZ 269389; the 42 other eggs/froglets in the clutch), still in their membranes (but with curvature accounted for) are 12.8 mm and 13.8 mm (the latter featured in Fig. 1B). These dimensions appear to approximate the SVL range for the 44 froglets. One of the two smaller froglets in membranes just mentioned has an irregularly shaped, somewhat flattened, approximately 1.8 x 1.2 mm mass of unresorbed yolk in its gut. All of the froglets appear to retain some yolk. External egg diameters range from 9.5 to 12.0 mm. All of the unemerged froglets (MVZ 269389) are in the same position in their membranes; the hind limbs are folded such that the tibio-femoral joint and feet are near the face; the forelimbs are tucked below the jaw so that the froglets are nearly round objects inside the egg membranes. As seen through the membranes at 60x, most of the froglets have resorbed their tails, but a few appeared to have a small fragment remaining and it is attached to the egg membrane. The bifid black-tipped egg tooth appears to be present in all of the froglets. The pigmentation of the froglets is quite uniform in pattern, and strongly resembles that of the adult female. They have a brown dorsum and a cream venter; the hind legs have bars of

brown on the cream ground color laterally, and the forearms have laterodorsal brown bars. The head is darker brown and more densely pigmented. All along the upper jaw, the brown pigment is interrupted by short, vertical, cream bars; there are two prominent white bars medially over each premaxilla. The bars are prominent and close together, then followed laterally by a broad brown bar. These color data demonstrate the advanced stage of development in the froglets.

The presence of the advanced, egg-membrane-bound froglets in the collecting bag a few hours after the introduction of a single adult female suggests that the species might be ovoviviparous. Furthermore, JRM has never found a clutch of *C. laticeps* eggs during his years of extensive collecting in Honduras. Given the single adult specimen and the circumstances of the discovery, however, a number of presumptions and questions require additional data to verify and resolve. For example, we assume that fertilization in the species is internal, likely by cloacal apposition as in *Eleutherodactylus coqui* (Eleutherodactylidae), although females of that species very shortly ovulate their fertilized eggs whereupon direct development ensues (Townsend et al. 1980. *Science* 212:469–471), in order for developing embryos to be retained in the oviducts of the female. We wonder whether

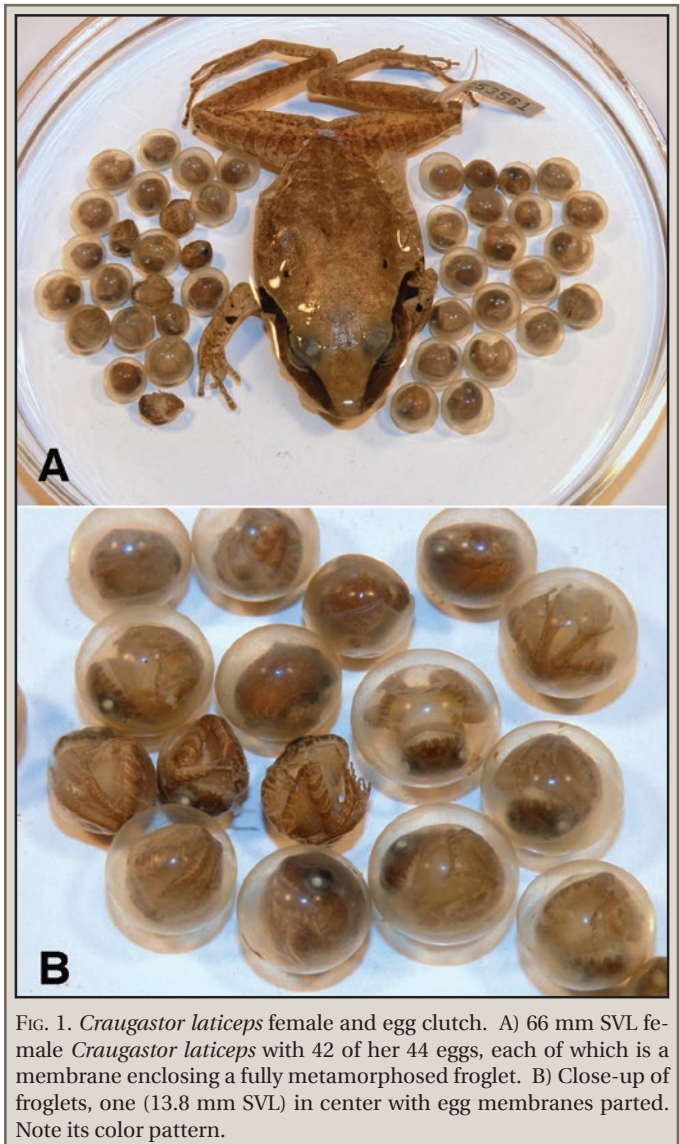


FIG. 1. *Craugastor laticeps* female and egg clutch. A) 66 mm SVL female *Craugastor laticeps* with 42 of her 44 eggs, each of which is a membrane enclosing a fully metamorphosed froglet. B) Close-up of froglets, one (13.8 mm SVL) in center with egg membranes parted. Note its color pattern.

the stress associated with collection precipitated the oviposition of the membrane-bound froglets, such that normally they would hatch in the oviducts just prior to birth, or whether oviposition precedes hatching of the froglets. How she was able to oviposit the large intramembranous froglets without bursting the egg membranes is of biomechanical interest. We have no information on the length of the gestation/developmental period, the endocrine maintenance of the “pregnancy,” nor any aspects of seasonality of reproduction. We lack information on egg sizes and numbers in standard clutches for the species; the presence of some yolk remaining in the gut of the advanced froglets supports the idea that the eggs are relatively large, and that the froglets are dependent on that yolk for their development through metamorphosis.

There are other reports of apparent ovoviviparity in related taxa. The now-extinct *Eleutherodactylus jasperi* (Eleutherodactylidae) was definitely ovoviviparous, based on several females that had 1–5 embryos that developed through metamorphosis in her oviducts (Wake 1978. *J. Herpetol.* 12:121–133). Furthermore, Lynn (1940. *Bull. Inst. Jamaica Sci. Ser.* 1:1–60) reported that he collected adult *E. orcutti* (Eleutherodactylidae) in Jamaica, placed them in a bottle, and upon return from the night’s collecting, found six newly hatched young in the bottle. Lynn suspected ovoviviparity, but his dissections of a number of females gave no support to that idea, and he referred to the finding as “mysterious.”

Our observations similarly leave the reproductive biology of *Craugastor laticeps* mysterious. We urge that extensive field research be initiated for this species (considered vulnerable in the IUCN Red List; 2013. <http://www.iucnredlist.org>). We also strongly recommend that, because specimens are now routinely tissueed, collectors should examine gonads and their ducts to sex adults and record any information relevant to the potential reproductive attributes of the animals that they collect—surprises await!

We thank Daniel Portik for photographing the female and her clutch.

JAMES R. McCRANIE, 10770 SW 164th Street, Miami, Florida 33157–2933, USA (e-mail: jmccrani@bellsouth.net); **MARVALEE H. WAKE**, Department of Integrative Biology and Museum of Vertebrate Zoology, University of California, Berkeley, California 94720-3140, USA (e-mail: mh-wake@berkeley.edu); **LEONARDO VALDÉS ORELLANA**, Gerente General de “Hondufauna,” Investigador Privado, Colonia América, Bloque 9, Casa 1806, Comayagüela, MDC, Honduras (e-mail: leovalor@hotmail.com).

CRAUGASTOR RANIFORMIS (Robber Frog). PARENTAL BEHAVIOR. The genus *Craugastor* contains ca. 113 species distributed in the Americas from the southwestern USA to northwestern South America (AmphibiaWeb 2013. <http://amphibiaweb.org/>). The representatives of this genus have a terrestrial mode of reproduction with direct development, depositing their eggs in fallen leaves or under rocks or tree trunks, where there is moisture for egg development. Parental care has been reported in *Craugastor angelicus*, *C. aurilegulus*, *C. crassidigitus*, *C. decoratus*, *C. fitzingeri*, *C. latrans*, *C. noblei*, *C. psephosypharus*, *C. talamancae* (Jameson 1950. *Copeia* 1950[1]:44–46; Bogert 1969. *Amer. Mus. Novitates* 2367:1–9; Hayes 1985. *J. Herpetol.* 19[1]:168–169; Savage et al. 1988. *Bull. S. California Acad. Sci.* 87:50–56; Campbell et al. 1994. *Herpetologica* 50[4]:412–419; Mendoza-Quijano et al. 2002. *Herpetol. Rev.* 33[2]:125; Whitfield and Pierce 2003. *Herpetol. Rev.* 34[4]:357–358; Ryan 2005. *Herpetol. Rev.* 36[4]:234–236; Whitfield et al. 2008. *Herpetol. Rev.* 39[1]:76). *Craugastor raniformis* occurs from southeast-central Panama to the San Juan

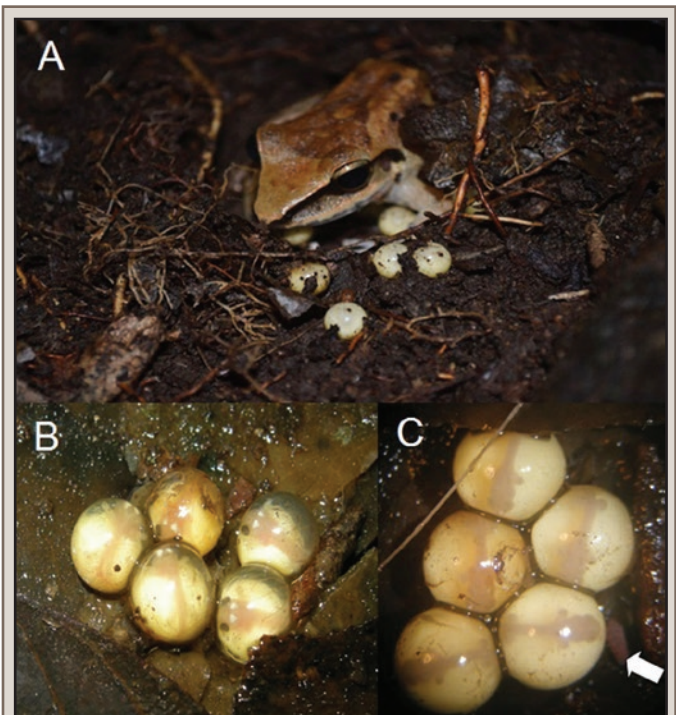


FIG. 1. Parental care in *Craugastor raniformis*. A) Female assisting a nest; eggs in stage 3 of development. B) Egg in stage 5 of development with presence of four limbs; C) Eggs with parasites, the white arrow indicates a parasitic organism.

de Micay River in Cauca, western Colombia, in the forested lowlands on the west side of the Andes Mountain Chain, and possibly as isolated populations in the Cauca and Magdalena River inter-Andean valleys (Lynch and Myers 1983. *Bull. Amer. Mus. Nat. Hist.* 175[5]:481–572). Here we report observations on the parental care of *C. raniformis*, as well as data on nesting sites and nest sizes within a premontane wet forest-warm transition, according to Holdridge classification (Instituto Geográfico Agustín Codazzi 1977. 13[11]:238).

In September 2011, a *C. raniformis* nest cavity measuring 58.8 x 66.7 mm was found in the “corregimiento” of Pianguüita-Bazan, Buenaventura, Valle del Cauca, Colombia (3.845250°N, 77.200001°W, 50 m elev.). The nest was next to a rotting log, in a ca. 60-mm deep hole in the forest floor amid fallen leaves. On 16 Sept at 2100 h, the first observation was made; the nest was found unattended, protected by the trunk and the leaves. Prior to this, an adult female *C. raniformis* (68.7 mm SVL) was seen perched on top of the trunk near the nest, possibly feeding.

The second observation was made on 17 Sept 2011 at 1905 h. An adult female *C. raniformis* was observed tucked into the cavity, on top of an egg clutch, protecting 95% of them with her body and forelimbs (Fig. 1). In addition, when the nest site was disturbed a little, the female performed “push” movements with the front legs in an attempt to not allow us to approach the eggs. Five eggs removed from the nest were completely spherical, with an abundant cream-white colored yolk and a translucent longitudinal band corresponding to the embryo. Five additional eggs were collected for observation of embryonic development. The eggs were in stage 3 (Townsend and Stewart 1985. *Copeia* 1985[2]:423–436). Five days following collection, the eggs began to develop microorganisms which became pathogenic. On the seventh day, when the embryos had reached stage 5 (four limb development; Townsend and Stewart 1985, *op. cit.*) (Fig. 1B), all

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eggs showed a complete invasion of fungi and other organisms' larvae (Fig. 1C), preventing their viability.

Based on this observation, it is likely that attending *C. rani-formis* females influence hatching success by protecting the eggs from attack by fungi and other predators. Females have been observed to leave the nest to perform other activities, although they do not venture far from it.

ALEJANDRO VALENCIA-Z. (e-mail: alejandrovalencia08@gmail.com), **ANDRES F. JARAMILLO-M.** (e-mail: pipejaramillo01@gmail.com), and **FERNANDO CASTRO-H.** (e-mail: fcastro112000@gmail.com), Laboratorio de Herpetología, Departamento de Biología, Universidad del Valle, A.A. 25360, Cali, Valle del Cauca, Colombia.

EUPARKERELLA TRIDACTYLA (*Sapinho-de-folhiço-de-três-dedos*). **DEFENSIVE BEHAVIOR.** *Euparkerella* is an Atlantic Forest endemic genus composed of four slow-moving leaf litter species (Ferreira et al. 2010. Herpetol. Notes 3:57–60). *Euparkerella tridactyla* is distributed throughout south and central regions of Espírito Santo state, southeastern Brazil (Frost 2013. Amphibian Species of the World: an Online Reference. Ver. 5.6. Electronic database accessible at <http://research.amnh.org/herpetology/amphibia/index.html>. American Museum of Natural History, New York; accessed 10 Aug 2013). This is an enigmatic species with few reports on its life history. Here we report for the first time defensive behaviors of *E. tridactyla*.

During fieldwork in 2009, 2012, and 2013, we hand-captured nine individuals of *E. tridactyla* within and around the

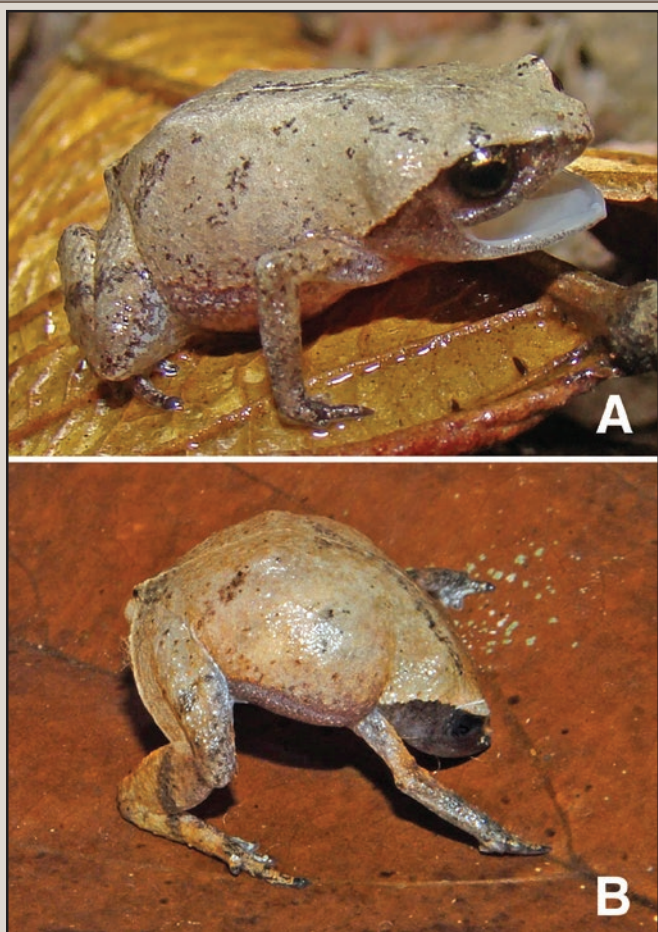


FIG. 1. Defensive behaviors of *Euparkerella tridactyla*: A) mouth-gaping, and B) body-raising display.

type locality, Reserva Biológica Augusto Ruschi (19.90694°S, 40.55553°W, datum: UTM; elev. 724–890 m), Santa Teresa municipality. Seven of these individuals were collected (MBML 7565; 7584–7589). In the field, one individual displayed mouth-gaping behavior (Fig. 1A; MBML 7565). In the laboratory during daytime, another eight individuals displayed immobility, fleeing, and active escape in sequence after being disturbed by forceps. Also in the laboratory, one of these individuals displayed a partial body-raising behavior (Fig. 1B; MBML 7586). The only other report of defensive posture for this genus is for *E. cochranae* displaying stiff-legged behavior (Toledo et al. 2011. Ethol. Ecol. Evol. 23:1–25). Mouth-gaping is presumably a threat display, while elevating the body presumably makes the frog appear larger to a predator.

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RODRIGO B. FERREIRA, Department of Wildland Resources and Ecology Center, Utah State University, Logan, Utah 84322-5230, USA (e-mail: rodrigoecologia@yahoo.com.br); **FABIO HEPP**, Museu Nacional do Rio de Janeiro, Departamento de Vertebrados, Quinta da Boa Vista, São Cristóvão, CEP 20940-040, Rio de Janeiro, Brazil (e-mail: fabiohepp@gmail.com); **CASSIO Z. ZOCCA** (e-mail: zoccabio@hotmail.com) and **FERNANDA C. F. LIRIO**, Sociedade dos Amigos do Museu de Biologia Mello Leitão, Av. José Ruschi, nº 4, CEP 29650-000, Santa Teresa, Espírito Santo, Brazil (e-mail: nanda_clf@hotmail.com).

HYLARANA GUENTHERI (*Günther's Frog*). **DIET.** *Hylarana guentheri* is widely distributed from central Vietnam throughout southern China, including Hainan and Taiwan. The species is common in lowland and mountainous areas (Fei et al. 2009. Fauna Sinica. Amphibia. Vol. 3. Science Press. 559–1847 pp.). The diet includes insects, earthworms, snails, and small frogs (Fei et al. 2010. Colored Atlas of Chinese Amphibians. Sichuan Publishing Group. 519 pp.). Here we report the first case of predation on a bat by this species.

On 11 Sept 2009, we encountered an adult *H. guentheri* on the ground near a pool eating a bat (Mt. Tianmenshan, Shangqing Town, Yingtan City, Jiangxi province, China). We could not identify the bat as only a part of the wing could be seen (Fig. 1). We took a few photos, and the frog jumped into the pool before we could make any further observations.

To our knowledge, there have been very few cases of predation on bats by frogs in the wild, including *Rana esculenta* (Országhová et al. 2003 Biologia 58:291–293) and *Rana ridibunda* (Kuzmin 1999. The Amphibians of the Former Soviet Union. Pensoft Publishers, Sofia. 538 pp.). It is possible that the bat was injured and picked up by the frog, as it may be unusual that the bat was flying near the ground. This report suggests that *H. guentheri* is an opportunistic predator that preys on non-specific food items depending on the availability.

JIAN-HUAN YANG (e-mail: jhyang@kfbg.org) and **YIK-HEI SUNG**, Kadoorie Conservation China, Kadoorie Farm and Botanic Garden, Lam Kam Road, Tai Po, New Territories, Hong Kong SAR, P. R. China (e-mail: yhsung@kfbg.org); **YING-YONG WANG** (e-mail: wangyy@mail.sysu.edu.cn), The Museum of Biology, Sun Yat-sen University, 135 Xingangxi Road, Guangzhou, P. R. China.

INCILIUS NEBULIFER (*Gulf Coast Toad*). **NECROPHILIA.** *Incilius nebulifer* (Bufonidae) occurs along the Gulf Coast of the

United States and Mexico (Mulcahy and Mendelson 2000. *Mol. Biol. Evol.* 17:173–189). At 2255 h on 18 May 2010, in Hidalgo Co., Texas, USA (26.19620°N, 98.12411°W; datum WGS 84), an adult male *Incilius nebulifer* was found amplexed with a deceased female of the same species. The temperature was 25.5°C and approximately 7.2 cm of rainfall occurred that day. The pair was found on a dirt road. The amplexus was photographed and a copy of the image was deposited in the University of Texas–Pan American vertebrate museum (voucher #05109).

Extremely dry habitats impose unique and intense pressures on amphibians. To our knowledge this is the first time this behavior has been observed for this species. This is a noteworthy observation because it may provide insight into the reproductive strategy of these toads in semiarid habitats. There may be an advantage to amplexing dead females if the eggs are still viable and can be extracted and fertilized by the male. This behavior has been described in other anurans and termed “functional necrophile strategy” by Izzo et al. (2012. *J. Nat. Hist.* 46:47–48).

MAYRA OYERVIDES (e-mail: mgoyervides@broncs.utpa.edu) and **FREDERIC ZAIDAN III**, Department of Biology, Center for Subtropical Studies, University of Texas-Pan American, 1201 W. University Dr., Edinburg, Texas 78539, USA (e-mail: fzaidan@utpa.edu).

LEPTODACTYLUS FRAGILIS (Mexican White-lipped Frog). ENDOPARASITES. *Leptodactylus fragilis* ranges from southern Texas to central Colombia and northern Venezuela (Dodd 2013. *Frogs of the United States and Canada*, Vol. 1, Johns Hopkins University Press, Baltimore, Maryland. 460 pp.). The purpose of this note is to add to the list of known helminth endoparasites of *L. fragilis*. A sample of eight *L. fragilis* (mean SVL = 32.4 mm ± 3.5 SD, range = 27–39 mm) was examined for helminths. Frogs were collected in Guanacaste Province, Costa Rica during 1963–64 and 1973–74 (LACM 157201, 157211, 157212, 157226, 157230, 157234, 57240, 157250).

Two nematode species were found in the large intestines. They were identified as *Schrankiana formosula* (N = 68; prevalence, number infected frogs/number examined frogs at 100x = 25%, mean intensity, mean number infected individuals = 34.0 ± 14.1 SD, range = 24–44) and *Cosmocerca podicipinus* (N = 3; prevalence = 38%, mean infection intensity = 1.0). Voucher specimens were deposited in the United States National Parasite Collection (USNPC) as: *Cosmocerca podicipinus* (USNPC 107220) and *Schrankiana formosula* (USNPC 107221). *Schrankiana formosula* is known from *Leptodactylus fuscus* from Brazil and *L. elenae* from Paraguay (Goldberg et al. 2007. *Comp. Parasitol.* 74:327–342). *Leptodactylus fragilis* is the third anuran species known to harbor *S. formosula* and represents a new host record for *Schrankiana formosula*; furthermore, Costa Rica is a new locality record for this nematode. *Cosmocerca podicipinus* is widespread in Meso and South American anurans (Goldberg et al., *op. cit.*) and was previously found in *L. fragilis* in Guanacaste Province, Costa Rica (Burse and Brooks 2010. *Comp. Parasitol.* 77:221–231).

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STEPHEN R. GOLDBERG, Department of Biology, Whittier College, Whittier, California 90608, USA (e-mail: sgoldberg@whittier.edu); **CHARLES R. BURSEY**, Biology Department, Pennsylvania State University, Shenango Campus, Sharon, Pennsylvania 16146, USA (e-mail: cxb13@psu.edu); **JEANETTE ARREOLA**, Department of Biology, Whittier College, Whittier, California 90608, USA (e-mail: jarreola@poets.whittier.edu).

LIMNONECTES GRUNNIENS. SALINE WATER TOLERANCE.

Individuals of *Limnonectes grunniens* were observed and collected (Museum of Vertebrate Zoology; ALS 297–305, 339) along the banks of saltwater channels in the Aru Islands, Maluku, Indonesia. The Aru Islands are a network of 95 islands in eastern Indonesia, most of which are separated by narrow brackish channels. Located on the Sahul Shelf, the Aru Islands share much of their fauna with New Guinea and formed a land bridge with New Guinea and Australia during glacial maxima. Ten *Limnonectes grunniens* were collected at night on 30 September 2011 along a saltwater channel adjacent to Desa Kongan, Kecamatan Aru Tengah, Kabupaten Kepulauan Aru (6.50277°S, 134.39137°E). All individuals were found along the banks of these saltwater channels, though two specimens collected were found on a small rock (2 m x 5 m) surrounded by water inside the channel. These rocks were located at least 3 m from other land and any access to them would require these frogs voluntarily entering saline water even at low tide. In addition, *L. grunniens* frequently jumped into the saline water as an escape response, often attempting to hide motionless under dead leaves or vegetation to avoid detection. Using a refractometer, we measured the salinity of the water in the channel to be 27 parts per thousand, just below the salinity of seawater which is ca. 31–37 parts per thousand. We conclude that this population of *L. grunniens* is capable of tolerating saline water at least for brief periods and represents another example of salt-water tolerance in dicoglossid frogs as also noted for *Feljervarya cancrivora*.

BENJAMIN R. KARIN (e-mail: benkarin@gmail.com) and **ALEXANDER L. STUBBS** (e-mail: astubbs@berkeley.edu), Museum of Vertebrate Zoology, 3101 Valley Life Sciences Building, Berkeley, California 94720-3161, USA; **UMILAELA ARIFIN** (e-mail: umilaela@gmail.com), School of Life Sciences and Technology - Institut Teknologi Bandung, Jl. Ganeca 10 Tamansari, Bandung, Indonesia 40132.

OSTEOPILUS SEPTENTRIONALIS (Cuban Treefrog). POST-INVASION SPREAD. *Osteopilus septentrionalis*, a native hylid of Cuba, was first recorded in Florida, USA, in 1931 in Key West, Monroe Co., where it may or may not have been native (Meshaka 2001. *The Cuban Treefrog in Florida: Life History of a Successful Colonizing Species*. Univ. Florida Press, Gainesville. 191 pp.). The Cuban Treefrog is highly vagile, able to thrive in urban settings and disturbed habitats, and has spread throughout peninsular Florida with a few isolated occurrences in the panhandle (Meshaka 2001, *op. cit.*; Meshaka 2010. *A Runaway Train in the Making: The Exotic Amphibians, Reptiles, Turtles, and Crocodylians of Florida*. Monograph 1. *Herpetol. Cons. Biol.* 6:1–101). Cuban Treefrogs have successfully invaded hardwood hammocks and other natural habitats, but further spread is limited by low relative humidity during the dry season in subtropical Florida and cold climate farther north (Meshaka 2001, *op. cit.*).

Cuban Treefrogs were first observed on the Archbold Biological Station (ABS; Highlands Co., Florida; 27.181°N, 81.350°W; elev. 42 m) more than 20 years ago, based on specimens deposited in the ABS Vertebrate Collection. The earliest ABS specimens were collected in 1987 (from a site 15 km N of ABS) and 1993 (found on the main research building at ABS). However, the first published record for Highlands Co. was in the late 1970s (Stevenson 1976. *Vertebrates of Florida*. Univ. Florida Press, Gainesville. 607 pp.). In July 2009, we saw and heard adult Cuban Treefrogs near a granite-lined drainage ditch that bisects the main grounds of ABS, and individuals were often seen on the exterior of the research building at night.

To determine the extent to which Cuban Treefrogs have invaded adjacent scrub habitats, we installed an array of 50 3.9-cm-diameter PVC pipes extending east and west from the main ditch, with the pipe grid covering an area of ca. 0.1 km². Pipes were checked on average every seven days from October 2009 through November 2010. Captured Cuban Treefrogs were euthanized and preserved, and native hylids were relocated well outside the grid to prevent recapture. We also measured snout-urostyle length (SUL) of most individuals to the nearest mm. In total, we captured nine Cuban Treefrogs (two at the ditch, four at 50 m, one at 100 m, and two at 150 m east of the ditch) and 76 native hylids, including 60 *Hyla squirella*, 14 *H. femoralis*, and two *H. cinerea* as far as 200 m away from the ditch. Mean SUL \pm SD was 37.3 \pm 6.7 mm for *O. septentrionalis* (range 28–45; N = 7), 28.7 \pm 5.3 mm for *H. femoralis* (19–37; N = 13), 23.8 \pm 4.3 mm for *H. squirella* (18–36; N = 47), and 41.0 mm for *H. cinerea* (N = 1).

Although 32% of the captures of native hylids occurred after 28 January 2010, no Cuban Treefrogs were captured after this date. January 2010 was a particularly cold month at ABS with record-setting minimum temperatures. Daily minimum temperatures at ABS were at or below 0° C for six consecutive days, followed by a low temperature of 2.8°C, and then five more days below 0°C; there were three days in January 2010 when the temperature dropped to -7°C. It is plausible that this extended period of extreme cold reduced the population of Cuban Treefrogs at ABS. Furthermore, Cuban Treefrogs have not colonized undisturbed oak scrub and scrubby flatwoods surrounding the developed part of ABS, despite the presence of many seasonally inundated wetlands. In addition to low humidity during the dry season, the frequent application of prescribed fire at ABS may impose a constraint on this species, either directly or indirectly via effects on vegetation structure and availability of suitable refuges. Refuge availability has previously been shown to be a factor limiting abundance of this species (Meshaka 2001, *op. cit.*).

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BETSIE B. ROTHERMEL (e-mail: brothermel@archbold-station.org), **ZACHERY R. FORSBURG**, and **NAIMA C. PHILLIPS**, Archbold Biological Station, 123 Main Drive, Venus, Florida 33960, USA.

RHINELLA GRANULOSA (Granulated Toad). PREDATION. Anurans are preyed upon by several kinds of invertebrates, such as water bugs (Giaretta and Menin 2004. J. Nat. Hist. 38:1711–1722), scorpions (Villanueva-Rivera et al. 2000. Herpetol. Rev. 31:100), spiders (Menin et al. 2005. Phyllomedusa 4:39–47), and all vertebrate groups (Pombal Jr. 2007. Rev. Bras. Zool. 24: 841–843; Toledo et al. 2005 Herpetol. Rev. 36:395–400). The present communication reports predation of *Rhinella granulosa* (Bufonidae) by a banana-spider of the Amazonian genus *Phoneutria* (species unidentified; Ctenidae). At 2118 h on 10 July 2013, the spider was observed preying on an adult male of *R. granulosa* (62.3 mm SVL). Our observation occurred at a residence in an urban area in the municipality of Santana, State of Amapá, North Brazil (0.022778°S, 51.164722°W; datum WGS84). The observation lasted at least eight minutes and during this time the spider had already captured the anuran with the aid of its pedipalps, and its chelicerae were inserted in the prey's lateral body.

DANIEL WELTON SILVA-SILVA (e-mail: dan.ws@hotmail.com), **KELLY JULIANA GAYA CORRÊA** (e-mail: kelly_juliana@hotmail.com), and

CARLOS E. COSTA-CAMPOS, Laboratório de Herpetologia, Departamento de Ciências Biológicas e da Saúde, Universidade Federal do Amapá, Campus Marco Zero, 68903-280, Macapá, AP, Brazil (e-mail: eduardocampos@unifap.br).

RHINELLA SCHNEIDERI (Cururu Toad). DIET. *Rhinella schneideri* is a large bufonid found in open and urban areas, and is widely distributed in South America, inhabiting some regions of Brazil, Paraguay, Bolivia, Argentina, and Uruguay (Pramuk 2006. Zool. J. Linn. Soc. 146:407–452). This species feeds mainly on arthropods (Batista et al. 2011. Herpetol. Notes 4:17–21; Duré et al. 2009. Phyllomedusa 8:27–39; Lajmanovich 1994. Rev. Hydrobiol. Trop. 27:107–112; Moreira and Barreto 1996. Rev. Bras. Zool. 123:313–320), however, like many anurans, it is considered to be a generalist and opportunistic predator.

On 08 February 2013, we collected a female *R. schneideri* (SVL = 905.5 mm; CFBH 35704) from a ranch on the Tietê River, located within the municipality of Barbosa, São Paulo state, southeast Brazil (21.25048°S, 49.92132°W; datum WGS84; elev. 371 m). Stomach contents included ten individuals of newly metamorphosed *Dermatonotus muelleri* (Mueller's Narrow-mouthed Frogs; mean SVL = 16.1 mm). It is known that adults of *R. schneideri*, as well as some congeneric species (Camilotti and Barreto-Lima 2011. Bioscience J. 27:993–994) feed on small vertebrates, such as birds (Vaz-Silva 2003, *op. cit.*) and legless lizards (Oda and Landgraf 2012. Bol. Assoc. Herpetol. Esp. 23:57–59). However, to our knowledge, this is the first record of an adult *R. schneideri* preying upon an anuran. At the time our observation was made, there was a massive emergence of *D. muelleri* in the area, which corroborates the opportunistic feeding behavior of *R. schneideri*. All specimens are housed at Coleção de Anfíbios “Célio F. B. Hadad” at UNESP, Rio Claro, Brazil.

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RODRIGO SAMUEL BUENO GAVIRA (e-mail: rodrigogavira@yahoo.com.br), **RAFAEL PARELLI BOVO** (e-mail: rpbovo@yahoo.com.br), and **DENIS VIEIRA ANDRADE**, Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, Rio Claro, São Paulo, Brazil, Caixa Postal 199, CEP 13506–900 (e-mail: denis@rc.unesp.br).

GYMNOPHIONA — CAECILIANS

DERMOPHIS GLANDULOSUS. PREDATION BY MICRURUS ALLENI. Little is known regarding predation on caecilians, due mainly to their fossorial nature and the difficulty to find them. It has been suggested that various semifossorial and fossorial snakes appear to be major predators of these amphibians (Savage 2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna between Two Continents, between Two Seas. Univ. Chicago Press, Chicago, Illinois. 934 pp.). Roze (1996. Coral Snakes of the Americas: Biology, Identification, and Venoms. Krieger Publ. Co., Malabar, Florida. 340 pp.) found that the coral snake *Micrurus nigrocinctus* eats caecilians, however he did not identify prey species. Solórzano (2004. Serpientes de Costa Rica: Distribución, taxonomía e historia natural. INBio, Heredia, Costa Rica. 792 pp.) suggested that other species of *Micrurus* also include caecilians in their diet.

On 18 April 2012, a juvenile male *Micrurus alleni* (UCR 21534) was found near Rio Sonador in Volcán of Buenos Aires, Puntarenas, Costa Rica (9.29797°N, 83.47062°W, WGS84; 1120 m elev.).

This region is classified as premontane rainforest (Bolaños et al. 2005. Mapa Ecológico de Costa Rica. Centro Científico Tropical, San José, Costa Rica). A few hours after collection the snake (420 mm TL) regurgitated a caecilian *Dermophis glandulosus* (UCR 21533; 240 mm TL). This specimen showed mechanical damage in the head and nuchal region, suggesting that it was ingested head first.

This is the first record of a predator for *D. glandulosus*, and also the first report of the species in the diet of *M. alleni*, supporting the hypothesis that coral snakes feed on caecilians. Solórzano (2005. Rev. Biol. Trop. 53:227–228) indicated that the diet of *M. alleni* is composed primarily of Marbled Swamps Eels (*Symbranchus marmoratus*); however, this eel is found in Costa Rica from sea level to 650 m elev. (Bussing 1998. Rev. Biol. Trop. 46:1–468), while *M. alleni* is relatively common from sea level to 1500 m elev. (Solórzano 2004, *op. cit.*), suggesting a dietary shift at higher elevations.

ERICK ARIAS (e-mail: eapiedra@gmail.com) and **GERARDO CHAVES**, Museo de Zoología, Escuela de Biología, Universidad de Costa Rica, San Pedro, 11501-2060, San José, Costa Rica (e-mail: cachi13@gmail.com).

TESTUDINES — TURTLES

CHRYSEMYS PICTA PICTA (Eastern Painted Turtle). **PREDATION.** On 22 August 2012 at 1030 h we observed a second-year Bald Eagle (*Haliaeetus leucocephalus*) kill and consume an adult *Chrysemys picta picta* along the bank of a farm impoundment at Chesapeake Farms, Kent Co., Maryland, USA (39.1962°N, 76.21707°W). The *C. p. picta* was basking ca. 1.5 m up the gradual, muddy bank of the 6.5-acre impoundment when the eagle landed beside the turtle, used both feet to turn the turtle on edge, and grasped the turtle in its left talon. The bird then flew to a height of ca. 15 m and dropped the turtle on the bank, at which point the turtle attempted to right itself. This pattern was repeated several times until the turtle remained motionless upon landing. The *H. leucocephalus* then picked up the *C. p. picta* and flew to a perch ca. 250 m from the capture sight and ca. 10 m above the ground, where it was seen consuming the apparently dead *C. p. picta*.

Ernst and Lovich (2009. Turtles of the United States and Canada. Johns Hopkins University Press, Baltimore, Maryland. 840 pp.) lists *H. leucocephalus* among the many predators of *C. p. picta*, but careful scrutiny of references therein (e.g., Vogt 1981. Natural History of Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, Wisconsin. 205 pp.; Ross 1989. Wisconsin Endangered Species Report 59:1–33) and other studies of the diet of *H. leucocephalus* (e.g., Smith 1936. Auk 53:301–305; Imler and Kalmbach 1955. U.S. Fish Wildl. Serv. Circ. 30; Clark 1982. J. Field. Ornithol. 53:49–51) reveals that such assertions are based on observations of *C. p. picta* shells below or in active *H. leucocephalus* nests. It is thus unclear if the turtles noted in these studies were depredated or collected as carrion, as *H. leucocephalus* is a frequent and voracious scavenger (e.g., Buehler 2000. In: The Birds of North America, No. 506: 40; Wilmer et al. 2003. Ecol. Lett. 6:996–1003). Further, if these *C. p. picta* were indeed depredated, the studies fail to document the means by which the turtles were killed by *H. leucocephalus* or if the turtles were consumed by non-nestling *H. leucocephalus*. Thus this observation apparently represents the first reported direct observation of predation of *C. p. picta* by *H. leucocephalus* and provides evidence for the inclusion of *C. p. picta* in the diet of non-nestling *H. leucocephalus*.

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AARON R. KROCHMAL, Department of Biology, Washington College, 300 Washington Avenue, Chestertown, Maryland 21620, USA (e-mail: akrochmal2@washcoll.edu); **STEVE HAMILTON**, 27996 Redmill Street, Kennedyville, Maryland 21645, USA.

LEPIDOCHELYS OLIVACEA (Olive Ridley Sea Turtle). **LEUCISTIC HATCHLING.** Along the Odisha coast of eastern India, “*arribadas*” (simultaneous mass nestings) of Olive Ridley Sea Turtles occur at three beaches *viz.*, Gahirmatha, Devi, and Rushikulya. Gahirmatha Beach, within Bhitarkanika National Park, was once regarded as the largest reported *arribada* nesting ground for Olive Ridleys in the world (Bustard 1976. Tigerpaper 3:25). The other two sites, Devi and Rushikulya, are outside the protected area, but are regularly monitored by the Odisha Forest Department during the nesting period.

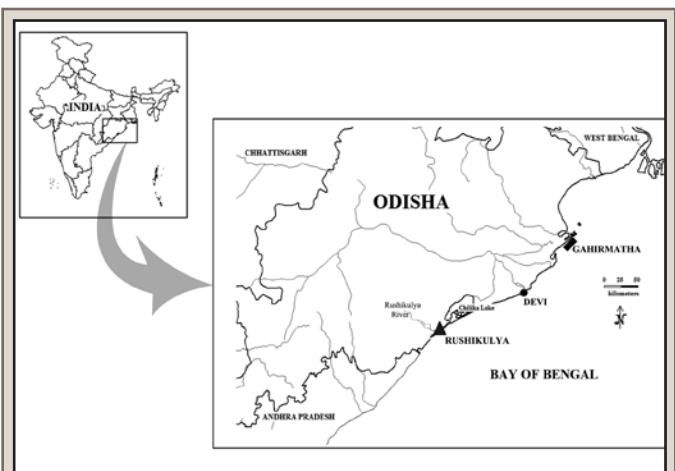


FIG. 1. Map showing the three *arribada* sites in Odisha coast. Solid fill triangle = site of observation at Rushikulya Beach. The coastline between these sites is used by *Lepidochelys olivacea* for sporadic nesting.



FIG. 2. *Lepidochelys olivacea* hatchlings observed at Rushikulya. A) Leucistic hatchling; arrow marks showing normal eye color and black sutures between plates of the carapace. B) Typical black hatchlings. C) Cluster of normal hatchlings. D) Arrow indicates the narrow white line surrounding the carapace of normal hatchlings.

Rushikulya Beach (19.3945°N, 85.0896°E; WGS 84) is the southernmost nesting site along the Odisha coast (Pandav et al. 1994. A Status Survey of Olive Ridley Sea Turtle [*Lepidochelys olivacea*] and its Nesting Habitats along the Orissa Coast, India. Wildlife Institute of India, Dehradun. 48 pp.). The site falls in the Ganjam district and is north of the Rushikulya River mouth from Purunabandha to Kantiagada village (Fig. 1). In 2012, an *arribada* occurred during the first week of March at Rushikulya Beach and the associated hatching event started after approximately 50 days (mid-April).

On 22 April 2012, while observing the hatching event we came across a rare leucistic hatchling of *L. olivacea*, along with the normal gray/black form (Fig. 2A). The white hatchling looked similar to the black form in size, shape, and structures (Fig. 2B). It was not a true albino because its eyes were of normal black color (typically red in albinos). It had a grayish tinge on the head and edge of the flippers. The sutures between the plates of the carapace and upper part of the beak were blackish. Normal hatchlings are dark gray, but appear black when wet (Fig. 2C), and a narrow white line surrounds the carapace, as well as the trailing edge of the fore and hind flippers (Fig. 2D). The leucistic hatchling was not collected as the species is protected. A literature survey suggests that the leucistic form of *L. olivacea* has not been reported earlier from the Indian coast. Media photographic records are available for leucistic sea turtles from Florida, and some studies have been performed on malformations in hatchlings of *L. olivacea* outside India (Ibarra and Gasca 2009. Vet. Méx. 40:371–380). A thorough monitoring of nesting sites in India during peak season may reveal additional aberrancies or deformities which might provide new insights on the biology and physiology of this species.

ANGSHUMAN RAHA (e-mail: adroitangshuman@gmail.com) and **PROSENJIT DAWN** (e-mail: prosenjit.dawn@gmail.com), Zoological Survey of India, Prani Vigyan Bhavan, M-Block, New Alipur, Kolkata-700053, West Bengal, India

TERRAPENE CAROLINA (Eastern Box Turtle). **DIET.** *Terrapene carolina* is known to consume carrion and small snakes,



FIG. 1. Eastern Box Turtle (*Terrapene carolina*) scavenging road-killed Cottonmouth (*Agkistrodon piscivorus*), Jackson Co., Mississippi, USA.

including snakes in the genus *Agkistrodon* (Jensen 1999. Herpetol. Rev. 30[2]:95; Ernst and Lovich 2009. Turtles of the United States and Canada. Johns Hopkins Univ. Press, Baltimore, Maryland. 840 pp.). On 5 July 2013, at approximately 1745 h, BD observed a road-killed *A. piscivorus* in Jackson Co., Mississippi, USA (30.528056°N, 88.548889°W, datum WGS84/NAD83). Upon returning 5 minutes later he discovered an adult *T. carolina* feeding on the snake carcass (Fig. 1). Photos were taken and the turtle was left undisturbed. Later that same evening, the turtle could not be located but the snake had been pulled to the margin of the road, possibly by the turtle. Similar behavior was noted by Jensen (*op. cit.*). This is the first diet record of a *T. carolina* consuming *A. piscivorus*. This observation also highlights an additional vulnerability of *T. carolina* to road mortality while scavenging carcasses.

BRYAN DAVIS, 3700 Howard Davis Rd, Moss Point, Mississippi 39562, USA (e-mail: bryandavisoutdoors@gmail.com); **ROGER D. BIRKHEAD**, Alabama Science In Motion, Auburn University, Auburn, Alabama 36849-5414, USA (e-mail: birkhrd@auburn.edu).

CROCODYLIA — CROCODYLIANS

ALLIGATOR MISSISSIPPIENSIS (American Alligator). **MAXIMUM CLUTCH SIZE.** *Alligator mississippiensis* is an oviparous crocodylian species that is characteristic of the Gulf Coast and lower Atlantic Coastal Plains of the USA (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 nesting ecology and clutch characteristics of this species have been well documented (Hall 1991. J. Herpetol. 25:133–141; Joanen and McNease 1989. Am. Zool. 29:987–998). The maximum clutch size previously reported for *A. mississippiensis* is 75 eggs (Platt et al. 2004. Florida Field Nat. 32:102–106), collected in 1925 from a nest at Lake Miccosukee, Jefferson Co., Florida, USA.

On 27 June 2012 two of us (LWJ and JJ) collected a clutch from a single nest containing 91 eggs. Further examination of the eggs for banding patterns (i.e., to determine viability) revealed that of the 91 eggs, 82 were fertile and 9 were infertile. The clutch was subsequently taken and hatched in captivity under optimum conditions. The clutch produced 60 hatchling alligators (66% success) on 30 August 2012. The clutch was collected on Eagle Lake in southeastern Colorado Co., Texas, USA (29.55870°N, 96.35287°W, WGS84; 46.6 m elev.)

Detailed examination of the eggs revealed essentially identical size and shape. In oviparous reptiles, data suggest that variability in egg width is restricted by the diameter of the pelvic aperture (Congdon and Gibbons 1985. Herpetologica 41:194–205; Thorbjarnarson 1994. Copeia 1994:907–919; Werner 1989. Israeli J. Zool. 35:199–213). Consequently, because of the egg homogeneity coupled with the uniform hatching date, we hypothesize this clutch was most likely produced by a single gravid female.

CORD B. EVERSOLE (e-mail: cord.eversole@students.tamuk.edu) and **SCOTT E. HENKE**, Department of Animal, Rangeland, and Wildlife Sciences, Caesar Kleberg Wildlife Research Institute (MSC 218), Texas A&M University-Kingsville, Kingsville, Texas 78363, USA; **RANDY L. POWELL**, Department of Biological and Health Sciences (MSC 158), Texas A&M University-Kingsville, Kingsville, Texas 78363, USA; **LARRY W. JANIK** and **JASON JANIK**, Janik Alligators LLC, El Campo, Texas 77437, USA.

ALLIGATOR MISSISSIPPIENSIS (American Alligator). **NESTS USED BY OTHER REPTILES IN COASTAL LOUISIANA.** Alligator nests have been documented to serve as commensal nesting

sites for other reptiles in the southeastern USA (see review and references in Enge et al. 2000. *J. Herpetol.* 34:497–503). Several species of turtle have been identified to nest in alligator nests in these studies, including *Pseudemys nelsoni* (Florida Redbelly), *Apalone ferox* (Florida Softshell), *Kinosternon subrubrum* (Florida Mud Turtle), *K. bairii* (Striped Mud Turtle), and *Sternotherus odoratus* (Common Musk Turtle) (Deitz and Jackson 1979. *J. Herpetol.* 13:510–512; Enge et al., *op. cit.*; Kushlan and Kushlan 1980. *Copeia* 1980:930–932). Eggs of *Anolis carolinensis* (Green Anole) have also been found in alligator nests (Deitz and Jackson, *op. cit.*; Kushlan and Kushlan, *op. cit.*), although far less commonly than turtle eggs. Snake eggs are also rarely found in alligator nests, but Deitz and Jackson (*op. cit.*) described *Farancia abacura* (Mud Snake) eggs in one alligator nest in Florida, as well as several specimens of *Seminatrix pygaea* (Swamp Snake) and *Nerodia cyclopion* (Green Water Snake).

In Louisiana, four clutches of *F. abacura reinwardtii* (Western Mud Snake) eggs and one female were found in two alligator nest mounds; one nest had been depredated and the other appeared to be a false nest (Hall and Meier 1993. *Copeia* 1993:219–222). Additionally, *S. odoratus* eggs were located within two alligator nests in southwestern Louisiana, with two additional nests containing *F. abacura* specimens and eggs (Carbonneau 1987. Unpubl. M.S. thesis. Louisiana State Univ. 54 pp.). We herein report on findings of new reptiles using alligator nests for egg deposition sites in coastal Louisiana, which to our knowledge have not been previously documented.

Alligator eggs were collected from numerous nests on Rockefeller Wildlife Refuge in Cameron and Vermilion parishes for various research projects between 25 June and 2 July 2013. Two clutches of snake eggs were incidentally found within alligator nests. The snake eggs (clutch 1, N = 12; clutch 2, N = 4) were in the nest mound, but not within the egg cavities in which the alligator eggs were deposited. The snake eggs were collected and incubated in a field incubator in the same manner as alligator eggs, as previously described (Joanen and McNease 1977. *Proc. World Mariculture Soc.* 8:483–489). On 23 July we noted the presence of shed snake skins adhering to the wire mesh container in which the eggs had been placed; regrettably the ventilation holes were large enough to allow escape of the hatched snakes. Examination of the eggshells suggested 8 of 12 eggs from the larger clutch had hatched. The shed skins were collected, and viewed under a dissecting microscope. The presence of one preocular scale and two postocular scales from one shed skin was indicative the hatched snakes were likely *Lampropeltis getula holbrooki* (Speckled Kingsnakes).

One egg of the second clutch of four eggs was then dissected, as we were concerned they were non-viable. A near-term Speckled Kingsnake was noted and the remainder of the clutch was then moved to a more secure container for continued incubation. On the morning of 26 July we found a live Speckled Kingsnake had hatched; it measured 21.0 mm TL, 18.5 SVL, and had a mass of 4.07 g. That afternoon a second snake was beginning to emerge. We attempted to assist it in liberating itself from the egg by gently cutting the eggshell further. The snake did not readily emerge so we replaced the egg mass in the incubator. The following morning that egg had hatched, the snake measured 22.5 mm TL, 20.0 mm SVL, and 4.42 g. Both snakes were released to the wild near the field incubator on the day of hatching. The remaining egg appeared desiccated and non-viable.

On 29 July 2013, we visited six additional alligator nests to collect vegetation and soil samples for an associated research

project. Two nests contained presumed skink eggs, but we had not previously attempted to incubate these, although we commonly encounter them in alligator nests. Each clutch contained approximately five eggs; some may have been overlooked due to their small size. One egg in one clutch appeared collapsed and non-viable when collected and incubated in our field incubator. On 5 August two hatchling Ground Skinks (*Scincella lateralis*) were found in the incubator; they each had a mass of 0.14 g. These were released near the field incubator that afternoon. On 8 August six more *S. lateralis* were found hatched. Four had masses of 0.17 g, and one had a mass of 0.11 g and another of 0.15 g. We suspect the two smaller skinks may have hatched with those measured on 5 August but were undetected, having been burrowed in the nesting vegetation at the time.

We incidentally collected twenty clutches of alligator eggs from nests on White Lake Conservation Area in Vermilion Parish, Louisiana on 23 June 2009. One nest contained ten *Pseudemys concinna* (River Cooter) eggs. These were incubated at our field laboratory and seven turtles hatched on 2 August. We occasionally find turtle eggs in coastal marsh nests on Rockefeller Refuge, but far less frequently than in Florida lakes as per Enge et al.'s (2000) multi-year, multi-site study (26.6% of 1586 active alligator nests had *P. nelsoni* eggs).

Kushlan and Kushlan (*op. cit.*) noted that commensal nesting in vertebrates is rare, thus our finding of three previously unreported reptile species using alligator nests is of interest. We regularly see *L. getula holbrooki* locally, and *S. lateralis* was the most commonly encountered reptile in a herpetofaunal study conducted in a nearby chenier habitat (W. Selman, unpubl. data). The River Cooter, however, occurs less commonly in southwestern Louisiana marsh habitats (Dundee and Rossman 1989. *The Amphibians and Reptiles of Louisiana*. Louisiana State Univ. Press, Baton Rouge, Louisiana. 300 pp.). The advantages and disadvantages of turtles nesting in alligator nests were discussed in detail by Enge et al. (*op. cit.*, and references therein). Hall and Meier (*op. cit.*) also discussed strategic advantages of commensal nesting in alligator nests for nesting turtles and snakes (and their eggs). Similar benefits and adverse effects may play a role in other reptiles using alligator nests, such as the taxa described herein: *L. getula holbrooki*, *S. lateralis*, and *P. concinna*.

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RUTH M. ELSEY (e-mail: relsey@wlf.la.gov), **WILL SELMAN, RYAN KING, MICKEY MILLER**, Louisiana Department of Wildlife and Fisheries, Rockefeller Wildlife Refuge, 5476 Grand Chenier Highway, Grand Chenier, Louisiana 70643, USA; **STEVEN G. PLATT**, Wildlife Conservation Society, 2300 Southern Blvd. Bronx, New York 10460, USA (e-mail: sgplatt@gmail.com).

SQUAMATA — LIZARDS

ANOLIS EQUESTRIS (Cuban Knight Anole). **NOCTURNAL ACTIVITY.** *Anolis equestris* is native to Cuba and has been introduced to Florida, USA (Kraus 2009. *Alien Reptiles and Amphibians: A Scientific Compendium and Analysis*. Springer, Dordrecht, Netherlands. 563 pp.; Krysko et al. 2003. *Florida Sci.* 66:74–79). This species consumes a wide variety of animals and plants including vertebrates, invertebrates, and fruit (Camposano et al. 2008. *Iguana* 15:212–219, Giery et al., unpubl.). Documented activity times for populations in southern Florida indicate that *A. equestris* activity falls between mid-morning and late afternoon, ceasing at sunset (Meshaka et al. 2004. *The Exotic Amphibians*

and Reptiles of Florida. Krieger Publ. Co., Malabar, Florida. 166 pp.). Here, we report on nocturnal activity of *A. equestris* in South Florida.

On 18 April 2013 between 2203–2215 h, a single adult *Anolis equestris* was observed at Fairchild Tropical Botanical Gardens, Miami, Florida, USA (25.677°N, 80.276°W, WGS84; <1 m elev.). This individual was observed consuming Lepidoptera attracted to an artificial light source positioned above a doorway. Nocturnal lizards (*Hemidactylus mabouia*) were also present around the light source and could represent another potential prey source for nocturnally foraging *A. equestris*. This is the first documentation of *A. equestris* using artificial light sources to allow for nocturnal activity.

JAMES T. STROUD, Department of Biological Sciences, Florida International University, 11200 SW 8th St, Miami, Florida 33199, USA (e-mail: JamesTStroud@gmail.com); **SEAN T. GIERY**, Department of Biological Sciences, Florida International University, 3000 NE 151st St, North Miami, Florida 33181, USA (e-mail: stgiery@gmail.com).

ANOLIS EQUESTRIS (Cuban Knight Anole) and ANOLIS DISTICHUS (Hispaniolian Bark Anole). EXOTIC INTRAGUILD PREDATION. *Anolis equestris* is native to Cuba and *A. distichus* is native to Hispaniola; both have been introduced to Florida, USA (Kraus 2009. Alien Reptiles and Amphibians: A Scientific Compendium and Analysis. Springer, [Dordrecht, Netherlands], 563 pp.; Krysko et al. 2003. Florida Sci. 66:74–79). *Anolis equestris* consumes a wide variety of animals and plants including vertebrates, invertebrates and fruit (Camposano et al. 2008. Iguana 15:212–219, Giery et al. 2013. Functional Ecol. 2013:1–6). Documented activity times for populations in southern Florida indicate that *A. equestris* activity falls between mid-morning and late afternoon, ceasing at sunset (Meshaka et al. 2004. The Exotic Amphibians and Reptiles of Florida. Krieger Publ. Co., Malabar, Florida. 166 pp.). Here, we report on an intraguild predation event of *A. equestris* in South Florida (Miami) on an *A. distichus*.

On 28 August 2013 at 1504 h, a single adult female *Anolis equestris* was observed at Florida International University, Modesto A. Maidique Campus, Miami, Florida (25.757°N, 80.376°W, WGS84; ~2 m elev.). This individual was observed consuming a juvenile *A. distichus* on a tree at ~2 m height. Ingestion took <1 minute. Prior to the predation event, the *A. equestris* was a uniform dark brown base color, with faded yellow barring. Upon predation of the smaller anole, the *A. equestris* rapidly returned to a more typical pattern—green base color with a yellow bar above the shoulder of the forelimb. During the predation event an adult male *A. distichus* was observed performing dewlap extension displays at the *A. equestris* from a distance of ~55 cm. Following consumption, the *A. equestris* proceeded to try and catch an adult female *A. distichus* between 1507–1508 h but failed. This is the first recorded observation of *Anolis equestris* preying on *Anolis distichus* in Florida.

JAMES T. STROUD, Department of Biological Sciences, Florida International University, 11200 SW 8th St, Miami, Florida 33199, USA; e-mail: JamesTStroud@gmail.com.

ANOLIS SAGREI (Brown Anole). SEXUAL CANNIBALISM. Sexual cannibalism occurs when a reproductive adult kills and consumes a potential mate. This form of sexual conflict is common among invertebrates, especially arachnids (Birkhead et al. 1988. Behaviour 106:112–118; Dick 1995. J. Zool. 236:697–706; Kaston 1970. Trans. San Diego Soc. Nat. Hist. 16:33–82; Polis 1980. Annu.

Rev. Ecol. Syst. 12:225–251), and typically involves the consumption of males by females. In contrast to its frequent occurrence among invertebrates, cannibalism of any form among adult vertebrates is typically reported only in isolated instances in captivity or under stressful conditions (Amstrup et al. 2006. Polar Biol. 29:997–1002; Gander 1934. Copeia 187; Martinez-Freiria et al. 2006. Herpetol. Bull. 96:26–28). Here, we describe four separate occurrences of sexual cannibalism involving the consumption of adult female *Anolis sagrei* by conspecific males, two of which occurred under natural conditions in a wild population.

Brown Anoles exhibit pronounced sexual size dimorphism. Males from our study populations on the islands of Eleuthera and Great Exuma in The Bahamas exceed females by 22–32% in mean adult snout–vent length (SVL) and 106–153% in mean adult body mass (Cox and Calsbeek 2010. Evolution 64:798–809). Both sexes typically consume a variety of small invertebrates, but only rarely consume vertebrate prey (Norval et al. 2007. Russ. J. Herpetol. 17:131–138). Although males of *A. sagrei* and other *Anolis* species are known to cannibalize conspecific juveniles (Cochran 1989. Herpetol. Rev. 20:70; Gerber 1999. Anolis Newsl. V:28–39; Gerber and Echternacht 2000. Oecologia 124:599–607; Nicholson et al. 2000. Herpetol. Rev. 31:173), we report cannibalism among adult *Anolis* lizards in the wild.

During a mark-recapture study in September 2007 on Eleuthera, The Bahamas (24.83°N, 76.32°W), we captured and temporarily confined ca. 20 *A. sagrei* adults of both sexes together in a 6-gal plastic bucket (containing a large pile of sea grape leaves, *Coccoloba uvifera*, to provide individuals with shelter and spatial structure) for transport to a nearby field station. Upon removal of the animals for measurement ca. 2–4 h after capture, two individual adult males were found with the hind limbs and tails of females protruding from their mouths. Both females had lacerations and bite marks on their heads and necks and were dead or nearly dead when removed from the males. We did not document the sizes of the individual males and females in this incident, which we interpreted as an unfortunate and unnatural response to high density and stressful conditions.

We later observed two separate instances of sexual cannibalism under natural conditions during mark-recapture studies of a second population on Regatta Point, near Georgetown, Great Exuma, The Bahamas (23.5°N, 75.75°W). On 7 September 2010, we captured an adult male that was lethargic and visibly



FIG. 1. Conspecific female removed from the mouth of male *Anolis sagrei*.

encumbered. Upon capture, the male immediately regurgitated a conspecific female that he had swallowed headfirst. The female was dead but nearly intact, with only the anterior tip of her head exhibiting signs of digestion. The female weighed 1.0 g (measured to the nearest 0.1 g with a Pesola spring scale) and the SVL and mass of the male after regurgitation were 63 mm and 6.2 g respectively. Although we did not dissect the female comestible to assess her reproductive condition, she exceeded the minimum size of maturity that we have previously established for this population (Cox and Calsbeek 2010. *Evolution* 64:1321–1330). In a separate instance on 28 May 2013, we captured an adult male with the hind limb of a conspecific female protruding from his mouth. The female was extracted and found to be partially digested, with digestion most pronounced at the anterior end (Fig. 1). The partially digested female weighed 1.0 g, and the SVL and mass of the male after regurgitation were 63 mm and 4.9 g respectively. Dissection of the female revealed mature ovaries with enlarged, vitellogenic follicles, indicating sexual maturity.

Although we do not know how frequently adult males of *Anolis sagrei* prey upon conspecific adult females, our independent observations under natural conditions suggest that sexual cannibalism in this species is not limited to isolated instances or unnatural conditions. In arthropods, sexual cannibalism of males by females has been interpreted as adaptive for males in cases where males have a low chance of finding another mate, and when being consumed during copulation leads to greater paternity (Andrade 1996. *Science* 201:70–72). This behavior may also be explained by adaptive mate choice in females if the decision of whether or not to cannibalize the male prior to mating is influenced by indicators of his genetic quality (Pearsons and Utey 2005. *Anim. Behav.* 69:89–94). By contrast, a non-adaptive explanation for sexual cannibalism includes “aggressive spillover,” where aggression during the juvenile stage leads to rapid growth, rapid growth leads to greater fecundity in the adult female, and the genetic correlation between aggression in the two life stages is the ultimate driver of sexual cannibalism (Arnqvist and Henriksson 1997. *Evol. Ecol.* 11:255–273). Adaptive explanations for sexual cannibalism of males are possible because after sperm transfer, a female can gain further fitness benefits from consuming the male. By contrast, a sexually mature female is a necessity for reproduction and presumably always represents a reproductive opportunity for a male. Thus, the sexual cannibalism of females by males in *A. sagrei* appears to be maladaptive. The framework of the “aggressive spillover” hypothesis or even that of male mate choice could hold potential explanations for this behavior (Sentenská and Pekár 2013. *Behav. Ecol. Sociobiol.* 67:1131–1139).

AARON M. REEDY (e-mail: amr3mb@virginia.edu), **CHRISTIAN L. COX**, and **ROBERT M. COX**, Department of Biology, University of Virginia, Charlottesville, Virginia 22904, USA; **RYAN CALSBECK** Department of Biology, Dartmouth College, Hanover, New Hampshire 03755, USA.

ANOLIS UNIFORMIS (Lesser Scaly Anole). SELECTED BODY TEMPERATURE. Body temperature (T_b) data collected in the field form the basis of most of the thermal biology reports in the herpetological literature (Avery 1982. *In* Gans and Pough [eds.], *Biology of the Reptilia*, Vol. 12, Physiology C, pp. 93–166. Academic Press, New York). In contrast, selected body temperatures (T_{sel}) in laboratory conditions are rarely reported even though they are essential to understanding behavior, natural history, and effects of global warming on ectotherms (Sinervo et al. 2010. *Science* 328:894–899). T_{sel} represents the range of core temperature

within which an ectothermic animal seeks to maintain itself by behavioral means (IUPS Thermal Commission 2003. *J. Therm. Biol.* 28:75–106). Hence, here we present data on *Anolis uniformis* body temperatures in both field and laboratory conditions.

Anolis uniformis is a small, widely distributed lizard that is found in tropical wet forest in northern Middle America. The thermal ecology of this species has not been adequately addressed (Birt et al. 2001. *J. Herpetol.* 35:161–166). Thus, during June 2013, we conducted field work in wet tropical rain forest habitat located in Macuspana, Tabasco, Mexico (17.6239°N, 92.4449°W; 195 m elev.). The data presented here are based on 17 adults (> 36 mm SVL; 9 females and 8 males; Campbell et al. 1989. *Biotropica* 21:237–243) of *A. uniformis* captured by noose and hand. Snout–vent length (SVL) was measured to the nearest 0.05 mm, and sex was determined for all individuals. T_b was recorded using a digital thermometer (Fluke model 51-II) with the sensor introduced one centimeter into the cloaca. We also recorded substrate temperature (T_s) at the exact point of observation and air temperature (T_a) 1 cm above the substrate where the lizard was captured.

In the laboratory, the lizards were maintained at 25°C in plastic containers. Laboratory experiments were conducted one day after capture using a thermal gradient. The thermal gradient consisted of a polycarbonate box 150 cm long x 100 cm wide x 70 cm high. The box was located in a room with controlled temperature of 20°C and two 150 W lamps were placed at different highs over the box to offer thermal gradient (20–50°C). The T_{sel} of individuals in the thermal gradient was taken manually each hour between 0930 and 1400 hs using the digital thermometer. Following laboratory experiments, all lizards were released at the site of capture.

Mean SVL was 38.2 mm (SD = 1.77, range = 36–41 mm). Mean T_b was 28.4°C (SD = 2.71°C, range = 24.5–32.7°C). Mean T_s was 26.1°C (SD = 1.15°C, range = 23.4–27.6°C) and mean T_a was 26.2°C (SD = 1.22°C, range = 23.4–27.9°C). A positive and significant correlation was found between T_b and the microhabitat temperature (Spearman Rank Correlation: $r = 0.70$, $P < 0.0001$, $N = 17$, based on T_s ; $r = 0.80$, $P < 0.0001$, $N = 17$, based on T_a). There was no statistically significant difference between sexes ($U = 34$, $P = 0.885$). Mean T_{sel} was 30.1°C (SD = 1.90°C, range = 22–34.4°C). Interquartile of 25% and 75% was 28.9 and 30.9°C, respectively. T_b shows that *A. uniformis* analyzed in this study was thermopassive, a mechanism where individuals do not need to invest time and energy actively selecting microhabitats for thermoregulation in tropical habitats (Huey and Slatkin 1976. *Q. Rev. Biol.* 51:363–384). T_{sel} suggests that *A. uniformis* can be considered a stenothermic species due to the narrow range of temperatures. Previous thermal ecology studies of anoles have also demonstrated these trends (Birt et al. 2001, *op. cit.*; Hertz 1974. *J. Herpetol.* 8:323–327; Hertz et al. 1993. *Am. Nat.* 142:796–818).

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RAFAEL A. LARA-RESENDIZ (e-mail: rlara@ibiologia.unam.mx), **ANÍBAL H. DÍAZ DE LA VEGA-PÉREZ** (e-mail: ahelios@ibiologia.unam.mx), Posgrado en Ciencias Biológicas, Instituto de Biología, Laboratorio de Herpetología, Universidad Nacional Autónoma de México, AP 70515, CP 04510, Distrito Federal, México; **PIERRE CHARRUAU**, Laboratorio de Herpetología, Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México, AP 70515, CP 04510, Distrito Federal, México (e-mail: charruau_pierre@yahoo.fr).

ASPIDOSCELIS EXSANGUIS (Chihuahuan Spotted Whiptail). **FEEDING BEHAVIOR.** *Aspidoscelis exanguis* is a parthenogenetic species of whiptail lizard that primarily ranges within the Chihuahuan Desert ecoregion of the southwestern United States and northern Mexico (Babb 2009. *In* Jones and Lovich [eds.]. *Lizards of the American Southwest: A Photographic Field Guide*, pp. 338–341. Rio Nuevo Publ., Tucson, Arizona). The species is an active diurnal forager that feeds mostly on arthropods, with termites, grasshoppers, beetles, and arachnids being important prey items (Degenhardt et al. 1996. *Amphibians and Reptiles of New Mexico*. Univ. New Mexico Press, Albuquerque. 431 pp.; Scudday and Dixon 1973. *Southwest. Nat.* 18:279–289; Smith 1989. *Southwest. Nat.* 34:418–429). Most published information on food preference is based on removed stomach contents identified to higher taxonomic categories, so little is known about specific food items taken and on the feeding behavior of the lizard in the wild. Herein, we report on the ambushing, subjugation, and consumption of a tarantula by an adult *A. exanguis* in a Black Gramma (*Bouteloua eriopoda*) dominated Chihuahuan Desert grassland landscape.

On 17 June 2009, at 0920 h, on Fort Bliss, McGregor Range in Otero Co., New Mexico, USA (32.418611°N, 105.852778°W, WGS 84; 1606 m elev.), an *A. exanguis* was observed ambushing and consuming an adult tarantula (*Aphonopelma* sp.) (Fig. 1). The lizard was observed subjugating the tarantula by grasping the tubercle dorsal portion of the thorax, utilizing vigorous head and body twisting, reminiscent of larger, predatory lizard behavior when overcoming large prey. The time frame it took for subduing the prey lasted *ca.* two minutes until the spider showed no signs of movement and was then consumed. Scudday and Dixon (*op. cit.*), mention that *A. exanguis* exhibit a higher foraging activity and more aggression towards prey (i.e., act of slamming prey on the ground) than other sympatrically occurring *Aspidoscelis* species, from which this observation appears to reflect those behaviors. To our knowledge, this is the first documented sighting of *A. exanguis* subjugating and consuming large prey of comparable size (*Aphonopelma* sp.).

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ARTURO ROCHA (e-mail: turyrocha@yahoo.com), **VICENTE MATA-SILVA**, and **JERRY D. JOHNSON** (e-mail: jjohnson@utep.edu), Department of Biological Sciences, University of Texas at El Paso, El Paso, Texas 79968, USA.



FIG.1. Adult *Aspidoscelis exanguis* consuming a tarantula (*Aphonopelma* sp.) in Otero County, New Mexico, USA.

ASPIDOSCELIS EXSANGUIS (Chihuahuan Spotted Whiptail), ASPIDOSCELIS NEOMEXICANA (New Mexico Whiptail), ASPIDOSCELIS UNIPARENS (Desert Grassland Whiptail). **BIFURCATED TAILS.** We report occurrences of bifurcated tails in three parthenogenetic whiptail species (Jones and Lovich 2009. *Lizards of the American Southwest: A Photographic Field Guide*. Rio Nuevo Publ. Tucson, Arizona. 567 pp.) captured during a long-term study (Bateman et al. 2008. *Restor. Ecol.* 16:180–190). Bifurcated tails have also been reported from museum specimens in *A. velox*, another parthenogenetic whiptail (Cordes and Walker 2013. *Herpetol. Rev.* 44:319–320).

We captured and released lizards from late May to mid-September from 2000 to 2006 from riparian forest habitat along the middle Rio Grande in central New Mexico from Albuquerque (35.008380°N, 106.681805°W) to Bosque del Apache National Wildlife Refuge (33.805122°N, 106.859980°W). We measured lizard snout–vent length (SVL), vent–tail length (VTL), and mass. When we encountered lizards with regenerated tails, we recorded the length from the vent to the start of tail regeneration (original tail length, OTL). For some lizards with bifurcated tails, we measured the length of the regenerated portion of the “second” tail (bifid tail length, BTL). The bifurcation typically began at the regenerated or damaged tail segment, as observed by Cordes and Walker (2013, *op. cit.*). In other cases, the bifurcation stemmed from within a portion of a regenerated tail as observed by Gogliath et al. (2012. *Herpetol. Rev.* 43:129) in *Ameiva ameiva*.

We captured four individual *A. exanguis* with bifurcated tails (20 July 2001, SVL = 73 mm, VTL = 92 mm, OTL = 27 mm, mass = 9.5 g; 27 July 2001, SVL = 82 mm, VTL = 141 mm, OTL = 56 mm, mass = 12.0 g; 11 July 2005, SVL = 60 mm, VTL = 116 mm, OTL = 61 mm; and 1 Aug 2005, SVL = 70 mm, VTL = 135 mm, OTL = 99 mm, BTL = 7 mm, mass = 5.5 g). We captured four individual *A. neomexicana* with bifurcated tails (10 June 2002, SVL = 71 mm, VTL = 87 mm, OTL = 15 mm, BTL = 60, mass = 10.5 g; 18 July 2002, SVL = 81 mm, VTL = 170 mm, OTL = 150 mm, BTL = 20, mass = 17.0 g; 27 June 2006, SVL = 77 mm, VTL = 99 mm, OTL = 19 mm, mass = 8.5 g; and 17 Aug 2006, SVL = 82 mm, VTL = 152 mm, OTL = 125 mm, BTL = 27, mass = 12.5 g). We captured three individual *A. uniparens* with bifurcated tails (7 July 2001, SVL = 69 mm, VTL = 117 mm, OTL = 86 mm, mass = 6.5 g; 13 July 2001, SVL = 65 mm, VTL = 121 mm, OTL = 87 mm, mass = 7.5 g; 11 June 2002, SVL = 67 mm, VTL = 123 mm, OTL = 85 mm, mass = 9.0 g). These records are among the first reports of bifurcated tails in *A. exanguis*, *A. neomexicana*, and *A. uniparens*.

The Middle Rio Grande Conservancy District, Bosque del Apache National Wildlife Refuge, and Albuquerque Open Space permitted access to study sites. The University of New Mexico Animal Care and Use Committee approved field techniques (protocol #20415). The long-term herpetofaunal study was funded by the USDA Forest Service – RMRS Middle Rio Grande Ecosystem Management Unit, Joint Fire Sciences Program, National Fire Plan, US FWS Bosque Improvement Initiative, and USFS S&PF NM Collaborative Forest Restoration Program.

HEATHER L. BATEMAN, Arizona State University at the Polytechnic campus, 7231 E. Sonoran Arroya Mall, Mesa, Arizona 85212, USA (e-mail: heather.bateman@gmail.com); **ALICE CHUNG-MACCOUBREY**, Inventory & Monitoring Program Manager, Sierra Nevada Network, Sequoia & Kings Canyon National Parks, 47050 Generals Highway, Three Rivers, California 93271, USA (e-mail: alice_chung-maccoubrey@nps.gov).

ASPIDOSCELIS GULARIS GULARIS (Texas Spotted Whiptail). **ACQUIRED COLOR PATTERN.** We have studied *Aspidoscelis gularis gularis* since 1985 near El Ranchito at a site on the Rio Grande near US Hwy 281 (26.028333°N, 97.645278°W, WGS84; ~16 m elev.), Cameron Co., Texas, USA (Walker 1987. Texas J. Sci. 39:313–334). On 4 August 2008, one of us (JEC) collected an adult male of this taxon (SVL 93 mm, tail length 281 mm, and body mass 22.9 g) with a remarkable dorsal color pattern. The specimen (Fig. 1A–C) was originally cataloged as University of Arkansas Department of Zoology 8474 and recently re-catalogued as Arkansas State University Museum of Zoology (ASUMZ) 32691. It is obvious that the essentially symmetrical rearrangement of alternating pale stripes and dark fields on the anterior part of the dorsum resulted from a major superficial injury that healed to produce the pattern featured in Fig. 1A, C. Surviving such an injury, resulting from a likely predator encounter, was remarkable in itself; however, the uniqueness of the acquired dorsal pattern deserves commemoration in the literature.

Adult males of *A. g. gularis* at El Ranchito have a ventral pattern consisting of an unspotted pink-red chin and throat, blue-purple chest, and the latter color in a checkerboard pattern on the abdomen (Fig. 1B; Walker et al. 1989. J. Herpetol. 23:119–130). The dorsal pattern includes six pale colored primary stripes that are fixed in position (ventral to dorsal; pairs of laterals, dorsolaterals, and paravertebrals) and one or two darker variable secondary stripes between the paravertebrals (the vertebral[s]). In some of the intervening dark areas between the stripes (the fields) are pale rounded spots (e.g., in the

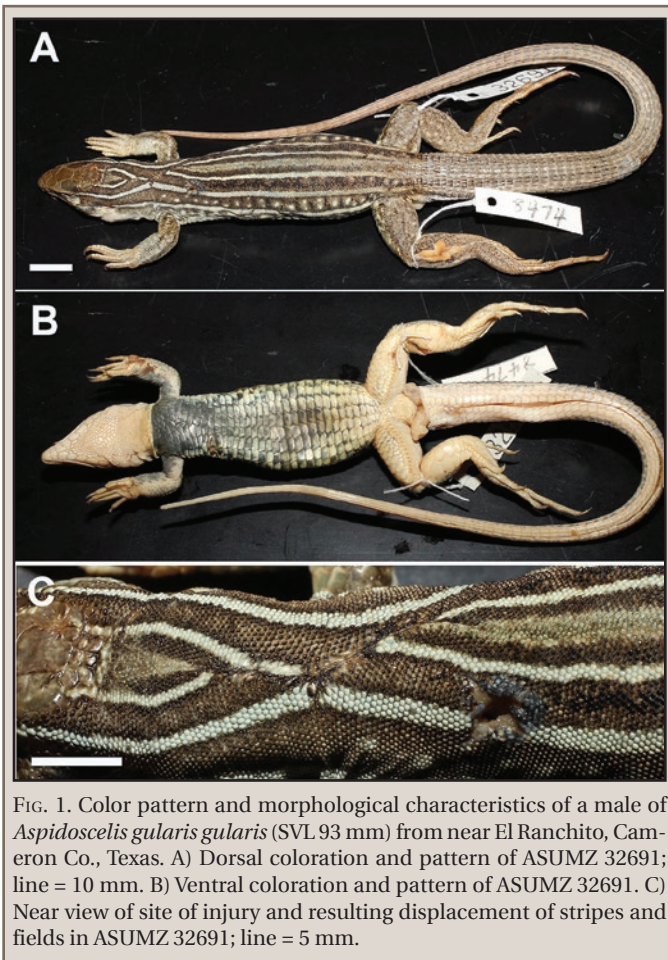


FIG. 1. Color pattern and morphological characteristics of a male of *Aspidoscelis gularis gularis* (SVL 93 mm) from near El Ranchito, Cameron Co., Texas. A) Dorsal coloration and pattern of ASUMZ 32691; line = 10 mm. B) Ventral coloration and pattern of ASUMZ 32691. C) Near view of site of injury and resulting displacement of stripes and fields in ASUMZ 32691; line = 5 mm.

upper lateral fields superior to lateral stripes). The dorsal pattern described is apparent in ASUMZ 32691, starting a few mm posterior to the forelimbs (Fig. 1A). In the post-cephalic region there is only a small pointed remnant of a vertebral stripe and the paravertebral stripe remnants are displaced medially to being only narrowly separated as the right stripe fragment extends posterior to the left (Fig. 1A). There is a scarred area just anterior to the forelimbs where no parts of the paravertebral and vertebral stripes remain, and beyond which the dorsolateral striped are noticeably displaced medially. In the latter region, the anterior ends of the interrupted paravertebral stripes are displaced medially to an open point (Fig. 1A). A near view of scars and displaced stripes and fields in the lizard, acquired by unknown means, is captured by Fig. 1C.

Specimens were collected under authority of Texas Parks and Wildlife Department permit SPR-1090-298 issued to JEC.

JAMES E. CORDES, Division of Sciences and Mathematics, Louisiana State University Eunice, Eunice, Louisiana 70535, USA (e-mail: jcordes@lsue.edu); **JAMES M. WALKER**, Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas 72701, USA (e-mail: jmwalker@uark.edu); **STANLEY E. TRAUTH**, Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467, USA (e-mail: strauth@astate.edu).

ASPIDOSCELIS LAREDOENSIS A (Laredo Striped Whiptail) × ASPIDOSCELIS GULARIS (Texas Spotted Whiptail). **DIFFERENTIAL RATE OF HYBRIDIZATION.** *Aspidoscelis laredoensis* is a hybrid-derived parthenogenetic species (Bickham et al. 1976. Herpetologica 32:395–399; Dessauer and Cole 1989. In Dawley and Bogert [eds.], Evolution and Ecology of Unisexual Vertebrates, pp. 49–71. Bull. 466. New York State Museum, Albany, New York; McKinney et al. 1973. Herpetologica 29:361–366; Parker et al. 1989. In Dawley and Bogert [eds.], Evolution and Ecology of Unisexual Vertebrates, pp. 72–86. Bull. 466. New York State Museum, Albany, New York; Wright et al. 1983. Herpetologica 39:410–416) that reproduces asexually by development of unreduced diploid eggs. Sexual reproduction by an individual of this species occurs only when its eggs are fertilized by sperm from a male of a gonochoristic species such as *A. gularis* (Trauth et al. 2013a. Herpetol. Rev. 44:138–140; Trauth et al. 2013b. Herpetol. Rev. 44:314–316; Trauth et al. 2013c. Herpetol. Rev. 44:316–318; Walker et al. 1989a. J. Herpetol. 23:119–130; Walker et al. 1989b. Copeia 1989:1059–1064; Walker et al. 1991. Herpetologica 47:152–164; Walker et al. 2008. Herpetol. Rev. 39:340) resulting in sterile triploid hybrid males and mostly sterile triploid females. However, it is possible that a rare hybrid female from these species could be fertile and become the founder of a new allotriploid parthenogenetic species as has occurred repeatedly through hybridization in the genus *Aspidoscelis* (see Dessauer and Cole, *op. cit.*; Reeder et al. 2002. Amer. Mus. Novitat. 3365:1–61).

There are two morphologically distinct clonal complexes of *A. laredoensis* (Walker 1987. Texas J. Sci. 39:313–334; Walker et al. 1989a, *op. cit.*; Walker et al. 1991, *op. cit.*), each of which originated from a different hybrid of *A. laredoensis* × *A. gularis* based on their histoincompatibility to skin transplants (Abuhteba et al. 2000. Can. J. Zool. 78:895–904; Abuhteba et al. 2001. Copeia 2001:262–266). We used phenotypic attributes to support identification of a hybrid of *A. laredoensis* A × *A. gularis* in order to establish that the rate of hybridization between these species is correlated with clonal complex. Complex B only rarely hybridizes (Walker et al. 1991, *op. cit.*). However, complex A is known to hybridize much more frequently (Walker et al. 1989a, *op. cit.*;

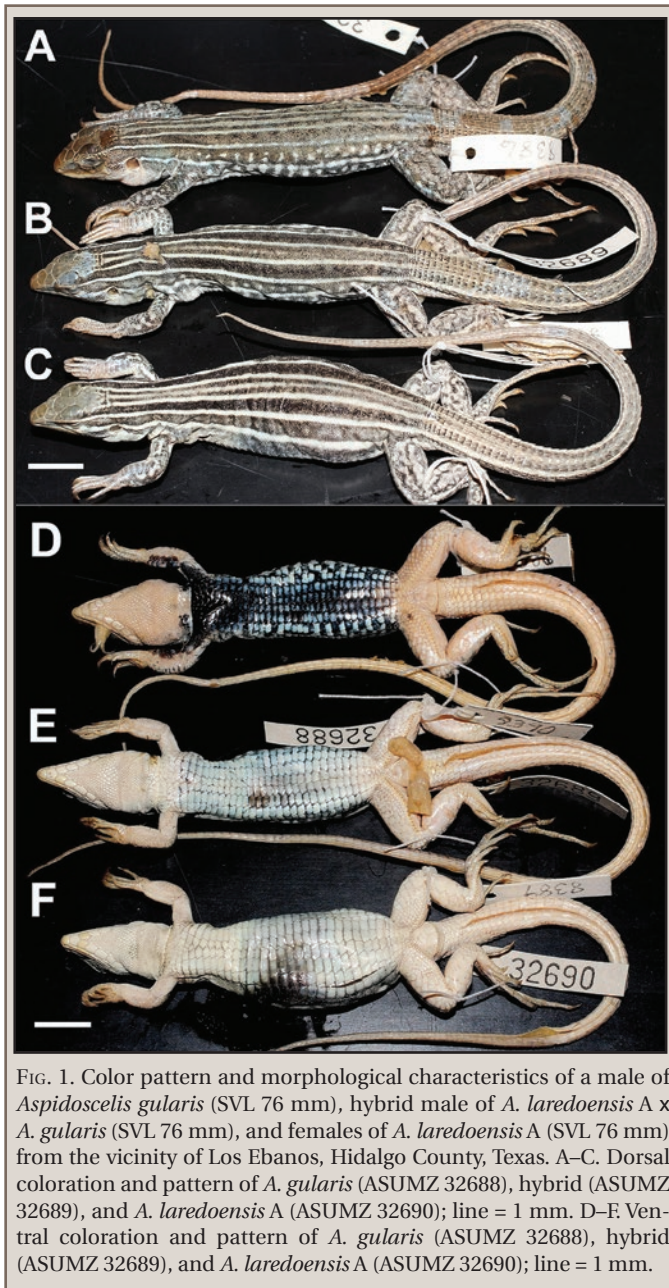


FIG. 1. Color pattern and morphological characteristics of a male of *Aspidoscelis gularis* (SVL 76 mm), hybrid male of *A. laredoensis* A x *A. gularis* (SVL 76 mm), and females of *A. laredoensis* A (SVL 76 mm) from the vicinity of Los Ebanos, Hidalgo County, Texas. A–C. Dorsal coloration and pattern of *A. gularis* (ASUMZ 32688), hybrid (ASUMZ 32689), and *A. laredoensis* A (ASUMZ 32690); line = 1 mm. D–F. Ventral coloration and pattern of *A. gularis* (ASUMZ 32688), hybrid (ASUMZ 32689), and *A. laredoensis* A (ASUMZ 32690); line = 1 mm.

this study) based on records for 20+ years (1986–2008) in an area near the Rio Grande (26.233889°N, 98.560833°W, WGS84; ~ 40 m elev.) in the vicinity of Los Ebanos, Hidalgo Co., Texas, USA. The male of *A. gularis*, male hybrid, and female of *A. laredoensis* A featured in Fig. 1A–F, originally cataloged as University of Arkansas Department of Zoology 8386, 8390, and 8389, respectively, and re-catalogued as Arkansas State University Museum of Zoology (ASUMZ) 32688, 32689, and 32690, respectively, were collected by one of us (JEC) on 22 June 2008 in the aforementioned area. We have also collected hybrids of *A. laredoensis* A x *A. gularis* from other sites in Dimmit, La Salle, Webb, Star, and Hidalgo counties, Texas, and Tamaulipas State, Mexico (Walker et al. 1989a, *op. cit.*). The distinctive Los Ebanos area, within a prominent oxbow of the Rio Grande, supports a thriving guild of whiptail lizards comprising large numbers of *A. gularis* (gonochoristic) and both clonal complexes A and B of *A. laredoensis* (diploid parthenogens). Here, these congeners are locally



FIG. 2. Enlarged postantebrachial scales of the hybrid (ASUMZ 32689); line = 1 mm.

dispersed such that opportunities for hybridization of *A. gularis* with each of *A. laredoensis* A and B are essentially present whenever lizards are active.

Prior to preservation, hybrid ASUMZ 32689 had a SVL of 76 mm, tail length of 263 mm, and body mass of 10.6 gm. This male could not be identified to *A. gularis* because of divergent features of both dorsal and ventral color patterns, as well as scutellation (see Conant and Collins 1998. *A Field Guide to Reptiles and Amphibians of Eastern and Central North America*, 3rd ed. Houghton Mifflin Co., New York, New York. 640 pp.). It lacked the low contrast darkly hued dorsal stripes/spots and fields, and lacked the intense purple-blue ventral suffusion of the mesopterygium, fore limbs, and thoracic/abdominal regions typical of *A. gularis* (Fig. 1A, D). Although the specimen resembles *A. laredoensis* A (Fig. 1C, F) more closely than *A. gularis* (Fig. 1A, D) or *A. laredoensis* B, characters indicating its hybrid origin are these aspects of color pattern: two pairs of pale straight-margined primary stripes (dorsolaterals, and paravertebrals), one pair of pale unevenly margined primary stripes resulting from contact with pale rounded spots and vertical bars, large distinct spots in brown to brown-black fields above (upper laterals) and below (lower laterals) lateral stripes nearest to ventral scales, a single indistinct and discontinuous vertebral stripe past midbody, thoracic and abdominal scales narrowly edged with purple-blue, and pink-red ventral surface of the head (Fig. 1B, E). In comparison, the typically patterned female of *A. laredoensis* depicted in Fig. 1C, F lacks large spots in the upper and lower lateral dark fields, does not have unevenly margined lateral stripes, and has a cream-white venter absent a pink-red throat and purple-blue edged thoracic and abdominal scales.

Also indicative of a hybrid origin for ASUMZ 32689 (comparison with *A. laredoensis* in paren) are the greatly enlarged mesoptychial scales bordering the gular fold (rather than enlarged); enlarged postantibrachial scales on posterior aspect of forelimbs (Fig. 2, rather than moderately enlarged), and 80 granular scales around midbody (compared with 91.8 ± 0.76 based on Walker et al. 1989b, *op. cit.*).

The specimen collected in 2008 described herein establishes that production of viable, if infertile, hybrids of *A. laredoensis* A x *A. gularis* has been ongoing in the Los Ebanos vicinity for 20+ years. The first of these was collected by combinations of the authors at Los Ebanos a few hundred meters from the Rio Grande in 1986 (Walker et al. 1989a, *op. cit.*) followed by collection of other hybrids over the years up to 2008. Remarkably, there are apparently strong pre-mating/post-mating isolating mechanisms to hybridization between *A. laredoensis* B x *A. gularis*, as only three hybrids representing this combination (Walker et al. 1991, *op. cit.*) have been collected in Texas and Mexico during ~75 expeditions since 1984. Internal examination of reproductive organs in the present hybrid by one of us (SET) revealed the following: the testes were enlarged and appeared to be functional; the epididymis was expanded and appeared to have sperm present.

Specimens were collected under authority of Texas Parks and Wildlife Department permit SPR1090-298 and USDI/IRGVNWR special use permit 21552-09-13-MS. Special thanks are given to Mitch Sternberg of the USFWS at Santa Ana NWR for providing the special use permit.

STANLEY E. TRAUTH, Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467, USA (e-mail: strauth@astate.edu); **JAMES E. CORDES**, Division of Sciences and Mathematics, Louisiana State University Eunice, Eunice, Louisiana 70535, USA (e-mail: jcordes@lsue.edu); **MARK A. PAULISSEN**, Department of Natural Sciences, Northeastern State University, Tahlequah, Oklahoma 74464, USA (e-mail: paulisse@nsuok.edu); **JAMES M. WALKER**, Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas 72701, USA (e-mail: jmwalker@uark.edu).

ASPIDOSCELIS LAREDOENSIS A (Laredo Striped Whiptail) x ASPIDOSCELIS GULARIS (Texas Spotted Whiptail). STOMACH CONTENTS. Diploid parthenogenetic *Aspidoscelis laredoensis* clonal complexes A and B, and gonochoristic parental species *A. gularis*, are syntopic at many sites in Texas and Mexico, mostly in the vicinity of the Rio Grande (Walker 1987. Texas J. Sci. 39:313–334). During the past 20+ years (1986–2008), it has not been unusual to find one or more hybrids of *A. laredoensis* A x *A. gularis* among collections from sites such as the one near the Rio Grande (26.233889°N, 98.560833°W, WGS84, ~40 m elev.) in the vicinity of Los Ebanos, Hidalgo Co., Texas (Walker et al. 1989. J. Herpetol. 23:119–130). Recently, SET examined stomach contents of hybrid male Arkansas State University Museum of Zoology (ASUMZ) 32689 (Trauth et al. 2013. Herpetol. Rev. 44: *in press*) collected by JEC on 22 June 2008 at the aforementioned site. We use this individual of 76 mm SVL as the basis for the first reported observations on the diet of a hybrid whiptail. Upon opening the body cavity of ASUMZ 32689, the stomach was seen to be distended to maximum capacity. The contents consisted almost entirely of termites (order Isoptera). By counting intact termites and detached heads it was found that the hybrid had consumed 181 of these insects. Although it would require several minutes for a lizard to consume such a large number of prey items while relatively stationary at an exposed termite colony

(and thus be susceptible to predation), such a bonanza discovery would yield far more calories per unit of time than the more difficult tactic of harvesting grasshoppers which are typically in evidence at Los Ebanos. Paulissen 2001. (J. Herpetol. 35:282–292) and Paulissen et al. 1992 (J. Herpetol. 26:153–158) reported that termites comprised the numerical majority of prey consumed by both of the parental species of the hybrid, *A. laredoensis* A and *A. gularis*, at several sites of syntopy in Texas.

The specimen was collected under authority of Texas Parks and Wildlife Department permit SPR-1090-298 and USDI/IRGVNWR special use permit 21552-09-13-MS. Special thanks are given to Mitch Sternberg of the USFWS at Santa Ana NWR for providing the special use permit.

STANLEY E. TRAUTH, Department of Biological Sciences, Arkansas State University, P. O. Box 599, State University, Arkansas USA, 72467 (e-mail: strauth@astate.edu); **JAMES E. CORDES**, Division of Sciences and Mathematics, Louisiana State University Eunice, Eunice, Louisiana USA, 70535 (e-mail: jcordes@lsue.edu); **MARK A. PAULISSEN**, Department of Natural Sciences, Northeastern State University, Tahlequah, Oklahoma USA, 74464 (e-mail: paulisse@nsuok.edu); **JAMES M. WALKER**, Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas USA, 72701 (e-mail: jmwalker@uark.edu).

ASPIDOSCELIS NEOMEXICANA (New Mexico Whiptail) x ASPIDOSCELIS INORNATA LLANURAS (Plains Striped Whiptail). PHENOTYPE. *Aspidoscelis neomexicana*, a hybrid-derived parthenogenetic species (Cole et al. 1988. Amer. Mus. Novitat. 2905:1–38; Parker and Selander 1984. Herpetologica 40:245–252), reproduces asexually by development of unreduced diploid eggs. Sexual reproduction in the species occasionally occurs when its eggs are fertilized by sperm from a male of *A. inornata* (Axtell 1966. Herpetologica 22:241–253; Cuellar and McKinney 1976. J. Exp. Zool. 196:341–350; Taylor and Medica 1966. Univ. Colorado, Ser. Biol. 22:1–9; Taylor and Walker 1996. Copeia 1996:945–954; Wright and Lowe 1967. Amer. Mus. Novitat. 2286:1–36) resulting in sterile triploid hybrid males or females.

Herein, we describe phenotypic attributes of the first hybrid of *A. neomexicana* x *A. inornata llanuras* reported as involving this subspecies and the first one reported from the westernmost part of the distribution of these species in New Mexico (see map in Cole et al., *op. cit.*). This female (originally catalogued as University of Arkansas Department of Zoology 6081 and re-catalogued as Arkansas State University Museum of Zoology 32423) was collected by JEC on 13 July 1998 in Hidalgo Co.: 21.321.6 km NW jct of US Hwy 90 and New Mexico Hwy 70, on 70 in the vicinity of the site at 32.515000°N, 108.876667°W (datum WGS84). Also obtained here during six visits between 1998 and 2001 were 17 (19.3%) *A. inornata llanuras* (gonochoristic), 22 (25.0%) *A. neomexicana* (diploid parthenogen), and 48 (54.5%) *A. uniparens* (triploid parthenogen). Prior to preservation, the hybrid had a SVL of 62 mm, tail length of 217 mm, and body mass of 6.3 gm. It could not be identified to *A. inornata llanuras* because of the presence of spots (i.e., rounded pale areas) in the dark fields between the stripes; this taxon is characterized by the lack of spots throughout ontogeny (Sullivan et al. 2013. Copeia 2013[3]:366–377; Wright and Lowe 1993. J. Arizona-Nevada Acad. Sci. 27:129–157). Although the specimen resembles *A. neomexicana* more closely than *A. inornata llanuras*, obvious phenotypic consequences of the hybrid genome are these intermediate aspects of color pattern (Fig. 1A–B): paired lateral and dorsolateral stripes relatively straight-margined, paired paravertebral stripes slightly unevenly margined,

single vertebral stripe with several interruptions and unevenly margined, strongly contrasting pale stripes and dark fields, incipient rather than distinct spots; and off-white to very pale blue rather than gray-blue venter. Data for four morphological characters are also consistent with the hypothesis for a hybrid origin for ASUMZ 32423 (comparison with *A. neomexicana* in paren): low number of granules around midbody (compared to 75–83, $N = 22$); moderately enlarged mesoptychial scales (Fig. 1C, rather than small); slightly enlarged postantibrachial scales (Fig. 1D, rather than granular), and incomplete circumorbital scales (Fig. 1E, rather than complete).

That production of viable, if not fertile, hybrids of *A. neomexicana* \times *A. inornata llanuras* is a rare event in the guild sampled at the Hidalgo Co. site is indicated by ASUMZ 32423 (0.01% being among 88 specimens collected (i.e., < 33% of observed whiptail lizards) in six visits from 1998 to 2001. The hybrid is an “immature” female with both oviducts highly regressed, exhibiting minimal enlargement posteriorly. Both gonads appear as minimally-expanded, linear strips of translucent tissue, exhibiting no evidence of developing follicles. Abdominal fat bodies are modestly enlarged. Based on these observations, we infer that the hybrid was sterile.

Specimens in Hidalgo Co. were collected under authority of permit number 1850 issued to JEC by the New Mexico Department of Game and Fish.

JAMES M. WALKER, Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas 72701, USA (e-mail: jmwalker@uark.edu);

JAMES E. CORDES, Division of Sciences and Mathematics, Louisiana State University Eunice, Eunice, Louisiana 70535, USA (e-mail: jcordes@lsue.edu);

STANLEY E. TRAUTH, Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467, USA (e-mail: strauth@astate.edu).

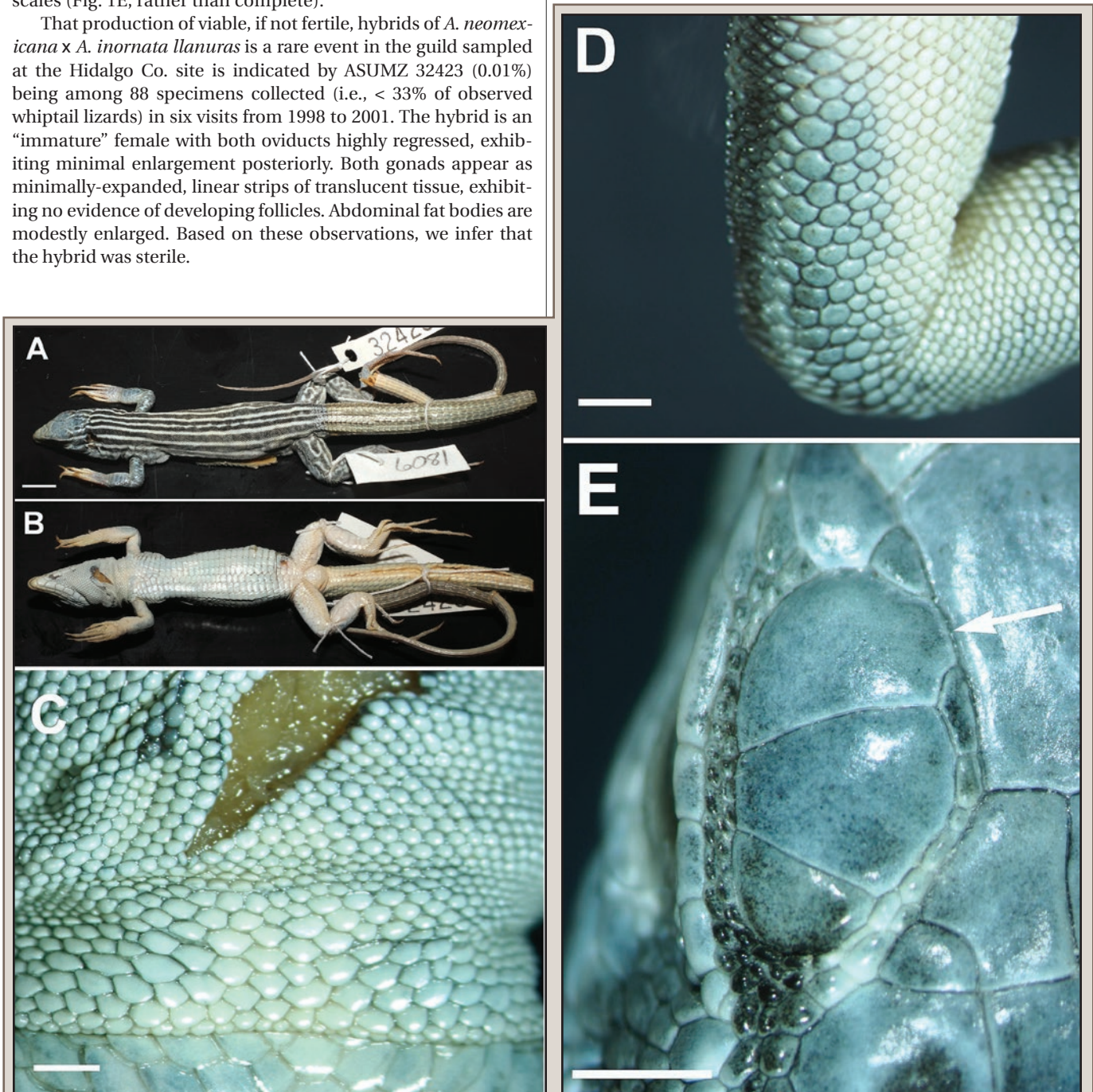


FIG. 1. Color pattern and morphological characteristics of a putative hybrid female specimen of *Aspidoscelis neomexicana* \times *A. inornata llanuras*. A) Dorsal coloration and pattern of ASUMZ 32423; line = 10 mm for A and B. B) Ventral coloration of ASUMZ 32423. C) Moderately enlarged mesoptychial scales of ASUMZ 32433; line = 1 mm. D) Slightly enlarged postantibrachial scales of ASUMZ 32423; line = 1 mm. E) Incomplete circumorbital scale series (see arrow) in ASUMZ 32423; line = 1 mm.

ASPIDOSCELIS SEXLINEATA (Six-lined Racerunner). ARTIFICIAL HABITAT. *Aspidoscelis sexlineata* is a “species in greatest conservation need” in Minnesota. It typically lives in sand prairies or bluff prairies, although Oldfield and Moriarty (1994. *Amphibians and Reptiles Native to Minnesota*. University of Minnesota Press, Minneapolis, Minnesota. 237 pp.) noted that it can inhabit the rock and cinder fill of railroad tracks and dike roads. We examined racerunner use of artificial habitat associated with the Prairie Island dike near Winona, Winona Co., Minnesota, USA. Completed in 1967, the dike is topped by a two-lane black-top road approximately 7–8 m above normal river level (less during periods of flooding). Sampling was conducted in a 4.7-km stretch extending northwest from Mississippi River Lock-and-Dam 5A toward Minnesota City. The river (northeastern) side of the dike was rip-rapped with boulders and chunks of concrete, whereas the southwestern side, which bordered bottomland marsh and forest, consisted of prairie-like habitat with patches of open sandy substrate. A remnant sand prairie that formerly existed near the southeastern end of the study stretch, where racerunners were observed as recently as the early 2000s, presumably served as the source of racerunners that inhabited the dike, but the site is now occupied by artificial wetlands.

Paired transect surveys, one on each side of the road, were conducted in 2010 on 15 July (5 pairs), 16 July (10), 21 August (10), 22 August (10), and 1 September (10). The 50-m transects were parallel to the road and randomly positioned with respect to distance from the southeastern end of the study stretch (0–4.7 km) and distance from the roadside (0–13 m). Data were collected by two observers using an event recorder to tally the number of racerunners observed within 1 m of each side of the transect. Substrate and shaded air temperature was measured at the start of each transect.

Racerunners were observed over a distance of 3 km on the southwestern side of the road ($N = 17$) and 1 km on the northeastern side ($N = 2$). Racerunners occurred from 2 m to 13 m from the edge of the road; mean distance on the southwestern side (7.23 m) and the northeastern side (5.50 m) were not significantly different ($t = 0.674$, $df = 13$, $p = 0.512$). The number of racerunners per transect was significantly greater on the southwestern side of the dike (paired t -test, $t = 3.028$, $df = 44$, $p = 0.004$). This may have been related to the greater substrate temperature on the southwestern side (paired t -test, $t = 3.305$, $df = 44$, $p = 0.002$), but racerunners may have been less detectable among the boulders on the northeastern side.

The substrate temperature for transects when racerunners were observed ranged from 26°C to 46°C, with a mean (32.8°C) slightly less than substrate temperatures selected in oak savannah (34.7°C) and open grassland (39.2°C) in Wisconsin (Kapfer and Pauers 2006. *Herpetol. Rev.* 37:420–423). Shaded air temperature ranged from 22°C to 34°C. Oldfield and Moriarty (*op. cit.*) reported that racerunners have been observed active in Minnesota at air temperatures as low as 22°C, and Fitch (1958. *Univ. Kansas Publ. Mus. Nat. Hist.* 11:11–62) reported an optimal air temperature in Kansas of 34°C.

Expanding the estimated densities of racerunners observed on the 50 m × 2 m transects on the southwestern (0.00378/m²) and northeastern (0.00044/m²) sides of the dike to the total area of potential habitat on each side yielded total estimates of 229 and 26 racerunners, respectively. These are likely underestimates because of imperfect detectability (Smolensky and Fitzgerald 2010. *J. Herpetol.* 44:372–381). Nevertheless, they fall within the range of densities reported by Bellis (1964. *Herpetologica*

20:9–16) in South Carolina (0.0245/m²) and Warner (2000. *Trans. Illinois St. Acad. Sci.* 93:239–248) in northwestern Illinois.

The southwestern-facing slope of the Prairie Island dike provides extensive artificial habitat similar to the bluff prairies typically inhabited by racerunners in southeastern Minnesota. This sort of artificial habitat may become increasingly important as bluff prairies decline in area due to encroachment by invasive woody plants. Kraszewski (2004. *A Survey of Native Flowering Plant Species on Goat Prairies in Winona, Minnesota*. Unpubl. B.A. thesis, Saint Mary's University of Minnesota, Winona. 29 pp.) used aerial photographs to estimate the areas of 10 bluff prairie remnants in the Winona area, some of which are inhabited by racerunners. Prairie area varied from 0.25 ha to 3.14 ha (mean = 1.49 ha). When Gerty (2013. *Species Richness in Relation to Both Remnant Size and Leafy Spurge [*Euphorbia esula*] Invasion*. Unpubl. B.A. thesis, Saint Mary's University of Minnesota, Winona. 19 pp.) remeasured the same areas on the ground, she found them broken into 20 remnants of 0.03–0.56 ha. In comparison, each side of the Prairie Island dike provides 6.07 ha of potential habitat, although racerunners do not necessarily occur along the entire road and available habitat is reduced during years with periods of high water.

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MICHELLE L. GOSSEN and **PHILIP A. COCHRAN**, Biology Department, Saint Mary's University of Minnesota, 700 Terrace Heights, Winona, Minnesota 55987, USA (e-mail: pcochran@smumn.edu).

ASPIDOSCELIS SEXLINEATA VIRIDIS (Prairie Racerunner). BURROW SITE FIDELITY. The burrows and burrowing activity of Prairie Racerunner, *Aspidoscelis sexlineata viridis*, have been well documented (Fitch 1958. *Univ. Kansas Publ., Mus. Nat. Hist.* 11:11–62; Hardy 1962. *Univ. Kansas Sci. Bull.* 43:3–73; Leuck 1982. *Copeia* 1982:416–424; Trauth et al. 2004. *The Amphibians and Reptiles of Arkansas*. Univ. of Arkansas Press, Fayetteville, 421 pp.). Burrow types, excavation sites, space use, and lizard activity were described by Hardy (*op. cit.*) and Leuck (*op. cit.*) from their observations of the lizards in outdoor enclosures, whereas Fitch (*op. cit.*) and Trauth et al. (*op. cit.*) described or illustrated burrows as reported from field studies on this species. In the present study, we report on an unusual incident of burrow site fidelity in *A. s. viridis*.

On 18 June 2013, one of us (SET) observed burrowing activity of a large (78 mm SVL) male Prairie Racerunner on a gradual-sloping, west-facing, red clay, highway embankment from ca. 1800–1840 h. The site is located on the Salem Plateau in the Ozarks Mountains (Randolph County, Arkansas 36.28215°N, 91.253°W). About 2 m² of ground surface had been disrupted earlier in the day with a potato rake by SET while searching for lizard egg clutches. The excavated site had previously contained numerous surface burrows prior to unearthing and had been photographed on 7 May 2010 (Fig. 1). What made this particular observation significant was that the lizard moved toward this disrupted excavation site from the surrounding grassy habitat and stopped abruptly at a point directly in front of the observer (within 1 m) before it began digging in the loosened soil. The lizard moved back and forth across the torn ground presumably searching for former burrow shelters. The lizard soon departed the area, but it then returned and repeated the searching and digging behavior in and around the dirt pile. A repetition of this searching/digging behavior in the dirt pile continued several times during a time span of ca. 35 min. Eventually, SET attempted to catch the lizard as it had partially



FIG. 1. Finger points to the open mouth of a Prairie Racerunner burrow photographed on 7 May 2010 (see text for site description). Arrow points to fresh soil tailing (an indication of the presence of a lizard) from a recently excavated burrow shelter.

dug a burrow shelter, but the lizard evaded the attempted capture and darted into the adjacent grassy habitat. Soon, the lizard returned and walked directly beside the observer's feet and began digging again into the dirt pile. Finally, the lizard dug into the same loose soil where it had previously evaded capture and soon disappeared far enough within its burrow so as to allow for its capture.

The digging behavior of this racerunner was similar to observations reported by Hardy (*op. cit.*), although not in the context of burrow fidelity. She termed the shelter created as being an "inactivity-tunnel," a nighttime refuge or one for periods of prolonged inactivity. The particular lizard reported here would dig with alternating front legs and by pushing into the soil inward with its snout; then, it would turn around and push the tailings out of the hole with its front legs and chest. This behavior was repeated several times until the lizard's body was well hidden inside the burrow. The loose soil tailings created by this type of burrowing behavior are shown in Fig. 1.

We have collectively studied *A. s. viridis* in many parts of the range in Arkansas and other states, and have often observed fleeing lizards work their way to what appeared to be a targeted burrow. We suggest that burrow fidelity, in addition to conservation of energy by continued use of a burrow, can also serve as a targeted escape route for a lizard.

STANLEY E. TRAUTH, Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467, USA (e-mail: strauth@astate.edu); **JAMES M. WALKER**, Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas 72701, USA (e-mail: jmwalker@uark.edu); **JAMES E. CORDES**, Division of Sciences and Mathematics, Louisiana State University Eunice, Eunice, Louisiana 70535, USA (e-mail: jcordes@lsue.edu).

ASPIDOSCELIS SEXLINEATA VIRIDIS (Prairie Racerunner). SKELETAL REMAINS. Between 1973 and 1980, Trauth (1983. *Amer. Midl. Nat.* 109:289–299) studied nesting habitat of *Aspidoscelis sexlineata* (as *Cnemidophorus sexlineatus*) across 10 states, during which 195 clutches of eggs and large numbers of lizards were excavated. The excavations took place mostly from within well-drained red clay exposures facing S to W along secondary highways and rural dirt roads. Most of this work was conducted in the Interior Highlands Region of Arkansas while studying *A. s. viridis* (Prairie Racerunner) where it was noted that, with

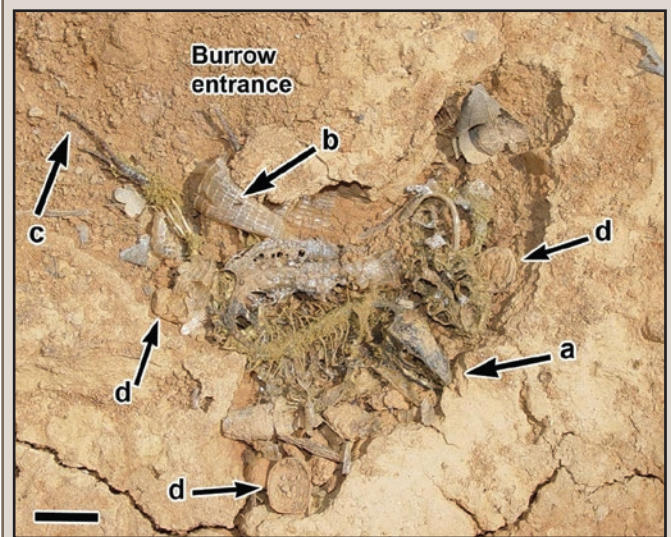


FIG. 1. Skeletal remains of a Prairie Racerunner photographed on 20 September 2003 (see text for site description). Characteristics of this species include a combination of the following structures (designated by labeled arrows): (a) a wedge-shaped head, (b) rectangular belly scutes, and (c) an elongated fourth toe. Eggshells (d) from a previous egg clutch of *A. s. viridis* are also evident. Line = 10 mm.

the hundreds of hours of excavation work, remains of expired lizards were never found. Thus, on 20 September 2003 SET was surprised by the discovery of clearly identifiable skeletal remains which we agree are those of a large Prairie Racerunner (Fig. 1) in a burrow shelter uncovered from beneath a flat rock (ca. 25 cm in diameter) on a gradual-sloping, south-facing, red clay embankment at 1435 h. The site is located within the Arkansas Army National Guard controlled Fort Chaffee Maneuver Training Center in the Arkansas River Valley, Sebastian Co., Arkansas, USA (35.20034°N, 94.15700°W; elev. 241 m). The lizard was occupying a nesting chamber that contained eggshells from a previous egg clutch (Fig. 1). Bacterial action on the lizard's undetached skin and/or the remaining flesh along the spine and hind legs cast a greenish tint to the exposed dorsum. Moreover, and based upon the presence of this greenish coloration, there appeared to be the corpse of another vertebrate beside the lizard, although its identity was not determined at the time of the discovery.

We have collectively studied *A. sexlineata* in many parts of the range in Arkansas and other states, and only SET has observed another instance of a dead racerunner in a burrow shelter. That instance occurred on 29 July 1982 in Pasco Co., Florida, in which the partially decomposed body of an Eastern Six-lined Racerunner, *A. s. sexlineata*, was infested with what appeared to be fire ants. These examples of deceased racerunners located in burrow retreats provide preliminary support for our hypothesis that many of them die by means other than predation. Nevertheless, it seems likely that skeletal remains of racerunners are ephemeral given their rare discovery during the large number of excavations performed by SET.

STANLEY E. TRAUTH, Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467, USA (e-mail: strauth@astate.edu); **JAMES M. WALKER**, Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas 72701, USA (e-mail: jmwalker@uark.edu); **JAMES E. CORDES**, Division of Sciences and Mathematics, Louisiana State University Eunice, Eunice, Louisiana 70535, USA (e-mail: jcordes@lsue.edu).



FIG. 1. Adult *Leptophis ahaetulla* preying upon an adult *Bogertia lutzae* in Pernambuco, Brazil.

BOGERTIA LUTZAE. PREDATION BY LEPTOPHIS AHAETULLA. *Bogertia lutzae* is a small bromelicolous lizard (Avila et al. 2010. J. Helminthol. 84:199–201) endemic to the northeast region of Brazil and is found in different ecosystems, mainly inhabiting sandbanks, Atlantic forest, and Caatinga (Rodrigues 1987. Arq. Zool. 1:105–230). *Leptophis ahaetulla* is a snake with a wide geographical distribution, occurring from southern Mexico to northern Uruguay (Albuquerque et al. 2007. J. Nat. Hist. 41:1237–1243; Carvalho et al. 2007. Biol. Geral Exper. 7:41–59). It is a primarily diurnal and semi-arboreal snake and is reported to occur over a wide range of habitats. The diet of *L. ahaetulla* consists predominantly of hylid frogs; however, there are also records of *Anolis* sp., *Thecadactylus rapicauda*, *Mastigodryas boddaerti*, and young birds in their diet (Albuquerque et al. 2007, *op. cit.*).

On 8 April 2013 at 1230 h we observed an adult *L. ahaetulla* preying upon an adult *B. lutzae*. This event occurred at Tapacurá Ecological Station, Pernambuco, Brazil (8.036°S, 35.199°W; datum WGS 84). The event was recorded at a forest edge. This is the first record of predation reported for *B. lutzae* by *L. ahaetulla*. The image of predation is available in the collection of images of Herpetology and Paleontology Laboratory of the Federal Rural University of Pernambuco - UFRPE, Recife, Pernambuco, Brazil.

DANIELA FILIPA FERREIRA TEIXEIRA (e-mail: danielateixeira9@ua.pt) and **GERALDO JORGE BARBOSA DE MOURA**, Universidade Federal Rural de Pernambuco, UFRPE, Paleoherpological and Herpetological Laboratory, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos, CEP, 52171-900, Recife, Pernambuco, Brazil.

CALLOPISTES MACULATUS (Chilean Iguana). SAUROPHAGY ON LIOLAEMUS. The highly endemic reptile diversity of Chile is characterized by lower numbers of lizard species, of predominantly small body sizes (SVL <180 mm), compared to adjacent countries. Among these species, *Callopiastes maculatus*, the largest known lizard (and only teiid) occurring in the country (SVL average: 150.5 ± 10.9 mm, range [adult size estimated from the largest 2/3 of a 38-specimen sample]: 135–173 mm), and the *Liolaemus* evolutionary radiation, one of the richest amniote genera on Earth and the richest vertebrate genus in Chile (Pincheira-Donoso et al. 2008. Zootaxa 1800:1–85), stand out as some of the most prominent elements of the indigenous herpetofauna. All



FIG. 1. Saurophagy of *Callopiastes maculatus* on *Liolaemus nitidus* in central Chile.

geographic areas where *C. maculatus* has been recorded are also inhabited by one or more species of *Liolaemus*. In these common areas, both groups of lizards are found in the same microhabitats, and overlap temporally (they are all diurnal). Surprisingly, however, ecological interactions among *Callopiastes* and *Liolaemus* have only rarely been documented in the literature (e.g., see Jaksic 1998. Ecología de los Vertebrados Terrestres de Chile. Pont. Univ. Católica Press, Santiago. 262 pp.). Here, we report a predation event between *C. maculatus* and *L. nitidus*, one of the largest known *Liolaemus* species (SVL average: 92.5 mm, range: 85.4–107.5 mm; Pincheira-Donoso et al. 2008. BMC Evol. Biol. 8:68).

The feeding ecology of *Callopiastes maculatus* is primarily insectivorous and secondarily carnivorous (including both heterospecific and conspecific small lizards, as well as birds and mammals), while other reports also describe consumption of plant material (Fuentes 1976. Ecology 57:3–17; Mellado 1982. Donana Acta Verteb. 9:372–373; Vidal and Ortiz 2003. Herpetol. Rev. 34:364–365). Within the lizard component of *C. maculatus* diet, only small *Liolaemus* species (*L. lemniscatus*, SVL average = 48.8 mm; *L. tenuis*, SVL average = 56.9 mm) have been observed as prey.

Near the city of Ovalle (30.39861°S, 71.22889°W), Coquimbo Region of Chile, we observed an adult male *Callopiastes maculatus* actively preying on an adult *Liolaemus nitidus* (Fig. 1). The observation took place on 10 January 2009, at 1310 h, and the recorded air temperature was 27°C. The feeding behavior of the *C. maculatus* consisted of multiple attacks to the body of the *L. nitidus*, which at the time of our initial observation was lying dead ~50 cm from a shrub (*Fabiana imbricata*). The *C. maculatus* was using this shrub as an intermittent shelter (possibly as a result of our presence) while periodically returning to the prey item to continue its attacks. Every attack to the lifeless *L. nitidus* lasted only a few seconds, and given the adult size of the prey, the predatory lizard showed signs of difficulty in handling it. Within 72 sec. of observation, the *C. maculatus* eventually moved the body of *L. nitidus* out of sight into the vegetation. Although it remains unknown whether the predator managed to eat the captured prey item, our report shows that *C. maculatus* will target other lizard species with only slightly smaller body sizes. In addition, from the ecological perspective of the prey, our observation reveals that the largest species of the genus *Liolaemus* are not only preyed upon by considerably larger vertebrates, such as

mammalian carnivores, birds of prey, or snakes, but also by other lizards. A recent study (Pincheira-Donoso 2012. *Anim. Biol.* 62:277–287) showed that saurophagy within *Liolaemus* mostly involves adults feeding on heterospecific and conspecific (i.e., cannibalism) newborns and juveniles. Collectively, our report challenges the generality for predators of *Liolaemus* lizards. This note provides a record of the largest known prey consumed by *C. maculatus*, while expanding the diversity of reptiles this large species feeds on.

MANUEL JARA, Facultad de Recursos Naturales, Universidad Católica de Temuco, Temuco, Chile (e-mail: jara.a.manuel@gmail.com); current address: Laboratory of Evolutionary Ecology of Adaptations, School of Life Sciences, University of Lincoln, Lincoln, LN2 2LG, United Kingdom; **DANIEL PINCHEIRA-DONOSO**, Laboratory of Evolutionary Ecology of Adaptations, School of Life Sciences, University of Lincoln, Lincoln, LN2 2LG, United Kingdom (e-mail: DPincheiraDonoso@lincoln.ac.uk).

CNEMIDOPHORUS OCELLIFER (Spix's Whiptail). PREDATION. Predation events are difficult to record in the natural environment (Shepard 2007. *Herpetologica* 63:193–202). Such reports are relevant because they present ecological interactions within ecosystem dynamics, thus providing key information concerning diet and natural life history of the species (Morin 1983. *Ecol. Monogr.* 53:119–138).

In natural environments, lizards serve as potential prey for arthropods (Bocchiglieri and Mendonça 2009. *Herpetol. Rev.* 40:438–438) and vertebrates such as other lizards (Faria and Araujo 2004. *Braz. J. Biol.* 64:775–786), snakes (Silva and Araújo 2008. *Ecologia dos Lagartos Brasileiros*. Technical Books, Rio de Janeiro. 271 pp.), and birds (Gogliath et al. 2010. *Herpetol. Bull.* 114:36–38). In this note, we describe a predation event of a terrestrial lizard, *Cnemidophorus ocellifer*, by a Great Egret (*Ardea alba*) on a sand dune beach complex in northeastern Brazil.

On 19 September 2012 at 1530 h during fieldwork at Mosqueiro's Beach, Aracaju, Brazil (11.0885°S, 37.1166°W) we observed a predation attack by a Great Egret on a *C. ocellifer*. The egret was observed walking slowly along the dunes, and suddenly changed its stance, beginning to walk faster with the neck stretched toward and facing upright. It then stopped close



FIG. 1. Great Egret predation upon *Cnemidophorus ocellifer* at Mosqueiro's Beach, Aracaju, Brazil.

to some herbaceous vegetation and remained still with the neck held in an S-shape, the typical posture of this species during stalking behavior. A few seconds later the egret attacked and captured the lizard with its bill (Fig. 1).

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BRUNO JACKSON ALMEIDA, Núcleo de Pós-Graduação em Desenvolvimento e Meio Ambiente, Universidade Federal de Sergipe, 49.000-000, São Cristóvão, Sergipe, Brazil (e-mail: bj.almeida06@gmail.com); **RAFAEL ALVES DOS SANTOS**, Núcleo de Pós-Graduação em Ecologia e Conservação, Universidade Federal de Sergipe, 49.000-000, São Cristóvão, Sergipe, Brazil; **BRUNO DUARTE DA SILVA**, Núcleo de Pós-Graduação em Ecologia e Conservação, Universidade Federal de Sergipe, 49.000-000, São Cristóvão, Sergipe, Brazil.

COPESGLOSSUM AFF. NIGROPUNCTATUM (Amazonian Skink). PREDATION. The Amazonian Pygmy-Owl (*Glaucidium hardyi*) typically feeds on arthropods and is considered insectivorous, although it may less commonly predate on small vertebrates such as birds, mammals, amphibians and reptiles (Sick 1997. *Ornitologia Brasileira*. Editora Nova Fronteira, Rio de Janeiro. 912 pp.). At 1000 h on 1 November 2012, while I was birdwatching on “ZF-2 Tower,” at “Reserva Cuieiras,” property of Instituto Nacional de Pesquisas da Amazônia, 80 km from Manaus, Amazonas, Brazil, I saw a *G. hardyi* perched near the tower. I approached quietly and took some photos. After a few minutes, the owl flew to a 30 m-high platform on the tower where it remained for a few seconds, as if in pursuit of prey. Upon returning to its perch, the owl was holding a *Copesglossum aff. nigropunctata* in its talons. The skink tried to escape, but the owl bit the dorsal region of the neck, killing it, and flew away with the prey. This is the first record of predation on a *C. aff. nigropunctata* by an Amazonian Pygmy-owl, and a rare record of vertebrate predation by this species.

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FELIPE BITTIOLI R. GOMES, Programa de Pós-graduação em Ecologia, Instituto Nacional de Pesquisas da Amazônia, C.P. 478, 69011-970, Manaus, Amazonas, Brazil and COAVAP – Vale do Paraíba Birdwatchers Club; e-mail: felipebrgomes@yahoo.com.br.

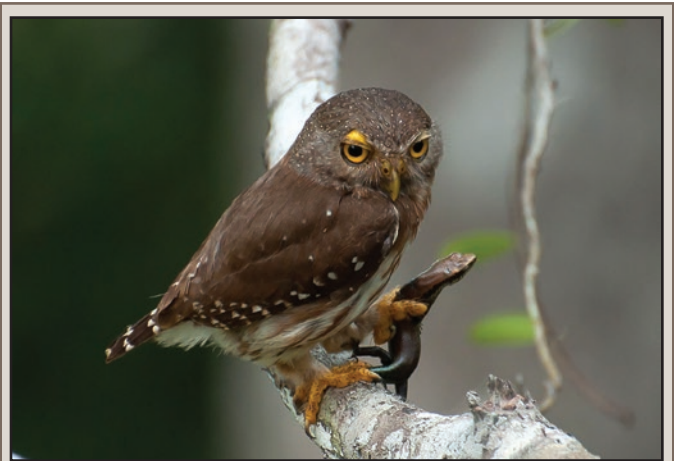


FIG. 1. An Amazonian Pygmy-Owl (*Glaucidium hardyi*) holding an Amazonian Skink (*Copesglossum aff. nigropunctata*).

TABLE 1. Observations of aggregations of Japanese Geckos (*Gekko japonicus*) in Fukuoka, Japan conducted from November 2011 to April 2012. Geocoordinates based on datum WGS84. A = # of *G. japonicus* observed in aggregation.

Site 1 Coordinates: 33.597266°N, 130.3748°E Natural Ground Elevation: 21 m											
Date	10 Dec	25 Dec	29 Dec	18 Jan	30 Jan	18 Feb	6 Mar	27 Mar	9 Apr	16 Apr	27 Apr
Time	1430 h	1030 h	1030 h	1130 h	1230 h	1330 h	1400 h	1230 h	1230 h	1300 h	1545 h
°C	7.5°	4.5°	7°	9°	8.5°	1°	12°	15°	21.5°	22°	19°
A group 1	4	5	4	7	6	6	6	3	7	2	4
A group 2	5	6	7	7	5	6	6	5	6	3	0
Site 2 Coordinates: 33.589433°N, 130.458316°E Natural Ground Elevation: 14 m											
Date	28 Nov	15 Dec	24 Dec	4 Jan	12 Dec	4 Mar	8 Apr	15 Apr	22 Apr		
Time	1830 h	1900 h	1800 h	1500 h	1830 h	1730 h	1500 h	1700 h	1600 h		
°C	17°	9°	6°	3°	6.5°	9°	22°	20°	22°		
A group 3	4	7	7	8	6	7	4	1	1		
A group 4*	5	10	11	8	6	5	4	2	1		

*View partially obscured by a small can placed in hole. # of animals present may be higher.

GEKKO JAPONICUS (Japanese Gecko). COLD WEATHER AGGREGATIONS. There is little in the literature discussing brumating aggregations of *Gekko japonicus* (Hisai 1997. Misc. Rep. Inst. Nat. Stud. 28:1–5 [In Japanese]; Hisai 1998. Misc. Rep. Inst. Nat. Stud. 29:1–3 [In Japanese]) and, to the best of my knowledge, nothing in English. Hisai (1997, 1998, *op. cit.*) continuously observed two brumating aggregations of *G. japonicus* behind sign boards on a building and also noted that this species has been reported to utilize woodpiles, potted plants, retaining walls, loose bark, and crevices of utility poles and buildings. Here I report on observations of four large aggregations of *G. japonicus* in weep holes (Fig. 1) in retaining walls at two sites in the city of Fukuoka, Japan. The aggregations were initially found during a survey of utilization of retaining walls by *G. japonicus*. As time permitted, observations were repeated from November 2011 through April 2012 (Table 1). These aggregations occurred in holes that were 1–1.5 m from the ground. Holes were viewed with a 3-LED flashlight and observation times were limited to 1 minute or less in an attempt to minimize disturbance to the animals. The geckos remained responsive on all but the coldest days (air temp < 3°C).



FIG. 1. Aggregation of six *Gekko japonicus* occupying a weep hole at a park in Fukuoka, Japan (33.597266°N, 130.3748°E) observed at 1400 h, 6 March 2012.

The aggregations were primarily comprised of adults, though juveniles were often present. Consistent with Hisai's observations, the geckos moved to and from holes throughout their brumation period. The aggregations fluctuated in size, peaking in December or January and grew smaller from January to April. The largest aggregation, consisting of at least 11 individuals, was observed on 24 December 2011 among group 4 at Site 2. At each site, the aggregations were in neighboring holes, though many other holes were available. All holes housing the aggregations had also been sites of oviposition as evidenced by the presence of unhatched gecko eggs and eggshells.

Among all groups, the geckos typically clustered near the back of the holes. However, in the latter half of April, after the brumation period had clearly ended, geckos were always observed near the mouths of the holes, retreating to the back upon being approached. During that time, the aggregations largely dispersed, though four geckos were observed occupying one hole at Site 1 during the final observation on 27 April.

Aggregating in lizards mitigates the effects of abiotic environmental factors, such as temperature fluctuations and evaporative water loss; it has been postulated that aggregative behavior evolved among multiple gecko species to take advantage of this (Lancaster et al. 2006. *Anim. Behav.* 72:199–207; Shah et al. 2003. *Behaviour* 140:1039–1052). The overall patterns observed in these *G. japonicus* aggregations, which peaked in late December and January, suggests that aggregative behavior during brumation in this species could be an adaptation to exploit the thermal inertia of a group as a means of protection against drops in temperature.

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KENT R. CALDWELL, 1-22-8 205 Yoshizuka, Hakata-ku, Fukuoka-shi, Fukuoka-ken, 812-0041 Japan; e-mail: Allosaurus.fragilis@gmail.com.

GEKKO MONARCHUS (Spotted House Gecko). REPRODUCTION. *Gekko monarchus* ranges from the Philippines and southern Thailand through Peninsular Malaysia and Singapore, eastward through the Indo-Australian Archipelago (Grismer 2011. *Lizards of Peninsular Malaysia, Singapore and their Adjacent Archipelagos*. Chimaira, Frankfurt am Main. 728 pp.). There is anecdotal information on its reproduction in Grismer (*op. cit.*) and

numerous accounts of clutches consisting of two eggs and communal nesting in various field guides on reptiles from Southeast Asia, for example, see Das (2006. A Photographic Guide to Snakes and Other Reptiles of Borneo. Ralph Curtis Books, Sanibel Island, Florida. 144 pp.). In this note we present information on reproduction of *G. monarchus* from West Malaysia from a histological examination of museum specimens. Minimum sizes for reproduction are given for both sexes.

A sample of 129 *G. monarchus* from West Malaysia collected 2002, 2003, 2004 to 2006, 2008, and 2011 and deposited in the herpetology collection of La Sierra University, Riverside, California, USA was examined. The sample consisted of 51 adult males (mean SVL = 78.1 mm \pm 6.5 SD, range = 58–90 mm), 30 adult females (mean SVL = 66.0 mm \pm 4.5 SD, range = 56–75 mm), 35 juveniles (mean SVL = 43.6 mm \pm 6.1 SD, range = 31–54 mm) and 10 neonates (mean SVL = 28.4 mm \pm 1.3 SD, range = 27–30 mm). All juveniles contained very small gonads indicating reproductive activity had not commenced. Neonates were within the size range for *G. monarchus* in Malkmus et al. (2002. Amphibians and Reptiles of Mount Kinabalu [North Borneo] Koeltz Scientific Books, Königstein. 424 pp.). *Gekko monarchus* were collected in West (Peninsular) Malaysia (by state): Johor (N = 64), Melaka (N = 3), Pahang (N = 60), Perak (N = 1), Penang (N = 2), Selangor (N = 3), Terengganu (N = 1).

A cut was made in the lower abdominal cavity and the left testis or ovary was removed, embedded in paraffin, cut into 5 μ m sections and stained with Harris hematoxylin followed by eosin counterstain. Enlarged follicles (> 4 mm) or oviductal eggs were counted. Histology slides were deposited in LSUHC.

Two stages were present in the testicular cycle: 1) recrudescence, characterized by a proliferation of germ cells in the seminiferous tubules, primary or secondary spermatocytes predominate; 2) spermiogenesis, seminiferous tubules lined by clusters of sperm or metamorphosing spermatids. Spermiogenesis was the predominant phase in the months data was available from: March (N = 9, 100%), June (N = 2, 100%), July (N = 16, 100%), August (N = 8, 63%), September (N = 16, 94%). The smallest reproductively active male (spermiogenesis) measured 58 mm SVL (LSUHC 5257) and was collected in March. The significance of males exhibiting recrudescence in August (N = 3) and September (N = 1) is not known. One of the August males (LSUHC 5766) measured 58 mm SVL and likely had not joined the breeding population.

Four stages were present in the monthly distribution of stages in the ovarian cycle of *G. monarchus* (Table 1); 1) quiescent, no yolk deposition; 2) yolk deposition, basophilic yolk granules in the ooplasm; 3) enlarged follicles > 4 mm; 4) oviductal eggs. The smallest reproductively active female (yolk deposition) measured 56 mm SVL (LSUHC 5710) and was from August.

TABLE 1. Monthly stages in the ovarian cycle of 30 *Gekko monarchus* from West Malaysia.

Month	N	Quiescent	Yolk depositon	Enlarged follicles > 4 mm	Oviductal eggs
March	5	3	1	0	1
June	1	0	0	0	1
July	8	5	1	0	2
August	4	3	1	0	0
September	12	5	3	1	3

Mean clutch size for 8 females was 1.9 ± 0.35 , range = 1–2. *Gekko monarchus* females were reproductively active in all months sampled. No female with oviductal eggs or corpora lutea and concurrent yolk deposition, indicating production of multiple clutches was found. Nevertheless this is likely possible in view of the extended breeding period and likely reflects our small adult female sample size (N = 30).

The presence of reproductively active males and females in all months examined and the observations of gravid females from March through November by Grismer (*op. cit.*) indicates *G. monarchus* exhibits a prolonged reproductive cycle. This was found to occur in other geckos from Southeast Asia including the congener *G. smithi* (Goldberg 2009. Texas J. Sci. 61:225–228, *Dixonius siamensis* (Goldberg 2008. Texas J. Sci. 60:233–238), and *Cyrtodactylus baluensis* (Goldberg 2012. Hamadryad 36:42–44).

STEPHEN R. GOLDBERG, Whittier College, Department of Biology, Whittier, California 90608, USA (e-mail: sgoldberg@whittier.edu); L. LEE GRISMER, La Sierra University, Department of Biology, Riverside, California 92515, USA (e-mail: lgrismer@lasierra.edu).

HEMIDACTYLUS MABOUIA (Tropical House Gecko). CANNIBALISM. Intraspecific predation (cannibalism) is a widespread ecological behavior that has been reported in numerous lizards (Blanco et al. 2012. Cuad. Herpetol. 26:91–93; Pincheira-Donoso 2012. Anim. Biol. 62: 277–287; Sales et al. 2011. Herpetol. Notes 4:265–267). *Hemidactylus mabouia* is a prolific colonizer, widely distributed, and frequently associated with urban areas, but also found in natural environments from the Amazonia to the Caatinga (Ávila-Pires 1995. Zool. Verh. Leiden. 299:1–706; Zamprogno and Teixeira 1998. Brazil. J. Biol. 58: 143–150). The diet reported for *H. mabouia* consists mainly of spiders, insect larvae, and termites (Rocha and Anjos 2007. Brazil. J. Biol. 67: 485–491). In this note we report a case of intraspecific predation by *H. mabouia*.



FIG. 1. Gravid female *Hemidactylus mabouia* preying upon a juvenile conspecific.

During the rainy season on 21 May 2013 at ca. 2110 h, we observed an adult female *H. mabouia* (57.5 mm in SVL) with two eggs in its abdomen (viewable through the skin) and a conspecific juvenile gecko (36.5 mm in SVL) inside its mouth (Fig. 1). The adult had a firm bite hold on the lateral region of the juvenile's torso. Our observation occurred in a residence in the urban area (0.002694°S, 51.091306°W, datum WGS84; 31 m elev.), municipality of Macapá, State of Amapá, northern Brazil. The observations here lasted 20–35 minutes. Seven minutes subsequent to ingestion, the adult female gecko regurgitated the juvenile. The regurgitation may have been caused by the body size of the juvenile, which represented more than half of SVL female adult. A previous case of cannibalism in this species was reported from southeastern Brazil (Pombal and Pombal, Jr. 2010. *Herpetol. Rev.* 41: 223–224). Cannibalism in *H. mabouia* might represent opportunistic feeding based on an increase in the juvenile population or as a strategy to minimize the ecological costs during periods of low arthropod availability.

CARLOS E. COSTA-CAMPOS (e-mail: eduardocampos@unifap.br) and **MAYARA F. M. FURTADO**, Laboratório de Herpetologia, Departamento Ciências Biológicas e da Saúde, Universidade Federal do Amapá, Campus Marco Zero, 68903-280, Macapá, AP, Brazil (e-mail: mayarafabiana@gmail.com).

HEMIDACTYLUS MABOUIA (African House Gecko). PREDATION BY CALLITHRIX PENICILLATA. *Hemidactylus mabouia* is an exotic lizard that broadly distributed in Brazil from forests to urban areas (Sousa and Freire 2010. *Biotemas* 23:231–234) but native to Africa. This is a nocturnal species, sheltering in crevices and under tree bark during the day. Marmosets (*Callithrix* spp.) are endemic Brazilian primates that consume different kinds of food, from plant reproductive parts to animals, such as insects, toads, and lizards (e.g., *Anolis*, *Mabuya*) (Martins and Setz 2000. *Int. J. Primatol.* 21:476–476; Passamani and Rylands 2000. *Primates* 41:27–38; Rylands et al. 2009. *In* Ford et al. [eds.], *The Smallest Anthropoids: the Marmoset/Callimico Radiation*, pp. 25–61. Springer, New York). In this short note, we describe an autotomy event in *H. mabouia* followed by its predation by *C. penicillata* (É. Geoffroy, 1812).

On 18 June 2013, while monitoring a group of *Callithrix penicillata* (eight individuals), we observed the capture and predation of an individual *Hemidactylus mabouia* by two marmosets (a juvenile and an adult). This event occurred in a Cerrado remnant, located in the urban area of Campo Grande, state of Mato Grosso do Sul, Brazil (20.301418°S, 54.365219°W). At 0929 h (ambient temperature = 28°C), a juvenile marmoset (< 6 months) was foraging on a trunk (ca. 60 cm circumference) at ca. 1.5 m above ground. It tracked and captured a *H. mabouia*. Instantaneously, the lizard released the tail while in the hands of the primate, launched itself to the ground, and remained motionless. The juvenile marmoset started to eat the tail, whereas the adult marmoset (> 2 years) searched the ground intensively. After 1 min (0930 h), the adult marmoset came down to the ground, leaped onto the lizard, captured it and brought it to its mouth. Later, the same individual marmoset climbed a tree at 2 m above ground and started to eat the lizard (Fig. 1). The juvenile marmoset made successive requests for food to the adult, which shared a small part of the lizard. From the tracking to the end of the ingestion approximately 6 min elapsed.

Tail autotomy in lizards is a mechanism that may reduce mortality by predation, since tail movements (postautotomy) may distract or confound the predator (Congdon et al. 1974. *Science*



FIG. 1. An adult *Callithrix penicillata* preying on *Hemidactylus mabouia* in Campo Grande, Mato Grosso do Sul, Brazil.

184:1379–1380). However, it is possible that this antipredator mechanism is more efficient against solitary predators than against individuals that forage in groups, such as marmosets.

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GILSON DA ROCHA-SANTOS (e-mail: gilsonsantos.bio@gmail.com) and **EDER BARBIER**, Programa de Pós-graduação em Biologia Animal, Centro de Ciências Biológicas e da Saúde, Universidade Federal de Mato Grosso do Sul, CEP 79.070-900, Av. Costa e Silva, s/n, Campo Grande, Mato Grosso do Sul, Brazil (e-mail: ederbarbier@hotmail.com); **DAYANE FERNANDES DA SILVA**, Rua Zeferino Vicente Almeida, 300, CEP 79.050-560, Campo Grande, Mato Grosso do Sul, Brazil (e-mail: dayane.fernandes.bio@gmail.com).

HOLASPIS GUENTHERI (Günther's Gliding Lizard). PREDATION. On 13 January 2010, at 1117 h, one of us (SI) observed and photographed an adult Senegal Kingfisher (Coraciiformes: Alcedinidae: *Halcyon senegalensis*) holding an adult *Holaspis guentheri* in its beak. The bird was perched on the landing strip barrier of the Joachim Mahothes Magouindi Airport (2.79°S, 10.06°E), Gamba, Ogooué-Maritime Province, southwestern Gabon. Neither the bird nor the lizard was collected, but their respective color patterns readily distinguish them from related taxa recorded in the region (Angehr et al. 2006. *In* Alonso et al. Gamba, Gabon: Biodiversité d'une forêt équatoriale africaine, pp. 327–351. *Bull. Biol. Soc. Washington* 12; Pauwels and Vande



FIG. 1. A Senegal Kingfisher (*Halcyon senegalensis*) with an adult Günther's Gliding Lizard (*Holaspis guentheri*).

weghe 2008. Reptiles du Gabon. Smithsonian Institution, Washington. 272 pp.). It is the first time that this specific predator-prey relationship is reported.

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OLIVIER S. G. PAUWELS, Département des Vertébrés Récents, Institut Royal des Sciences naturelles de Belgique, Rue Vautier 29, B-1000 Brussels, Belgium (e-mail: osgpauwels@yahoo.fr); **SAFFIAN ITAM** (e-mail: saffian@gmail.com).

LIOLAEMUS MONTICOLA (Mountain Lava Lizard). PREDATION ON LIOLAEMUS LEMNISCATUS. *Liolaemus* is a diverse genus of small to medium-sized, omnivorous lizards, distributed in the southern hemisphere of the Neotropical realm. *Liolaemus monticola* is endemic to Chile and is distributed in Andean scrub from Coquimbo to Maule regions, from 500–3000 m elev. (Pincheira-Donoso and Nuñez 2005. Publ. Ocas. Mus. Nac. Hist. Nat. Chile 59:1–486). This species is an active forager on insects with more than 50% of its reported diet as ants (Fuentes and Ipinza 1979. J. Herpetol. 13:123–124; Vidal and Labra 2008. Herpetología de Chile. Science Verlag, Santiago. 593 pp.). Here I report an observation of saurophagy.

On 21 January 2011, at 1100 h, on a sunny day with an ambient temperature of 22°C, an adult *L. monticola* (mean SVL 157



FIG. 1. *Liolaemus monticola* eating a juvenile *L. lemniscatus*.

mm and tail length at 94 mm) was observed attacking and then ingesting a juvenile *Liolaemus lemniscatus* (SVL = 45 mm) at Fundo Las Lomas, Colina County, Metropolitan region, Central Chile (33.065546°S, 70.670172°W, WGS84; elev. 810 m). The adult was resting in the soil and then chased the *L. lemniscatus* when it approached, taking ca. five minutes to capture and ingest the small lizard, and then sought refuge under some rocks. The habitat was an open and rocky scrubland dominated by *Baccharis linearis* and *Proustia cuneifolia*, with an additional assemblage of annual forbs. The area is not currently pristine with the original vegetation showing anthropogenic disturbance as a result of wood and charcoal extraction, and livestock use. To my knowledge, this is the first record of saurophagy for *L. monticola* as well as for the entire genus of *Liolaemus* (cf. Vidal and Labra, *op. cit.*).

JUAN C. TORRES-MURA, Unión de Ornitólogos de Chile, Mosquito 459 Of 103, Santiago, Chile; e-mail: torresmura@gmail.com.

LIOLAEMUS WIEGMANNII. PREDATION. Lizards are typical prey items for birds, however direct observations of predation are relatively rare in the field. The sand lizard *Liolaemus wiegmanni* (SVL = 42–64 mm), is largely restricted to sandy soils of a vast region of Argentina and Uruguay (Ceï 1993. Reptiles del Noroeste, Nordeste y Este de la Argentina. Museo Regionale di Scienze Naturali. Torino, Italy. 949 pp.). This species occurs along coastal sand dunes of the Buenos Aires Province in semi-fixed dunes, usually far away from open spaces and beach (Block et al. 2012. J. Herpetol. 46:608–613). This note reports a single observation of predation on *Liolaemus wiegmanni* by a Burrowing Owl (*Athene cunicularia*). The Burrowing Owl is commonly found in grassy plains of Argentina, being the most abundant owl in agroecosystems (Bellocq and Kravetz 1994. Ecol. Austral. 4:29–34). Reptiles, like the sand lizard, are generally less common prey item in the owl's diet (0.3%, Sanchez et al. 2008. Ornitol. Neotrop. 19:71–80).

During a lizard survey through coastal sand dunes in Arenera Galati (37.38658°S, 57.05781°W; datum Campo Inchauspe), Buenos Aires Province, on 31 October 2008 at 1030 h, we observed the carcass of an adult female of *L. wiegmanni* (SVL = 52 mm; total length = 64 mm) lying a few centimeters away from an *A. cunicularia* burrow. The burrow was located on a dune and the owls were present at the moment of the observation. The lizard's body was completely intact suggesting that the lizard had been recently caught. The specimen of *L. wiegmanni* (UNMDP 1778) was deposited in the Herpetological Collection of the Universidad Nacional de Mar del Plata, Buenos Aires, Argentina.

CAROLINA BLOCK (e-mail: cblock@mdp.edu.ar), **OSCAR A. STELLATELLI** (e-mail: os2830@gmail.com), and **LAURA E. VEGA**, Laboratorio de Vertebrados, IIMyC, CONICET - Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, Funes 3250 (B7602AYJ) Mar del Plata, Buenos Aires, Argentina (e-mail: levega@mdp.edu.ar).

MEROLES CUNEIROSTRIS (Wedge-snouted Sand Lizard). CANNIBALISM. Cannibalism has been observed in a diverse number of reptile species; numerous studies have shown that it is not only common, but that it may play an integral role in shaping the ecology of a species and community dynamics (Fox 1975. Annu. Rev. Ecol. Syst. 6:87–106; Jenssen et al. 1989. Anim. Behav. 38:1054–1061; Keren-Rotem et al. 2006. Behav. Ecol. Sociobiol. 59:723–731). Studies suggest that cannibalism is common in generalist predators that might prey on conspecifics opportunistically. This pattern has been observed in diverse

taxa, and most reported cases involve larger individuals feeding on younger, smaller conspecifics (e.g., Polis and Myers 1985. *J. Herpetol.* 19:99–107; Pincheira-Donoso 2012. *Anim. Biol.* 62:277–287; Siqueira and Rocha 2008. *S. Am. J. Herpetol.* 3:82–87). Among lacertid lizards, cannibalism has been mainly documented among island species characterized by high population densities and limited food resources (Amat et al. 2008. *Amphibia-Reptilia* 29:329–336; Pafilis et al. 2009. *Naturwissenschaften* 96:1107–1113; Perez-Mellado and Corti 1993. *Bonn. Zool. Beitr.* 44:193–220; Žagar et al. 2012. *Acta Herpetol.* 7:29–39). This behavior, however, has been poorly documented among continental species.

On 27 December 2011 near the Gobabeb Training and Research Centre, Erongo, Namibia (23.561986°S, 15.041616°E, datum WGS84; 408 m elev.) we observed a juvenile *Meroles cuneirostris* being eaten by a conspecific adult female (SVL = 44 mm; tail length = 72 mm; 2.6 g). At ca. 1100 h, while attempting to capture the juvenile, an adult female dashed from underneath a small bush and began to chase the juvenile. The chase lasted less than 30 sec. before the female captured the juvenile, biting down on its head and then violently shook her own head. The juvenile then briefly escaped but was recaptured in the same manner. The female relocated to a spot underneath the bush where initially observed and continued to grip the head and neck of the juvenile as it struggled to escape, tightening her grip every few moments. After several minutes the juvenile became lifeless, and the female began to swallow the juvenile whole, headfirst. The entire consumption of the juvenile was completed in ca. 3 min., during which time the female appeared to have no trouble swallowing. Afterward the female remained under the bush for nearly 5 min. and then sprinted ca. 30 m away across the open sand.

There have been no prior examples of cannibalism in any *Meroles* species to date. The diet of *M. cuneirostris* is primarily insectivorous, and relative food availability is thought to remain constantly low throughout the year in this temperate desert climate (Goldberg and Robinson 1979. *Herpetologica* 35:169–175). At the time of this observation, median juvenile SVL for this population was 33 mm (range = 27–42 mm; N = 53).

JACKIE L. CHILDERS, Museum of Vertebrate Zoology, 3101 Valley Life Sciences Building, Berkeley, California 94720-3161, USA (e-mail: jackielynchilders@gmail.com); **DOUGLAS A. EIFLER**, Environmental Science Program, Haskell Indian Nations University, Lawrence, Kansas 66046, USA (e-mail: doug.eifler@gmail.com).

MESALINA OLIVIERI (Olivier's Sand Lizard). CESTODE ENDOPARASITES. *Mesalina olivieri* is known from Algeria, Western Sahara, Tunisia, Libya, Egypt, Israel, Jordan, Iraq, and Saudi Arabia (Bar and Haimovitch 2011. *A Field Guide to Reptiles and Amphibians of Israel*. Herzliya, Israel. 245 pp.). We know of no endoparasite records for this species. The purpose of this note is to establish the initial helminth list for *M. olivieri*.

One female *M. olivieri* (SVL = 48 mm) collected April 1956 in the Central Negev Region, Israel and deposited in the herpetology collection of the Tel Aviv Museum of Natural History (TAUM), Tel Aviv, Israel as TAUM 2201, was examined for endoparasites. A lateral slit was made on the left side and the coelomic cavity was examined for endoparasites using a dissecting microscope. Found were 30 oblong whitish, bodies measuring ca. 1 mm in length. They were regressively stained in hematoxylin, cleared in xylol, mounted in balsam, studied under a compound microscope and identified as tetrathyridia larvae of the

cestode, *Mesocestoides* sp. Voucher helminths were deposited in the United States National Parasite Collection, USNPC, Beltsville, Maryland as USNPC 107017. The life cycle of *Mesocestoides* sp. is unknown but is thought to utilize three hosts, a vertebrate definitive host, a vertebrate second intermediate host and an arthropod first intermediate host (Rausch 1994. *In* Khalil et al. [eds.], *Keys to the Cestode Parasites of Vertebrates*, pp. 309–314. CAM International, Oxon, U.K.). Tetrathyridia are commonly found in the body cavities of amphibians, reptiles, and rodents (Padgett and Boyce 2004. *J. Parasitol.* 90:108–113). *Mesocestoides* sp. was previously reported in the congener *M. guttulata* from Israel (Goldberg and Bursey 2012. *Herpetol. Rev.* 43:136). *Mesocestoides* sp. in *Mesalina olivieri* is a new host record.

We thank Shai Meiri (TAUM) for permission to examine *M. olivieri*, Ezra Maza for facilitating the loan, and the National Collections of Natural History at Tel Aviv University for providing *M. olivieri* for this study.

STEPHEN R. GOLDBERG, Department of Biology, Whittier College, PO Box 634, Whittier, California 90608, USA (e-mail: sgoldberg@whittier.edu); **CHARLES R. BURSEY**, Department of Biology, Pennsylvania State University, Shenango Campus, Sharon, Pennsylvania 16146, USA (e-mail: cxb13@psu.edu).

MESALINA OLIVIERI (Olivier's Sand Lizard). REPRODUCTION. *Mesalina olivieri* is known from Algeria, Western Sahara, Tunisia, Libya, Egypt, Israel, Jordan, Iraq, and Saudi Arabia (Bar and Haimovitch 2011. *A Field Guide to Reptiles and Amphibians of Israel*. Pazbar LTD, Herzliya, Israel. 245 pp.). Schleich et al. (1995. *Amphibians and Reptiles of North Africa*. Koeltz Scientific Publishers, Koenigstein. 627 pp.) reported *M. olivieri* from Oran, Algeria commenced mating in October after emergence from aestivation, females with fully developed eggs occurred from mid-October to the end of May, and at least two clutches of 2–4 eggs were produced. In Jordan, clutches of 4–8 eggs were produced (Disi et al. 2001. *Amphibians and Reptiles of the Hashemite Kingdom of Jordan*. Edition Chimaira, Frankfurt am Main. 408 pp.). In this note I present information on the reproductive cycle of *M. olivieri* from Israel.

A sample of 39 *M. olivieri* collected 1941 to 1965 in Israel consisting of 16 adult males (mean SVL = 44.6 mm ± 2.9 SD, range = 40–50 mm), 17 adult females (mean SVL = 44.6 mm ± 3.3 SD, range = 40–51 mm), 2 juvenile males (mean SVL = 37.0 mm ± 2.8 SD, range = 35–39 mm) and 4 juvenile females (mean SVL = 38 mm ± 1.7 SD, range = 35–39 mm) was examined from the National Collections of Natural History at Tel Aviv University (TAUM), Tel Aviv, Israel by Region Name: Arava Valley TAUM 1832, 2602, 4113; Central Negev TAUM 1121, 1480, 1481, 1483, 1486, 1490, 1731, 1741, 2201, 2475, 2500, 2501, 3438, 4367, 5964, 5982; Northern Negev TAUM 1116, 1131, 1445, 1479, 1484, 1485, 1492, 1496,

TABLE 1. Monthly stages in the ovarian cycle of 17 *Mesalina olivieri* females from Israel; one April female (*) with oviductal eggs was also undergoing yolk deposition.

Month	N	Quiescent	Early yolk depositon	Follicles > 4 mm	Oviductal eggs
January	1	0	0	1	0
March	6	1	2	1	2
April	9	2	3	1	3*
November	1	1	0	0	0

1967, 3682, 3951, 3991, 3996; Southern Coastal Plain TAUM 1493, 1495, 2064, 2456, 2953, 2954, 5965.

The left testis was removed from males and the left ovary was removed from females for histological examination. Gonads were embedded in paraffin and histological sections were cut at 5 μm and stained with hematoxylin followed by eosin counterstain. Enlarged ovarian follicles (> 4 mm) and oviductal eggs were counted. No histology was performed on them. Histology slides were deposited at TAUM.

Two stages were observed in the testicular cycle: Spermiogenesis, (seminiferous tubules are lined by sperm or clusters of metamorphosing spermatids); Recrudescence (proliferation of germ cells prior to spermiogenesis), was observed in two juvenile males from September, measuring 35 mm and 39 mm SVL, respectively). Males exhibiting spermiogenesis by month were January (N = 1), March (N = 4), April (N = 8), May (N = 1), November (N = 1). The smallest reproductively active male measured 40 mm SVL (TAUM 1121) and was collected in April. The presence of the November male undergoing spermiogenesis suggests *M. olivieri* exhibits a testicular cycle similar to the congener *Mesalina guttulata* from Israel (Goldberg 2012. Zool. Mid. East 56:27–30) which also initiates sperm formation in autumn.

Four stages were noted in the ovarian cycle of *M. olivieri* (Table 1): Quiescent (no yolk deposition; Early yolk deposition (yolk granules in the ooplasm); Enlarged ovarian follicles > 4 mm; Oviductal eggs. The smallest reproductively active *M. olivieri* females measured 40 mm SVL (TAUM 1731) 3 follicles > 4 mm, early yolk deposition (TAUM 2501) both collected in March. Four smaller females with quiescent ovaries, 35 (September), 38 (December), 38 (January), 39 mm (January) SVL, respectively, were considered juveniles. Mean clutch size (N = 8) was 3.4 ± 0.74 , range = 2–4. One female from April with oviductal eggs was undergoing concurrent yolk deposition for a subsequent clutch indicating *M. olivieri* can produce multiple clutches in the same reproductive season in Israel.

I thank Shai Meiri (TAUM) for permission to examine *M. olivieri*, Ezra Maza for facilitating the loan and the National Collections of Natural History at Tel Aviv University for providing *M. olivieri* for this study.

STEPHEN R. GOLDBERG, Department of Biology, Whittier College, PO Box 634, Whittier, California 90608, USA; e-mail: sgoldberg@whittier.edu.

NOROPS PENTAPRION (Lichen Anole). DIRECTED AERIAL DESCENT. Lizards with gliding or directed aerial descent behaviors are well known from the Old World Tropics (e.g., *Draco*, *Ptychozoon*), and snakes and frogs exhibiting these behaviors are found both in the Old and New World Tropics (Dudley et al. 2007. Annu. Rev. Ecol. Evol. Syst. 38:179–201). However, lizards showing directed aerial descent have not been reported from the New World Tropics. Here we report on directed aerial descent capability and behavior in *Norops pentaprion*, a canopy lizard from eastern Costa Rica, southern Nicaragua, and western Panama (Köhler 2010. Zootaxa 2354:1–18).

The initial discovery of this behavior in *N. pentaprion* was serendipitous in July 2001 when an individual was captured on a walk-up meteorological tower at canopy level (~ 25 m) at La Selva Biological Station in the Atlantic lowlands of Costa Rica. After identification, the animal was returned to the original location on the tower, but upon release to a horizontal tower brace, it executed a controlled aerial descent to a tree in the distance below. Individuals of *N. pentaprion* have been occasionally observed on



FIG. 1. Frames from video of a *Norops pentaprion* individual executing an aerial rotation during directed aerial descent. Arrows track the lizard's descent.

our meteorological towers subsequent to our first observation of directed aerial descent. The lizards are typically at canopy level but are sometimes found well above the canopy on the highest levels of the towers (up to 42 m). While the typical response of *N. pentaprion* to the presence of personnel on the tower is to race

down the tower or hide on the opposite side of vertical supports, the animals will occasionally jump from the tower to escape when approached. Since 2001 we have observed directed aerial descent by *N. pentaprion* from canopy towers on several occasions. In at least two instances the lizard landed at lower levels on the tower, but in other occurrences they covered substantial distance to adjacent trees including aerial rotations of near 180°. During more than one observation, animals appeared to glide with near-horizontal trajectories towards termination of the descent.

Similar to some snakes, frogs, lizards, and ants showing directed aerial descent, *N. pentaprion* does not have strongly specialized features associated with gliding behavior such as skin flaps, skin extensions, or webbed feet. *Norops pentaprion* has a relatively flattened head and wide body. During aerial descent this lizard proceeds headfirst, with limbs partially extended and the body strongly flattened, a position that may take advantage of regions of relatively loose skin along the sides of the body (Guyer and Donnelly 2005. *Amphibians and Reptiles of La Selva, Costa Rica, and the Caribbean Slope*, Univ. California Press, Berkeley, California. 299 pp.).

At La Selva Biological Station this species is uncommon in the understory and is usually found on trees limbs. *Norops pentaprion* is a member of a closely-related group of anoline lizards subjected to a recent analysis of morphology and morphometrics (Köhler, *op. cit.*); these related taxa share similar body size characteristics with *N. pentaprion* and are frequently arboreal. Future observations of some of these species may result in the discovery of similar directed-aerial descent behavior.

Canopy pioneer Donald Perry reported lizards with a rose dewlap parachuting between trees in the canopy in Costa Rican forests (Perry 1986. *Life Above the Jungle Floor*, Simon and Schuster, Inc. New York, New York. 170 pp.), but the species was not identified. In their description of *Norops pentaprion*, Guyer and Donnelly (*op. cit.*) indicated that parachuting behavior likely occurs in this species on the basis of our initial observations and those of Perry. Our repeated observations verify directed aerial descent in this species and confirm that the lizard observed by Perry was *N. pentaprion*, the only lizard in the region with magenta dewlap coloration.

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STEVEN F. OBERBAUER, Department of Biological Sciences, Florida International University, Miami, Florida 33199, USA (e-mail: oberbaue@fiu.edu); **CRAIG GUYER**, Department of Biological Sciences, 331 Funchess Hall, Auburn University, Auburn, Alabama 36849, USA (e-mail: guyercr@auburn.edu); **VINICIO PANIAGUA**, La Selva Biological Station, Organization for Tropical Studies, Puerto Viejo de Sarapiquí, Costa Rica; **DIEGO DIERICK**, Department of Biological Sciences, Florida International University, Miami, Florida 33199, USA; **MAUREEN A. DONNELLY**, Department of Biological Sciences, Florida International University, Miami, Florida 33199, USA (e-mail: maureen.a.donnelly@gmail.com).

OPLURUS CUVIERI CUVIERI (*Madagascan Spiny-tailed Iguana*). **PREY**. Several studies have shown that *Oplurus cuvieri cuvieri* (Opluridae) primarily feeds on invertebrates with a high proportion of ants, but also consumes plant matter such as leaves, twigs, flower buds and seeds (Bloxam et al. 1996. *Prim. Rep.* 46:189–201; Brillet 1982. *Rev. Ecol. Terre Vie* 36:79–148; Mori and Randriamahazo 2002. *Afr. J. Ecol.* 40:61–64; Randriamahazo and Mori 2012. *Current Herpetol.* 31:8–13). Brillet (*op. cit.*) also reported that *O. c. cuvieri* feeds on small mammals, but it is unclear



FIG. 1 *Oplurus cuvieri cuvieri* captured by a fledgling Madagascar Bulbul.

whether this was an observation under natural conditions or in captivity. In addition, *O. c. cuvieri* has been suggested as a potential predator on nestlings of birds based on the observation that adult Rufous Vangas (*Schetba rufa*) intensely attacked an individual iguana that came close to a nest (Eguchi 2005. In *Social Organization of the Rufous Vanga*, pp. 83–104. Kyoto Univ. Press, Kyoto). Here, I report on a case of predation on a bird by *O. c. cuvieri*.

During a field study in Ampijoroa forest in Ankarafantsika National Park, Madagascar, I observed a predation event of an adult *O. c. cuvieri* on a fledgling of the Madagascar Bulbul (*Hypsipetes madagascariensis*). At ca. 1130 h on 28 November 2011, a fledgling *H. madagascariensis* fell to the ground from a nest in a tree approximately 4 m high. Several avian species such as, the Sickie-billed Vanga (*Falco leucurus*) and the Broad-billed Roller (*Eurystomus glaucurus*) repeatedly flew down and pecked at the fledgling, attempting to capture it, but the parent birds of the fledgling mobbed the other birds and protected the fledgling from their attacks. At 1215 h, a male *O. c. cuvieri* rushed to the fledgling from ca. 10 m away while several birds were still attempting to attack the fledgling, but the lizard failed to capture the fledgling due of the parents' mobbing. This iguana and several birds continued their predation attempts on the fledgling, and the parents of the fledgling had gradually let up mobbing over the course of almost 3 hours of protecting their offspring. Then at 1415 h, the iguana successfully bit and captured the fledgling in its forth attack (Fig. 1), 2 h following its first attempted attack. The parents did not mob the iguana after it captured the fledgling. The iguana tore the body and began consumption, banging the bird on the ground and then against the trunk of the tree while climbing many times. This is the first reported evidence for the predation of vertebrates by *O. c. cuvieri* in the wild.

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RYO ITO, Primate Research Institute, Kyoto University, Inuyama, Aichi, 484-8506 Japan; e-mail: ryo.j.h.ito@gmail.com.

PETRACOLA VENTRIMACULATUS (*Spotted Lightbulb Lizard*). **CANNIBALISM**. *Petracola ventrimaculatus* is a gymnophthalmid

lizard endemic to the northern Peruvian Andes (Kizirian et al. 2008. Zootaxa. 1700:53–62). The natural history of this species is poorly known and there is no published information regarding its diet. However, species of the related genus *Proctoporus* are known to feed on arthropods—mostly beetles, ants, and spiders (Doan 2008. J. Herpetol. 42:16–21).

While clearing and staining three specimens of *P. ventrimaculatus* for a taxonomic review, a hatchling (SVL = 22.93 mm) of *P. ventrimaculatus* was found in the stomach of an adult male conspecific (SVL = 65.2 mm), collected on 18 September 2006 at Puente Hierba Buena (6.981131°S, 78.379764°W), Province of Celendín, Cajamarca Region, Perú. The stomach contents of the other two specimens included one mite, coleopterans (three adults and two larvae), and one amblypygid. This is the first record of cannibalism in the Gymnophthalmidae, as well as the first prey items reported for the diet of *P. ventrimaculatus*.

The male specimen of *Petracola ventrimaculatus* is deposited in the herpetological collection of the Museo de la Universidad San Marcos, Lima, Perú (MUSM 26233). We thank C. Torres for allowing access to the collection of the MUSM.

LOURDES Y. ECHEVARRIA (e-mail: lourdes.20@gmail.com) and **PABLO J. VENEGAS**, División de Herpetología-Centro de Ornitología y Biodiversidad (CORBIDI), Santa Rita No. 105 Of. 202, Urb. Huertos de San Antonio, Surco, Lim, Perú (e-mail: sancarranca@yahoo.es).

PHYMATURUS EXTRILIDUS. PREDATION. On 28 November 2011 at 1710 h, we observed a female Red-backed Hawk (*Buteo polyosoma*) presenting an adult *Phymaturus extrilidus* to a nest of two approximately 1.5-week-old chicks above a canyon known as Aguada de Pinchagua at the Multiple Use Nature Reserve Don Carmelo, Ullum Department, San Juan Province, Argentina (30.977504°S, 69.083017°W, 3122 m elev.). The hawk had removed the head of the lizard prior to arriving at the nest to feed it to the chicks (Fig. 1). Although Red-backed Hawks are known to eat lizards (Jiménez 1995. Hornero 14:1–9), this is the first record of one eating this species and the first record of a confirmed predator for *P. extrilidus* (Lobo et al. 2012. Copeia 2012:12–22). R. E. Espinoza confirmed the identity of the lizard.

MAURICIO ARMANDO PÉREZ, Facultad de Ciencias Exactas, Físicas, y Naturales, Departamento de Biología, Universidad Nacional de San Juan, San Juan, Argentina (e-mail:elcodorniz81@gmail.com); **CARLOS EDUARDO BORGHI** (e-mail:cborghi@unsj-cuim.edu.ar) and **VERÓNICA ALE-**



FIG. 1. Female *Buteo polyosoma* feeding an adult *Phymaturus extrilidus* to two nestlings.

JANDRA BENINATO, Facultad de Ciencias Exactas, Físicas, y Naturales, Instituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan, San Juan, Argentina (e-mail: vbeninato@gmail.com).

PHYMATURUS SPECTABILIS. PREDATION. *Phymaturus spectabilis* is a medium-sized liolaemid lizard endemic to northwestern Patagonia, found in rocky outcrops near Ingeniero Jacobacci, Departamento 25 de Mayo, southwestern Río Negro Province, Argentina. Predation data are absent for this species, but it has been reported to share its habitat with potential reptile predators such as the colubrid snakes *Philodryas patagoniensis* and *P. trilineata*, and the viperid *Rhinocrophis ammodytoides* (Scolaro et al. 2008. Zootaxa 1786:48–70). Here I report an observation of predation of *P. spectabilis* by a Lesser Grison (*Galictis cuja*).

On 7 December 2011 during a field trip to Paraje Yuquiche, Río Negro Province, northwestern Patagonia, Argentina (41.434050°S, 69.751983°W, datum WGS84; elev. 942 m), I observed a Lesser Grison moving below a shrub (*Stillingia patagonica*) at the bottom of a rocky outcrop, where I had earlier observed three individuals of *Liolaemus elongatus* basking. When I approached to get a closer view I realized that the grison was holding a dead *Phymaturus spectabilis* in its mouth. As soon as it saw me, the grison released the dead lizard from its mouth and retreated. The dead lizard was identified as a juvenile female (69.1 mm SVL). The head of the lizard had been completely crushed, indicating that the grison had captured the lizard by this part of its body. It has been reported previously that Lesser Grisons in Patagonia prey secondarily on reptiles (Diuk-Wasser and Cassini 1998. Stud. Neotrop. Fauna Environ. 33:3–6), however, this is the first case of predation on *Phymaturus* lizards.

Erika Kubisch verified the identifications and the *P. spectabilis* (PH229) was deposited in the Herpetological Collection of the Centro Regional Universitario Bariloche (CRUB), San Carlos de Bariloche, Río Negro.

FACUNDO CABEZAS-CARTES, Departamento de Zoología, Laboratorio de Ecofisiología e Historia de vida de Reptiles, INIBIOMA-CONICET, Centro Regional Universitario Bariloche, Universidad Nacional del Comahue, San Carlos de Bariloche (8400), Río Negro, Argentina; e-mail: facundo.cabezas.cartes@gmail.com.

PHYSIGNATHUS LESUEURII (Australian Water Dragon). MUTILATION BY RAVENS. During spring and summer 2005 I observed two instances of Australian Ravens (*Corvus coronoides*) removing parts of the tail from adult Australian Water Dragons (*Physignathus lesueurii*) at the Australian National Botanic Gardens, Canberra, Australia (35.27894°S, 149.11048°E). In the first instance, a raven approached and landed on a pavement cement path approximately 2 m from an adult male dragon (size of the lizard was nearly 1 m in total length). The dragon showed little response other than obvious visual contact. The raven then clasped the dragon's tail (about 10–15 cm from the tip) with its bill and dragged the dragon by the tail in different directions. This occurred for nearly one minute, the dragon running in place as it was being pulled. The raven then ran in circles around the dragon, still holding the tail, with the lizard spinning in one spot and still running in place. After another 30 seconds of this behavior part of the tail snapped off, and the raven flew away with it. A second similar event involved an adult female dragon and possibly the same raven about two weeks later. The raven was first observed already clasping the tail of the dragon, again about 10–15 cm from the tip, on the same path as the first event. This time the raven shook the tail vigorously, breaking off the tip within 20 sec

of first being observed. The raven flew off with the tail piece. I could not confirm whether the raven(s) consumed the tails.

Tail breakage induced or caused by ravens appeared to be deliberate, rather than a failed attempt at predation. It seems likely that the ravens consumed the tails (or the muscle component). Corvids are known for their problem solving abilities (e.g., Weir et al. 2002. *Science* 297:981), and ravens may be responsible for previous observations of incomplete tails in Australian Water Dragon populations. Thompson (1993. *Wildl. Res.* 20:613–619) speculated that the 41–47% rate of tail breakage/regeneration in adult water dragons in another population was due to predators, rather than intraspecific fighting. My observations partially support this idea, but also suggest deliberate “mutilation” by ravens. Further observations of the proportion of tail loss in a population, along with confirmation of ravens consuming the tails (or parts of them), are needed to determine both the cognitive underpinning of tail removal by ravens and its importance to Australian Water Dragon populations.

J. SEAN DOODY, Department of Ecology and Evolutionary Biology, University of Tennessee, 569 Dabney Hall, Knoxville, Tennessee 37996-1610, USA; e-mail: jseandood@gmail.com.

PLESTIODON FASCIATUS (Five-lined Skink). ARTIFICIAL HABITAT USE. In central Ontario, Canada, from 1 May to 31 August 2012, systematic surveys were conducted to examine the impacts of roads on reptiles. Surveys were conducted along 13 km of Highway 69/400 in Parry Sound District and 6 km of Highway 529 in Magnetawan First Nation. Of the 28 *Plestiodon fasciatus* found on or within 3 m of a road, 3 (11%) were dead, while the remaining 25 (89%) were alive and interacting with the road. Interactions were categorized as either crossing the road (3 individuals; 12%) or hiding under cover alongside the roadside (22 individuals; 88%; Fig. 1). Only 2 individuals (9%) were found under natural cover objects (rock, grass thicket), while 20 individuals (91%) were found under anthropogenic debris (garbage, tires, sections of retread and cardboard). During haphazard surveys of non-road sites, 7 individuals were observed, 2 (29%) of which were under natural cover and 3 (43%) were under artificial cover (habitat was not recorded for 2 skinks).

Interestingly, only 6% of all of the skinks found on Magnetawan First Nation (both road and non-road sites; Fig. 1) were found under natural cover, suggesting that artificial cover may be preferred habitat within this population. If this is the case, the high level of refuse found along the roadside may attract skinks to areas that subject them to an increased likelihood of road mortality. Road mortality is a known threat to *P. fasciatus* populations in Ontario (COSEWIC 2007. COSEWIC assessment and update status report on the Five-lined Skink, *Eumeces fasciatus*, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 50 pp.), and elsewhere across the species' range (Illinois; COSEWIC 2007, *op. cit.*, and Florida; Aresco 2003. *J. Wildl. Manage.* 69:549–560).

It has been previously documented that *P. fasciatus* only occasionally uses artificial cover objects in some populations (e.g., Hecnar 1994. *Can. J. Zool.* 72:1510–1516). In central Ontario, *P. fasciatus* is thought to select habitat based on specific microhabitat characteristics; specifically, rocks averaging 55 cm in length that provide thermal conditions that vary by no more than 1.99°C (Quirt et al. 2006. *J. Herpetol.* 40:335–342) and that provide an optimum cover temperature range of 28°C to 36°C (Fitch 1954. *Univ. Kansas Publ. Mus. Nat. Hist.* 8:1–156). The specificity of this species' habitat preference is so strong that degradation

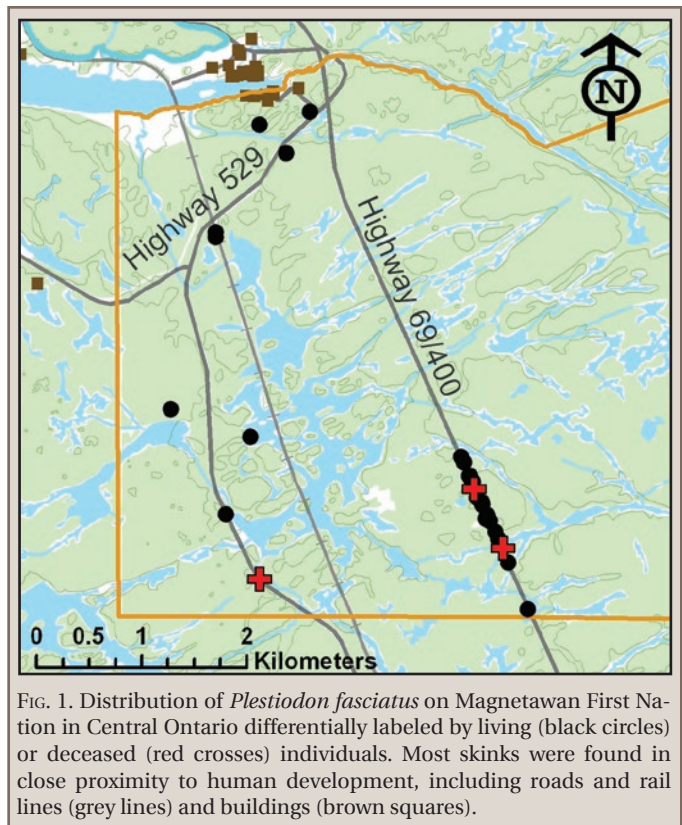


FIG. 1. Distribution of *Plestiodon fasciatus* on Magnetawan First Nation in Central Ontario differentially labeled by living (black circles) or deceased (red crosses) individuals. Most skinks were found in close proximity to human development, including roads and rail lines (grey lines) and buildings (brown squares).

or alteration of microhabitat has been linked to population declines (COSEWIC 2007, *op. cit.*). In our observations, temperature underneath artificial cover averaged 23.5°C (N = 16), which is 4.5°C cooler than the previously reported selected minimum optimum cover temperature (28°C) for this species. So, why would *P. fasciatus* be selecting these artificial cover objects? One possible explanation may be that factors other than temperature, such as an increase in potential prey, are contributing to the increased skink abundance around roadways.

During the course of our road surveys, insects were collected to examine insect road mortality, with an estimated total of 12,900 dead insects collected after colliding with vehicles (Baxter-Gilbert et al., unpubl. data). Insects are known to be a major food source for *P. fasciatus* (COSEWIC 2007, *op. cit.*), and a fecal sample from one of the live Five-lined Skinks on Magnetawan First Nation was comprised mostly of beetle elytra. It might be that the abundance of *P. fasciatus* around roadways is correlated with the increased availability of immobilized prey items. Our observations demonstrate a need to study the relationship between lizard ecology and roadways to determine if anthropogenically-created resources, such as roadside refuse and road-killed insects, are attracting these reptiles to a known population threat.

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JAMES BAXTER-GILBERT (e-mail: jx_baxtergilbert@laurentian.ca), **JULIA L. RILEY** (e-mail: jx_riley@laurentian.ca), and **JACQUELINE D.**

LITZGUS, Department of Biology, Laurentian University, Sudbury, Ontario, P3E 2C6, Canada (e-mail: jlitzgus@laurentian.ca).

PLESTIODON GILBERTI (Gilbert's Skink). PREDATION. *Plestiodon gilberti* typically occur in open grassy areas where burrows or rocks provide quick cover. They also occupy woodlands, streams, and other wetland areas (Behler and King 1979. The National Audubon Society Field Guide to North American Reptiles and Amphibians. Alfred A. Knopf, New York, New York. 744 pp.; Stebbins and McGinnis 2012. Field Guide to Amphibians and Reptiles of California. Univ. California Press, Berkeley. 538 pp.). Their association with wetland areas increases their risk of predation by wading birds, including Great Egrets (*Ardea alba*), which are opportunistic predators that take a variety of prey, such as crustaceans, insects, frogs, tadpoles, lizards, snakes, and small mammals. Great Egrets have been observed in the Florida Keys searching for *Anolis* lizards (McCrimmon et al. 2011. *In A. Poole* [ed.], The Birds of North America Online. Cornell Lab of Ornithology, Ithaca, New York; doi: 10.2173/bna.570).

On 19 April 2013, while hiking along a trail approximately 675 m E of the San Joaquin River in Fresno Co., California, USA (36.8765°N, 119.7796°W; 90 m elev.), we observed a Great Egret in an upland area struggling with something in its beak. Upon initial observation the item appeared to be a snake but after further examination of photographs taken of the egret, the prey was identified as an adult *P. gilberti*. The skink was whipping its tail back and forth, forcing the bird to attempt a better grip. The bird tossed the lizard into the air and recaptured it with its beak, swallowing the skink whole in less than 30 sec. Although likely a common occurrence based on the similar habitat associations of these two species, this observation, to our knowledge, is the first to be reported.

HOWARD O. CLARK, JR. (e-mail: hclark@harveyecology.com) and **SUSAN I. HAGEN**, H. T. Harvey & Associates, 7815 N Palm Ave., Suite 310, Fresno, California 93711-5511, USA.



FIG. 1. Great Egret (*Ardea alba*) predating a Gilbert's Skink (*Plestiodon gilberti*) in Fresno Co., California

PSEUDOTRAPELUS SINAITUS (Sinai Agama). ENDOPARASITES. *Pseudotraperelus sinaitus* is widely distributed in the Middle East where it inhabits rocky desert habitats (Bar and Haimovitch 2011. A Field Guide to Reptiles and Amphibians of Israel. Pazbar Ltd, Herzliya, Israel. 245 pp.). To our knowledge there are no reports of endoparasites from this species. The purpose of this note is to establish the initial parasite list for *P. sinaitus*.

The body cavity of one female (SVL = 83 mm) *P. sinaitus* collected 23 April 1952 in Israel, Northern Negev Region and deposited in the Tel Aviv University Museum (TAUM), Israel as TAUM 688 was examined for endoparasites. A mid-ventral incision was made and the coelomic contents were examined under a dissecting microscope. Two nematodes were found. The stomach wall was punctured in preservation and some contents had spilled into the body cavity. Thus it is likely the infection site for the nematodes was the stomach. The nematodes were cleared on a glass slide in a drop of lactophenol, cover slipped, examined under a compound microscope, and identified as two immature ascarid nematodes. Voucher nematodes were deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland as USNPC 106981.

Ascaridoids commonly utilize vertebrates as intermediate hosts; development to the adult nematode occurs when the intermediate host (in this case a lizard) containing infective larvae is eaten by the definitive host (Anderson 2000. Nematode Parasites of Vertebrates, Their Development and Transmission, CABI Publishing, Oxon, UK. 650 pp.). *Pseudotraperelus sinaitus* represents a new host record for larval ascarid nematodes.

We thank Shai Meiri (TAUM) for permission to examine *P. sinaitus*, Erez Maza for facilitating the loan, and the National Collections of Natural History at Tel Aviv University for providing the *P. sinaitus* for this study.

STEPHEN R. GOLDBERG, Whittier College, Department of Biology, Whittier, California 90608, USA (e-mail: sgoldberg@whittier.edu); **CHARLES R. BURSEY**, Pennsylvania University, Department of Biology, Shenango Campus, Sharon, Pennsylvania 16146, USA (e-mail: cxb13@psu.edu).

PSEUDOTRAPELUS SINAITUS (Sinai Agama). REPRODUCTION. *Pseudotraperelus sinaitus* is widely distributed in the Middle East and is known from Libya, Egypt, Israel, Jordan, Syria, Saudi Arabia, Arabian Peninsula, U.A.E., Oman, Sudan, Ethiopia, and Eritrea where it inhabits rocky desert habitats (Bar and Haimovitch 2011. A Field Guide to Reptiles and Amphibians of Israel. Pazbar Ltd, Herzliya, Israel. 245 pp.). There is anecdotal information on its reproduction found in Bar and Haimovitch (*op. cit.*; Disi et al. 2001. Amphibians and Reptiles of the Hashemite Kingdom of Jordan, An Atlas and Field Guide. Edition Chimaira, Frankfurt am Main, Germany. 408 pp.; Schleich et al. 1996. Amphibians and Reptiles of North Africa. Koeltz Scientific Publications, Koenigstein, Germany. 630 pp.), indicating a spring-summer breeding season with clutches of 5–9 eggs produced. In this note I provide additional information on *P. sinaitus* reproduction from a histological examination of gonads from museum specimens.

A sample of 24 *P. sinaitus* deposited in the Zoological Museum of the Department of Zoology, Tel Aviv University (TAUM), Tel Aviv, Israel, was examined. The sample consisted of 13 males (mean SVL = 78.2 mm \pm 4.3 SD, range = 71–83 mm), 10 females (mean SVL = 75.3 mm \pm 5.1 SD, range = 68–73 mm), and one juvenile female (SVL = 54 mm) collected 1941–1958 in Israel (32.01587°N, 34.78740°E). Vouchers utilized in this study include:

TABLE 1. Monthly stages in the ovarian cycle of 10 *Pseudotrapelus sinaitus* females from Israel.

Month	N	Quiescent	Yolk deposition	Enlarged follicles > 4 mm	Oviductal eggs
April	6	2	1	2	1
May	2	0	0	1	0
Sept	1	1	0	0	0
Nov	1	1	0	0	0

TAUM 688, 696–698, 701, 705, 709–711, 713–716, 855, 1123, 1279, 1317, 1460, 1839, 2146, 2595, 2985, 3048, 3119.

An incision was made in the lower abdominal cavity and the left testis or ovary was removed, embedded in paraffin, cut at 5 μ m sections, and stained with Harris hematoxylin followed by eosin counterstain. Enlarged follicles > 4 mm or oviductal eggs were counted. Histology slides are deposited in TAUM.

Two stages were observed in the testicular cycle: 1) recrudescence. A proliferation of germ cells occurs for the next period of sperm formation; primary and/or secondary spermatocytes predominate; 2) spermiogenesis. Lumina of the seminiferous tubules are lined by sperm or rows of metamorphosing spermatids. Monthly distribution of stages were: March (N = 3, spermiogenesis); April (N = 7, 1 recrudescence, 6 spermiogenesis); May (N = 1, spermiogenesis); October (N = 1, recrudescence); November (N = 1, recrudescence). The smallest reproductively active male (spermiogenesis) measured 72 mm SVL (TAUM 2146) and was collected in March.

Four stages were observed in the monthly ovarian cycle (Table 1): 1) quiescent, no yolk deposition; 2) early yolk deposition, basophilic yolk granules in the ooplasm; 3) enlarged ovarian follicles > 4 mm; 4) oviductal eggs. Mean clutch size for five females was 4.4 ± 1.3 SD, range = 3–6. The three smallest reproductively active females each measured 73 mm SVL; (1) TAUM 2595, early yolk deposition, collected in April; (2 and 3) TAUM 696, 2985, 3 follicles > 4 mm, collected in April. Schleich (*op. cit.*) also reported 73 mm SVL as the minimum size for reproductive maturity of *P. sinaitus* females. I arbitrarily considered one slightly smaller reproductively inactive female from April (TAUM 701, SVL = 70 mm) as being an adult. One reproductively inactive smaller female (TAUM 1123, SVL = 54 mm) was clearly a juvenile.

My histological findings confirm *P. sinaitus* exhibits a reproductive cycle typical of numerous temperate zone lizards. Breeding occurs in spring; renewal of germinal epithelium (recrudescence) in males for the forthcoming spring spermiogenesis occurs in autumn. No reproductive activity was exhibited in autumn females. Three is a new minimum clutch size for *P. sinaitus*.

I thank Shai Meiri (TAUM) for permission to examine *P. sinaitus*, Erez Maza for facilitating the loan, and the National Collections of Natural History at Tel Aviv University for providing samples of *P. sinaitus* for this study.

STEPHEN R. GOLDBERG, Whittier College, Department of Biology, P.O. Box 634, Whittier, California 90608, USA; e-mail: sgoldberg@whittier.edu.

SCELOPORUS ANAHUACUS (Anahuacan Graphic Lizard). SELECTED BODY TEMPERATURE. Field body temperatures of reptiles have been widely reported (Avery 1982, *In* Gans and Pough [eds.], *Biology of the Reptilia*, Vol. 12, Physiology C, pp. 93–166. Academic Press, New York), but reports on preferred or

selected body temperature is actually quite rare in the literature (Sinervo et al. 2010. *Science* 328:894–899) because measurement in a laboratory thermal gradient under standard conditions is required (Huey 1982. *In* Gans and Pough [eds.], *Biology of the Reptilia*, Vol. 12, Physiology C, pp. 25–91. Academic Press, New York). *Sceloporus anahuacus* is a viviparous lizard of the *grammicus* group, which inhabits high elevation pine forest. This species is endemic to central Mexico in Sierra Nevada, Distrito Federal, and Estado de México (Ramírez-Bautista et al. 2009. *Herpetofauna del Valle de México, Diversidad y Conservación*. CONABIO-UAH. 210 pp.). There have been several reports detailing thermal ecology in *grammicus* group members (Güizado-Rodríguez et al. 2011. *Southwest. Nat.* 56:120–124; Lemos-Espinal et al. 1995. *Can. J. Zool.* 73:2184–2191; Woolrich-Piña et al. 2006. *Acta Zool. Mex.* 22:137–150), and specific to *S. anahuacus* within field conditions (Ávila-Bocanegra et al. 2012. *Herpetol. Bull.* 121:27–29), but the selected body temperature has not been documented. Here, we provide preliminary selected temperatures of wild-caught individuals of this species under laboratory conditions.

During May 2007, one of us (UOGV) conducted field work in the Ejido Magdalena Petlatlaco, Delegación Magdalena Contreras, Sierra del Ajusco, Distrito Federal, México (19.2210°N, 99.2856°W; 3500–3930 m elev.), located in a forested area dominated by pine trees (*Pinus* sp.). The data presented here are based on 10 adults (> 46 mm SVL; 6 females and 4 males) of *S. anahuacus* captured by hand. In the laboratory, the lizards were separated by gender and maintained at 25°C in plastic containers with soil, trunks, and grass, and hydrated with a sprinkler every day. Laboratory experiments were conducted two days after capture using a thermal gradient, which consisted of a wood box (150 cm long x 150 cm wide x 70 cm high) divided into ten tracks of 15 cm each to prevent interaction between lizards. The box was located in a room with a controlled temperature of 20°C and three 150 W lamps were placed at different heights over the box to offer the thermal gradient (20–50°C). Body temperature data were collected manually using a digital thermometer (Fluke model 51-II) with the sensor introduced one centimeter into the cloaca during each hour between 1330 and 1930 hs.

Mean selected body temperature was 32.64°C (SD = 2.73°C, range = 26.0–36.5°C). Interquartile of 25% and 75% was 32.1 and 34.2°C, respectively. These results suggest *S. anahuacus* maintains its thermal requirements similar to others species of the *grammicus* group (Güizado-Rodríguez et al 2011, *op. cit.*; Lara-Resendiz and Díaz de la Vega-Pérez, in press, *Herpetol. Rev.*; Lemos-Espinal et al. 1995, *op. cit.*; Woolrich-Piña et al. 2006, *op. cit.*). Specifically, the mean selected body temperature is higher than that reported by Ávila-Bocanegra et al. (2012, *op. cit.*) for this species under field conditions. Finally, we propose for future research to assess the thermal biology of the *S. grammicus* group based in tolerance ranges, selected body temperatures in laboratory, body temperatures taken in the field coupled with environmental temperatures, in order to address the patterns of thermoregulation and to determine if the thermal biology in this group of lizards is limited by the environment or if it is evolutionarily conservative.

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RAFAEL A. LARA-RESENDIZ, Posgrado en Ciencias Biológicas, Instituto de Biología, Laboratorio de Herpetología, Universidad Nacional Autónoma de México, AP 70515, CP 04510, Distrito Federal, México (e-mail: rlara@ibiologia.unam.mx); **URI OMAR GARCÍA-VÁZQUEZ**, Labora-

torio de Herpetología, Museo de Zoología, Facultad de Ciencias, Universidad Nacional Autónoma de México, AP 70399, CP 04510, Distrito Federal, México (e-mail: urigarcia@gmail.com).

SCELOPORUS GRANDAEVUS (Cerralvo Island Sator). **REPRODUCTION.** *Sceloporus grandaevus* is known only from Isla Cerralvo in the Gulf of California where it is most commonly found in rocky arroyos (Grismer 2002. *Amphibians and Reptiles of Baja California, Including its Pacific Islands and the Islands in the Sea of Cortés*, University California Press, Berkeley. 399 pp.). Grismer (*op. cit.*) observed gravid females from June through October. The purpose of this note is to present additional information on *S. grandaevus* reproduction from a histological examination of museum specimens.

A sample of 11 *S. grandaevus* was examined consisting of 9 males (mean SVL = 72.1 mm \pm 3.8 SD, range = 67–78 mm) and 2 females (mean SVL = 58.5 mm \pm 0.71 SD, range = 58–59 mm), collected August 1969 at Isla Cerralvo, (24.25000°N, 109.91666°W) Baja California Sur, Mexico and deposited in the herpetology collection, University of Arizona (UAZ), Tucson, Arizona as UAZ 31487, 31493, 31494, 31539, 31500, 31622, 31742, 31743, 31745–31747.

A cut was made in the lower abdominal cavity and the left testis or ovary was removed, embedded in paraffin, cut at 5 μ m and stained with Harris hematoxylin followed by eosin counterstain. Enlarged ovarian follicles > 5 mm or oviductal eggs were counted. No histology was performed on them. Histology slides were deposited at UAZ.

Eight of the nine males exhibited spermiogenesis (lumina of the seminiferous tubules were lined by sperm or rows of metamorphosing spermatids), one male had regressed seminiferous tubules which contained spermatogonia and Sertoli cells, however the epididymis contained moderate amounts of sperm. The smallest reproductively active male (spermiogenesis in progress) measured 67 mm SVL (UAZ 31494).

Both females contained clutches of 6 and 7 eggs, respectively (N = 2, mean = 6.5 \pm 0.71 SD, range = 6–7 eggs). The smallest reproductively active female (7 oviductal eggs) measured 58 mm SVL (UAZ 31539).

I thank George L. Bradley (UAZ) for permission to examine *S. grandaevus*.

STEPHEN R. GOLDBERG, Whittier College, Department of Biology, Whittier, California 90608, USA; e-mail:sgoldberg@whittier.edu.

SCELOPORUS SCALARIS (Light-bellied Bunchgrass Lizard).

CLUTCH SIZE. *Sceloporus scalaris* is an oviparous species with the breeding season occurring during the summer (Vázquez-Díaz and Quintero-Díaz. 2005. *Anfibios y Reptiles de Aguascalientes*. CONABIO y CIEMA. 2nd ed. México, D.F. 318 pp.). Some information has been published on the reproduction of *S. scalaris*, including a clutch of 4–8 eggs reported from México Valley (Ramírez-Bautista et al. 2009. *Herpetofauna del Valle de México: Diversidad y Conservación*. UAEH, CONABIO, Pachuca. 213 pp.). Additionally, one specimen from a population in extreme western Nuevo León deposited 5 eggs on 11 August (Lemos-Espinal and Dixon 2013. *Amphibians and Reptiles of San Luis Potosí*. Eagle Mountain Publishing, LC, Eagle Mountain, Utah. 300 pp.). Populations from Aguascalientes have been reported to lay clutches of 9–13 eggs, where it was observed that the females retain the eggs until they are almost fully developed embryos (Vázquez-Díaz and Quintero-Díaz 2005, *op. cit.*). Herein we present the largest clutch size yet reported for *S. scalaris*.



FIG. 1. Clutch of 15 eggs of *Sceloporus scalaris* found at Mesa Montoro, Aguascalientes, Mexico.

On 14 August 2013 at 1700 h, we found a female *S. scalaris* with a clutch of 15 eggs (Fig. 1) beneath a rock in oak savanna at Mesa Montoro, Aguascalientes, México (22.019912°N, 102.562113°W, datum WGS84; elev. 2366 m). Although the female fled after being disturbed, *S. scalaris* is the only species of oviparous lizard in the area.

RUBÉN A. CARBAJAL-MÁRQUEZ, Centro de Investigaciones Biológicas del Noroeste, Instituto Politécnico Nacional No. 195, Col. Playa Palo de Santa Rita Sur, C.P. 23096, La Paz, Baja California Sur, México (e-mail: redman031@hotmail.com); **GUSTAVO E. QUINTERO-DÍAZ**, Universidad Autónoma de Aguascalientes, Centro de Ciencias Básicas, Departamento de Biología, Avenida Universidad No. 940, Aguascalientes, Aguascalientes 20131, México (e-mail: gequintmxags@hotmail.com).

SCELOPORUS SCALARIS (Light-bellied Bunchgrass Lizard).

MATING BEHAVIOR. Little is known about the reproductive behavior of *Sceloporus scalaris*. In the literature there is only information about the mating or courtship of this widely distributed species from La Michilia, Durango, México (Gutiérrez and Ortega 1986. *Bull. Maryland Herpetol. Soc.* 22:23–25). We provide here an observation of mating behavior of *Sceloporus scalaris* in a population from Aguascalientes, México.

During a field survey on 29 May 2013 at 1040 h, at Mesa Las Preñadas, El Llano, Aguascalientes, México (21.93409°N,



FIG. 1. Male and female *Sceloporus scalaris* displaying mating behavior at Mesa Las Preñadas, Aguascalientes, México.

101.88137°W, datum WGS84; 2432 m elev.), we observed a pair of *S. scalaris* engaged in mating behavior. The male was biting the tail of the female, while she bit the neck of the male, forming a ring with their bodies and exposing their bellies. Both males and females exhibit a white belly in this *Sceloporus* species and in this belly-up position the pair displayed a striking contrast to the surrounding low-growing, green vegetation, presumably making them more vulnerable to predation (Fig. 1). As we approached, the lizards remained in this position for about five minutes, then the male released the female and both tried to escape. The specimens were deposited in the Herpetological Collection, Universidad Autónoma de Aguascalientes (UAA-CV-R 0258–0259). According to our observations, reproductive activity in this population begins in May with the mating events, and gravid females and neonates observed in mid-June.

RUBÉN A. CARBAJAL-MÁRQUEZ, Centro de Investigaciones Biológicas del Noroeste, Instituto Politécnico Nacional No. 195 Col. Playa Palo de Santa Rita Sur, C.P. 23096, La Paz, Baja California Sur, México (e-mail: redman031@hotmail.com); **CHRISTIAN M. GARCÍA-BALDERAS, GUSTAVO E. QUINTERO-DÍAZ, ANA G. PÉREZ-DELGADILLO**, and **RARAM-URI REYES-ARDIT**, Universidad Autónoma de Aguascalientes, Centro de Ciencias Básicas, Departamento de Biología, Avenida Universidad No. 940, Aguascalientes, Aguascalientes 20131, México.

SCELOPORUS SPINOSUS (Eastern Spiny Lizard). AVIAN PREDATION. The natural history of *Sceloporus spinosus* is well known, with some reports documenting predators (Leyte-Manrique 2007. Bol. Soc. Herpetol. Mex. 15:23–24; Solano-Zavaleta et al. 2008. Herpetol. Rev. 39:469). This species is a widespread endemic found over much of central México. It ranges between 1500 and 2300 m elev. (Mendoza-Quijano et al. 2007. In IUCN 2013. IUCN Red List of Threatened Species, ver. 2013.1 <www.iucnredlist.org>). Herein we provide the first observation of predation on *S. spinosus* by a Solitary Eagle (*Harpyhaliaetus solitarius*), a near threatened bird species (BirdLife International 2012. In IUCN 2013. IUCN Red List of Threatened Species, ver. 2013.1 <www.iucnredlist.org>).

On 16 December 2012 at 1552 h, during a survey in Juan Grande Mountain, Aguascalientes, México (21.942281°N, 101.910708°W, datum WGS84; 2276 m elev.), we observed an adult *H. solitarius* preying an adult male *S. spinosus* approx. 100 mm SVL (Fig. 1). Our observation occurred in habitat dominated by

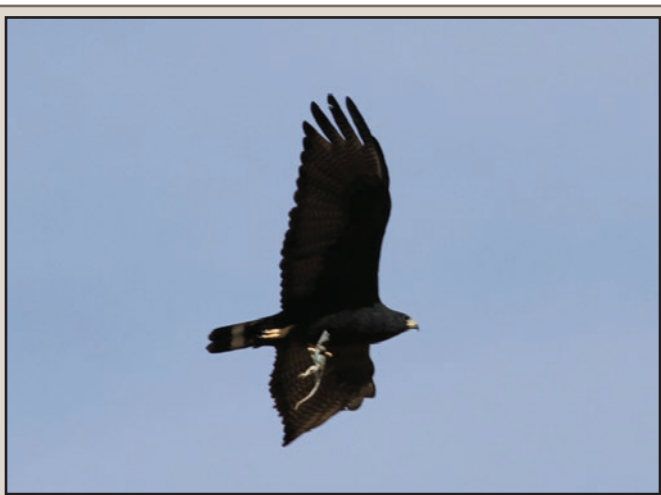


FIG. 1. Solitary Eagle female (*Harpyhaliaetus solitarius*) preying an adult male *Sceloporus spinosus*.

Dodonea viscosa, *Prosopis laevigata*, and *Quercus potosina*. During our observation the *S. spinosus* was perched on a rock, then a Solitary Eagle suddenly came down from behind and grabbed the lizard in its talons and flew away. This observation is the first photographic evidence of the predation of *Harpyhaliaetus solitarius* on an adult *S. spinosus*.

GUSTAVO E. QUINTERO-DÍAZ (e-mail: gequintmx@yahoo.com.mx), **CAROLINA CHÁVEZ-FLORIANO**, Universidad Autónoma de Aguascalientes, Centro de Ciencias Básicas, Departamento de Biología, Avenida Universidad No. 940, Aguascalientes, Aguascalientes 20131, México; **RUBÉN A. CARBAJAL-MÁRQUEZ**, Centro de Investigaciones Biológicas del Noroeste, C.P. 23096, La Paz, Baja California Sur, México (e-mail: redman031@hotmail.com).

SPHENOMORPHUS MACULATUS (Spotted Forest Skink). REPRODUCTION. *Sphenomorphus maculatus* is known from Myanmar, Thailand, Laos, Cambodia, Vietnam, eastern India, Andaman Islands and southern China inhabiting evergreen forests and more open areas up to 800 m (Das 2010. A Field Guide to the Reptiles of South-East Asia, Myanmar, Thailand, Laos, Cambodia, Vietnam, Peninsular Malaysia, Singapore, Sumatra, Borneo, Java, Bali. New Holland Publishers Ltd. London. 376 pp.). Das (*op. cit.*) reported it as an oviparous species, producing clutches of 4–5 eggs. The purpose of this note is to report information on the reproductive cycle of *S. maculatus* from Thailand.

A sample of 44 *S. maculatus* consisting of 21 adult males (mean SVL = 55.5 mm ± 4.7 SD, range = 48–66 mm), 21 adult females (mean SVL = 57.1 mm ± 5.1 SD, range = 50–56 mm) and 2 juvenile females (mean SVL = 47.5 mm ± 0.71 SD, range = 47–48) collected in 1969 and deposited in the herpetology collection of the Field Museum of Natural History (FMNH), Chicago, Illinois USA was examined from the following localities: Thailand, Nakhon Ratchasima Province, Amphoe Pak Thong Chai (14.7197°N, 102.0214°E) FMNH 182403, 182405, 182407–182410, 182420, 182423–182425, 182427, 182429, 182430, 182432, 182433, 182435–182438, 182440, 182443–182446, 182448, 182450–182453, 182455, 182457, 182458, 182460, 182465, 182466, 182469, 182472, 182474, 182482, 182484, 182486, 182499; Thailand, Nakhon Nayok Province, Sarika falls (14.3213°N, 101.2511°E) FMNH 182414; Thailand, Sara Buri Province, Muak Lek (14.6638°N 101.2027°E) FMNH 182507.

A cut was made in the lower abdominal cavity and the left testis or ovary was removed, embedded in paraffin, cut at 5µm and stained with Harris hematoxylin followed by eosin counterstain. Enlarged ovarian follicles > 5 mm or oviductal eggs were counted. No histology was performed on them. Histology slides were deposited in FMNH.

TABLE 1. Monthly changes in the ovarian cycle of 21 adult *Sphenomorphus maculatus* females from Thailand.

Month	N	Quiescent	Yolk depositon	Enlarged follicles > 5 mm	Oviductal eggs
February	2	2	0	0	0
March	7	7	0	0	0
April	4	2	0	2	0
May	7	1	3	1	2
June	1	0	0	0	1

All males examined from February (N = 2), March (N = 7), April (N = 9), June (N = 1), July (N = 1) were undergoing spermiogenesis (seminiferous tubules are lined by sperm or groups of metamorphosing spermatids). It thus appears the *S. maculatus* males examined exhibited an extended period of sperm production. The only male examined from August contained a regressed testis in which the seminiferous tubules contained spermatogonia and Sertoli cells. Before the significance of this single male with a regressed testis can be ascertained, examination of additional specimens are needed. The smallest reproductively active males both measured 48 mm SVL (FMNH 182450, 182407) and were collected in February and April, respectively.

Monthly stages in the ovarian cycle are in Table 1. Four stages were observed: 1) quiescent, no yolk deposition; 2) early yolk deposition, vitellogenic granules in ooplasm; 3) enlarged follicles > 5 mm; 4) oviductal eggs. Mean clutch size (N = 6) = 3.7 ± 1.6 SD, range = 2–6. Clutches of two and six eggs represent new minimum and maximum clutch sizes for *S. maculatus*. The smallest reproductively active female 51 mm SVL (FMNH 182474) contained two enlarged ovarian follicles (> 5 mm) and was collected in May. Whether the nine *S. maculatus* females from February–March with quiescent ovaries indicates a period of female reproductive inactivity will require further study.

I thank Alan Resetar (FMNH) for permission to examine *S. maculatus*.

STEPHEN R. GOLDBERG, Whittier College, Department of Biology, P.O. Box 634, Whittier, California 90608, USA; e-mail: sgoldberg@whittier.edu.

STROPHURUS CILIARIS (Northern Spiny-tailed Gecko). COMMUNAL NESTING. Communal nesting is widespread in reptiles, and is more common than currently appreciated because the eggs and nests of many species are either unknown or rarely recorded in nature (Doody et al. 2009. *Quart. Rev. Biol.* 84:229–252). One group with secretive nests are the diplodactylid geckos. Unlike the hard-shelled eggs of gekkonid geckos, which are often deposited in relatively conspicuous sites (e.g., under bark, logs, or rocks, on cave walls, in houses), the pliable-shelled eggs of diplodactylid geckos are generally deposited underground where higher humidity or soil moisture is required to promote successful development (Bustard 1968. *Copeia* 1968:162–164). Details of the eggs and nests of most of the ~125 diplodactylid species are thus, unknown. Accordingly, communal nesting is rarely reported in these species (Doody et al., *op. cit.*). Herein we report on eight communal nests of *Strophurus ciliaris* that were found while excavating the nesting warrens (groups of burrows) of the Yellow-Spotted Monitor (*Varanus panoptes*) in tropical northern Australia.

During May and June 2013 we studied the nesting biology of *V. panoptes* (data reported elsewhere) at El Questro Wilderness Park in the east Kimberley Region of Western Australia (15.895033°S, 128.132456°E). The area consists of savannah woodland situated in the wet-dry tropics, with distinct wet (Nov–March) and dry (April–Oct) seasons. The nesting warrens, each comprising 6–21 burrows within a ca. 10 m² area, were in sandy soils of sandhill habitat along creeks and rivers. Warrens were excavated by hand (with the aid of shovels and picks) to a depth of up to 3.6 m (Doody et al. 2014. *J. Herpetol.* 48: *in press*). During the excavation process we found 15 *S. ciliaris* eggs and 48 eggshells comprising 11 nests in small, back-filled chambers constructed in the floor of burrows of four *V. panoptes* nesting warrens at two locations. One warren contained no *V. panoptes* eggs in that year

(but contained eggshells from previous years). Nest depths were < 1 m; depths of three of the nests averaged 45 cm (range = 30–60 cm). We incubated four of these eggs to hatching under ambient temperatures in a makeshift field laboratory; all were confirmed to be *S. ciliaris*. Hatching dates were 10, 16, 22, and 28 June. We assumed that the remaining eggs and eggshells were also *S. ciliaris* based on their similar size and shape, and the absence of other pliable-shelled gecko species in the study area.

There are three interesting implications of our findings. First, like other geckos, *S. ciliaris* lays two eggs. Thus, eight (73%) of the clutches represented communal nests. Second and relatedly, it is interesting (and possibly a novel finding) that *S. ciliaris* mothers added their eggs to other clutches that were completely buried. In at least six of the communal nests the eggs were together within the same back-filled chamber excavated by the first mother. Communal back-filled reptile nests generally involve clusters of nests, rather than egg complements of multiple mothers in one chamber (Doody et al., *op. cit.*). If the alternative is true, that multiple mothers excavated or entered a single nest to lay at the same time, this also represents an interesting and novel finding (although it is considered less likely). Third, our data suggest that *S. ciliaris* is a common burrow associate of *V. panoptes*, at least during nesting. The distributions of the two species overlap in the Kimberley region of Western Australia, the Top End of the Northern Territory, and the gulf country and central desert regions of Queensland (Wilson and Swan. 2008. *A Complete Guide to Reptiles of Australia*, New Holland, Sydney. 512 pp.). The severe population-level declines incurred by *V. panoptes* due to poisoning by invasive Cane Toads, *Bufo marinus* (Doody et al. 2009. *Anim. Conserv.* 12:46–53), could thus eventually reduce nesting sites for *S. ciliaris* and other burrow associates (we also found the eggs of *V. gouldii*, and adults of 14 species of reptiles and amphibians in the warrens). The functional role of *V. panoptes* burrows in the savannah woodland ecosystem thus needs more scientific attention, particularly in areas ahead of the Cane Toad front in the west Kimberley region.

J. SEAN DOODY, Department of Ecology and Evolutionary Biology, University of Tennessee, 569 Dabney Hall, Knoxville, Tennessee 37996-1610, USA (e-mail: jseandoody@gmail.com); **HUGH JAMES**, School of Environmental and Life Sciences, University of Newcastle, Callaghan, New South Wales 2308, Australia (e-mail: hugh.james@uon.edu.au); **DEREK DUNLOP**, Department of Ecology and Evolutionary Biology, University of Tennessee, 569 Dabney Hall, Knoxville, Tennessee 37996-1610, USA (e-mail: ddreptiles@hotmail.com); **DOMENIC D'AMORE**, Department of Natural Sciences, Daemen College, 4380 Main Street, Amherst, New York 14226, USA (e-mail: ddamore@daemen.edu); **MATT EDGAR**, School of Environmental and Life Sciences, University of Newcastle, Callaghan, New South Wales 2308, Australia (e-mail: medgar1900@gmail.com); **MAIK FIDEL**, 2/151 Main Road, Lower Plenty, Victoria 3093, Australia (e-mail: mantis_maik@hotmail.com); **DAVID MEADOWS**, Department of Natural Sciences, Daemen College, 4380 Main Street, Amherst, New York 14226, USA (e-mail: david.meadows@daemen.edu); **CHRISTOPHER W. WALMSLEY**, Department of Anatomy and Developmental Biology, Monash University, Clayton, Victoria 3800, Australia (e-mail: c.w.walmsley@gmail.com); **SIMON CLULOW**, School of Environmental and Life Sciences, University of Newcastle, Callaghan, New South Wales 2308, Australia (e-mail: simon.clulow@newcastle.edu.au); **COLIN McHENRY**, Department of Anatomy and Developmental Biology, Monash University, Clayton, Victoria 3800, Australia (e-mail: colin.mchenry@monash.edu).

TRAPELUS SAVIGNII (Egyptian Sand Agama). REPRODUCTION. *Trapelus savignii* is known from Egypt and Israel where

it is diurnal and found in sandy habitats (Baha El Din 2006. A Guide to the Reptiles and Amphibians of Egypt. The American University in Cairo Press, Cairo. 359 pp.; Bar and Haimovitch 2011. A Field Guide to Reptiles and Amphibians of Israel. Pazbar LTD 1989, Herzliya, Israel. 245 pp.). There is anecdotal information on its reproduction in Bar and Haimovitch (*op. cit.*). The purpose of this note is to add information on the reproductive biology of *T. savignii* utilizing information from a histological analysis of gonadal material.

A sample of 35 *T. savignii* collected in Israel from 1946 to 2012 and deposited in the herpetology collection of the Natural History Collections of Tel Aviv University (TAUM) was examined, consisting of 9 adult males (mean snout-vent length, SVL = 76.6 mm \pm 7.1 SD, range = 68–85 mm) 10 adult females (mean SVL = 87.9 mm \pm 5.6 SD, range = 81–98 mm), 7 subadult males (mean SVL = 52.9 mm \pm 4.3 SD, range = 48–59 mm), 7 subadult females (mean SVL = 55.0 mm \pm 6.2 SD, range = 45–63 mm) and 2 subadults of indeterminate sex (mean SVL = 44.5 mm \pm 2.1 SD, range = 43–46 mm).

A cut was made in the lower abdomen and the left testis or ovary was removed, embedded in paraffin, cut into 5 μ m sections and stained with Harris' hematoxylin followed by eosin counterstain. Enlarged follicles > 5 mm or oviductal eggs were quantified. Histology slides were deposited in TAUM. *Trapelus savignii* from Israel examined (by region) from TAUM were: Northern Negev Region: TAUM 635–637, 639, 640, 643–645, 1213, 1227, 1917, 2545, 2632, 2633, 5162, 5534, 5535, 5995, 5999, 6005, 6416, 6420, 6421–6426, 6428, 6398, 6399, 6439, 8475, 16128, Southern Coastal Region: TAUM 1233.

Three stages were noted in the testicular cycle (Table 1): 1) regressed, seminiferous tubules reduced in size, containing spermatogonia and interspersed Sertoli cells; 2) recrudescing, proliferation of germ cells for the next period of spermiogenesis (sperm formation); 3) spermiogenesis, seminiferous tubules lined by sperm or clusters of metamorphosing spermatids. The presence of spermiogenic males in March and April indicate *T. savignii* is a spring breeder. The smallest mature males (spermiogenesis in progress) all measured 68 mm SVL and were collected

TABLE 1. Monthly stages in the testicular cycle of 9 adult male *Trapelus savignii* from Israel.

Month	N	Regressed	Recrudescing	Spermiogenesis
March	5	0	0	5
April	2	0	0	2
August	1	1	0	0
September	1	1	0	0

TABLE 2. Monthly stages in the ovarian cycle of 10 adult female *Trapelus savignii* from Israel.

Month	N	Quiescent	Yolk depositon	Enlarged follicles > 5 mm	Oviductal eggs
April	1	0	1	0	0
May	1	0	1	0	0
June	2	1	0	0	1
August	2	0	0	1	1
September	4	4	0	0	0

in March TAUM 5999, 6399, 6439. Testes of smaller males (48–59 mm) were either regressed or in recrudescence and were classified as juveniles.

Four stages were noted in the ovarian cycle (Table 2): 1) quiescent (no yolk deposition); 2) yolk deposition (basophilic granules in ooplasm); 3) enlarged pre-ovulatory follicles > 5 mm; 4) oviductal eggs. The period of female reproductive activity encompassed April through August (Table 2). Mean clutch size (N = 3) was 6.3 \pm 3.8 SD, range = 2–9. The smallest reproductively active female (TAUM 5535), measured 81 mm SVL, exhibited early yolk deposition and was collected in April. There was no indication (oviductal eggs and concurrent yolk deposition in the same female) to suggest *T. savignii* produces multiple clutches in the same reproductive season. However, the apparent absence of females in the process of preparing a second clutch may be a reflection of small sample size (N = 10). Six smaller females (range 45–63 mm) exhibited quiescent ovaries and were considered as juveniles. One *T. savignii* (TAUM 6421) of indeterminate sex (SVL = 46 mm) was also considered a juvenile.

My finding of one female with oviductal eggs and one with enlarged pre-ovulatory follicles from August (Table 2) confirms the statement in Bar and Haimovitch (*op. cit.*) that *T. savignii* oviposits in August. The presence of reproductive activity in March and April (Tables 1, 2) indicates *T. savignii* commences reproduction early in the spring in Israel. The clutch values reported herein, to my knowledge, represent the first reported for *T. savignii*. In addition, it appears males mature at smaller body sizes than females.

I thank Shai Meiri (TAUM) for permission to examine *T. savignii*, Erez Maza for facilitating the loan and the National Collections of Natural History at Tel Aviv University for providing specimens of *T. savignii* for this study.

STEPHEN R. GOLDBERG, Whittier College, Department of Biology, PO Box 634, Whittier, California 90608, USA; e-mail: sgoldberg@whittier.edu.

UROSAURUS BICARINATUS (Tropical Tree Lizard). BIFURCATION. *Urosaurus bicarinatus* is a small phrynosomatid endemic to Mexico, found from southern Sonora to Chiapas, primarily along the Pacific versant and interior valleys (Feldman et al. 2011. Mol. Phyl. Evol. 61:714–725; Köhler 2008. Reptiles of Central America, 2nd ed., Herpeton Verlag Elke Köhler, Offenbach. 400 pp.; Wiens 1993. Herpetologica 49:399–420; Wilson and Johnson 2010. In Wilson et al [eds.], Conservation of Mesoamerican Amphibians and Reptiles, pp. 31–235. Eagle Mountain Publ., LC, Eagle Mountain, Utah), from near sea level to 2500 m elevation (Wilson and Johnson 2010, *op. cit.*). Herein, we report an incidence of tail bifurcation in a *U. bicarinatus* from the coastal lowlands of Oaxaca, Mexico.

On 23 June 2013, at 0940 h, an adult female *U. bicarinatus* was observed resting on a tree trunk on a slope with tropical deciduous forest, ca. 3 km N of La Soledad, Municipality of Tututepec, Oaxaca (18.157883°N, 96.091658°W, WGS 84; elev. 25 m). When the lizard was caught, we noticed that it had a bifurcated tail (Fig. 1). Bifurcation of the tail was represented by the end section of the original tail and the new regenerated tail. This bifurcation was located 41 mm posterior to the cloaca. Length of the original segment after the bifurcation was 15 mm (left side) and the regenerated section was 30 mm (right side). The new regenerated tail section was likely the result of an incomplete autotomy of the original tail (Goin and Goin 1971. Introduction to Herpetology, 2nd ed. W. H. Freeman and Co., San Francisco,



FIG. 1. Female Tropical Tree Lizard (*Urosaurus bicarinatus*) with tail bifurcation found near La Soledad, Oaxaca, México.

California, 353 pp.; Clark 1973. HISS News-J. 1:158). Bifurcated or multiple tail regeneration cases have been published for many species of lizards, including members in the family Phrynosomatidae (see Cordes and Walker 2013. Herpetol. Rev. 44:319; Gogliath et al. 2012. Herpetol. Rev. 43:129; Kumbar and Ghadage 2011. Herpetol. Rev. 42:94; Mata-Silva et al. 2010. Herpetol. Rev. 41:352–353; Mitchell et al. 2012. Herpetol. Rev. 43:650; Tamar et al. 2013. Herptol. Rev. 44:135–136, and citations therein). To the best of our knowledge this is the first report of tail bifurcation in *U. bicarinatus*.

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VICENTE MATA-SILVA, Department of Biological Sciences, The University of Texas at El Paso, El Paso, Texas 79968, USA (e-mail: vmata@utep.edu); **ARTURO ROCHA**, Department of Biological Sciences, El Paso Community College, El Paso, Texas, USA (e-mail: turyrocha@yahoo.com); **JERRY D. JOHNSON**, Department of Biological Sciences, The University of Texas at El Paso, El Paso, Texas 79968, USA (e-mail: jjohnson@utep.edu); **LARRY DAVID WILSON**, 16010 S.W. 207th Avenue, Miami, Florida 33187, USA, and Centro Zamorano de Biodiversidad, Escuela Agrícola Panamericana Zamorano, Depto. Francisco Morazán, Honduras (e-mail: bufodoc@aol.com).

VARANUS GLEBOPALMA (Black-palmed Monitor). NOCTURNAL ACTIVITY AND FORAGING. Monitor lizards are thought to be diurnal, based on a body of ecological research and on eye structure. Studies of the eye structure of *Varanus exanthematicus* and *V. griseus* have suggested that prey capture in these species is reliant on visual cues, based on the presence of cone cells in the eyes (Bhattacharjee 1992. Exp. Eye Res. 55:243; Röhl and Horn 2000. Mertensiella 2:291–306). The morphological similarity of monitor lizards led Röhl and Horn (*op. cit.*) to conclude that all *Varanus* species possess the same or similar eye structure and therefore all are diurnal.

However, a number of observations suggest that some monitor lizards occasionally undertake crepuscular and/or nocturnal activity. Of the 53 known species of monitor lizards, field observations of crepuscular or nocturnal activity have been recorded in nine species (*V. spenceri*, *V. panoptes*, *V. tristis*, *V. glebopalma*, *V. rosenbergi*, *V. melinus*, *V. glauerti*, *V. salvator*, and *V. dumerilli*), and six species in captivity (*V. acanthurus*, *V. giganteus*, *V. indicus*, *V. keithhorni*, *V. mertensi*, and *V. varius*) (Bohme and Ziegler 1997. Herpetofauna 19:26–34; Cota et al. 2008. Biawak 2:152–158; Fyfe

1980. Herpetofauna 12:15; Irwin et al. 1996. Herpetofauna 26:50; Irwin et al. 1996. Herpetol. Rev. 27:192–194; Jones 1998. Herpetofauna, 28:50; Rokylle 1989. Herpetofauna 7:4–8; Trembath 2000. Herpetofauna 30:52; Uyeda et al. 2013. Biawak 7:25–30; Valentic 1995. Herpetofauna 25:49–50; Yong et al. 2008. Nature in Singapore 1:21–22).

In particular, there are several reports of crepuscular activity in *V. glebopalma*. Christian (1977. Victoria Herpetol. Soc. Newsl. 6:11–13) suggested that *V. glebopalma* does most of its foraging during the first couple of hours after sunset. Wilson and Knowles (1988. Australia's Reptiles: A Photographic Reference to the Terrestrial Reptiles of Australia. Cornstalk, Pymble. 447 pp.) stated that “although active by day, it is commonly crepuscular and can often be disturbed foraging just after sundown.” Two individuals were spotlighted active at night between 1900 and 2100 h by Shea et al (1988. West. Austral. Herpetofauna 18:16), and Valentic (1994. South Austral. Herpetol. Group Newsl. 87:11) observed an individual active in twilight period (1830–1900 h) catching and swallowing prey. It was thus surprising that the only quantitative study on *V. glebopalma* resulted in a lack of nocturnal behavior. In a radio-telemetry study of the spatial ecology of *V. glebopalma*, Sweet (1999. Mertensiella 2:317–366) failed to record any crepuscular or nocturnal activity other than specimens that had been disturbed after dark, despite considerable effort to support previous accounts. Sweet concluded that previous observations of nocturnal/crepuscular activity were a result of the animal being disturbed by the observer. It is only through the continual documentation of observations that we can fully understand the apparent disparity between these findings. This note presents two further observations of nocturnal activity from *V. glebopalma* in tropical northwestern Australia.

At 2300 h on 6 May 2012, an adult male *V. glebopalma* (SVL 253 mm, TL 751 mm) was observed moving across a large flat rock approximately 0.5 m in height and through a clump of spinifex grass. The animal continued to move for another 8 m across another flat section of rock where it was captured. At the time of the observation, there was a full moon and little to no cloud cover. Although the surrounding area was being burned by a small, slow moving fire, the nearest fire front was 300 m from the animal's location. However, it is possible that the animal detected the fire through olfaction from its roost. In a second observation, while spotlighting at approximately 1950 h 28 June 2012, a frog's alarm call drew the attention of observers to a rocky area on the side of a sandstone gorge. Upon closer inspection a *V. glebopalma* was observed for 15 minutes feeding on a frog (unidentified *Litoria* sp.). When observers moved closer to confirm the species of frog, the animal became wary and swallowed the frog prior to retreating into a hole among fallen rocks and boulders. A short search failed to relocate the animal. The temperature at the time of observation was 19.5°C. Sunset that night occurred at 1722 h, and there was a half moon.

Our observations provide further evidence that *V. glebopalma* may forage nocturnally. The lack of crepuscular and nocturnal behavior in Sweet's (*op. cit.*) study may reflect population and/or seasonal variation. Alternatively, observations of nocturnal activity in the species may reflect lizards that were flushed from their roost sites by potential predators (S. Sweet, pers. comm.). However, the growing number of observations suggests that nocturnal behavior occurs in some populations. Interestingly, Sweet (*op. cit.*) noted that *V. glebopalma* adopts a sit and wait, or ambush, foraging strategy that may be unique to monitor lizards. This strategy may allow *V. glebopalma* to forage during low light

conditions. Investigations into the eye structure of *V. glebopalma* should be undertaken to test for any differences between this and other species of monitor lizards.

DAVID RHIND, Department of Anatomy and Developmental Biology, Monash University, Clayton, Victoria, Australia, 3800 (e-mail: darhi1@student.monash.edu); **J. SEAN DOODY**, Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, Tennessee, USA (e-mail: jseandooddy@gmail.com); **RYAN ELLIS**, Department of Terrestrial Zoology, Western Australian Museum, 49 Kew Street, Welshpool, Western Australia, Australia 6106 (e-mail: r.ellis87@hotmail.com); **AMY RICKETTS**, El Questro Wilderness Park, PO Box 909, Kununurra, Western Australia, Australia 6743 (e-mail: aricketts@dncinc.com.au); **GAVIN SCOTT**, El Questro Wilderness Park, PO Box 909, Kununurra, Western Australia, Australia, 6743, Australia (e-mail: gavin.scott.photos@gmail.com); **SIMON CLULOW**, School of Environmental and Life Sciences, University of Newcastle, Callaghan, New South Wales, Australia 2308 (e-mail: simon.clulow@newcastle.edu.au); **COLIN MCHENRY**, Department of Anatomy and Developmental Biology, Monash University, Clayton, Victoria, Australia, 3800 (e-mail: colin.mchenry@monash.edu).

SQUAMATA — SNAKES

CHILOMENISCUS STRAMINEUS (Variable Sandsnake). ENDO-PARASITES. *Chilomeniscus stramineus* occurs in two disjunct populations. The eastern population ranges from southwestern Arizona, south through western Sonora, Mexico to northern Sinaloa, Mexico; the western population is restricted to Baja California (Grismer 2002. Amphibians and Reptiles of Baja California Including its Pacific Islands and the Islands in the Sea of Cortés. Univ. Calif. Press, Berkeley. 399 pp.). To our knowledge there are no helminths reported from *C. stramineus*. The purpose of this note is to establish the initial helminth list for *C. stramineus* as part of an ongoing survey of the helminths of reptiles from Baja California.

The coelomic cavity of one male *C. stramineus* (SVL = 203 mm) collected at 24 km S Loreto (26.0167°N, 111.3500°W, datum: WGS84), Baja California Sur, Mexico in January 1974 and deposited in the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA as LACM 138142 was examined. Two oval shaped whitish endoparasites ca. 2 mm in length, found in the body cavity, were studied under a dissecting microscope. Based on body shape, pseudoanulation, and hook root morphology, the parasites were identified as an oligacanthorhynchid acanthocephalan cystacanth. It was deposited in the United States National Parasite Collection, Beltsville, Maryland, USA as USNPC 106939. Acanthocephalans require an arthropod intermediate host in which the cystacanth develops (Kennedy 2006. Ecology of the Acanthocephala. Cambridge Univ. Press, Cambridge, UK. 249 pp.). *Chilomeniscus stramineus* likely become infected with cystacanths when feeding on infected insects (Grismer, *op. cit.*). Because development beyond the cystacanth does not occur, snakes likely serve as paratenic (= transport) hosts. *Chilomeniscus stramineus* represents a new host record for oligacanthorhynchid acanthocephalan cystacanths.

We thank Greg Pauly (LACM) for permission to examine *C. stramineus*.

STEPHEN R. GOLDBERG, Whittier College, Department of Biology, Whittier, California 90608, USA (e-mail: sgoldberg@whittier.edu); **CHARLES R. BURSEY**, Pennsylvania State University, Shenango Campus, Department of Biology, Sharon, Pennsylvania 16146, USA (e-mail: cxb13@psu.edu); **JEANETTE ARREOLA**, Whittier College, Department of Biology, Whittier, California 90608, USA (e-mail: jarreola@poets.whittier.edu).

CROTALUS ADAMANTEUS (Eastern Diamondback Rattlesnake). ANTI-PREDATOR BEHAVIOR. Snakes exhibit a variety of defensive behaviors when confronted with potential predators. Among rattlesnakes, the most common defensive behaviors include fleeing, coiling, head hiding, body bridging, body flattening, hissing, tongue-flicking, discharging scent gland secretions, vibrating the tail (rattle), and striking (Klauber 1972. Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind. Univ. California Press, Berkeley. 1533 pp.; Weldon and Burghardt 1979. J. Chem. Ecol. 5:141–151). Although primarily terrestrial, rattlesnakes are adept swimmers and will enter water readily in order to pursue food, mates and refuge, and to escape harassment or danger (Klauber, *op. cit.*). While defensive/anti-predator behaviors of most rattlesnakes have been well-described (Klauber, *op. cit.*), few if any reports exist regarding anti-predator behavior of rattlesnakes while in water. Here we describe anti-predator behavior exhibited by *C. adamanteus* while swimming.

On 28 December 2003 at approximately 1200 h, we observed an adult (Total Length [TL] ca. 150 cm) *C. adamanteus* swimming across a small lake (25.40005°N, 80.65630°W, datum: WGS84) on Long Pine Key in Everglades National Park, Florida, USA. The snake was swimming along the shoreline approximately 30 m from land with its head elevated and majority of its body, though not the tip of its tail, visible above the water's surface. As the snake continued swimming, it passed an adult (TL ca. 210 cm) *Alligator mississippiensis* (American Alligator) in shallow water along the shoreline. The alligator turned and rapidly began to pursue the snake from directly behind. When the alligator was within approximately 2.5 m of the snake, the snake suddenly stopped swimming and raised the tip of its tail out of the water. The alligator, at this point approximately 1 m from the snake, abruptly stopped swimming and ceased moving towards the snake. Due to a strong breeze and moderate wave action, we were unable to discern if the snake vibrated its tail (and rattle). After approximately 15 sec, the rattlesnake lowered its tail and resumed swimming towards the shoreline. The alligator allowed the snake to open up a distance of approximately 5 m between them before slowly resuming pursuit. However, within approximately 1 min the snake reached the shore and crawled into the adjacent pine forest.

It is unclear what component of the rattlesnake's behavior deterred the alligator from attacking. Rattlesnakes, like many snakes when threatened, discharge scent gland secretions from the cloaca and multiple reports contend that alligators can distinguish between venomous and non-venomous snakes, presumably by chemical cues (McIlhenny 1935. The Alligator's Life History. Ten Speed Press, Berkeley, California. 117 pp.; Neill 1971. Last of the Ruling Reptiles. Columbia Univ. Press, New York. 486 pp.). However, controlled laboratory studies with captive alligators and snakes failed to corroborate this suggestion (Weldon and McNease 1991. Herpetologica 47:403–406). Whether the raised tail of the rattlesnake resulted in a chemical (scent gland secretion), auditory (vibrating rattle), or visual (tail color) cue remains unknown, but the behavior clearly appeared to be a deliberate and effective warning display.

In addition to the observed defensive behavior by the rattlesnake, to our knowledge this is also the first report of attempted predation by *A. mississippiensis* on *C. adamanteus* in the wild. Given that these two species are often sympatric, encounters between these animals are likely not uncommon.

We thank Allan Woodward and Paul Moler for sharing their knowledge of rattlesnake and alligator interactions in Florida.

The findings and conclusions in this note are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

RUSTIN M. GOODEN, U.S. Fish and Wildlife Service, Sewee Visitor and Environmental Education Center, Awendaw, South Carolina 29429, USA; **THOMAS R. RAINWATER**, U.S. Fish and Wildlife Service, Ecological Services Field Office, Charleston, South Carolina 29407, USA (e-mail: rtrainwater@gmail.com); **STEVEN G. PLATT**, Wildlife Conservation Society, Myanmar Program, Office Block C-1, Aye Yeik Mon 1st Street, Hlaing Township, Yangon, Myanmar.

***CROTALUS ATROX* × *CROTALUS HORRIDUS* (Western Diamond-backed Rattlesnake × Timber Rattlesnake). NATURAL HYBRID.** Hybridization in rattlesnakes has been unequivocally demonstrated in captivity as a result of intentional or unintentional breeding (Klauber 1972. *Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind*. Univ. California Press, Berkeley. x + 1533 pp.; Rubio 1998. *Rattlesnake: Portrait of a Predator*. Smithsonian Press, Washington. 240 pp.). In nature, however, documentation of putative hybrid rattlesnakes is scant and ascertained primarily by way of morphological characters (e.g., Campbell et al. 1989. *Herpetologica* 45:344–349); molecular methods (allozymes, mtDNA, msats) are rarely used (e.g., Murphy and Crabtree 1988. *Herpetologica* 44:119–123; Gerard et al. 2011. *BMC Evol. Biol.* 11:291; see Campbell and Lamar 2004. *Venomous Reptiles of the Western Hemisphere*. Cornell Univ. Press, Ithaca, New York. 870 pp.). Here, using the mtDNA genes ATPase 8 and ATPase 6 as markers and assessing scalation and color pattern, we report on a subject that we suspect to be a natural hybrid of *Crotalus atrox* × *Crotalus horridus*.

On 2 May 2007 a large (~ 1 m total length) rattlesnake was found coiled on a trail 4.8 km N of the town of Blue, 64 km NE of Austin, Lee Co., Texas, USA. The area is categorized as Post Oak Savannah but the immediate landscape that surrounds this property is disturbed and largely agricultural. Using the methods described in Douglas et al. (2006. *Mol. Ecol.* 15:3353–3374), we obtained DNA from a sample of shed skin. A comparative analysis of the sequence information (ATPase 8 and 6) obtained from the hybrid to a pre-existing phylogeny of rattlesnakes and other North American pitvipers (M. E. Douglas et al., unpubl. data) revealed that the haplotype was that of *C. horridus*. Thus, owing to matrilineal inheritance of mtDNA, we assigned the hybrid's mother to be *C. horridus*. The overall appearance of the subject appears intermediate to that of the putative parents (Fig. 1A). The paired parietal marking, post-ocular stripe, and mottled venter pattern (not visible) are *C. horridus*-like, whereas the broad dorsal blotches and black and white rings on the tail are *C. atrox*-like.

To our knowledge, this is the second record of natural hybridization between *C. atrox* and *C. horridus*. Meik et al. (2008. *Southwest. Nat.* 53:196–200), using morphological characters (e.g., scales, color pattern), provided robust evidence for hybridization between *C. atrox* and *C. horridus* in a subadult (SVL = 667) female subject collected 50 km W of Denton, in Wise Co., Texas (University of Texas at Arlington [UTA] R-52942; Fig. 1B). This specimen bears a striking resemblance to the hybrid reported here (Fig. 1A). Our analysis of scalation and color pattern of the present hybrid essentially mirrors the results of Meik et al. (*op. cit.*). However, in our analysis of interocularials we followed the definition provided by Klauber (*op. cit.*), which includes counting a subocular and a supralabial. Our count for interocularials was 5-5 (both sides of the head). Using this definition, the hybrid



FIG. 1. A) The adult male hybrid (*Crotalus atrox* × *C. horridus*) from Lee Co., Texas. B) The subadult female hybrid (*C. atrox* × *C. horridus*) described by Meik et al. (*op. cit.*) from Wise Co., Texas.

described in Meik et al. (2008, *op. cit.*) is 5-5 rather than 3 (i.e., 3-3) as reported (J. Meik, pers. comm.).

We thank Hugh Brown for alerting us to the snake we report here. Margie Crisp helped with care and assisted in obtaining photographs of the hybrid. Louis Porras helped to measure scales. Jesse Meik and Carl Franklin discussed hybridization in rattlesnakes, and they allowed us to use their image of the hybrid rattlesnake (*C. atrox* × *C. horridus*) discussed in their 2008 publication. Ryan Sawby kindly prepared the digital image for publication.

WILLIAM B. MONTGOMERY, P.O. Box 656, Elgin, Texas 78621, USA (e-mail: crotalus53@gmail.com); **GORDON W. SCHUETT**, Department of Biology and Center for Behavioral Neuroscience, Georgia State University, 33 Gilmer Street SE, Atlanta, Georgia 30303-3088, USA (e-mail: gwschuett@yahoo.com); **MARLIS R. DOUGLAS** and **MICHAEL E. DOUGLAS**, Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas 72701, USA.

***DROMICODRYAS BERNIERI* (Bernier's Striped Snake). DIET.** Few studies have investigated the ecology of Madagascar's more common diurnal colubrid snake species (Glaw and Vences 2007. *A Field Guide to the Amphibians and Reptiles of Madagascar*. 3rd ed. Vences & Glaw, Köln. 496 pp.; Kaloloha et al. 2011. *Herpetol. Notes* 4:397–402). *Dromicodryas bernieri* has only been documented preying upon saurian prey and is assumed to be strictly saurophagous (Cadle 2003. *In* Goodman and Benstead [eds.],



FIG. 1. *Dromicodryas bernieri* consuming an adult *Boophis doulioti* in Mariarano, northwest Madagascar.

The Natural History of Madagascar, pp. 997–1004. Univ. Chicago Press, Chicago and London); Gehring 2006. Zeitschrift des Kölner Zoo - Heft 49:127–141). Here we report on the predation of an amphibian by a *D. bernieri*.

On 2 August 2011, at 1130 h, at the edge of the main thoroughfare in Mariarano Village, North West Madagascar (15.44878°S, 46.69146°E, datum: WGS84) we encountered a *D. bernieri* with an adult frog, *Boophis doulioti*, that it had seized and partially ingested, head first (Fig. 1). For approximately 3 min we observed the snake attempting to consume the frog; however, our presence seemed to distract the snake and it moved further into the undergrowth with its amphibian prey in its mouth. Considering that *B. doulioti* is locally abundant in this area, even during the long dry season, it is reasonable to assume that this predation event is not unique and that this amphibian forms a regular part of the diet of *D. bernieri* at this location.

We thank the Transitional Government of Madagascar, the Ministère de l'Environnement et des Forêts for allowing us to undertake this work (permit 54710/MEF/SG/DGE/DREBOE), Operation Wallacea for funding, Development and Biodiversity Conservation Action for Madagascar (DBCAM) for logistics and our local guides and team at Mariarano Village.

ROBERT GANDOLA (e-mail: robertgandola747@hotmail.com), **STUART GRAHAM**, **MARC RABENANDRASNA**, and **CATRIONA HENDRY**, 27 Arfield Park, Dublin 13, Ireland.

DRYMARCHON MELANURUS (Central American Indigo Snake). DIET. *Drymarchon melanurus* is known to feed on a wide variety of prey, including small mammals, frogs, fish, hatchling turtles, birds, and snakes (Irwin et al. 2003. J. Kansas Herpetol. 7:13–18; Stevenson et al. 2010. Southwest. Nat. 9:1–18). On 5 October 2011, at about 1430 h, AVN found an adult *D. melanurus* near the CIE (Centro Interpretativo Ecológico) inside the Biosphere Reserve of “El Cielo” (23.88555°N, 99.16861°W, datum WGS84; elev. 360 m), municipality of Gómez Farías, state of Tamaulipas, México. The snake was in the process of feeding on an adult *Spilotes pullatus* (Fig. 1). After an hour, the *D. melanurus* had ingested half of the prey and subsequently it crawled under a rock with the prey in its mouth. When checked 2 h later, the prey was found, regurgitated and abandoned by the predator. To our knowledge this represents the first record of *D. melanurus* preying on *S. pullatus*.

ALFONSO HERNÁNDEZ-RÍOS, Laboratorio de Herpetología, Instituto de Biología, Universidad Nacional Autónoma de México, Distrito Federal 04510, México (e-mail: ahr@ibiologia.unam.mx); **ELÍ GARCÍA-PADILLA**,



FIG. 1. *Drymarchon melanurus* attempting to prey on a *Spilotes pullatus* in Tamaulipas, México.

Jaguares #18 Casa del Sol, Oaxaca de Juárez 68128, México (e-mail: quetzalcoat186@gmail.com); **ADRIÁN VILLEGAS-NIETO**, Centro Interpretativo Ecológico, Reserva de la Biósfera El Cielo, Gómez Farías, Tamaulipas, México (e-mail: villegas82k@hotmail.com).

CHILABOTHRUS (=EPICRATES) CHRYSOGASTER CHRYSOGASTER (Turks Island Boa). CLIMBING BEHAVIOR. *Chilabothrus (=Epicrates) chrysogaster chrysogaster* is considered to be a rare example of an active terrestrial foraging boid (Reynolds and Gerber 2012. J. Herpetol. 46:578–586). Out of over 350 observations of active boas on Big Ambergris Cay, Turks and Caicos



FIG. 1. *Chilabothrus chrysogaster chrysogaster* demonstrating rarely documented climbing behavior.

Islands, British West Indies, only two individuals were found active off of the ground (Reynolds and Gerber, *op. cit.*). It is thought that juveniles of this species, like others of the genus, might be largely arboreal, though this has not been conclusively demonstrated (Reynolds and Gerber, *op. cit.*). While Big Ambergris Cay is mostly scrub and coppice, some arboreal habitat does exist, though boas have never been found higher than 2 m off the ground (Reynolds and Gerber, *op. cit.*). However, on larger islands in the Turks and Caicos such as North and Middle Caicos, remnant tropical dry forest and pine barrens exist, which provide a great deal of arboreal habitat.

On 12 October 2012, BNM observed a previously unobserved climbing behavior in this species on Pine Cay, Turks and Caicos Islands (Fig. 1). The individual (SVL ca. 1000 mm; likely female) was climbing a telephone pole located along a road in secondary tropical dry forest habitat with a canopy height of ~7 m. The individual was using a stereotyped version of concertina locomotion often associated with other snake species, such as rat snakes (genus *Pantherophis*) and boa constrictors (*Boa constrictor*). The motion consists of lateral undulation against a scaffold (Jayne and Herrmann 2011. *J. Exp. Biol.* 214:2189–2201). This represents a rare observation of climbing in this species, and suggests that individuals employ a similar strategy to other frequent climbers such as rat snakes and boa constrictors.

R. GRAHAM REYNOLDS, Department of Biology, University of Massachusetts, Boston, Massachusetts 02125, USA (e-mail: rgraham.reynolds@umb.edu); **B. NAQQI MANCO**, Department of Environment and Maritime Affairs, Turks and Caicos Island Government, Turks and Caicos Islands, British West Indies.

HEMACHATUS HAEMACHATUS (Rinkhals). DIET / CANNIBALISM. Although African elapids are well known to be ophiophagous (FitzSimons 1962. *Snakes of Southern Africa*. Purnell and Sons Ltd., Johannesburg. 423 pp.) and may consume congeners (Shine et al. 2007. *J. Zool.* 272:183–193), only one species is known to be cannibalistic (*Naja nivea*; FitzSimons, *op. cit.*). On 10 December 2012 on the farm Ryswick (27.9009°S, 029.2107°E, datum WGS84; elev. 1790 m) in the district of Harrismith of the Free State province, South Africa, I collected an adult male *Hemachatus haemachatus* that had been shot by the landowner. Upon dissection, the snake (SVL = 877 mm; tail length = 200 mm; mass = 661 g) was found to have consumed a smaller female conspecific (SVL = 509 mm, tail length = 118 mm, mass = 105.95 g). The adult male had also recently consumed three toads (*Amietophrynus* sp.; mass = 130.08 g), while a single partially digested toad was found in the digestive tract of the female (*Amietophrynus* sp.; mass = 11.04 g). I thank Graham Alexander for assisting with snake dissection and manuscript preparation.

SHIVAN PARUSNATH, School of Animal, Plant, and Environmental Sciences, University of the Witwatersrand, Johannesburg, South Africa, P.O. Wits, 2050; e-mail: shivan.parusnath@gmail.

HETERODON PLATIRHINOS (Eastern Hog-nosed Snake). DIET. *Heterodon platirhinos* primarily feeds upon amphibians, but it has been reported to eat reptiles, mammals, birds, fishes, and invertebrates (Ernst and Ernst 2003. *Snakes of the United States and Canada*. Smithsonian Books, Washington, D.C. 668 pp.). The only reports of avian consumption were an unidentified bird (Surface 1906. *Bull. Pennsylvania State Dept. Agric. Div. Zool.* 4:113–208.) and a nestling sparrow (Conant 1938.

Am. Midl. Nat. 20:1–200.). Here, we report predation upon an adult Northern Mockingbird (*Mimus polyglottos*) by a female *H. platirhinos* (SVL = 658 mm) from 5.3 km S of Howey-in-the-Hills, Lake Co., Florida, USA. When captured in June 2004, the snake's body was distended by a large prey item. In captivity, the snake died two days after regurgitating the partially digested bird. Both the snake and bird are deposited in the Florida Museum of Natural History (UF 169545).

MARK B. ROBERTSON, 5610 NW 31st Terrace, Gainesville, Florida 32653, USA; **KEVIN M. ENGE**, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Road, Gainesville, Florida 32601, USA (e-mail: kevin.enge@myfwc.com).

HETERODON PLATIRHINOS (Eastern Hog-nosed Snake). REPRODUCTION. There is a lack of consensus regarding the oviposition frequency of *Heterodon platirhinos*. *Heterodon* spp. have been described as laying eggs every other year or less frequently (Greene 1997. *Snakes: The Evolution of Mystery in Nature*. Univ. California Press, Berkeley. 365 pp.). In South Carolina, the small proportion of mature female *H. platirhinos* bearing oviducal eggs suggests that annual oviposition is uncommon (Smith 1976. *Ecology* 57:252–264), whereas body mass data in Kansas has been interpreted to suggest that mature females oviposit annually (Platt 1969. *Univ. Kansas Publ., Mus. Nat. Hist.* 18[4]:253–420). Moreover, observations of captive *H. platirhinos* producing two clutches in the same breeding season (Wenzel 1990. *Bull. Chicago Herpetol. Soc.* 25:86) suggest that this trait is plastic and may be influenced by resource availability.

We radiotracked 17 adult *H. platirhinos* (10 females, 7 males) between April 2009 and November 2011 at Cape Cod National Seashore, Barnstable Co., Massachusetts, USA. The study area was located at the northern terminus of the Cape Cod peninsula in an approximately 1800 ha early-successional sand dune landscape. Snakes were relocated approximately once every three days from May–August and less frequently during the early spring and fall. When not observed directly, oviposition was inferred by measuring body mass. Females oviposited from mid-June to mid-July (Table 1). Of the seven females successfully radiotracked during the nesting season, six deposited eggs. Four of these were successfully radiotracked in consecutive years and all

TABLE 1. Summary of *Heterodon platirhinos* oviposition events from Cape Cod National Seashore, Massachusetts, USA, 2009–2011. Asterisk (*) indicates that snake was observed actively depositing eggs.

Snake ID	SVL	Year	Pre-oviposition body mass (g)	RCM (%)	Oviposition date	Hatch date
D	685	2009	370	47.8	08–12 Jul	-
H	610	2009	308	34.4	11–15 Jul	-
F	580	2009	-	-	11 Jul*	-
D	685	2010	415	42.9	22 Jun*	14–16 Aug
H	610	2010	382	37.7	22–24 Jun	-
K	780	2010	541	44.7	22–24 Jun	-
L	585	2010	245	41.6	07 Jul*	01 Sep
N	520	2010	198	52.0	22–27 Jun	-
K	780	2011	-	-	22–23 Jun*	-
N	520	2011	-	-	29–30 Jun*	-
Mean (SE)	-	-	-	43.0 (2.2)	-	-

four deposited eggs in both years. Moreover, we observed well-developed eggs in the oviducts of an eighth radiotracked female that was predated on 01 July 2009. Thus, during this three-year period there were 12 cases where it was possible to determine if the females we were tracking produced a clutch of eggs and/or oviposited. In 11 of 12 instances (~92%) they did so, indicating that at our study site, a high proportion of mature female *H. platirhinos* oviposit annually. Although it may seem surprising to document annual reproduction near the northern extent of this species' range, moderate coastal temperatures, which appear to extend the activity season relative to other *H. platirhinos* sites at similar latitudes, combined with a locally abundant prey base (*Anaxyrus fowleri* and *Scaphiopus holbrookii*) may explain the high oviposition frequency at our study site. The mean relative clutch mass (RCM) for *H. platirhinos* in our study (mean = 0.430, SE = 0.022, N = 7 events) is similar to that reported by Seigel and Fitch (1984 *Oecologia* 61:293–301; mean RCM = 0.439).

Work was carried out under scientific collecting permit #017.10SCRA issued by the Massachusetts Division of Fisheries and Wildlife and scientific research and collecting permits #CACO-2011-SCI-0005 and #CACO-2011-SCI-0018 issued by the National Park Service. Work was approved by the Institutional Animal Care and Use Committee of Montclair State University (Ref #2009-01).

SCOTT W. BUCHANAN, Department of Biology and Molecular Biology, Montclair State University, Montclair, New Jersey 07043, USA (e-mail: scott_buchanan@my.uri.edu); **BRAD C. TIMM**, Department of Environmental Conservation, UMASS, Amherst, Massachusetts 01003, USA (e-mail: timm@eco.umass.edu); **ROBERT P. COOK**, Cape Cod National Seashore, Wellfleet, Massachusetts 02667, USA (e-mail: robert_cook@nps.gov); **RICHARD COUSE**, Department of Environmental Studies, Antioch University New England, Keene, New Hampshire 03431, USA (e-mail: rcouse@antioch.edu).

LACHESIS MUTA (Surucucu, Atlantic Forest Bushmaster). PARASITISM. Snakes are parasitized by a wide variety of helminths, mainly nematodes (Silva et al. 2001. *Rev. Brasil. Parasitol. Veterinaria* 10:91–93). *Lachesis muta* is a tropical rainforest species and the largest viperid of the Americas. Herein we report the nematodes found in a *L. muta* from an Atlantic Forest population in northeastern Brazil.

At 1840 h on 5 August 2012 at the Natural Heritage Reserve (RPPN) Pedra D'Antas, State of Pernambuco (8.69339°S, 35.85824°W, datum SAD 69; elev. 584 m) we found a dead female *L. muta* (total length = 104 cm; Fig. 1A). The snake was underweight with visible vertebral columns. During a necropsy we found one male (30.35 mm) and three female (too damaged to measure) *Hastospiculum onchocercum* in the coelomatic cavity

(Fig. 1B). The snake is housed in the Herpetological Collection of the Universidade Regional do Cariri (URCA-H 4184). Nematodes are housed in the Parasitological Collection of the Universidade Regional do Cariri (URCA-P 362). Although *Hastospiculum* has been found in the coelomatic cavity of snakes and lizards throughout Central and South America, this is the first record of *H. onchocercum* parasitizing *L. muta*.

JOÃO ANTONIO DE ARAUJO FILHO (e-mail: araujofilhoaj@gmail.com), **CÍCERO RICARDO DE OLIVEIRA**, AND **ROBSON WALDEMAR ÁVILA**, Departamento de Ciências Biológicas, Universidade Regional do Cariri – URCA, R. Cel. Antônio Luiz, 1161, Campus do Pimenta, 63105-000, Crato, Ceará, Brazil; **IGOR JOVENTINO ROBERTO**, Programa de Pós-Graduação em Bioprospecção Molecular, Universidade Regional do Cariri – URCA, R. Cel. Antônio Luiz, 1161, Campus do Pimenta, 63105-000, Crato, Ceará, Brazil; **WALTÉCIO DE OLIVEIRA ALMEIDA**, Departamento de Química Biológica, Centro de Ciências Biológicas e da Saúde – CCBS, Universidade Regional do Cariri – URCA, Campus do Pimenta, CEP 63105-100, Crato, Ceará, Brazil.

LAMPROPELTIS SPLENDIDA (Desert Kingsnake). DIET. *Lampropeltis splendida* consumes other snakes, including those within the genus *Thamnophis* (Werler and Dixon. 2000. *Texas Snakes: Identification, Distribution, and Natural History*. Univ. Texas Press, Austin. 437 pp.; Ernst and Ernst. 2003. *Snakes of the United States and Canada*. Smithsonian Institution Press, Washington D. C., 668 pp.; Lemos-Espinal and Smith 2007. *Anfibios y Reptiles del Estado de Chihuahua, México*. UNAM, Tlalnepantla, México. 613 pp.). *Thamnophis marcianus* is also consumed by snakes within the genus *Lampropeltis* (Ernst and Ernst 2003, *op. cit.*); however, species-specific observations are lacking. We herein present the first confirmed record of *L. splendida* feeding on *T. marcianus*.

On 15 September 2012 at 1419 h a female *L. splendida* (SVL = 660 mm; tail length = 102 mm; 111 g) was found crossing a dirt road in the Municipality of Chihuahua, Chihuahua, Mexico (28.675959°N, 105.964771°W, datum WGS84; elev. 1368 m). Following capture, the snake regurgitated a female *T. marcianus* (SVL = 485 mm, tail length = 124 mm, 86 g) that had been swallowed head-first. The *L. splendida* was released but the *T. marcianus* was deposited in the Herpetological Collection, Universidad Autónoma de Aguascalientes (UAA-CV-0353).

RUBÉN A. CARBAJAL-MÁRQUEZ, Centro de Investigaciones Biológicas del Noroeste, Instituto Politécnico Nacional No. 195 Col. Playa Palo de Santa Rita Sur, C.P. 23096, La Paz, Baja California Sur, México (e-mail: redman031@hotmail.com); **ZAIRA Y. GONZÁLEZ-SAUCEDO**, Universidad Autónoma de Querétaro, Facultad de Ciencias Naturales, Cerro de las Campanas s/n, Querétaro, Querétaro 76017, México; **GUSTAVO E. QUINTERO-DÍAZ**, Universidad Autónoma de Aguascalientes, Centro de Ciencias Básicas, Departamento de Biología, Avenida Universidad No. 940, Aguascalientes, Aguascalientes 20131, México; **MARTÍN LARA**, Juan Mata Ortíz, #4042, C.P. 32230, Ciudad Juárez, Chihuahua, México.

LEPTODEIRA ANNULATA (Banded Cat-eyed Snake). DIET. *Leptodeira annulata* is a nocturnal semi-arboreal colubrid snake that inhabits forested areas in the cerrado, pantanal, caatinga, and rain forest regions of Brazil (Freitas 2003. *Serpentes Brasileiras*. Malha de Sapo Publicações, Lauro de Freitas-BA. 160 pp). It is usually found near water bodies and feeds primarily on amphibians, with occasional records of small lizards and other snakes in its diet (Cantor and Pizzatto 2008. *Herpetol. Rev.* 39:462–463). Here we report the first record of a *L. annulata* preying on *Crossodactylus bokermanni*, a frog species endemic



FIG. 1. A) Dead female *Lachesis muta* from Atlantic Forest in the Pernambuco state, northeastern Brazil; B) the coelomatic cavity of the snake.

PHOTO BY IGOR J. ROBERTO

to the Serra do Espinhaço, Minas Gerais, Brazil (Leite et al. 2008. *Megadiversidade* 4:162).

On 11 February 2012, a *L. annulata* was collected and deposited in Coleção Herpetológica da Universidade Federal de Minas Gerais (UFMG 1022; female; SVL = 290 mm) that had consumed a *C. bokermanni* (UFMG 11303; SVL = 32 mm) in the Municipality of Itacambira, Minas Gerais, Brazil (17.014133°S, 43.3056166°W, WGS 84; elev. 1020 m). *Leptodeira annulata* is known to prey on bufonid, hylid, and leptodactylid frogs (Cantor and Pizzatto, *op. cit.*); however, this is the first predation record on a hylodid species. The observation is also interesting because *L. annulata* is considered nocturnal, while *C. bokermanni* is diurnal (Wachlewski 2007. *J. Nat. Hist.* 42:1422). This suggests that *L. annulata* may capture *C. bokermanni* while the frogs are in nocturnal refugia.

HANS THOMASSEN (e-mail: hans.da.bio@gmail.com), **FERNANDO LEAL** (e-mail: fernando.lealbh@gmail.com), and **PAULO C. A. GARCIA** (e-mail: pcgarcia@gmail.com), Universidade Federal de Minas Gerais, Instituto de Ciências Biológicas, Departamento de Zoologia, Avenida Antônio Carlos, 6627, 31270-010, Belo Horizonte, Minas Gerais, Brazil.

LIASIS OLIVACEUS BARRONI (Pilbara Olive Python). DIET. Although the diet of most Australian pythons is relatively well documented, the diet of *Liasis olivaceus barroni* remains poorly known. *Liasis olivaceus* is a highly opportunistic predator that is generally associated with aquatic habitats. Shine and Slip (1990. *Herpetologica* 46:283–290) characterized the diet of *L. olivaceus* as approximately 26% reptilian, 26% avian, and 48% mammalian prey, but their study did not include individuals of the Pilbara subspecies. The diet of *L. o. barroni* is not well understood apart from few records and observations that include “waterbird species” including “ducks,” “pigeons” including *Geophaps plumifera* (Spinifex Pigeon), *Petrogale rothschildi* (Rothschild’s Rock-wallaby), small Euros (*Macropus robustus*), captive birds such as *Melopsittacus undulates* (Budgerigar) and finch species (Barker and Barker 1994. *Pythons of the World*. Vol. 1. Australia. Advanced Vivarium Systems, Lakeside, California 171 pp.; Pearson 2006. *Landscape* 19:32–39; Pearson 2007. *In* Swan [ed.], *Keeping and Breeding Australian Pythons*, pp. 174–181. Mike Swan Herp Books, Australia).

During August 2010, a road-killed *L. o. barroni* (total length = 2.8 m; ca. 7 kg) was found next to a large permanent water body near Tom Price, Western Australia. Dissection revealed two previously unknown prey items: a sub-adult *Egretta novaehollandiae* (White-faced Heron; ca. 50 cm in height) and an adult *Chenonetta jubata* (Australian Wood Duck). *Liasis o. barroni* has been identified as an opportunistic ambush predator, often observed at water’s edge in ambush position awaiting prey items. The association between the species and aquatic habitats within the Pilbara region suggest avian fauna, particularly water birds, are a frequent prey items in addition to mammals attracted to water resources.

RYAN J. ELLIS, Department of Terrestrial Zoology, Western Australian Museum, 49 Kew Street, Welshpool, Western Australia, 6106, Australia; e-mail: Ryan.Ellis@museum.wa.gov.au.

MASTIGODRYAS MELANOLOMUS (Salmon-bellied Racer). DEFENSIVE BEHAVIOR. Defensive behavior of snakes is variable and includes biting, death-feigning, tail detachment, and various postures, including distorting head shape to a form similar to that observed among venomous species (Solórzano 2004. *Snakes of Costa Rica*. Instituto Nacional de Biodiversidad,



FIG. 1. *Mastigodryas melanolomus* entangled with *Buteo magnirostris* in San Vito de Coto Brus, Puntarenas Province, Costa Rica.

Heredia, Costa Rica. 792 pp.). Here we describe a novel defensive behavior in *Mastigodryas melanolomus* not previously observed in snakes.

On 28 May 2012, at 0700 h in a coffee plantation in southern Costa Rica (Coto Brus County, 8.7805°N, 82.9602°W, datum WGS84; elev. 1200 m), we observed a subadult *M. melanolomus* entangled with a *Buteo magnirostris* (Roadside Hawk) on the ground (Fig. 1). We did not observe the start of the engagement, but we assume that the hawk attacked the snake (Stiles and Skutch 2007. *Guía de Aves de Costa Rica*. Instituto Nacional de Biodiversidad, Heredia, Costa Rica. 572 pp.). The hawk attempted to fly but failed, hopping about 50 cm from its original position. The snake was coiled around the wings and legs of the hawk, constraining its movement and precluding flight. The hawk attempted to fly three times but each attempt failed. After the third attempt, the hawk and snake remained still on the ground for several minutes. The hawk was breathing heavily and seemed without energy. We did not observe the conclusion of the interaction.

Based on previous observations, when *M. melanolomus* is handled by humans it typically coils around one’s hands but does not bite; we suspect that this strategy might also be employed for defense against predators when fleeing is not possible. By preventing flight and keeping its head out of range of a hawk’s beak and talons, *M. melanolomus* may remove a raptor’s primary killing mechanisms and exhaust it in a protracted struggle.

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FEDERICO OVIEDO-BRENES (e-mail: federico.oviedo@ots.ac.cr), **JOSÉ MIGUEL CHAVES-FALLAS**, Las Cruces Biological Station, Organización for Tropical Studies, Coto Brus, Costa Rica; **JUAN G. ABARCA**, Sistema de Estudios de Posgrado. Facultad de Microbiología. Universidad de Costa Rica, Costa Rica.

MICRURUS DIASTEMA (Variable Coralsnake). DEFENSIVE BEHAVIOR. An adult *Micrurus diastema* (FLMNH 144690) was collected from a campsite (15.49°N, 88.28°W, datum WGS84; elev. 1325 m) approximately 4 km W of La Fortuna, Dept. Santa Bárbara, Honduras, during the early morning of 2 July 2005. While photographing the live snake, we observed it perform a tail-flattening defensive behavior, a form of self-mimicry called the protean effect (Gehlbach 1972. *Forma et Functio* 5:311–320;



FIG. 1. *Micrurus diastema* performing the first stages of tail-flattening defensive behavior by elongating its posterior to draw attention.

Roze 1996. Coral Snakes of the Americas: Biology, Identification, and Venoms. Krieger Publishing, Malabar, Florida. xii + 328 pp.). The snake flattened its yellow-banded tail and extended the posterior portion of its body, moving the tail in a manner similar to typical anterior/head movement (erecting the tail while flattening it to appear like a head), while simultaneously tucking its actual yellow-banded head under its body (Fig. 1). This type of defensive behavior has been seen from numerous genera within the Elapidae, including *Micrurus surinamensis* (Roze, *op. cit.*) but this is the first documented case from *M. diastema*. The behavior serves several purposes, including predator distraction (Roze, *op. cit.*).

We thank Roberto Downing M. for arranging the logistics of our work, and helping to obtain collection and export permits. Conrado Gonzáles, Martha Moreno, Ibrahim Padilla, and Carla Cárcamo of the Departamento de Areas Protegidas y Vida Silvestre (DAPVS) of the Administración Forestal del Estado Corporación Hondureña de Desarrollo Forestal (AFE-COHDEFOR), Honduras, generously provided permission to collect and export scientific specimens. Fieldwork was supported by Operation Wallacea and the Reptile and Amphibian Conservation Corps (RACC).

BROOKE L. TALLEY, Department of Zoology, Southern Illinois University – Carbondale, Carbondale, Illinois 62901, USA (e-mail: btalley@siu.edu); **LARRY D. WILSON** Centro Zamorano de Biodiversidad, Escuela Agrícola Panamericana Zamorano, Departamento de Francisco Morazán, Honduras; **JOSIAH H. TOWNSEND**, Department of Biology, Indiana University of Pennsylvania, Indiana, Pennsylvania 15705-1081, USA, and Centro Zamorano de Biodiversidad, Escuela Agrícola Panamericana Zamorano, Departamento de Francisco Morazán, Honduras (e-mail: josiah.townsend@iup.edu).

MICRURUS NIGROCINCTUS (Central American Coralsnake).

DIET. *Micrurus nigrocinctus* is a relatively common semi-fossorial snake that ranges from southern Mexico to northern Colombia; its diet is known to include caecilians, lizards, and snakes (Ray et al. 2012. *Herpetol. Rev.* 43:148). On 30 November 2012 at 0245 h an adult male *M. nigrocinctus* (SVL = 44.7 cm, total length = 52.0 cm; La MICA Biological Station/Team Snake Panama #2012-210) was found on the entrance road to El Copé, Coclé Province, Republic of Panama, between the communities of Las Tibias and El Copé (08.62343°N, 080.57100°W; datum WGS84). The *M. nigrocinctus* was attempting to feed on a dead female *Erythrolamprus bizona* (SVL = 33.7, total length = 39.0 cm; La MICA Biological Station/Team Snake Panama #2012-211), which was flattened and stuck to the road. When approached and

poked with a stick the *M. nigrocinctus* continued to try to ingest the *E. bizona* for approximately 1 min, after which the *E. bizona* was released. This is the first record of *M. nigrocinctus* attempting to feed on a snake within the genus *Erythrolamprus* and of *M. nigrocinctus* attempting to feed on carrion. I thank La MICA Biological Station for logistical support, ANAM for permit (SE/A-22-12) and P. Santana for field assistance.

JULIE M. RAY, La MICA Biological Station, El Copé de La Pintada, Coclé Province, Republic of Panama; e-mail: julie.ray@lamica.org.

MICRURUS TENER (Texas Coralsnake). ABERRANT PATTERN.

Here we describe unusual dorsal blotches, or a “target” pattern, appearing on *Micrurus tener*, a species that normally bears a pattern of tri-colored rings. Aberrant pattern variations are occasionally reported in snakes; Bechtel (1995. *Reptile and Amphibian Variants: Colors, Patterns, and Scales*. Krieger Publ. Co., Malabar, Florida. 224 pp.) reviewed many examples. Strecker (1935. *Baylor Univ. Bull.* 38:1–69) reported exceptional color patterns in *M. tener* and Gloyd (1938. *Herpetologica* 1:121–124) reported a bite involving a melanistic specimen. On 6 October 2012 one of us (TW) found an aberrantly colored *M. tener* crossing Chandler Road (30.757137°N, 95.660561°W, datum WGS84; elev. 94 m) in Crabbs Prairie, Walker Co., Texas, USA. The snake (Fig. 1; adult female; 47.6 g), which exhibited scutellation patterns consistent with *M. tener*, was donated to Houston Zoo and accessioned into the live collection (HZI 27381).

The typical black, red, and yellow colors characteristic of the species are present, however, the pattern is far from typical. The head and neck are predominantly yellow, with the black restricted to a mask like pattern around the eyes and connecting through the rostral and adjacent scales. The black nuchal band is reduced to a dorsal blotch, barely in contact with the parietals, the center of which has faint flecks of red and yellow. The ground color of the body is red, with many scales being posteriorly tipped with black, but less so on the lateral scale rows. There are 17 black body “bands” appearing as blotches. Each blotch has the appearance of a target, the first (outer) ring being yellow and

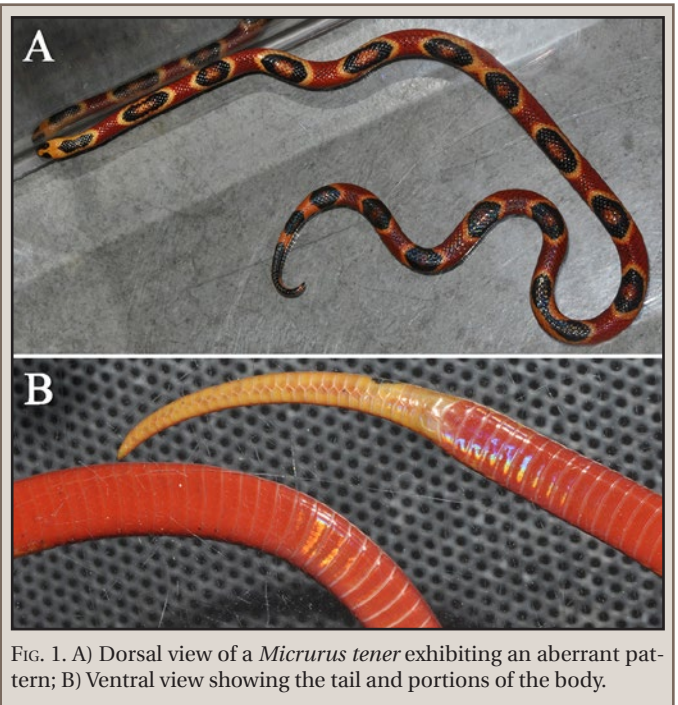


FIG. 1. A) Dorsal view of a *Micrurus tener* exhibiting an aberrant pattern; B) Ventral view showing the tail and portions of the body.

the second black, with sharply defined edges. The inner rings are red with a yellow center but, with indistinct edges bleed into one another. The venter is nearly uniform red with minute black specks, occurring on a few scales, and some yellow from the dorsal blotches entering onto the extreme lateral edges of some ventrals. The subcaudals are predominantly orange, with a "wash" of red appearing at the medium seams of the divided subcaudals. We thank Houston Zoo, Inc. for consent to report on this unusual specimen.

WILLIAM L. FARR, 11019 Wainfleet Lane, Houston, Texas 77096, USA (e-mail: williamfarr@sbcglobal.net); **THAD WARREN**, 67 Chandler Road, Huntsville, Texas 77320, USA (e-mail: tosk47@hotmail.com).

NERODIA FLORIDANA (Florida Green Watersnake). DIET. *Nerodia floridana*, North America's largest watersnake, occupies most of Florida, small parts of southern Alabama and Georgia, and a portion of southern South Carolina. Fish and adult frogs have been reported to comprise the bulk of its diet; however, it has also been known to consume salamanders, tadpoles, small turtles, and invertebrates (Ashton and Ashton 1981. Handbook of Reptiles and Amphibians of Florida. Part 1. The Snakes. Windward Publ., Miami, Florida. 176 pp.). Here we report several new diet records for *N. floridana*.

In the course of long-term monitoring of aquatic snake populations on the U.S Department of Energy's Savannah River Site (SRS), Aiken and Barnwell counties, South Carolina, USA, we documented the following diet items from individual *N. floridana* captured in plastic minnow traps: 6 June 2006 (33.286533°N, 81.488019°W, datum WGS84), *Erimyzon sucetta* (Lake Chub-sucker); 1 July 2006 (33.255185°N, 81.585210°W), *Lepomis gulosus* (Warmouth) and *Lithobates sphenoccephalus* (Southern Leopard Frog); 29 March 2007 (33.161047°N, 81.692606°W), two larval *Ambystoma opacum* (Marbled Salamander); 25 June 2008 (33.161047°N, 81.692606°W), two *Acantharchus pomotis* (Mud Sunfish; total length = 48 and 75 mm). On 2 July 2010, a *N. floridana* (SVL = 534 mm) was collected dead in hoop trap set for turtles at Pond 2 on the SRS (33.255185°N, 81.585210°W). Dissection revealed two crayfish (species not determined). No additional prey were found, indicating this was not a case of secondary ingestion. Crayfish are considered a rare diet item for *Nerodia* spp. and have not been documented in *N. floridana* (Gibbons and Dorcas 2004. North American Watersnakes: a Natural History. Univ. Oklahoma Press, Norman. 438 pp.). Finally, at 2025 h on 18 December 2012, an adult *N. floridana* (SVL = ~ 70 cm) was

seen consuming a large *Ameiurus* sp. (bullhead catfish; Fig. 1) at the edge of a wetland in Grassy Waters Preserve (26.816926°N, 80.174894°W), Palm Beach Co., Florida, USA.

PHILIP VOGRINC, **JOHN D. WILLSON**, University of Arkansas, Department of Biological Sciences, Fayetteville, Arkansas 72701, USA (e-mail: jwillson@uark.edu); **ANDREW M. DURSO**, Utah State University, Logan, Utah 84322, USA; **LARRY A. BRYAN**, Savannah River Ecology Laboratory, PO Drawer E, Aiken, South Carolina 29803, USA; **ZACH ROSS**, New York University, New York, New York 10003, USA; **JOSHUA HOLBROOK**, Florida Atlantic University, Boca Raton, Florida 33431, USA; **DON FILIPIAK**, Fort Lauderdale, Florida 33301, USA.

NERODIA SIPEDON (Northern Watersnake). DIET. Although Gibbons and Dorcas (2004. North American Watersnakes: a Natural History. Univ. Oklahoma Press, Norman. 438 pp.) listed eight species of ictalurid catfish that have been reported in the diet of *Nerodia sipedon*, their list did not include *Pyloodictis olivaris* (Flathead Catfish). On 4 September 2012, we encountered an adult *N. sipedon* (total length = 95 cm) in the process of swallowing a juvenile *P. olivaris* (total length = 26 cm). They were found in shallow water along the shoreline of Pollander Lake, an Upper Mississippi River backwater, immediately upstream from the spillway that extends from Lock and Dam 5A to the Minnesota shoreline, Winona Co., Minnesota, USA (44.080°N, 91.684°W; datum WGS 84). The snake had swallowed most of the head of the catfish, which was still alive when they were observed. Previously, *P. olivaris* has been found in the diet of three other *Nerodia* species (Gibbons and Dorcas, *op. cit.*; Tyson et al. 2008. Herpetol. Rev. 39:472).

MARK A. ROSS (e-mail: maross09@smumn.edu) and **PHILIP A. COCHRAN** (e-mail: pcochran@smumn.edu), Biology Department, Saint Mary's University of Minnesota, 700 Terrace Heights, Winona, Minnesota 55987, USA.

PELAMIS PLATURA (Yellow-bellied Seasnake). REPRODUCTION / MATING BEHAVIOR. The elapid seasnake *Pelamis platura* has the widest distribution range of any snake, including most of tropical and subtropical Pacific and Indian oceans from Central America to Madagascar. Its reproductive cycle is considered to be continuous throughout the year (Ineich 1988. L'Année Biologique, 4ème sér. 27:93–117) but two birthing peaks have been reported in Costa Rica, one in December and January and another in July and August (Solorzano 2004. Serpientes de Costa Rica. Editorial INBio, Santo Domingo Heredia, Costa Rica. 791 pp.). Solorzano and Sasa (2011. Herpetol. Rev. 42:443–444)



FIG. 1. *Nerodia floridana* consuming an *Ameiurus* sp. (bullhead catfish) at Grassy Waters Preserve, Palm Beach Co., Florida, USA.

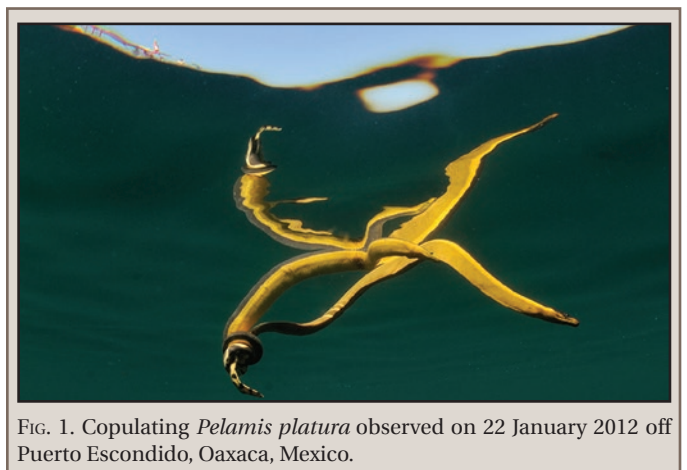


FIG. 1. Copulating *Pelamis platura* observed on 22 January 2012 off Puerto Escondido, Oaxaca, Mexico.

PHOTO BY M. DUNE/DORIS/FESSM/FR

reported the first observation of mating behavior for the species. They observed copulating specimens floating at the sea surface in Costa Rica in August 2009. We here report a second copulation observation (Fig. 1) made in natural conditions off Puerto Escondido (Oaxaca, Mexico) ca. 4 km from the coast (15.60°N, 97.13°W, datum WGS84; 22 January 2012). Copulation occurred just below the water's surface, as in the first observation reported above, and lasted over 15 min; the diver (MD) left before its end. Both snakes moved repeatedly from vertical to horizontal position with their tails intertwined and most often maintained a vertical position. Water temperature was ca. 23°C. This is the second observation of mating behavior in the species and is consistent with a continuous or bimodal mating season in Central America.

We wish to thank the DORIS website (<http://doris.ffessm.fr/>) that enables information exchange among scientists, biologists, divers, and underwater photographers.

IVAN INEICH, Muséum National d'Histoire Naturelle, Département de Systématique et Évolution, UMR CNRS 7205 (Origine, Structure et Évolution de la Biodiversité), 25 rue Cuvier, CP 30, F-75005 Paris, France (e-mail: ineich@mnhn.fr); **MICHEL DUNE**, 304 rue Thimonnier, F-69400 Villefranche sur Saône, France (e-mail: michel.dune@wanadoo.fr).

PHILODRYAS TRILINEATA (Argentina Mousehole Snake).

DIET. *Philodryas trilineata* is a large (maximum length = 200 cm) species endemic to the Monte biogeographic region in western Argentina (Giraud and Scrocchi 2002. *Smithson. Herpetol. Inform. Serv.* 132:1–53). The diet of *P. trilineata* is known to include birds, mammals, lizards, and other snakes; some individuals are known to hunt domestic fowl or rabbits (Cei 1993. *Reptiles del Noroeste, Nordeste y Este de la Argentina. Herpetofauna de las Selvas Subtropicales, Puna y Pampas. Mus. Reg. Sci. Nat. Torino.* 945 pp.; Laspiur et al. 2012. *Herpetol. Rev.* 43:151–152). Rodents are frequently reported as prey, but consistent data about diet of this species are lacking. Here we report the first vouchered case of predation by *P. trilineata* on *Microcavia australis*.

On 12 February 2011, at 1015 h, we collected an adult *P. trilineata* (total length = 1635 mm) near Puerto Madryn city, Chubut, Argentina (42.7894°S, 65.0049°W, datum WGS84; elev. 11 m). During transport to the laboratory, the snake regurgitated a partially digested juvenile *M. australis* (Fig. 1). Based on comparison with *Microcavia* specimens from Chubut (N = 33), we estimate a



FIG. 1. *Philodryas trilineata* and partially digested adult *Microcavia australis* from Chubut Province, Argentina.

total length of 130 mm for the prey. The snake and its prey were deposited in the Herpetological Collection LJAMM of Centro Nacional Patagónico (LJAMM-CNP 8236). We thank D. Udrizar Sauthier for *Microcavia* identification and revision of comparative material.

IGNACIO MINOLI (e-mail: minoli@cenpat.edu.ar), **CRISTIAN HERMAN FULVIO PEREZ**, CENPAT-CONICET, Boul. Alte. Brown 2915, Chubut, Argentina; **DIEGO JANISH ALVARES**, Laboratório de Herpetologia, Departamento de Zoologia, Inst. Biociencias, UFRGS, Av. Bento Gonçalves, 9500, Porto Alegre, RS, Brazil; **LUCIANO JAVIER AVILA**, CENPAT-CONICET, Boul. Alte. Brown 2915, Chubut, Argentina (e-mail: avila@cenpat.edu.ar).

PITUOPHIS CATENIFER AFFINIS (Sonoran Gophersnake).

PREDATION. On 9 October 2012, 1400 h, one of us (ECB) found a juvenile *Pituophis catenifer affinis* (SVL ca. 500 mm) entangled with a *Scolopendra heros* (Giant Centipede; total length ca. 178 mm; photo voucher UAZ 57469-PSV) on a path near the western base of Cathedral Rock near Sedona, Yavapai Co., Arizona, USA (34.886467°N, 111.801529°W, datum WGS84; elev. 1524 m). When found, the centipede was wrapped around the posterior two thirds of the snake. The anterior one third of the snake was free, outstretched in an attempt to escape. The animals were disentangled and it became apparent that the centipede was indeed preying upon the snake. The latter exhibited a sizable mid-dorsal wound where the centipede had gnawed through the snake's back. When freed the gophersnake moved slowly away while the centipede rapidly departed.



FIG. 1. *Scolopendra heros* preying on a young-of-year *Pituophis catenifer*.

RANDALL D. BABB, Arizona Game and Fish Department, 7200 E. University Drive, Mesa, Arizona 85207, USA (e-mail: rbabb@azgfd.gov); **E. CHUCK BUSBOOM**, 2625 S. Terrapin Circle, Mesa, Arizona 85209, USA (e-mail: busboomx6@cox.net).

PITUOPHIS CATENIFER (Gophersnake). **DIET.** *Pituophis catenifer* is primarily a predator of rodents, but also takes birds, bird eggs, and lizards (Rodríguez-Robles 2002. *Biol. J. Linn. Soc.* 77:165–183). Here we describe the first confirmed predation by *P. catenifer* on *Dipodomys ingens* (Giant Kangaroo Rat), a federally and state listed (endangered) species. *Pituophis catenifer* have been observed within colonies of *D. ingens*, and use their burrow systems as shelter (Williams and Kilburn 1991. *Mammalian Species* 377:1–7). On 12 December 2012 a *D. ingens* burrow system in the Carrizo Plain, San Luis Obispo Co., California, USA (35.3081°N, 119.8787°W; elev. 655 m) was being excavated for

preservation purposes. A female *P. catenifer* (SVL = 989 mm; tail length = 144) sheltering within the burrow was inadvertently fatally injured during the excavation process. Upon examining the snake a prey bolus was found and extracted. The prey was determined to be an adult male *D. ingens* based on hind foot length (48.8 mm). Predation on *D. ingens* by *P. catenifer* has long been suspected and our observation provides conclusive evidence. This predation event is also notable both due to the relative size of the prey item (88 adult male Giant Kangaroo Rats at this site averaged 123 g; s.d. \pm 12.9) and the time of the year. Although winter days in the Carrizo Plain can afford clear skies and moderate daytime temperatures, offering opportunities for heliothermic temperature regulation, nighttime temperatures frequently fall below 0°C, and prolonged periods of precipitation and cloud cover can occur. The anterior portion of this *D. ingens*, including the head, had been digested, suggesting that the snake had been able to maintain body temperatures sufficient to permit digestion despite the season. We thank M. Huising, M. Hemenez, and B. Windecker for their assistance. SunPower Corporation and NRG Energy provided additional support.

HOWARD O. CLARK, JR. (e-mail: hclark@harveyecology.com), **KIRK W. SETSER**, and **ROBERT K. BURTON**, H. T. Harvey & Associates, 7815 N Palm Ave., Suite 310, Fresno, California 93711-5511, USA.

PLIOCERCUS ELAPOIDES (Variegated False Coralsnake). REPRODUCTION / CLUTCH SIZE. Little information has been published on the reproduction of *Pliocercus elapoides*. However, a clutch of 4–8 eggs (August deposition) is known from northern Guatemala (Köhler 2003. Reptiles of Central America. Herpeton, Verlag Elke Köhler, Offenbach. Germany. 367 pp.; Lee 2000. A Field Guide to the Amphibians and Reptiles of the Maya World, The Lowlands of Mexico, Northern Guatemala, and Belize. Cornell Univ. Press. Ithaca, New York. 402 pp.). The natural history of this uncommon species in Mexico is poorly known.

On 22 April 2010 at 1827 h, we found a female *P. elapoides* (UAA-CV 0355, SVL = 350 mm; tail length = 220 mm) in a montane cloud forest in the Sierra Madre Oriental at Alaquines, San Luis Potosí, México (22.122500°N, 99.504890°W, datum WGS84; elev. 1405 m). On 1 May 2010 at 0100 h (after nine days in captivity) she deposited seven eggs in a depression in the substrate below leaf litter. The eggs averaged 15 mm in length (SE = 0.8164).

RUBÉN A. CARBAJAL-MÁRQUEZ, Centro de Investigaciones Biológicas del Noroeste, Instituto Politécnico Nacional No. 195, Col. Playa Palo de Santa Rita Sur, C.P. 23096, La Paz, Baja California Sur, México (e-mail: redman031@hotmail.com); **GUSTAVO E. QUINTERO-DÍAZ**, Universidad Autónoma de Aguascalientes, Centro de Ciencias Básicas, Departamento de Biología, Avenida Universidad No. 940, Aguascalientes, Aguascalientes 20131, México; **ZAIRA Y. GONZÁLEZ-SAUCEDO**, Universidad Autónoma de Querétaro, Facultad de Ciencias Naturales, Cerro de las Campanas s/n, Querétaro, Querétaro 76017, México; **GUILLERMO MARTÍNEZ-DE LA VEGA**, Instituto de Investigación de Zonas Desérticas de la Universidad Autónoma de San Luis Potosí, Altair No. 200, Fracc. Del Llano, C.P. 78377, San Luis Potosí, SLP, México.

SPILOTES PULLATUS (Tiger Ratsnake). DIET. *Spilotes pullatus* is a diurnal generalist that typically feeds on small rodents, birds, and bird eggs (Hartmann et al. 2009. Pap. Avul. Zool. 49:343–360; Mendonça et al. 2011. Herpetol. Notes 4:425–427). On 11 December 2012, at 2145 h, on the property of Chico Mendes Institute for Biodiversity Conservation, ICMBIO (7.38383°S, 39.3544°W; datum WGS 84) in the Araripe National Forest, State of Ceará,

Brazil, we observed an attempted predation by *S. pullatus* on the eggs of *Turdus rufiventris* (Rufous-bellied Thrush). Predation was not successful due to “mobbing” behavior of the adult *T. rufiventris* (Yamamoto and Ades 2002. Rev. Etol. 4:75–94), followed by intense vocalization away from their nest. This is the first record of *S. pullatus* attempting predation on *T. rufiventris*.

JOSIVAN SOARES DA SILVA (e-mail: Josivan.biologia@gmail.com), **CARINA CARNEIRO DE MELO MOURA** (e-mail: carinacarneiro@yahoo.com.br), **GERALDO JORGE BARBOSA DE MOURA** (e-mail: geraldobjm@yahoo.com.br), Universidade Federal Rural de Pernambuco, Paleoherpological and Herpetological Laboratory, UFRPE, Rua Dom Manoel de Medeiros, Dois Irmãos - CEP: 52171-900, Recife, PE, Brazil.

STORERIA DEKAYI (Dekay's Brownsnake). SEASONAL ACTIVITY. The annual activity period of *Storeria dekayi* varies with latitude (Ernst and Ernst. 2003. Snakes of the United States and Canada. Smithsonian Univ. Press, Washington, D.C. 668 pp.). Few data are available for northern populations, but Vogt (1981. Natural History of Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee. 205 pp.) stated that they emerge in late April and are most often seen in May and October as they cross roads while moving to and from hibernacula. Here I present data on activity of *S. dekayi* from a population on the western side of Pheasant Branch Marsh, Dane Co., Wisconsin, USA (43.110°N, 89.493°W; datum WGS 84; Cochran 1988. Bull. Chicago Herpetol. Soc. 23:69–71).

On most days from mid-1981 to mid-1984, I drove Pheasant Branch Road along the slope of a ground moraine adjacent to marsh and observed *S. dekayi* on the road only during spring and fall (Fig. 1). The only three living individuals were recorded on 2 May, 11 May, and 5 October, consistent with the dates for the 25 dead snakes. Mean first sighting date for 1982–1984 was 26 April

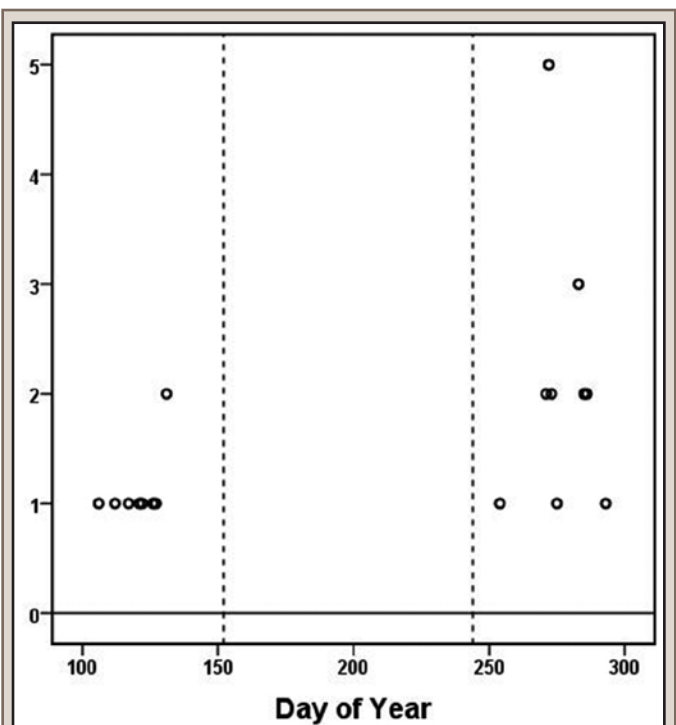


FIG. 1. Dot plot showing dates on which *Storeria dekayi* were observed on Pheasant Branch Road, Dane Co., Wisconsin (N = 25 dead and 3 living snakes). The dashed vertical lines indicate 1 June and 1 September.

(SE = 5.8 d) and mean last date for 1981–1983 was 7 October (SE = 6.6 d). During the same periods, *Thamnophis sirtalis* tended to be found both earlier (mean first date: 18 April; SE = 3.2 d) and later (mean last date: 29 October, SE = 3.3 d), but the difference was significant only for the end of the season (paired-*t* tests: spring – *t* = 1.589, d.f. = 2, *p* = 0.253; fall – *t* = 6.803, d.f. = 2, *p* = 0.021). These observations present a more detailed documentation of general descriptions of activity periods presented in regional field guides (e.g., Vogt, *op. cit.*). Voucher specimens were placed in the University of Wisconsin-Madison Zoology Museum (UWZM 22556, 22594) and the Milwaukee Public Museum (MPM 30266, 33146).

PHILIP A. COCHRAN, Biology Department, Saint Mary's University of Minnesota, 700 Terrace Heights, Winona, Minnesota 55987, USA; e-mail: pcochran@smumn.edu.

THAMNOPHIS SIRTALIS SIRTALIS (Eastern Gartersnake).

HABITAT USE. Terrestrial snakes typically congregate during colder months in dry, underground refugia; however, some snake species will partially or completely submerge themselves in flooded sites to hibernate (Carpenter 1953. Ecology 34:74–80; Costanzo 1985. Physiol. Zool. 58:682–692). *Thamnophis sirtalis* normally hibernate in terrestrial habitats such as rock piles, debris filled wells, old stumps, rodent burrows, crevices in shale, ant mounds, crayfish and prairie dog burrows (Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Books, Washington, DC. 680 pp.). Published accounts of crayfish burrow use by *Thamnophis* spp. indicate either daily refugia use (Dalrymple and Reichenback 1984. Biol. Cons. 30:195–200) or were identified by burrow excavation (Carpenter, *op. cit.*). Few observations have identified either the frequency/seasonality of use or the species of crayfish creating burrows.

During an investigation of *T. s. sirtalis* ecology in Lake Forest, Illinois, USA (42.260°N, 87.883°W; datum WGS84) we observed snakes entering and exiting burrows of an invasive crayfish species, *Cambarus diogenes* (Devil crayfish). On 11 March 2011 three juvenile snakes were observed emerging from a *C. diogenes* burrow and were PIT tagged. The PIT tagged snakes were found again on 6 June and 10 October 2011 at the same site with individuals either partially emerged or basking outside of the burrow. Additional anecdotal evidence of use was presence of silty, clay-like soil on freshly emerged individuals, and high density of individuals surrounding burrows. Our observations are the first confirmation that *T. s. sirtalis* use burrows of *C. diogenes* and indicate that they use these structures throughout the year as refugia.

MATTHEW G. MOST (e-mail: mmost@luc.edu) and **TERRY GRANDE**, Department of Biology, Loyola University Chicago, 1032 W. Sheridan Road, Chicago, Illinois 60660, USA; **ROB CARMICHAEL**, Wildlife Discovery Center at Elawa Farm, 1401 Middlefork Drive, Lake Forest, Illinois 60045, USA.

VIPERA ASPIS HUGYI (Southern Italian Asp). MELANISM.

Melanism, excess of dark pigmentation in the skin, is common in some snakes (Lorioux et al. 2008. Amphibia-Reptilia 29:1–5), resulting from the over-production or dispersion of melanin by melanophores (Sherbrooke et al. 1989. Amer. Mus. Novit. 2943:1–14). In cold environments, dark phenotypes (with low reflectance on the skin) may have a thermoregulatory advantage over lighter phenotypes (Clusella-Trullas et al. 2008. Funct. Ecol. 22:232–238) but are less cryptic and therefore may be more vulnerable to predation (Clusella-Trullas et al. 2007. J. Therm. Biol. 32:235–245).

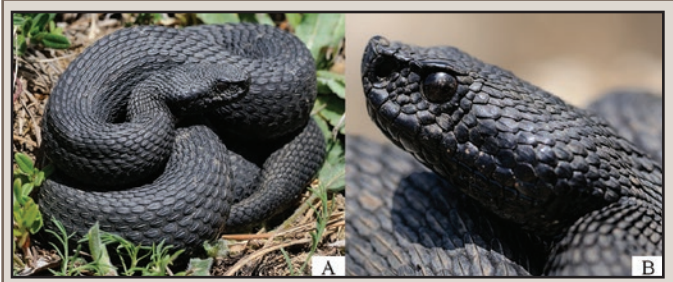


FIG. 1. Melanistic adult female *Vipera aspis hugyi*: whole body (A); close up on the head (B).

PHOTOS BY M. R. DI NICOLA

Vipera aspis hugyi is endemic to southern Italy and usually treated as subspecies of *Vipera aspis*, although in some studies it has been raised to species rank (Zuffi 2002. Amphibia-Reptilia 23:191–213). Color polymorphism is not accentuated in this subspecies and the pattern usually consists of a broad wavy line, often fragmented in round or oval patches, with a dark outer edge that is often black, and a lighter central area.

On 2 May 2012, around 1020 h, a melanistic adult female *V. aspis hugyi* was encountered basking at the edge of a pine forest at 1300 m elev. in the Sila mountainous plateau, Calabria, Italy. The body was almost completely black except for some small pale dots on the labial scales and a few reddish ventral scales in the terminal part of the tail; the eyes were also very dark, with barely visible reddish pigmentation (Fig. 1). A normally-pigmented adult female *V. aspis hugyi* was found in the same area two days earlier.

Although melanism has been reported for other subspecies of *V. aspis* (Monney et al. 1996. Rev. Suisse Zool. 103:81–100; Naulleau 1973. Bull. Soc. Zool. France 98:595–596) it doesn't seem to have been scientifically recorded for *V. aspis hugyi*, although a photograph of a melanistic specimen was published in Brodmann (1987. Peter Brodmann, Die giftschlanger Europas und die gattung *Vipera* in Africa und Asien, Kummerly+Frey 148 pp.). Thus, this record constitutes only the second published account of melanism in *V. aspis hugyi*. It is unclear whether melanism is rare in *V. aspis hugyi* or if the paucity of records is simply due to insufficient sampling. We thank Johan De Smedt for his advice and Arthur Anker and Marco Colombo for their comments to the manuscript.

MATTEO R. DI NICOLA, via Bobbio 6, 20144 – Milano, Italy (e-mail: teodini@fastwebnet.it); **GREGOIRE J. MEIER**, via degli Orti 3, 6809 – Medeglia, Switzerland (e-mail: greg.m@hotmail.com).

XENOCHROPHIS MACULATUS (Spotted Keelback). DIET.

Xenochrophis maculatus is a terrestrial and semiaquatic diurnal snake with a distribution restricted to southeastern Asia (Das 2010. A Field Guide to the Reptiles of South-east Asia. New Holland Publishers Ltd., London, U.K. 376 pp.). Along the Lower Pierce Trail in the Central Catchment Nature Reserve, Singapore, at 2217 h on 05 January 2013, we found an adult female *X. maculatus* (SVL = 64.6 cm, tail length = 14.4 cm, 105 g) with an obvious food bolus near its mid-body. The snake was perched 56 cm off the ground on vegetation approximately 3 m from a reservoir edge. The snake died in transport to the laboratory and dissection revealed the prey item as an adult *Limnonectes malesianus* (27.89 g, ~ 36% of the snake's pre-ingestion mass; Fig. 1). Both the *X. maculatus* and *L. malesianus* were deposited in the Raffles Museum of Biodiversity Research (ZRC 2.7000 and ZRC 1.12501, respectively). *Xenochrophis maculatus* is known to prey upon



FIG. 1. *Xenochrophis maculatus* with ingested *Limnonectes malesianus* in Central Catchment Nature Reserve, Singapore.

frogs and fish (David and Vogel 1996. *The Snakes of Sumatra: An Annotated Checklist and Key with Natural History Notes*. Edition Chimaira, Frankfurt, Germany. 260 pp.); however, we were unable to find any references documenting specific prey or prey size. We thank the National Parks Board of Singapore for issuing us work permit NP/RP11-03-1 and Kelvin K. P. Lim at the Raffles Museum of Biodiversity Research for accessioning specimens.

ALEX FIGUEROA, Department of Biological Sciences, University of New Orleans, New Orleans, Louisiana 70122, USA (e-mail: afigueroa21@gmail.com); **RYAN JAMES ROBERT McCLEARY**, Department of Biological Sciences, National University of Singapore, Singapore 117543.

XENOPHOLIS SCALARIS (Wucherer's Ground Snake). DEFENSIVE BEHAVIOR. *Xenopholis scalaris* is a dipsadid snake found in leaf litter in humid tropical forests of Bolivia, Brazil, Peru, Ecuador, Colombia, Suriname, and French Guiana (Lehr and Doan 2013. *In IUCN Red List of Threatened Species*, version 2013.1. <www.iucnredlist.org>. Downloaded 5 March 2013). Defensive behavior of this species is relatively unknown. We observed defensive behavior of *X. scalaris* on three occasions in southern Bahia, Brazil. The observations occurred on 1) 17 September 2012 at 2230 h in an area of Atlantic forest at Michelin Ecological Reserve (13.816667°S, 39.133333°W; datum SAD69),



FIG. 1. *Xenopholis scalaris* from southern Bahia, Brazil, exhibiting flattening and head hiding defensive behavior.

Igrapiúna municipality; 2) 3 May 2009 at 1600 h on a trail between a secondary forest and cocoa plantation at RPPN Serra Bonita (15.42387°S; 39.54736°W), Camacan municipality; and 3) 24 February 1992 at the Centro de Pesquisas do Cacau, CEPEC/CEPLAC (14.767492°S; 39.228062°W), Ilhéus municipality. In all observations, the snakes flattened their bodies, hid their heads, and remained motionless for several minutes (Fig. 1). The third observation was of two neonates. Although body flattening behavior has been described for this species (Martins 1996. *In K. Del Claro [ed.], Anais do XIV Encontro Annual de Etologia*, pp. 185–199. Sociedade Brasileira de Etologia, Universidade Federal de Uberlândia, Brazil) this is the first time the head-hiding behavior (Greene 1988. *In Gans and Huey [eds.], Biology of the Reptilia*, pp.1–152. Alan R. Liss, New York) has been noted.

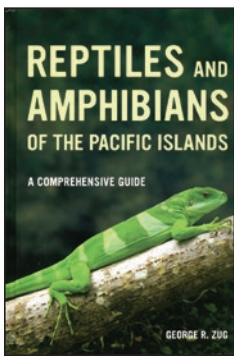
CAIO VINICIUS DE MIRA MENDES, RENAN MANOEL DE OLIVEIRA, DANILO SILVA RUAS, IURI RIBEIRO DIAS, and ANTÔNIO JORGE SUZART ARGÔLO (e-mail: ajargolo@gmail.com), Universidade Estadual de Santa Cruz – UESC, Campus Soane Nazaré de Andrade, Rodovia Jorge Amado, Km 16, Bairro Salobrinho, CEP 45662-900, Ilhéus, Bahia, Brazil.

BOOK REVIEWS

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Reptiles and Amphibians of the Pacific Islands

George R. Zug. 2013. University of California Press, Berkeley (www.ucpress.edu). x + 306 pp., 35 pls, 5 maps. Hardcover. US \$70.00. ISBN 9780520274952 (also available in Softcover and e-Book formats for US \$34.95).



ALLEN ALLISON

Bishop Museum, 1525 Bernice Street,
Honolulu, Hawaii 96817, USA
e-mail: allison@hawaii.edu

The Pacific Ocean is the world's largest geographic feature, comprising about a third of the globe, but its tropical oceanic islands take up less than 0.05% of the Earth's land surface, a collective area around the size of the U.S. state of West Virginia or the country of Costa Rica. However, these Pacific oceanic islands, most of which are tiny, include well

over half the world's island total and are home to a diverse and fascinating herpetofauna.

Organizing the Pacific islands into regions has long vexed geographers. In a highly influential work, de Brosses (1756) coined the term Polynesia, applying it to all the islands of the Pacific. Later, one of the great Pacific explorers, Dumont d'Urville (1832) subdivided the central and south Pacific into three contiguous areas, Polynesia, Micronesia, and Melanesia, based on the physical and cultural attributes of the people. These terms remain in current use but are generally now regarded as somewhat simplistic.

Biogeographers have been less successful in dividing up the Pacific (Kay 1979), and have generally tried to force adjacent islands and island groups into regional assemblages based on faunal or floral relationships. The various proposed schemes remained stubbornly incongruent. In an insightful review, Stodart (1992) distinguished between different island types, viz., atolls, elevated limestone (*makatea*), and high islands. He produced a scheme, based on the high islands, that remains broadly consistent with the biogeography of various Pacific taxa. He demonstrated for a number of taxa that New Guinea was a major source area for much of the Pacific, with species richness on high islands diminishing with distance from New Guinea (Stodart 1992). This pattern is very clear in the herpetofauna of the western Pacific (Allison 1993).

George Zug, in his outstanding and highly useful book, takes a very practical but somewhat unusual approach, dividing the Pacific into forty regional areas based on political and geographic criteria. He also includes within his treatment five islands or island groups in the Eastern Pacific, Islas Revillagigedo, Isla del Coco, Isla Malpelo, Clipperton Island, and the Galapagos. While

this scheme tends to bring together taxa from very different evolutionary lineages, it helps to put the greater Pacific herpetofauna into a clear regional perspective. Although there are no native species shared between the Eastern and Western Pacific, many of the wide-ranging human commensals, such as the geckos *Hemidactylus frenatus* and *Lepidodactylus lugubris*, now occur in both areas.

Overall, Zug treats a total of 187 taxa. Of these, 151 are native or probably native to some part of the Pacific (i.e., they didn't disperse via human transport), and 35 are introduced. One species of skink, *Carla tutela*, endemic to Halmahera Island west of New Guinea, was once thought to have been introduced to Guam but those populations are genetically similar to *Carla ailanpalai* which is endemic to the Admiralty Archipelago north of New Guinea and may have been introduced to Guam during WWII (Austin et al. 2011).

In his preface Zug makes it clear that his intended readership is "casual to avid naturalists who live on or visit Pacific islands." He also mentions that the book contains much new data and hopes that it will also be useful to professional herpetologists. In both regards he has succeeded admirably.

His introduction, which is barely six pages long, is one of the finest summaries I've ever encountered that puts the Pacific into a historical and regional perspective, starting with the geological history and ending with a discussion of patterns of human settlement.

Although this is a minor point in the context of this book, the introduction mentions Pangaea but not Gondwana. Inasmuch as the geological history of much of the Pacific, particularly the richest areas in the southwest, involved the breakup of Gondwana following its separation from Pangaea, it might have been useful to mention a few general details about that.

I would have also liked to see a bit more about the navigation skills of the Pacific peoples as many of the reptiles that are widespread in the Pacific were transported by humans. It is increasingly clear that the early Polynesians had acquired much more than "elementary navigation skills" and were navigating across vast distances long before European explorers reached the area.

In the next section Zug explains his regionalization scheme for the Pacific, characterizing it as "arbitrary" and includes a checklist of species known to inhabit each of the major islands or island groups. This checklist will assist naturalists in gaining a familiarity with the species known from the various groups. It will also serve as something of a snapshot of current patterns of distribution and diversity. As Zug points out in his preface, molecular studies have shown that a number Pacific species formerly thought to be widespread, are actually complexes of closely related taxa. As more groups are studied this subdivision of species will undoubtedly continue. In addition new species continue to be discovered.

The next section introduces terms used to identify species. I quite liked the fact that Zug explicitly defines what he means

by small, medium, midsize, etc. He gets by with a minimum of jargon. This would certainly not surprise those who know him.

The next 70 pages include 35 color plates, each presented on facing pages, and including virtually all species treated. The quality of the plates varies but generally they are excellent.

Most of the rest of the book, 221 pages, includes detailed accounts of the various species. Each major group, e.g., frogs, is treated in a brief introduction, followed by treatment of each family followed by a detailed, standardized account of each species. Details on the calls of the frogs (all but three of which are introduced) are included under reproduction. The accounts are excellent and include many useful historical and ecological details. Although the book lacks an identification key, I don't think that this is needed given the generally small number of species found in each area and the high quality of the images. In a few cases there are line drawings to facilitate the identification of similar species.

Each species treatment also includes a common name. Zug has generally chosen names that are in widespread use for well-known taxa but has coined many new names for more obscure taxa. These names clearly reflect Zug's overall emphasis on practicality. I was pleased to see that for species of skinks in the genus *Emoia* he dispensed with the use of "emo skink," a name that has somehow crept into the popular literature. Moreover, a quick Google search will quickly confirm that "emo" has many other meanings. Instead Zug focuses on physical features and habitat preferences that are diagnostic and easy for an avid naturalist to remember.

The book concludes with an overall checklist of species, each with a little square "tick" box in front of the scientific name followed by the common name, together with an appendix on the sources of illustrations and indexes to common and scientific names. I think that it would have been useful to also include an index to place names mentioned in the text but this is a minor point.

There do not appear to be any major typographical errors in the book. It is produced to a high standard of quality and is well organized and highly readable. Anyone with an interest in the Pacific, including naturalists, conservation biologists, biogeographers or herpetologists, will find this book indispensable. In my view George Zug has encapsulated a big chunk of his life's work into a masterpiece that should be on everyone's bookshelf.

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Lissemys punctata, the Indian Flap-shelled Turtle

Dieter Gramentz. 2011. Chimaira Buchhandelsgesellschaft mbH, Frankfurt am Main, Germany (www.chimaira.de). 278 pp. Hardcover. US \$79.95 (Zoo Book Sales). ISBN 978-3-89973-496-6.

Rafetus, the Curve of Extinction

Peter C.H. Pritchard. 2012. Living Art Publishing, Ada, Oklahoma (www.livingartpublishing.com). 174 pp. Hardcover. US \$69.50. ISBN 978-0-9787556-9-0.

PETER A. MEYLAN

Natural Sciences, Eckerd College, 4200 54th Ave. S., St. Petersburg, Florida 33711, USA
e-mail: meylanpa@eckerd.edu

It is great to see this focused interest in softshelled turtles. The Trionychidae is a family of bizarre reptiles whose members are easily recognized because they are so morphologically distinctive; but otherwise the group may be underappreciated. Each book treats a single species of softshell. These two species are at opposite ends of the softshell turtle spectrum—a small, common, and very terrestrial cyclanorbine and a rare, gigantic, and completely aquatic trionychine. And these volumes are at opposite ends of the spectrum of species treatments. The Gramentz volume strikes me as "Catalogue of American Amphibians and Reptiles account" meets "Biology of the Reptilia." It is a minutely detailed recounting of the extensive literature on a species that was listed on Appendix 1 of CITES in 1975 when it probably should not have been. The Pritchard volume is classic Pritchardian pontification. It has the subtitle, "The Story of the Giant Softshell Turtle of the Yangtze and Red Rivers." A complex story it is; it is a very personal voyage through the author's interactions with *Rafetus swinhoei*, one of those species whose living representatives might just be counted on the fingers of one hand. It was listed by CITES in 2005 (TRAFFIC 2013) when it should have been recognized as endangered at least 50 years ago. Despite the differences between the volumes a great deal of trionychid biology is packed into each one.

The Gramentz volume is a summary and compilation of the surprisingly extensive published literature on what I would argue is the softshell that exhibits the most primitive morphology among living forms. It is astounding that the author identified 346 references that are relevant to understanding the biology of *Lissemys punctata*. It is clear from this work that *Lissemys* is an important model organism for biological research on the Indian subcontinent. In contrast, much of the Pritchard book is a summary of his observations on the very poorly known species, *Rafetus swinhoei*, from the literature, interviews, and observations



made during numerous travels. Pritchard establishes for the first time that it is a truly giant species and he verifies that it is on the brink of extinction. But he goes far afield with chapters on the origin of turtles, a chapter on museums, and a chapter in which he considers candidates for the rarest turtle. Whereas the *Lissemys* volume is tightly organized with an extensive bibliography, the *Rafetus* volume is disorganized, and amazingly, its bibliophile author has not provided a literature cited!

Although I have played a supporting role in understanding the genus *Rafetus* and I have tried to keep up with developments in its conservation, I found the Pritchard volume to be tough to follow at times and then repetitive at others. It would have benefited from a more critical peer review, serious editing, and reorganization. My sense is that it was probably published pretty much as it was first drafted. Furthermore, it is not clear who the target audience is. If it were the scientific and conservation communities, it seems that it would have seen more attention in review and a bibliography would have been added. However, the way it is written it assumes that the reader is familiar with softshell turtle literature, some of which is quite obscure (i.e., Heude 1880).

The *Lissemys* volume will prove valuable to anyone doing comparative biology that involves turtles. As I have said elsewhere (Meylan 1991), it seems unfortunate that the biology of “the turtle” is too frequently based on *Trachemys scripta*. This *Lissemys* volume should prove useful in making more readily accessible the voluminous literature on a very different lineage of cryptodire. The volume also makes it quite clear that *Lissemys* has very interesting biology for a trionychid. It is kinosternid-like in that it is the only living softshell that regularly aestivates on land for a significant portion of the year and it seems to have embryonic diapause so that clutches laid at different times all hatch with the same monsoon rains. The reproductive biology of this species and its control appear to be remarkably well understood.

Although the *Lissemys* volume is better organized and documented, it is the *Rafetus* volume that covers new ground. Pritchard makes the very important work of Heude (1880) available in English for the first time. He lists all of the known specimens of this elusive species including many that he discovered via careful examination of museum collections in China and Vietnam. He establishes its giant size and makes a good argument that the largest turtles, living or extinct, may have been softshells. He identifies the most likely areas where additional living *R. swinhoei* might survive. Also, in covering all aspects of the genus *Rafetus*, he does a reasonable job of summarizing what is known about the smaller species in the genus, *R. euphraticus*, which could also use some serious conservation attention.

In the section in which he argues for *R. swinhoei* being the rarest of all turtles, it becomes clear that collectors of rare turtles are a real problem. It is also clear why this one is so rare, and it fits a pattern that Pritchard buries in his rambling introduction, that big animals are high on the curve of extinction. But you have to be really interested in softshelled turtles to make it through this book. It's not that the author gets off track; it seems that there often is no track. So, I am not sure to whom I could recommend this book beyond turtle aficionados. For biologists and libraries, the *Lissemys* volume is likely to be more useful, if only as a guide back to the original literature which one hopes would be cited in place of this volume in most cases.

It is interesting that *Lissemys* was CITES listed in 1975 but has still served as a model species. It is still harvested in large numbers and undoubtedly has suffered declines throughout its

range (what turtle species has not?), but appears to have biological properties that make it resilient. The giant *R. swinhoei*, on the other hand, is dedicated to river channels and oxbows. It may turn up a few more times; but only the most extraordinary measures will prolong the existence of this species. What other large softshells do we need to look at as quickly as possible to determine their true conservation status? The rest of the diversity of the Cyclanorbininae is in Africa and all four taxa are poorly known. The largest of them, *Cyclanorbis elegans*, has apparently become very hard to find. Is it the next *Rafetus*?

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The Eponym Dictionary of Amphibians

Bo Beolens, Michael Watkins, and Michael Grayson. 2013. Pelagic Publishing, Exeter, United Kingdom (www.pelagicpublishing.com). xiii + 244 pp. Hardcover. US \$49.99. ISBN 978-1-907807-41-1.

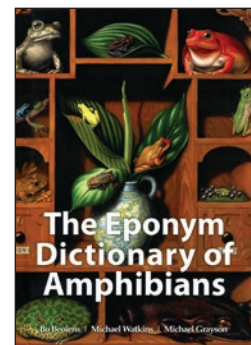
AARON M. BAUER

Department of Biology, Villanova University,
800 Lancaster Avenue,
Villanova, Pennsylvania 19085, USA
e-mail: aaron.bauer@villanova.edu

Scientific names are sources of endless fascination for professionals and amateurs alike: Who was that frog named after? Is that *smithii* named for Malcolm or Hobart? Here are the answers. Beolens et al. here complete the cataloguing of tetrapod eponyms, having previously considered birds (Beolens and Watkins 2003), mammals (Beolens et al. 2009), and reptiles (Beolens et al. 2011).

This is a compact volume of double-columned text. Although it appears sturdy at first glance, the book is not as well produced as the authors' reptile eponym work, although it is also considerably less expensive. The text is not illustrated, but the cover of the book is graced by a striking image entitled *Frog Cabinet* by Madeline von Foerster. It depicts 13 frog species (only five of which have eponymous names) in the cubbies of a cabinet, with two closed drawers meant to represent “all the frog species not yet discovered, and those who might die out before becoming known to us” (p. ii).

As in the reptile volume, a brief introduction explains the “rules” applied in the book. Accounts are provided, in alphabetical order, for those persons who are commemorated by either scientific names or common names (the latter, unfortunately,



based on Frank and Ramus (1995), which coined many arbitrary, incorrectly derived, and inappropriate names). Also included are other nouns that have served as the source of names that might be mistaken as being eponyms. For example, *Hyla andersonii* is named for Anderson, South Carolina and *Psychrophrynella illimani* for Nevado Illimani, a mountain in Bolivia. Not surprisingly, many of the same people have been commemorated in the names of both amphibians and reptiles, thus a good number of biographic entries in this book were also in *The Eponym Dictionary of Reptiles*, some repeated nearly verbatim and others significantly expanded or shortened.

I enjoyed this book and learned a lot from it. However, I found it unsatisfying on two levels. First, the authors' choice of biographic details often seems arbitrary. Authorship of a single publication is often mentioned, but this is as likely to be a minor paper as it is to be the subject's most important and well-known treatise. Examples include Carlo Gené, whose most important herpetological work (Gené 1839), the first treatise of the amphibians and reptiles of Sardinia, is not cited, G. K. Noble, whose influential book *Biology of the Amphibia* (Noble 1931) is not mentioned, J. G. Schneider, none of whose numerous herpetological books are noted, and Ronald Crombie, who is cited as the author of a list of Smithsonian herpetological publications rather than for his original work on the West Indies, the Philippines, or Palau.

One might argue that more comprehensive biographies are warranted for lesser known people, however, it seems a bit unbalanced to allocate only eight lines to Carl Gans, for decades one of the world's leading herpetologists, whereas Philippe Brunneau de Miré and Sir Basil Thomson, both fascinating in their own right, but not herpetological giants, are accorded 36 and 44 lines respectively—among the most extensive entries in the book.

An inherent problem of the style “so-and-so is at such-and-such an institution” is that a retirement or death immediately makes the account seem outdated. Many of those honored by amphibian eponyms have indeed done one or the other since their biographies were written. For example, Hobart Smith, Paolo Vanzolini, Eugenio Izecksohn, and Jorge Jim, all treated as living in the book, have all since passed away, although, to be fair, all but Jim (who died in 2011) were still living when the book went to press. A more difficult to explain and embarrassing mistake is listing Robert Stebbins as having passed away in 2000, 13 years before his actual demise.

A large number (although a small percentage) of the approximately 1600 entries include factual errors of one sort or another. For example, Thomas Bell was not an assistant to J. E. Gray (Adler 1989), Ernst Ahl was never the director of the Berlin Museum (Paepke 2013), Mario Peracca did not visit the Cape Verde Islands (Andreone and Gavetti 2007), and Giacomo Doria was the founder of a museum in Genoa, not Turin (Adler 2012). According to Boelens et al., the Russian scientist Leopold Schrenk “believed that mammoths which he found preserved in the permafrost must have died recently, and thought that they were subterranean animals that ate earth!” (p. 193). In fact, Schrenk (1871), as part of his studies of Siberian mammoths, recorded these as the beliefs of Arctic peoples; they were not his own views.

At least one entry appears to refer to the wrong person. That for Wagner cites Johann Andreas Wagner as the person commemorated in the name *Leptodactylus wagneri* (Peters, 1862); however, Wilhelm Peters, in fact, named this frog for Friedrich Johann Carl Moritz Wagner (better known as Moritz Wagner), who collected the holotype in Ecuador (Wagner et al. 2012).

Boelens et al. (2011) also linked the name of the snake *Diaphorolepis wagneri* Jan, 1863 to Johann Andreas Wagner, but it too was collected by Moritz Wagner. Its description does not indicate the source of the name, but Moritz is again the likely honoree. I caught these errors because I have worked on both the specimens described by Peters and those collected by Moritz Wagner, but I wonder how many other misattributed eponyms I may have missed!

Among contemporary herpetologists, institutions and timelines are sometimes incorrect. For example, Fritz Jürgen Obst was trained in the German Democratic Republic and spent his entire professional career in Dresden (formerly in East Germany), not partly in the west, and Robert C. Drewes has worked at the California Academy of Sciences since 1970, not 1998 as stated by Boelens et al. American university names seem to have been especially confused, as Richard Thomas is stated to have received his doctorate from the University of Louisiana [*sic*, Louisiana State University] and Victor Twitty's undergraduate degree is stated to be from Butler College, Princeton University [it was from Butler University in Indianapolis].

A number of eponyms are noted as having uncertain origin, but at least some are quite easily determined. For example, I was easily able to find the meaning of the specific epithet of *Pseudoeurycea tillicxtil*, the black-footed salamander, in an online Nahuatl dictionary — not surprisingly it means black foot. Other names of unknown derivation could have perhaps been checked by asking the authors of these names themselves, as was clearly done in the case for some names (e.g., those proposed by Annamarie Ohler that honor members of her family).

Typographical errors are relatively few, e.g., Port Elisabeth [*sic*, Elizabeth] (p. 84) and Alfred Russel Wallace's Brazilian expedition began in 1848 not 1948 (p. 227), but seem to plague accounts of German namesakes: Ein Frauenfahrt urn [*sic*, um] die Welt (p. 101), Ostafrikanischen Inseln [*sic*, Inseln], Detley [*sic*, Detlef] Langer (p. 119).

Boelens et al. provide the authors and dates of the Latin names they present. At one level this is helpful, but it would have been more useful if they had followed the convention of placing author and date in parentheses if the specific epithet is not used in conjunction with the generic name with which it was originally paired.

On the positive side, in this book we learn a little about a lot of people, some quite obscure, who have been immortalized in nomenclature. Among some of the more interesting entries are those that reveal that *Allobates algorei* honors former American vice president Al Gore, that *Hyla carnifex* is named after John Lynch (*carnifex* = hangman, to hang unlawfully is to lynch, get it?), and that two African frog names have epithets derived from the name of Charles Lemaire, who may have been the inspiration for the central character of Kurtz in Joseph Conrad's *Heart of Darkness* (although other people have also been proposed as Conrad's model for Kurtz).

On the whole, *The Eponym Dictionary of Amphibians* leaves a lot to be desired. However, it is the only book that does what it does. Relatively detailed biographies of herpetologists may be found in Kraig Adler's *Contributions to the History of Herpetology* series, but no other book provides thumbnail sketches of all those who have had amphibians named after them (including a very large number of non-herpetologists). For those with an interest in the history of herpetology, a curiosity about etymology, or an abiding love of trivia, this book will make an enjoyable read, if not a reliable reference.

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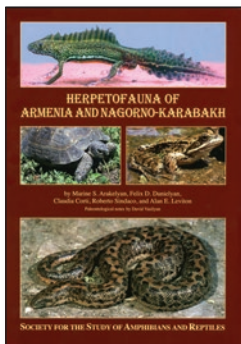
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Herpetofauna of Armenia and Nagorno-Karabakh

Marine S. Arakelyan, Felix D. Danielyan, Claudia Corti, Roberto Sindaco, and Alan E. Leviton. 2011. Society for the Study of Amphibians and Reptiles. Ithaca, New York. iii + 149 pp. Hardcover. US \$40.00. ISBN: 978-0-916984-84-7.



STEVEN C. ANDERSON

University of the Pacific,
Stockton, California 95211, USA
and *California Academy of Sciences,*
San Francisco, California 94118, USA
e-mail: asaccus@aol.com

Although the Caucasus Ranges have been designated a biodiversity hotspot, there are no recent reviews of the herpetofauna and literature of Armenia or Nagorno-Karabakh, two of the southern-

most republics of that region. Indeed, most people in the West would be hard put to place a finger on them on a map. This slim volume was designed to fill that gap. Nagorno-Karabakh

is surrounded by Armenia, apart from its southern border, which abuts Iran. Armenia is also bordered by Iran; it lies between Azerbaijan to the east, Georgia in the north, and Turkey to the west. The history of Nagorno-Karabakh is complicated; the current government considers it to be an independent republic, while Armenia and Azerbaijan both claim the territory. It is currently an unsettled dispute. The region has previously been claimed by Persia, the Russian Empire, and the Soviet Union. Internationally, it is considered a province of Azerbaijan, although its ethnic composition is primarily Armenian.

The first four authors accomplished the field work over some two decades; the editing and bibliography reveal the sure hand of Leviton. The book is traditional in its layout, the taxonomic treatment preceded by a discussion of the geography of the region, climate, biodiversity, conservation, and habitats. The authors recognize five zones, based on vegetation types, and five azonal habitats. A table correlates each species with these categories; thus much important information is presented in an economical space. These zones and habitats are described in the text. There are two pages of paleontological notes by David Vasilyan indicating that the modern Armenian herpetofauna dates back at least to the Upper Miocene. For those of us interested in the history of herpetology, there is a section on the history of herpetology of Armenia, similar in structure to those appearing in other SSAR publications.

The heart of the book consists of the taxonomic section, beginning with keys to the herpetofauna, based on easily seen external characters. The major characters are shown in photographs of actual specimens, rather than the more familiar generalized line drawings. Such a presentation has both costs and benefits, but the photographs are clear and show the characters effectively without too much distracting extraneous information. The species accounts each begin with the Latin name and author and an English common name. This is followed by a primary synonymy applying to specimens from Armenia and Nagorno-Karabakh, the type locality, notes on taxonomy, general distribution, distribution in the study area, general information, and a status of conservation statement. Importantly, and rare in taxonomic publications, each species account contains a section listing the references applying to the individual species. Lacking from a taxonomist's point of view, are the museum registry number of the holotype, a citation to the publication of the original description, a diagnosis, and lists of collecting and observation localities. However, these omissions are secondary to the intended purpose of the book, which is an introduction of the fauna and useful to the general reader and to non-herpetology specialists. In any case, the extensive bibliography will lead the interested researcher and collection curator to this and other information.

Following the text, there are 152 figures in 32 excellent color plates showing each species, a distribution map with unnamed and unnumbered spot localities, these followed by ecozone and habitat photographs. The bibliography alone covers 28 pages. It attempts to cover all publications covering the study area, from the earliest literature to that of the year of publication. The format is similar to that used in Leviton and Anderson (2010).

A trivial complaint perhaps, but Table 1 lists six reptile species endemic to Armenia. Endemism has no biological

significance when applied to national boundaries. On the other hand, it may be useful politically in grant proposals for government funds, protecting national fauna, etc.

Those of us who are taxonomists know that taxonomy is a moving target, as generic and species names change all-too-frequently, and common names have never been stabilized as they are for birds. The recognition of family and higher categories also changes, especially frequently today with the advent of phylogenetic and cladistic classifications. This makes the publication of synonymies and bibliographies especially important. This is exemplified by the following quote from the current book:

Bufo variabilis, because it is considered a member of the “*viridis*” complex, was transferred to the new genus *Pseudepidalea* when they established it for the *Bufo viridis* complex (Frost et al. 2006). However, Dubois and Bour (2010:23) argue that this is invalid because, in their view, it creates nomenclatural confusion with respect to the application of the nomen *Bufo*. Thus, they conclude, *Pseudepidalea* must be considered a junior objective synonym of *Bufo* Rafinesque 1815, a subgenus they include within *Bufo*, and which would include *viridis* and would include all species included in the *Bufo viridis* complex, or, if treated as a genus, then, e.g. *Bufo viridis*, *Bufo variabilis*, et al. (Dubois and Bour 2010:24–25).

Anyone confused yet? In any case, Dubois and Bour (2010) notwithstanding, many or most taxonomists have accepted the nomenclature of Frost et al. (2006), if prematurely. This leaves West Asian *Bufo viridis* with an entirely new name, *Pseudipedalea variabilis*, which does not occur in combination in the literature prior to 2006. So much for nomenclatural stability.

This book creates a new template for subsequent similar volumes in local and national taxonomic accounts. It needs a place in all collection libraries and in the hands of field biologists, reserve managers, and others with responsibilities for the fauna of Armenia and/or Nagorno-Karabakh.

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Texas Amphibians. A Field Guide

Bob L. Tipton, Terry L. Hibbitts, Troy D. Hibbitts, Toby J. Hibbitts, and Travis J. LaDuc. 2012. The University of Texas Press, Austin, Texas (<http://utpress.utexas.edu/>). xiv + 309 pp. Softcover. US \$24.95. ISBN 978-0-292-73735-8.

CHRISTOPHER J. BELL

Department of Geological Sciences,
The University of Texas at Austin,
Austin, Texas 78712, USA
e-mail: cjbell@mail.utexas.edu



For decades, the herpetofauna of Texas captured the attention of both professional and avocational herpetologists. The remarkably diverse herpetological biota of Texas is, at least in part, a reflection of the diversity of biotic provinces that are united geopolitically in that vast state. To judge by the books and monographs that were available historically, especially those readily available to the public, the point of emphasis for Texas herpetology traditionally was centered on the snakes. Among the earliest of the modern volumes on the herpetology of Texas was a pocket field guide to the snakes of Bexar County (Davenport, 1943). It was soon followed by the first of many editions and impressions of the popular booklet on venomous snakes by Werler (e.g., 1950, 1953, 1978), and later by works that addressed medical aspects of venomous snakes in Texas (Huang et al. 1975), focused on the famous rattlesnake ‘round-ups’ in the state (Kilmon and Shelton 1981; Adams and Thomas 2008), and provided updates to Werler’s work (Price 1998, 2009). More expansive volumes that provided coverage of non-venomous as well as venomous species appeared by 1965 (Raun 1965), and were substantial and widely available by the mid 1980s (Tennant 1984, 1985, 2006; Vermersch and Kuntz 1986; Dunlap 1994; Werler and Dixon 2000). The popular appeal of snakes in the state remains undiminished, and is reflected today by the wide availability in garden shops, nurseries, and even coffee shops of a waterproof, quick-reference guide (Pustejovsky 2010). The snakes of Texas have been well served, and served in style, in the literature.

To be sure, amphibians and reptiles were treated collectively in some detail in other volumes, but early summaries were more technical, were intended for specialists, and generally were presented as relatively dry annotated lists without (Brown 1950) or with (Raun and Gehlbach 1972) maps, but devoid of photographs and descriptions (another such list was published by Kutac and Caran in 1994). Dixon’s volume on amphibians and reptiles (1987, 2000; see also Dixon et al. 2007) provided a welcome change and included expanded discussion of natural history data, up-to-date taxonomic keys, distribution maps (with ranges documented at the county level), extensive review of the literature, and photos of select species in black-and-white format. The latter were helpful, but still lacked the appeal that so often drew the non-specialist to the natural history section of the (now almost defunct) local book store.

Departure from that traditional state of affairs began with the volume produced by Garrett and Barker (1987) who ushered in a new tradition of publishing non-technical field guides with

descriptions, color photographs, and distribution maps. The volume by Bartlett and Bartlett (1999) was an important update in a similar format. The recently released third edition of *Amphibians and Reptiles of Texas* by Dixon (2013) brings together for all readers a balanced coverage of non-technical text, maps, color photographs, and an extensive review of the literature on the herpetofaunal species of Texas. It certainly will serve to increase awareness of, and interest in, the herpetofauna of the state. But it is not easily carried in the field.

I have heard colleagues decry the field guide as a dying genre of published literature. Some view that demise as collateral damage in the broader and general decline of print media in favor of readily portable digital devices. Others apparently interpret concerns about the decline in outdoor activities among modern children (Louv 2008) as a harbinger of doom for the pocket guide. I admit that my proclivities tend towards an accumulation of books, and I embrace the accusatory labels of 'fuddy-duddy' and 'walking anachronism' that are proffered by students and colleagues who stand with jaws agape in disbelief when they learn that I do not carry a cell phone ("How do you text?") or tablet or other digital devices of our modern age. I also welcome the proximity of those same companions when they gaze over my shoulder as I pull out a field guide to aid in the identification of a darting damselfly, and am happy when they ask to thumb the volume on their own. Field guides clearly continue to serve the many purposes they have served for decades, as handy quick-references, teaching aides, inexpensive navigation guides for the budding naturalist who is grappling for the first time with the complexities of some small component of the world's biodiversity, and succinct guides for the professional or specialist exploring a new geographic area or a new taxonomic group.

Texas Amphibians is the latest release in the Texas Natural History Guides series published by The University of Texas Press, and is the third in that series to embrace a herpetological subject matter. It was preceded, perhaps unsurprisingly, by two volumes addressing snakes; one by Dixon and Werler (2005) and another by Price (2009). The volumes in the series are produced with an emphasis on a portable format that still permits (and, indeed, promotes) quality imagery. The book is sized for easy transport; at 4.5 in x 7.5 in I can slide this field guide into the back pocket of my jeans, drop it in a vest pocket, or carry it effortlessly in a backpack or daypack. The volume sells for \$24.95, but a 33% discount is available for purchases made through the website for the press (<http://utpress.utexas.edu/index.php/books/tiptep>), thus dropping the cost to only \$16.72.

The size of the book conforms to the others in the series, and that placed some limits on format, content, and presentation of data. The end product suffers little from those restrictions, and is a handy and helpful compendium that is both informative and easy to use. A four-page table of contents is followed by a brief foreword from James Dixon, who sets the book in the context of both geography and conservation. The 328 numbered pages include introductory sections on the basic biology of amphibians, conservation concerns (with Texas exemplars placed in the broader context of global amphibian declines), notes and tips on how to observe and photograph amphibians, an informative discussion of the laws and regulations that govern the collection of amphibians in Texas, notes on captive maintenance, comments on taxonomic practices adopted by the authors, keys to the salamander and frog species of Texas, a generic key to amphibian larvae, and systematic accounts of 72 species (30 salamanders and 42 anurans) with known records from Texas, to which are

appended accounts of an additional six species that possibly occur in the state, but require verification. The bulk of the text (234 pp.) is dedicated to the systematic accounts. A list of state and U.S.-based international herpetological societies is provided in an appendix, along with notes on three museums, and some relevant web sites. The final sections of the book are dedicated to a glossary of terms, a brief bibliography, and indices of common and scientific names. The outer edges of the inside of the front and back covers provide rulers in inches and centimeters, respectively.

A few black-and-white illustrations are provided in the keys to highlight anatomical features, but the book is stunningly adorned with 177 color photographs, all but one of which depict living animals (the sole exception is a photograph depicting the photography set-up used by the authors in the field). The photos are good or excellent throughout, and the majority are sized to fit 1/3 of the height of the page. Most species are depicted in two or more photographs, permitting ready visualization of pattern or color variations, or anatomical details in close-up views. There is at least one photograph for all but two species; the exceptions are an as-yet unnamed species of *Eurycea* from the Pedernales River, and *Eurycea robusta* (known only from the holotype, an image of which was subsequently published by Dixon 2013).

A map depicting geographic distribution is provided for each of the 72 species known to occur within Texas. The maps are of a standard size, county boundaries of the state are depicted, and geographic range is indicated by gray-scale shading. Care appears to have been taken to depict the known (or inferred) range of the species as accurately as possible, given the scale of the maps (i.e., shading, does not conform solely to county boundaries). Geographic ranges of nominal subspecies are not differentiated. Several species of *Eurycea* are documented only from localized springs that would be minuscule if depicted on maps of this scale; for those, standard 1 cm dots are centered on the known locality or localities. The only obvious error in the maps is that the range of the 'Rio Grande' species of *Siren* was copied onto the map for *Siren intermedia* (see discussion by Dixon [2013] for a review of the taxonomic complications surrounding the two taxa, and a map for comparison).

Species accounts are organized taxonomically and according to a standardized format, with text grouped under the sequential headings Size, Description, Similar Species, Distribution, Natural History, Reproduction, Subspecies (when relevant), and Comments and Conservation. Both scientific and common names are provided at the beginning of each account, and with few exceptions follow Crother (2008). Only the common name is provided in the photo captions, but the photos are conveniently placed in close proximity to the text for each species. This format is common to all volumes in The University of Texas Natural History Guides series, and represents a significant stylistic difference from the traditional Peterson Field Guide series, in which taxon illustrations were, until recently, placed in a collection of plates bound near the center of the volume (e.g., Conant and Collins 1991). A style somewhat similar to the Peterson one is followed by the Audubon guides, in which images are clustered at the front of the book, with text and maps in the back (e.g., Behler and King 1988). I confess to a degree of ambivalence about these varying organizational styles; each serves a purpose and a particular category of user, and I have found myself at different times, and with different guides, variably favoring each style over the other, depending often upon the relative degree of my ignorance with the subject matter. Perhaps the harmonious accommodation

of both styles in the newer editions of the Peterson Series (e.g., Conant and Collins 1998) is the way to achieve maximum utility in the service of the broadest possible community.

The third edition of Dixon's *Amphibians & Reptiles of Texas* (2012) was published after the release of *Texas Amphibians* (2012). The two volumes ultimately will serve different (but overlapping) audiences, and some comparative comments are in order. At the time of publication of *Texas Amphibians*, the photos it contained were unique, but 11 of them were reprinted by Dixon (2012). The duplicated images are of *Ambystoma tigrinum*, *Eurycea latitans*, *Eurycea quadridigitata*, *Eurycea tridentifera*, *Notophthalmus viridescens*, *Pseudacris clarkii*, *Pseudacris crucifer*, *Gastrophryne carolinensis*, *Scaphiopus hurteri*, *Lithobates sphenoccephala*, and *Eleutherodactylus planirostris*. Interestingly, and somewhat disturbingly, in the case of three shared images, the county-level provenience information provided in the two volumes is different (*Pseudacris clarkii*, either Sterling County or Iri-son County; *Pseudacris crucifer*, either Jasper County or Houston County; *Gastrophryne carolinensis*, either Houston County or Anderson County). In twelve other instances, the images in the two volumes are clearly of the same individual animals, taken on the same habitat setting, presumably in a single photo-shoot, but the animals have slightly different orientations or positions (*Ambystoma maculatum*, *Eurycea naufragia*, *Eurycea sosorum*, *Desmognathus auriculatus*; *Necturus beyeri*, *Notophthalmus viridescens*, *Anaxyrus debilis*; *Hyla chrysoscelis*, *Hyla cinerea*, *Gastrophryne olivacea*; *Hypopachus variolosus*, and *Lithobates grylio*). The similarity in photos undoubtedly stems from the fact that photos for Dixon's volume were provided by Toby Hibbitts, one of the authors of *Texas Amphibians*. In almost all cases, the images published by Tipton et al. are of a sharper quality and have greater clarity than the images reproduced in Dixon's book. Taxonomic coverage in the two volumes is nearly identical, with equal treatment of the anurans, but the Tipton et al. volume covers two additional and unnamed species of *Eurycea*.

Any book published on amphibians in recent years has addressed a taxonomic group that now is experiencing declining populations across the globe, and challenging threats to persistence. One of the unique features of the Texas amphibian fauna is the taxonomic diversity of *Eurycea* in the state. Many of these salamanders are tied to the karst geology and hydrology of the eastern edge of the Edwards Plateau. The morphologic, genetic, and taxonomic diversity among these salamanders continues to be a topic of intense exploration, and the elucidation of even basic natural history data for many species remains an elusive goal. The extremely localized geographic distribution of many of the species makes them a particularly challenging group, both for basic biological study, and for conservation efforts. Many of these issues are necessarily touched upon in this field guide, and special attention was called to the conservation status of the various species. Since the publication of *Texas Amphibians*, the conservation status of at least four species has changed. *Eurycea tonkawae* is now listed as threatened by the U.S. Fish & Wildlife Service. *Eurycea waterlooensis* now is listed as endangered by the same agency, and the listing status of both *Eurycea chisholmensis* and *Eurycea naufragia* now is 'proposed endangered' (see U.S. Fish & Wildlife Service species profiles at <http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=D02T, ...=D033, ...=D02X, and ...=D02S, respectively>). As further testimony to the ever-changing picture on Texas amphibians, I note that the final book manuscript was sent to press a few weeks before the massive Bastrop County fire swept through important

habitats for the Houston toad, *Anaxyrus houstonensis* (Travis La-Duc, pers. com. Sept., 2013); the impact on toad populations has not yet been fully assessed. These issues only serve to enhance the importance of this book, especially for the young people of the state of Texas who will utilize this guide to acquaint themselves with what may well be a rapidly changing component of their native biota.

In some respects, this book may be considered to be long overdue. The only other book dedicated solely to the amphibians of Texas is a field guide to the anurans of Big Bend National Park (Dayton et al. 2007). The volume by Tipton et al. clearly fills an obvious need for a portable, low-cost guide to the amphibians of Texas. Indeed, with the appearance of this volume, lizards now stand as the most prominent group still in need of greater attention and documentation (lizard lovers in Texas may decorate their shelves only with Frank Blair's 1960 monograph on *Sceloporus olivaceus*, Vermersch's 1992 volume documenting species from the south-central portion of the state, a more expansive regional guide that covers Texas and the southwest [Jones and Lovich 2009], and Axtell's detailed distribution maps issued in 30 parts over approximately 20 years [e.g., Axtell 1987, 2005]).

The quality photographs in *Texas Amphibians* enhance the value of the book for non-specialists, and as the most up-to-date summary of the known amphibian fauna of Texas, it is of direct interest to all professional herpetologists. Beyond its obvious utility as a reference guide in the field, the book also will serve as an excellent introduction to the amphibians of Texas and will be useful as a classroom resource for K-12 teachers who seek useful tools to shape lesson plans and discussions about biodiversity, conservation, and natural resources of Texas. The low cost of this volume should, I think, guarantee a broad circulation, and serves as an additional enticement towards the maintenance of print media. Although internet photos are available for many (not all) of the species discussed in this book, they are sometimes of low quality, may be difficult to compare efficiently, and, if your eyes are as bad as mine, are almost always difficult to appreciate on sunny days when viewed on hand-held screens (and at night those screens destroy your night-vision).

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Amphibians of Eastern Europe.

Part 1. Order Caudata

Yevgen Pysanets. 2012. Yevgen Pysanets, Kiev, Ukraine (available through amazon.com). 207 pp. Softcover. US \$29.00. ISBN 978-966-02-6514-1.

AARON M. BAUER

Department of Biology,
Villanova University,
800 Lancaster Avenue,
Villanova, Pennsylvania 19085, USA
e-mail: aaron.bauer@villanova.edu



This book deals with the salamander fauna of Eastern Europe, defined as the European portions of the former Soviet Union. Ten species in six genera in the families Hynobiidae and Salamandridae are treated in the dual Ukrainian/English text. Ten species may not seem like very many, but the area covered by the book has a continental climate with great temperature extremes and some of the taxa covered barely extend into the region. For example, *Salamandra salamandra*, *Ichthyosaura alpestris*, and *Lissotriton montandoni* all enter Eastern Europe only in the Ukrainian Carpathians.

As this is intended as the first volume in a larger work on the amphibians of the region, it actually includes some more comprehensive features, such as illustrated keys to both the salamanders and frogs of Eastern Europe. The scientific names and authorities of these 30 amphibian species, along with their vernacular names in Ukrainian and English, are provided in a table. Threats to and conservation measures for amphibians are also provided in tabular form, as is a summary of frog and salamander conservation status (including listings by IUCN, the Bern Convention, and national red lists).

Other general information is included in a 17-page section providing biographies of zoologists who have contributed to the study of the Eurasian herpetofauna. These span five centuries from Conrad Gessner to Heinz Wermuth and draw heavily for both text and images from Kraig Adler's biographies in the SSAR *Contributions to the History of Herpetology* series.

The heart of the book is its species accounts. These follow very abbreviated family and genus comments and include subsections dealing with taxonomy, distribution, karyology, sexual dimorphism, morphology and coloration, life history, reproduction, development, behavior, and diet. In the account for *Salamandrella keyserlingii* the English text is about one page in length, whereas the Ukrainian is about six times longer. The discrepancy in other accounts is not as marked but if one wishes to get the fullest picture of a particular species, it may be necessary for non-Ukrainian readers to use Google Translate.

Accounts are each illustrated by a shaded distribution map (within Eastern Europe only), habitat photos, and photos of breeding males and females, as well as larvae, pedomorphs, non-breeding adults, and color or pattern variants, as appropriate. These are all in color and of high quality, although their printed size is quite small (mostly less than 80 mm in maximum dimension).

For the most part, the English portions of the book are not actual translations, but rather extended synopses of the Ukrainian content. This can be seen, for example, on page 26, where pre- and climax metamorphosis are discussed in Ukrainian, but not in English. In other places the English captions for certain figures do not provide all of the information given in the Ukrainian (p. 27), and some figures are not referenced in the English text at all (e.g., figures 7–9 in the section dealing with reproduction on pages 18–19). Principal components figures on pages 162–163 have English captions, but the relevant information printed on the plots themselves (the localities of sampled *Lis-sotriton*) are only in Ukrainian (except for two Romanian place names). Page headers are given only in Ukrainian. In most cases Ukrainian section headers are followed by English, and the associated text starts with the English version, then the Ukrainian, but in the section on the basics of amphibian systematics starting on page 51 the text is entirely in Ukrainian except for English figure legends. In the taxonomic accounts, Ukrainian comes first for families and genera, but species accounts start with English.

Translation is an issue in this book and typos are rife in the English text. The map on page 10, for example, incorrectly translates “western” as “eastern.” Genera is rendered as “genuses” (p. 79), taxa as “taxons” (p. 86), marked as “market” (p. 86), and endangered as “indangered” (p. 153). Wording is awkward in some places, but understandable. Only on page 69 was I truly unable to decipher the English text. On page 145 the English figure captions are incorrect, having been duplicated from those on page 147. An errata sheet has been glued inside the back cover of the book, but none of the examples noted above are included.

One of the book’s most useful features is its extensive (16 pp.) literature cited, with about 325 entries, arranged with references written in languages using the Cyrillic alphabet first, followed

by those using the Roman alphabet. Many references, particularly those published in smaller regional journals, are likely to be unfamiliar to readers outside the region. Coverage appears to be quite good, especially for Ukraine, which is both home to the author and the richest region for salamanders within the scope of the book. Unfortunately, there are many typos in this section as well (e.g., Univercity), and Latin names are often not italicized. There is no index to the book in either language.

Salamanders of Eastern Europe have been treated in a number of other books that are available in English, most notably Kuzmin’s (1999) *Amphibians of the Former Soviet Union*. Although this is now getting rather out of date, Kuzmin (2013) has just released a new volume with the same title. Kuzmin’s work is both broader in scope and much more massive than that of Pysanets, but also considerably more expensive. Detailed species accounts, though again dated, also appear (in German) in the salamander volumes of *Handbuch der Reptilien und Amphibien Europas* (Grossenbacher and Thiesmeier 1999, 2003; Thiesmeier and Grossenbacher 2004). Despite numerous language and editorial issues, Pysanets’ book provides a compact, affordable, and up-to-date overview of the caudate fauna from the Carpathians to the Urals and from the Arctic Sea to the Caucasus.

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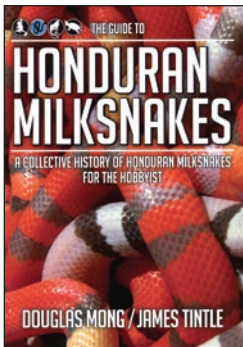
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PUBLICATIONS RECEIVED

Honduran Milksnakes: A Collective History of Honduran Milksnakes for the Hobbyist

Douglas Mong and James Tintle. 2013. ColdBlooded Publishing, Valrico, Florida (www.facebook.com/ColdBloodedPublishing). 170 pp. Softcover. US \$49.95. ISBN 978-0-9897804-0-7.

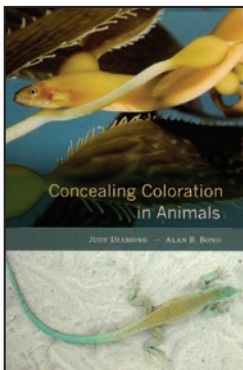


The Honduran Milksnake (*Lampropeltis triangulum hondurensis*), a large (up to 2.4 m TL) Central American colubrid whose color pattern mimics that of co-occurring venomous coral snakes (*Micrurus* spp.), has become very popular among herpetoculturists. Although there are several naturally occurring regional color pattern variants, captive breeders have taken this founder stock and produced a remarkable array of color and pattern morphs. Individual chapters

cover the origins of breeding stock, genetics of color pattern inheritance, captive maintenance and breeding, health and disease, and four chapters are devoted to various morphs. Color photographs occupy most pages, and likely account for the book's high price. Although this book would have benefited from a stronger editorial hand, hobbyist breeders and keepers at all levels will find this a rich and visually stimulating source of information and perhaps inspiration.

Concealing Coloration in Animals

Judy Diamond and Alan B. Bond. 2013. Harvard University Press, Cambridge, Massachusetts (www.hup.harvard.edu). Hardcover. x, [2], 271 pp. US \$29.95. ISBN 978-0-674-05235-2.



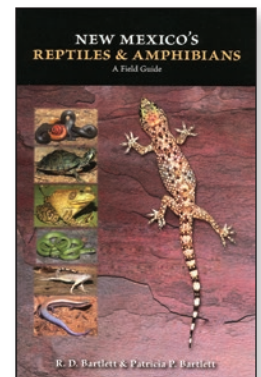
This is an engaging book for a general audience that deals with a topic of broad biological relevance. Concealing coloration has captured the attention of some of the most well known zoologists of the past two centuries, including Henry Bates (of Batesian mimicry fame), Alfred Russel Wallace, and Ernst Mayr. Even Theodore Roosevelt became embroiled in debates over the topic. This book draws on these historical examples, as well as modern work by Hopi Hoekstra, Michael Nachman, Bree Rosenblum, and others, to investigate topics such

as color as signal, perception, the nature of color, and eyes and their sensitivity. Examples are drawn from across the spectrum of animals. The case of industrial melanism in the moth *Biston betularia* is, of course, explored but many cases of herpetological crypsis are also presented. Appropriately, the book is illustrated

throughout with color photos of high quality, among which phrynosomatid lizards are especially well represented. Despite its brevity and accessibility, the book includes 30 pages of notes and approximately 600 references, facilitating the reader's access to the rich literature on this topic. This inexpensive volume should be of interest to evolutionary biologists as well as sensory and cognitive scientists and would serve as an excellent accompaniment to an undergraduate seminar class on the biology of color or similar topics.

New Mexico's Reptiles & Amphibians: A Field Guide

R. D. Bartlett and Patricia P. Bartlett. 2013. University of New Mexico Press, Albuquerque (www.unmpress.com). 228 pp. Softcover. US \$24.95. ISBN 978-0-8263-5207-1.

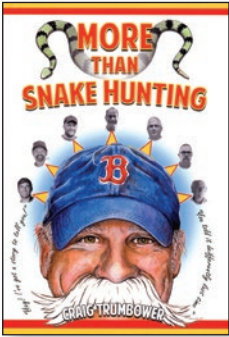


This book should appeal to general readers wanting a quick and handy reference to the herpetofauna of this corner of the American Southwest. Individual species accounts—consisting of brief statements concerning taxonomy, abundance/range, habitat, size, identifying features, voice (for anurans), similar species—are accompanied by small (25 x 25 mm), shaded distribution maps showing range only within New Mexico. The taxonomy used is up to date, but the authors note cases where disagreement remains (e.g., *Rana* vs. *Lithobates*, *Bufo* vs. *Anaxyrus*, *Masticophis* vs. *Coluber*). Each species is illustrated by a color photo, although geographic origin of specimens depicted is not provided, information that would have enhanced their usefulness. Photographs of animals, as well as representative habitats, are aggregated in a section of color plates to keep printing costs low. The photographs should make it possible for users to identify the majority of species, while in other cases readers are directed to consult range maps to determine species ID. Those requiring a more detailed treatment of New Mexico's herpetofauna will want to consult Degenhardt et al.'s *Amphibians and Reptiles of New Mexico*, long the definitive treatment of the subject.

A growing number of titles have appeared in recent years that present stories of hunting for amphibians and reptiles (“herping”), following in the tradition made famous by Carl Kauffeld (*Snakes and Snake Hunting* and *Snakes: The Keeper and the Kept*). However, books in the post-Kauffeld era mostly do not come close to matching those classics. Here, we take brief looks at some recent additions to this genre of herpetological publishing.

More than Snake Hunting

Craig Trumbower. 2012. ECO Herpetological Publishing, Rodeo, New Mexico. 278 pp. Hardcover. US \$29.95 ISBN 978-0-9852936-2-8.

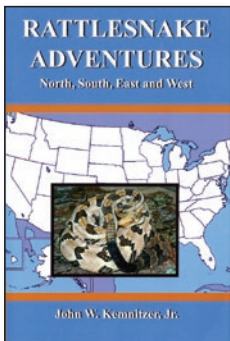


Trumbower offers ten chapters of snake hunting adventures set in South Carolina, Florida, Texas, Arizona, and California. These are presented in “storytelling” fashion, and often are as much about the hunters as about the snakes they seek. Specific chapters recall field searches for, among other targets, Blacktail, Eastern Diamondback, and Canebrake (= Timber) rattlesnakes, Eastern Indigo Snakes, and Rosy Boas. A long chapter on *Lampropeltis alterna* (the Gray-banded King-snake) includes field-hunting vignettes from

a handful of veteran “*alterna* hunters.” One chapter captures the essence of reptile “expos”—the sometimes-huge trade shows where live animals are bought and sold. This work has the feel of an “insider” book, written for and about a circle of the author’s closest friends and field companions, but those outside the circle will likely find these tales entertaining.

Rattlesnake Adventures: North, South, East and West

John W. Kemnitzer, Jr. 2011. Serpent’s Tale Natural History Book Distributors, Lanesboro, Minnesota (www.zoobooksales.com). 183 pp. Softcover. US \$17.95. ISBN 978-1-885209-66-5.

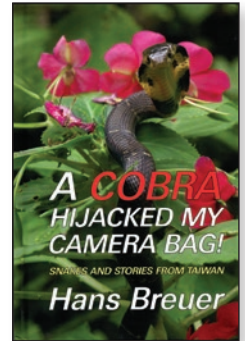


This collection—something of a sequel to Kemnitzer’s *Rattlesnake Adventures: Hunting with the Old Timers*, published in 2006—consists of 21 individually authored stories and articles. It includes original contributions as well as previously published material, but all focus on the subject of rattlesnakes. The mix of authors includes familiar contemporaries (e.g., Richard Bartlett, David Barker, John Behler, William Brown) and others likely to be encountered for the first time in print.

Some names are from long ago—Howard Gloyd, Moody Lentz (an associate of Marlin Perkins), and Isabelle Kauffeld (then-wife of Carl Kauffeld, but later married to Roger Conant and best known for her photographs in Conant’s field guides). Subject matter comprises tales of those who hunted rattlesnakes for hides or illegal collection for the pet trade, the search for zoo specimens in remote areas, and includes Gloyd’s famous description of the magnificent Prairie Rattlesnake dens of South Dakota. A number of grainy, black-and-white photos are scattered throughout.

A Cobra Hijacked My Camera Bag! Snakes and Stories from Taiwan

Hans Breuer. 2012. Coachwhip Publications, Landisville, Pennsylvania (www.coachwhipbooks.com). 243 pp. Hardcover. US \$29.95. ISBN 1-61646-129-2.



Naturalist Hans Breuer, a German national transplanted to Taiwan and later to Borneo, shares stories of discovery of Taiwanese herpetofauna. Breuer enthusiastically recounts his progression from rank amateur, fully ignorant of the local fauna, to one with growing expertise and who has since made several important discoveries. His writing is engaging, entertaining, and scientifically informed. Mixed in with the field stories, readers will encounter interesting facts about the ophidofauna, herp keeping, wildlife smuggling, Taiwanese culture, and much more. Much of the narrative focuses on field experiences with particular species or groups of snakes (elapids, pitvipers, ratsnakes, etc.), with color photos included for all.

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