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Geographic distribution: *Opheodrys aestivus*

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The Quarterly News-Journal of the Society for the Study of Amphibians and Reptiles

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

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

ANNUAL DUES AND SUBSCRIPTIONS: Annual membership dues for the year 2005 in the Society for the Study of Amphibians and Reptiles are as follows: **REGULAR** membership US\$60 (Student \$30)—includes *Journal of Herpetology* and *Herpetological Review*; **PLENARY** membership US\$80 (Student \$45)—includes *JH*, *HR*, and annual subscription to the *Catalogue of American Amphibians and Reptiles*; **INSTITUTIONAL SUBSCRIPTION** \$115—includes *JH* and *HR*. Additional fee for airmail postage outside USA \$35 for one year. Additional membership categories available on the SSAR webpage: <http://www.ssarherps.org/pages/membership.html>.

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

Payment must be made in USA funds, payable to "SSAR," or by International Money Order, or with VISA or MasterCard (account number and expiration date must be provided). Payment should be sent to: Theodora Pinou, SSAR Treasurer, Department of Biological & Environmental Sciences, Western Connecticut State University, 181 White Street, Danbury, Connecticut 06810, USA. Fax: (203) 837-8769; e-mail: PinouT@wcsu.edu.

Future Annual Meetings

2006 — Site pending, 12–17 July (with ASIH, HL)

2007 — Saint Louis, Missouri (with ASIH, HL)

About Our Cover: *Vipera raddei*

The *Vipera xanthina* complex comprises eight species according to recent treatments (Nilson et al. 1999; Kaupia. Darmstädter Beiträge zur Naturgeschichte, Heft 8, 1999:99–102; Ananjeva et al. 2004. Colored Atlas of Reptiles of the North Eurasia: Taxonomic Diversity, Distribution, Conservation Status. St. Petersburg, 2004: 230 pp.) allocated to the subgenus *Montivipera*: *xanthina*, *bornmuelleri*, *bulgardaghica*, *albizona*,

wagneri, *raddei*, *albicornuta*, and *latifii*. The Armenian Viper, *Vipera* (*Montivipera*) *raddei raddei* Boettger, 1890 is distributed in the southern regions of Armenia and Nakhichevan (Azerbaijan) as well as in adjacent regions of Turkey and Iran. *V. r. kurdistanica* Nilson & Andrén, 1986, is known from northeastern Iran to Lake Urmia.

The cover image depicts *V. raddei*, a rare, narrowly endemic and declining species included in the Red Lists of Armenia (1987) and the former USSR (1984) (see Jeff Etlings' article in this issue [p. 231] of *Herpetological Review* describing current conservation-oriented field research on this species). It occurs at elevations of 1000 to 2700 m in xerophytic montane associations, in particular oak forests and open juniper woodlands, favoring rocky slopes with sparse brush cover. The distribution pattern in the southern spur ranges of the Lesser Caucasus reflects the mosaic of suitable habitats in this region.

The cover photo was taken by **Nikolai L. Orlov**, who found and photographed the basking snake in situ in the morning among rock outcrops, 2300 m elevation, in the Megri District of southern Armenia. This population, first discovered in 2004, is associated with a rocky subalpine meadow. The snakes here appear to differ from those elsewhere by their darker coloration. Orlov used a tripod-mounted Fujifilm FinePix S2 Pro digital camera, with a Nikkor 60mm f2.8 macro lens, capturing the image using available light.

Orlov, who has authored more than 160 publications, is a senior research scientist in the Department of Herpetology, Zoological Institute, Russian Academy of Sciences (Saint Petersburg, Russia; <http://www.zin.ru/labs/herplab/index.html>). His interests focus on the herpetofauna of Palearctic and Oriental Asia: biodiversity, biogeography, ecology, taxonomy, phylogeny, conservation, and captive breeding.



SSAR BUSINESS

Seibert Award Winners for 2005 Announced

The 14th annual Seibert Awards were presented at the 48th Annual Meeting of the SSAR in Tampa, Florida, 5–12 July 2005. These awards are named in honor of Henri C. Seibert, an early and tireless supporter of SSAR (having served as an officer for over 20 years). In recognition of outstanding student presentations at the annual meeting, a single award was given in each of the following categories: Physiology/Morphology (5 eligible presentations), Evolution/Systematics (5 eligible presentations), Ecology (16 eligible presentations), and Conservation (9 eligible presentations). All four awardees will receive a check for US \$200 and a book from Chuck Crumly at the University of California Press.

The Winners—Physiology/Morphology: **Diana Andres**, Rod Mackie, Steve Secor, and Bobby Espinoza, Cal State University, Northridge; University of Illinois, Urbana-Champaign; University of Alabama, Tuscaloosa, “The grass is greener: Costs of diet switching may inhibit insect eating by herbivorous reptiles.” Ecology: **Deborah Hutchinson**, Frank Schroeder, Alan Savitzky, Akira Mori, Jerrold Meinwald, and Gordon Burghardt, Old Dominion University; Cornell University; Kyoto University; University of Tennessee, “Chemical evidence for sequestration of defensive toxins in the Asian snake *Rhabdophis tigrinus* (Colubridae: Natricinae).” Conservation: **Kristen Bell** and Maureen Donnelly, Florida International University, “Influence of forest fragmentation on community structure of frogs and lizards in lowland Costa Rica.” Evolution/Systematics: **Daniel Moen**, Stony Brook University, “Cope’s Rule in cryptodiran turtles: Do extant species reflect a trend of phyletic size increase?”

Honorable Mention—Physiology/Morphology: **Sean Graham**, Matthew Grober, and Gordon Schuett, Georgia State University, “Seasonal timing of the mating period in cottonmouths (*Agkistrodon piscivorus*): Evidence from sex steroids, urogenital tract histology, and male sexual behavior.” Ecology: **Michael Benard**, University of California, Davis, “Survival trade-offs between two predator-induced phenotypes in Pacific treefrogs (*Pseudacris regilla*).” Conservation: **Brian Todd**, Betsie Rothermal, and Whit Gibbons, Savannah River Ecology Lab, “Forest clearing reduces growth and survival of recently metamorphosed southern toads (*Bufo terrestris*).” Evolution/Systematics: **Tom Devitt**, University of California, Berkeley, “Phylogeography of a ring species: The *Ensatina eschscholtzii* complex revisited.”

The judges were Chuck Crumly (University of California Press), Bobby Espinoza (California State University, Northridge), David Hardy, Sr. (Tucson, AZ), Kirsten Nicholson (Washington University), Charles Peterson (The College of New Jersey), Marion Preest (The Claremont Colleges), and Stephen Richter (Eastern Kentucky University).

Grants-in-Herpetology: Annual Report (2005)

An award in the amount of US \$500 was made to each of the

following individuals:

Conservation.—**Jodi Rowley**, James Cook University. Project title: “Uncovering the secret lives of frogs. Why some frogs are declining from a fatal disease and others are doing just fine.”

Field Research.—**Dean A. Croshaw**, University of New Orleans/Savannah River Ecology Laboratory. Project title: “Polyandry in *Ambystoma talpoideum* and its consequences for individuals and populations.”

Laboratory Research.—**Sean Graham**, Georgia State University. Project title: “Endocrine regulation of the mating season in cottonmouths (*Agkistrodon piscivorus*): Evidence from sex steroids, urogenital tract histology, and male sexual behavior.”

Herpetological Education.—**David Wojnowski**, Kent State University. Project title: “Project SAVE (Saving Africa’s Vital Ecosystems).”

Travel.—**Juan M. Guayasamin**, University of Kansas. Project title: “Phylogenetic relationships of Glass Frogs (Anura: Centrolenidae).”

International.—**Jennifer Germano**, University of Otago, New Zealand. Project title: “How do homing capabilities affect the success of translocations of *Leiopelma pakeka*?”

Bibliographic Research.—**Keith A. Metzger**, State University of New York-Stony Brook. Project Title: “A comprehensive literature survey of lepidosaur diets.”

2005 Grants-in-Herpetology Committee.—Chair: Erik R. Wild. Reviewers: Jeffrey Parmelee, Tiffany M. Doan, Craig E. Nelson, Kirsten Nicholson.

SSAR congratulates the 2005 GIH recipients and thanks the committee members for their efforts.

Grants-in-Herpetology 2006 Proposals

Proposals are now being accepted for the 2006 SSAR Grants-in-Herpetology Program. This program is intended to provide financial support for deserving individuals or organizations involved in herpetological research, education, or conservation. Application deadline is 31 December 2005. Grant application details are available at:

<<http://www.ssarherps.org/pages/GIH.html>>

Florida is home to over 8% of the world’s known turtle species and is a significant area for both turtle diversity and habitat. Twenty-five of the 54 turtle species found in the United States also occur in Florida. They are represented in upland communities, such as scrub and sandhill, in rivers, lakes, swamps, and even coastal habitats, such as salt marsh, mangrove communities and marine systems. Certainly, habitat diversity and species richness makes Florida a chelonian hotspot.

The FTCT focuses its efforts on the conservation of non-marine species. This work is accomplished independently or in partnership with agencies and other non-governmental organizations. To date, the FTCT has:

- organized and co-sponsored a symposium on the status and conservation of Florida turtles;
- co-sponsored a national workshop on the ecology, status and conservation of diamondback terrapins;
- initiated the development of both a national and Florida Diamondback Terrapin Working Group;
- partnered with the Gopher Tortoise Council on a project that distributed an educational book to nearly 3,000 elementary school libraries throughout the range of the gopher tortoise;
- partnered with the Gopher Tortoise Council on a project that distributed an educational slide/PowerPoint presentation and supplemental resource notebook to educators throughout the range of the gopher tortoise;
- co-developed and funded the Pinellas County School District’s Florida turtle track pack;
- organized Florida turtle educational exhibits at nature festivals and environmental events;
- and assisted the Florida Fish and Wildlife Conservation Commission with the development of a diamondback terrapin educational poster and exhibit.

Members of the FTCT include biologists, land managers, agency representatives, environmental consultants, educators, conservationists, and concerned citizens. In addition to supporting conservation work, members receive discounts on meeting registration fees and opportunities to attend organized field trips. For more information please visit www.ftct.org.

NEWSNOTES

Florida Turtle Conservation Trust Launches New Website (www.ftct.org)

The Florida Turtle Conservation Trust (FTCT) was formed in 1999 by a group of Florida biologists and conservationists concerned with the conservation outlook for Florida turtles. Our purpose is to promote the conservation of all Florida turtle species and the preservation of intact, free-ranging populations and their associated ecosystems throughout the state of Florida. The FTCT is committed to and supports education, conservation, research, and management efforts with the above goals in mind.

MEETINGS

Meetings Calendar

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

7–9 October 2005—Gopher Tortoise Council Annual Meeting, Palatka, Florida, USA. Information: www.gophertortoisecouncil.org.

21–23 October 2005—Snakebites in the New Millennium Symposium, University of Nebraska Medical Center, Omaha, Nebraska, USA. Information: <http://app1.unmc.edu/cce/snakebites/>

5–6 November 2005—Kansas Herpetological Society Annual Meeting, Pittsburg State University, Pittsburg, Kansas, USA. Information: <http://www.ku.edu/~khs/AnnualMeetingInfo.html>.

31 March–2 April 2006—Symposium—Conservation and Herpetology: The Middle American Connection. Miami-Dade College, Miami, Florida, USA. Information available from Larry David Wilson, organizer, by e-mail: lwilson@mdc.edu. See additional information on p. 352 of this issue.

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, **María del Rosario Castañeda** or **Michele Johnson**; postal and e-mail addresses may be found on the inside front cover.

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

Comparative Analysis Of Morphological Characters Associated With Arboreality And Orthinophagy In Snakes

Several morphological characters are correlated with diet and habitat use. In snakes, gape size and relative head length are correlated with maximum prey size, while arboreal habits are associated with tail length, body size and heart position. The insular endemic pitvipers *Bothrops insularis* (SE Brazil) and *Gloydus shedaoensis* (NE China) are under similar selective pressures not shared by their mainland closest relatives. On islands, adults of both species have an almost exclusively avian diet (while mainland species feed on mammals), and show an increase in arboreality relative to mainland relatives. The authors compared morphological characters associated with dietary habits and arboreality between mainland and insular *Bothrops* and *Gloydus* species and assessed phylogenetic relationships between *B. insularis* and mainland species. Results show that both *B. insularis* and *G. shedaoensis* have significantly longer heads and smaller litter sizes than mainland relatives. However, body size, tail and fang length, and heart position only differ between *B. insularis* and mainland relatives. The authors suggest caution, in the absence of multiple studies on single species, when interpreting character changes related with shifts in selective pressures.

WÜSTER, W., M. R. DUARTE, AND M. D. G. SALOMÃO. 2005. Morphological correlates of incipient arboreality and ornithophagy in island pitvipers, and the phylogenetic position of *Bothrops insularis*. *Journal of the Zoological Society of London* 266:1–10.

Correspondence to: Wolfgang Wüster, School of Biological Sciences, University of Wales, Bangor LL57 2UW, Wales, United Kingdom; e-mail: w.wuster@bangor.ac.uk.

Comparison of Flying Performance in *Draco* Lizards

Previous studies on flying lizards of the genus *Draco* found an isometric relationship between wing area and body mass, even though there is significant intraspecific variation in body size. Based on this isometric pattern and on aerodynamic theory, the authors hypothesized that smaller species would perform better at gliding than larger species. Within the genus, larger body size has evolved independently several times, with larger species occurring in lineages found in sympatry with other *Draco* species. Additionally, none of the single-species communities is composed of a large-bodied species. The authors' objective was to establish a possible association between body size and locomotor performance evolution. To test for gliding performance, trials were conducted using separate takeoff and landing poles of known height and distance from each other. Maximum velocity (adjusted for wind velocity and direction), total height lost during the glide, and total glide angle were estimated based on trial videos. Data was collected for 11 species covering the range of body sizes in the genus and independent contrasts were calculated to correct for phylogenetic autocorrelation. Results agree with the predictions: smaller species have higher velocity, lose less altitude and have smaller angles during glides. Furthermore, results support gliding performance in *Draco* lizards can be estimated from morphological data alone. The authors discuss the ecological implications of larger size and its apparent fitness cost overcome only in the presence of other flying lizards.

McGUIRE, J. A., AND R. DUDLEY. 2005. The cost of living large: comparative gliding performance in flying lizards (Agamidae: *Draco*). *The American Naturalist* 166:93–106.

Correspondence to: Jimmy A. McGuire, Museum of Vertebrate Zoology, University of California, Berkeley, California 94720, USA; e-mail: m McGuire@socrates.berkeley.edu.

Sea-Level Rise Impact On Turtle Nesting Habitat

One of the inevitable consequences of global warming is an increase in sea-level. To estimate the impact on turtle nesting habitat, the authors measured individual beach profiles and developed elevation models using geographic information systems. Fieldwork was done in Bonaire, Netherlands Antilles, where four species of turtles nest: *Eretmochelys imbricata*, *Caretta caretta*, *Chelonia mydas*, and *Dermochelys coriacea*. Data on potential turtle nesting sites collected from 1993 to 2000 was used to estimate relative nesting use of different beaches. Three different sea-level rise scenarios were considered: 0.2, 0.5 and 0.9 m, which represent the full range of potential sea-level rise estimated by the Intergovernmental Panel on Climate Change (2001). Associations between physical characteristics (length, width, slope, elevation, aspect, and land use behind the beach), nesting activity and flooding vulnerability were estimated. Potential nesting area was estimated based on the preferred elevation range for *E. imbricata* and *C. caretta*. Results show that nesting activity was correlated with beach slope, with steeper beaches more frequently used. Based on

the models, 14% of the total beach would be lost to inundation with a 0.2 m sea-level increase; 31% and 50% would be lost with 0.5 and 0.9 m rises, respectively. No relationship was found between nesting activity and vulnerability, or between nesting activity and land use behind the beach. With a 0.2 m sea-level rise, preferred nesting areas for *E. imbricata* and *C. caretta* would decrease 11%; the decrease would be 41% and 21% with a 0.5 and 0.9 m sea-level rise respectively. Even though it is difficult to anticipate the effect of sea-level rise on turtle nesting habitat and to predict female response to the rise, estimations that allow identification of vulnerable areas are necessary for future coastal management decisions.

FISH, M. R., I. M. CÔTÉ, J. A. GILL, A. P. JONES, S. RENSHOFF, AND A. R. WATKINSON. 2005. Predicting the impact of sea-level rise on Caribbean sea turtle nesting habitat. *Conservation Biology* 19:482–491.

Correspondence to: Isabelle M. Côté, School of Biological Sciences, University of East Anglia, Norwich NR4 7TJ, United Kingdom; e-mail: i.cote@uea.ac.uk.

Effects of Early Evolutionary History in Present-Day Ecology

Two main theories on the origin of ecological traits have been proposed: 1) the ‘deep history hypothesis,’ which states that differences in ecological traits among species arose early in the evolutionary history of clades and that present day assemblages are based on those preexisting differences, and 2) the ‘competition hypothesis,’ which argues that niche differentiation occurred in relatively recent ecological time, resulting from shifts in prey availability, competition, or dietary preferences. The authors combined phylogenetic and ecological data to reconstruct the evolution of dietary shifts in squamates and test two predictions consistent with the ‘deep history hypothesis’: 1) the presence of a strong relationship between diet and phylogeny and 2) the ability to identify nodes in which dietary shifts have occurred. One hundred and eighty-four species, of 12 families, were included in the analysis. Two phylogenetic hypotheses were considered, a composite tree reflecting the traditional view and a recently proposed alternative (Townsend et al. 2004). Canonical correspondence analysis was used to measure the association between dietary composition and phylogeny, and to identify points of diet divergence in squamates. Results show a strong relationship between diet and evolutionary history, and significant dietary shifts in Iguania/Scleroglossa, Agamidae/Iguanidae, Scincidae, Varanidae, Gymnophthalmidae, and Teiidae. Results also suggest deep history has played an important role in lizard diet specification and could account for the actual niche partitioning in communities of non-closely related species. However, authors also point out that although present-day differences have ‘ancient roots’, current interspecific interactions still have a strong influence on present assemblages. Traits associated with dietary and other ecological shifts in squamates are also discussed.

VITT, L. J., AND E. R. PIANKA. 2005. Deep history impacts present-day ecology and biodiversity. *Proceeding of the National Academy of Science* 102:7877–7881.

Correspondence to: Laurie J. Vitt, Sam Noble Oklahoma Museum of Natural History and Zoology Department, University of Oklahoma, Norman, Oklahoma 73072, USA; e-mail: vitt@ou.edu.

Colonization Patterns of Beta *Anolis* (*Norops*) Lizards

The lizard genus *Anolis* is distributed from southeastern North America, to tropical South America, including Central America and the West Indies. The traditional view suggests that West Indian species represent over-water dispersal from a mainland ancestor with subsequent inter-island colonizations. The focus of this study is the highly diverse mainland clade *Norops* (or Beta section), which recent analyses have suggested is derived from a West Indian ancestor. Highly successful island-to-mainland colonizations are particularly rare. The authors included mitochondrial ND2 (189 spp., *Norops* and non-*Norops*), and nuclear ITS-1 (51 spp., *Norops*) sequences. Phylogenetic analysis included parsimony and Bayesian methods. The ancestral state reconstruction (mainland or West Indian) was performed on the mitochondrial-only tree, using a Bayesian tree-sampling technique (Pagel and Lutzoni 2002). Additionally, Wilcoxon signed-ranks and Shimodaira-Hasegawa tests were performed to test alternative relationships within the *Norops* clade. A West Indian *Norops* ancestor was reconstructed in all trees, as well as a mainland ancestor in the node that leads to all mainland species. The combined analysis (ND2 and ITS-1) of *Norops* reconstructs three geographically circumscribed clades: Cuba, Jamaica, and Mainland. The Jamaica and Mainland clades are recovered as sister taxa, to the exclusion of the Cuban clade, supporting the hypothesis of mainland *Norops* being nested within a West Indian group. Alternative reconstructions were rejected by the Shimodaira-Hasegawa test but not by the Wilcoxon signed-ranks test. The authors discuss alternative scenarios, and particular characteristics of West Indian *Anolis* communities that might have promoted this successful island-to-mainland colonization.

NICHOLSON, K. E., R. E. GLOR, J. J. KOLBE, A. LARSON, S. B. HEDGES, AND J. B. LOSOS. 2005. Mainland colonization by island lizards. *Journal of Biogeography* 32:929–938.

Correspondence to: Kirsten E. Nicholson, Department of Biology, Campus Box 1137, Washington University, St Louis, Missouri 63130-4899, USA; e-mail: knicholson@biology2.wustl.edu.

Effects of Inactivity in Skeletal Motor Nerve Terminals in *Cyclorana alboguttata*

The authors studied the effects of prolonged inactivity associated with aestivation on neuromuscular transmission in the burrowing frog *Cyclorana alboguttata*. This species lives in semi-arid environments and is active for short periods of time after heavy precipitation. Between active periods, frogs burrow underground and experience a metabolic depression. To measure the effects of inactivity, the authors compared the structure and function of neuromuscular junctions on the iliofibularis muscle between active individuals and individuals that had been aestivating for 6 months. Structure variables included number, shape and length of primary, secondary and tertiary neuron branches. Function measurements included end-plate potentials (EPPs), miniature end-plate potentials (MEPPs), and resting membrane potential (RMP). EPPs and MEPPs were used to calculate quantal content (number of acetyl-

choline vesicles released per synapse by the nerve), quantal size (response of the muscle to the spontaneous release of a single synaptic vesicle), mean probability of transmitter release and number of active release sites. No significant differences were found between active and aestivating individuals in terminal structure, RMP or MEPPs. However, in the aestivating group the mean amplitude of induced EPPs significantly decreased and the proportion of nerve stimulations that failed to induce an EPP significantly increased. Quantal content was significantly higher in active frogs; in aestivating frogs there was a significant reduction in the probability of transmitter release and in the number of active release sites. Comparisons with previous studies on anurans and mammals are presented. In addition, characteristics of *C. alboguttata* physiology of aestivation and potential mechanisms of nerve preservation are discussed.

HUDSON, N. J., N. A. LAVIDIS, P. T. CHOY, AND C. E. FRANKLIN. 2005. Effect of prolonged inactivity on skeletal motor nerve terminals during aestivation in the burrowing frog, *Cyclorana alboguttata*. *Journal of Comparative Physiology A* 191:373–379.

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Foraging Mode of *Bradypodion pumilum* and the Foraging Mode Dichotomy

Two foraging strategies, sit-and-wait and active, have been well accepted in lizard ecology. Other life history characteristics (e.g., type of prey, home range size, clutch size, daily energy expenditure) are associated with foraging mode, making the distinction a useful organizing concept. Due to the taxonomic bias and small taxon sampling, recent studies have questioned the validity of this partition. The author studied time budget and foraging mode in the chameleon *Bradypodion pumilum*, which represents a highly derived taxon difficult to classify, since it possesses traits that belong to each of the foraging modes. Association between levels of activity and sex, age, time of day and ambient temperature were assessed and lag-sequential analysis was applied to test for non-random association between foraging behavior and behaviors preceding it. In addition, the author presents an interspecific analysis of foraging mode using discriminant function analysis (DFA) on number of movements per minute (MPM) and percent time moving (%TM) data from the literature. The resulting discriminant function classified *B. pumilum* as an active forager. DFA results support the traditional cutoff values for classification of foraging modes (sit-and-wait foragers %TM < 15 and MPM < 1.0). Finally, the author comments on the intraspecific variability in foraging behavior, the value of the sit-and-wait and active forager dichotomy, and the utility of DFA to support this distinction.

BUTLER, M. A. 2005. Foraging mode of the chameleon, *Bradypodion pumilum*: a challenge to the sit-and-wait versus active forager paradigm? *Biological Journal of the Linnean Society* 84:797–808.

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Evaluating the Impact of Trade on Wild Populations

The increasing trade of amphibians and reptiles has raised questions of whether this trade is affecting wild populations' survival and if it is contributing to the global amphibian and reptile decline problem. The authors review data on US shipments of amphibians and reptiles from 1998 to 2002 from the United States Fish and Wildlife Service (USFWS) Law Enforcement Management Information System (LEMIS). The authors found that the vast majority of the imported and exported species are for commercial use, including food, pets and traditional medicine, and that more than a million individuals, body parts, and products are shipped across the US borders every year. Most of the shipments are declared as wild caught with a significant amount of the records registered at or above the genus level, that is, with no species-specific information. Additionally, several species might be considered particularly vulnerable when trade volume is compared with biological characteristics and geographic distribution. Species with wide ranges, high densities and high reproductive productivity may be able to tolerate intensive collecting. Although the data do not confirm active unsustainable collection, it does provide information on the large volume of animals taken from the wild, the deficiencies of the LEMIS system, and the necessity for stricter regulations to prevent overcollecting.

SCHLAEPFER, M. A., C. HOOVER, AND C. K. DODD, JR. 2005. Challenges in evaluating the impact of the trade in amphibians and reptiles on wild populations. *BioScience* 55:256–264.

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Origins and Phylogenetic Relationships of Lissamphibia

Relationships among living amphibians (Lissamphibia) have been difficult to resolve, in part due to the large gap in time and morphology between fossils and extant forms. As a reflection of this ambiguity, there is still controversy about lissamphibian origins and whether the group is monophyletic. To address these questions, the authors sequenced 8 mitochondrial genomes of living amphibians and combined them with previously published genomes of amphibians (6 spp.) and other vertebrates (6 spp.). Phylogenetic reconstructions were performed using parsimony, maximum likelihood, neighbor-joining and Bayesian analyses. Alternative phylogenetic hypotheses within Lissamphibia were tested using approximately unbiased (AU) and Shimodaira-Hasegawa (SH) tests. Bayesian molecular dating that allows for an estimation independent of a molecular clock was used to calculate divergence times for major groups. Results from all phylogenetic approaches support the monophyly of Lissamphibia and Batrachia (Anura and Caudata). Alternative reconstructions rendering Lissamphibia paraphyletic and Anura and Gymnophiona as sister taxa were rejected by AU and SH tests. However, the Caudata sister to Gymnophiona hypothesis was not rejected. Additionally,

the authors tested the compatibility of their molecular time estimates with fossil time estimates on three alternative hypotheses: Lissamphibia is monophyletic with 1) Temnospondyli as sister group, or 2) Lepospondyli as sister group, and 3) Lissamphibia is not monophyletic, with Gymnophiona related to Microsauria (Lepospondyli), and Batrachia related to Temnospondyli. Results support the hypothesis of lissamphibian monophyly with Temnospondyli as sister group. Finally, the potential geographic origins of each group are discussed, considering current distributions, plate tectonics, clade ages, and fossil record.

ZHANG, P., H. ZHOU, Y. Q. CHEN, Y. F. LIU, AND L. H. QU. 2005. Mitogenomic perspectives on the origin and phylogeny of living amphibians. *Systematic Biology* 54:391–400.

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ZOO VIEW

“Vipers should cover the world like Sherwin-Williams paint.”—Joe Laszlo explaining why his viper collection at the San Antonio Zoo was so large.

During the 1980s, one of the finest collections of living true vipers ever assembled was at the San Antonio Zoological Gardens where Jozsef (Joe) Laszlo was curator. Through Joe’s efforts, the Zoo became recognized as a place where a number of viperid taxa rarely seen could be appreciated. His contribution to our understanding of the captive management of European vipers was critical. Laszlo was certainly a pioneer in focusing on husbandry issues, and the International Herpetological Symposium (IHS) issues an annual award in his name to a person who significantly contributes to captive management. When he died unexpectedly in 1987, his loss cast an unbelievable gloom in the zoo community; he was truly beloved. Joe was my first herpetological friend to die and I still miss him. See Murphy (1988. *Herpetol. Rev.* 19:5–6) and Card and Murphy (2000. *SSAR Herpetol. Circ. No.* 27:1–44) for details of his life and contributions to herpetology.

Joe’s office was in the center section of the reptile building. Piles of reprints, correspondence, and handwritten notes littered his desk. To breed vipers, Laszlo was convinced that the interface between temperature and light was important for success. The off-exhibit area being small, he was unable to build a spacious hibernaculum to cool his temperate zone vipers so he installed a soft drink cooler instead to house the animals. Banks of



FIG. 1. Example of human allometric scaling and poor grooming. Joe Laszlo (left) and James Murphy in 1982. Photo courtesy of Bert Langerwerf, modified by David T. Roberts.

fluorescent lights were suspended everywhere with an array of different bulbs which he was testing. Racks of shoe boxes and terrariums held a bewildering assortment of vipers. Joe was sure to call whenever he acquired any new viper, especially from Europe, and I still remember his excitement and enthusiasm when his first Armenian vipers (*Montivipera raddei*) came to the Zoo.

Today, Joe would be proud of the advances in our understanding of viperid biology and particularly impressed with the multifaceted program described in the following article by curator Jeff Ettling at the St. Louis Zoo. However, Laszlo would be saddened to discover that the wild population of this beautiful snake in Armenia have declined nearly 90% in approximately twenty years.

New Books and Papers

For captive managers, two new books have surfaced which are useful for ensuring proper sex ratios for the charges in the collection. The first is edited by Nicole Valenzuela and Valentine A. Lance and the title is *Temperature-Dependent Sex Determination in Vertebrates* (2004. Smithsonian Books, Washington DC; ISBN:1-58834-203-4). Lance was a reproductive physiologist at the Center for the Reproduction of Endangered Species (CRES) at the San Diego Zoo for many years. The book is organized into four sections: Prevalence of Temperature-Dependent Sex Determination of Vertebrates; Thermal Effects, Ecology, and Interactions; Evolutionary Considerations; and Conclusions: Missing Links and Future Directions. The second book is *Reptilian Incubation: Environment, Evolution and Behaviour*, edited by D. C. Deeming (2004. Nottingham University Press, Nottingham UK; ISBN:1-897676-11-5).

The Wildlife Conservation Society, headquartered at the Bronx Zoo, has published a book relevant to the Asian chelonian crisis. The authors are Win Maung and Win Ko Ko and the book is *Turtles and Tortoises of Myanmar* (2002. Wildlife Conservation Society, Yangon).

In 1829, Edward Turner Bennett wrote a fascinating book called *The Tower Menagerie: Comprising the Natural History of the Animals Contained in that Establishment, with Anecdotes of Their Characters and History. Illustrated by Portraits of Each, Taken from Life, by William Harvey, and Engraved on Wood by Branston and Wright*. The London Tower Menagerie (1245–1832) was not an ideal facility for reptiles but at various times over a span of nearly 600 years, the anaconda (called *Python Tigris* Var. by Bennett, likely Ceylonese pythons, *Python molurus pimbura*), over 100 rattlesnakes (called *Crotalus horridus*), and the alligator (called *Crocodylus lucius*) lived in the Tower. The Indian boa (called *Python Tigris*) laid a clutch of eggs which did not hatch. An interesting new book about the long history of the Royal Collection of Wild and



FIG. 2. Illustration of American Alligator (*Alligator mississippiensis*) living in Royal Menagerie, Tower of London from Robert Huish’s “The Wonders of the Animal Kingdom Exhibiting Delineations of the Most Distinguished Wild Animals in the Various Menageries of the Country” in 1830. Alligators and crocodiles are described as follows: “Living, as it were, in the confines of both land and water, these enormous animals extend their dominion equally over the inhabitants of both elements. Here they enjoy an absolute rule, and dread none of the common dangers which assault other less powerful animals.” Bennett’s specimen was said to be young, measuring not more than three feet in length, did not grow for two years, and was fed raw beef weekly which may be why the head seems abnormally small. Credit: Courtesy of Smithsonian Institution Libraries, Washington, DC.

Ferocious Beasts kept at the Tower Menagerie has been written by Daniel Hahn — *The Tower Menagerie* (2004. Jeremy P. Tarcher/Penguin, New York; ISBN:1-58542-335-1).

Workers with herps may not have considered the opportunity to see play in their animals. Gordon Burghardt has just published a comprehensive book called *The Genesis of Animal Play. Testing the Limits* (2005. MIT Press, Cambridge, Massachusetts; ISBN:0-262-02543-4). There are many references to play behavior in lower vertebrates, including an intriguing observation on possible play in amphibians by Kevin Zippel. Full disclosure: the African cichlid (*Tropheus duboisi*) playing with a submersible thermometer on the dust jacket lived in my home aquarium for many years. Many days I would hear this strange tapping noise and finally realized that the fish was hitting the side of the tank with the thermometer. I was reluctant to mention it to Gordon at first for fear of being labeled a lunatic hearing strange noises.

Jack Frazier has been a Smithsonian Research Associate based at the National Zoo's Conservation and Research Center in Front Royal, Virginia for many years. Jack is a major player in sea turtle conservation. It was gratifying to see that his commitment to their protection has been recognized in a terrific new book by James R. Spotila (*Sea Turtles. A Complete Guide to Their Biology, Behavior, and Conservation*. 2004. The Johns Hopkins University Press, Baltimore and London; ISBN: 0-8018-8007-8, p. 84). In 1997, Jack published a paper which is relevant to zoo biologists ("Sustainable development: modern elixir or sack dress?" *Environ. Conserv.* 24:182–193). The five central arguments of this paper are: (1) the expression has tremendous popularity and the term "sustainable" has appeared in countless contexts for decades; (2) although it is undefined, the term "sustainable development" is often used in so-called scientific discourse; (3) from the context in which it is used it routinely refers to continual growth (like cancer); (4) a major danger in its persistent use is that people who should be considering the concept carefully, consent its use in order to have social recognition and access to grants, etc.; (5) an attempt to attain continual growth cannot be consistent with biological conservation, whether considered as biological diversity or as ecological services.

Hans-Werner Herrmann, former herpetological curator at the Cologne Zoo and researcher with CRES, has published two papers in 2004: "A new frog species of the genus *Cardioglossa* from the Tchabal Mbabo Mtns, Cameroon (Anura: Arthroleptidae)" [*Herpetozoa* 17:119–125]; "Anuran habitat selection and temporal partitioning in a montane and submontane rainforest in Southwestern Cameroon—first results" [*Salamandra* 40:239–260].

In my last column (see p. 102), I noted the availability on CD of several Powerpoint presentations concerning herpetology. In order to simplify the acquisition of these programs, the permissions officer at Smithsonian Institution Libraries has agreed that recipients can keep them permanently rather than having to return them as I communicated earlier.

—James B. Murphy, Section Editor

Saint Louis Zoo Wildcare Institute: Center for Conservation of Near East Mountain Vipers

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Over the past decade, the Saint Louis Zoo has focused its efforts on the captive management and reproduction of mountain vipers, *Montivipera*, of the Near East. With a vested history in this snake complex, the Zoo found value in focusing its conservation efforts on a group largely ignored by other zoological institutions. The Zoo's studies of captive vipers have already provided useful information on reproduction and behavior (Ettling 1996; Ettling and Marfisi 2002).

In May 2004 the Saint Louis Zoo officially announced its new Conservation Division, the Wildcare Institute. Under the umbrella of the Institute are 12 Conservation Centers that focus on endangered species and their habitats. The goal of the Institute is to work through partnerships to help animals, ecosystems and people simultaneously. The key to the success of the Wildcare Institute will be collaboration with universities, government agencies, conservation organizations, field researchers and other zoos. The Center for Conservation of Near East Mountain Vipers will focus on helping implement conservation management and public education to ensure the future of mountain vipers in the wild.

The *Montivipera xanthina* complex is comprised of eight species with a distribution that includes southeastern Europe, Asia Minor, Armenia, and western Asia. Our limited knowledge of their natural history is due in part to restricted and isolated rocky habitats (Nilson and Andrén 1986). Over the past 20 years the combination of habitat alteration, over-collection, and unnaturally high



FIG. 1. Surgical implantation of transmitter. Individuals in photo are as follows: Alexander Malkhasyan (left), Jeff Ettling (center), Aram Agasyan (right rear), and Andy Snider (right front).



FIG. 2. Jeff Ettling demonstrating the use of radiotelemetry equipment.

mortality resulting from human persecution has drastically reduced many mountain viper populations (Nilson and Andr  n 2000). In fact, five of the eight species are now listed by the IUCN as vulnerable, endangered, or critical. Unless proper equipment, public education, and human resources necessary for conducting basic conservation activities are allocated, this complex of snakes faces an uncertain future.

In June 2004 the first long-term project of the Center for Conservation of Near East Mountain Vipers was initiated. The species targeted for the inaugural study was the Armenian viper, *Montivipera raddei*. The population numbers of *M. raddei* have dropped a staggering 88% over the past 20 years, primarily because of habitat alteration and over-collection. As a result it is listed as a species of concern in Armenia's National Red Data Book. For effective conservation of *M. raddei*, as well as other species, it will be necessary to establish a network of nature reserves. With little data available on home range size and demography, it is difficult to make sound management decisions at the current time.

The project is a collaborative effort that involves individuals from five institutions: Jeff Ettling (Saint Louis Zoo), Andy Snider (Detroit Zoological Institute), Dr. Nikolai Orlov, Dr. Natalia Ananjeva, and Roman Khalikov (Russian Academy of Sciences), Dr. Aram Agasyan and Alexander Malkhasyan (Armenia Ministry of Nature Protection), and Konstantin Shiryayev (Tula Exotarium, Russia).

The study is utilizing radio-telemetry and mark/recapture to determine the home range size, seasonal activity patterns, habitat preferences, and demography of *M. raddei*. Our selected study site is in Khosrov Nature Reserve, considered one of the most important protected areas in Armenia because of its unique plant and animal communities. Over 50% of all Armenian plants and 171 animal species (60 endemic species) are represented in the

Reserve. To date, six vipers have been implanted with radio transmitters. An additional four snakes were planned to be implanted with transmitters in May 2005. The movement patterns and habitat preferences of these snakes will be monitored for a period of five years. In addition to the specimens with transmitters, all *M. raddei* that are captured within the study site are sexed, weighed, measured, and permanently marked for future identification with subcutaneous implanted passive transponders.

Although the radio-telemetry study will provide the fundamental information necessary for development of conservation management guidelines for *M. raddei*, it must also be accompanied by a strong educational component. With assistance from the Zoo's education staff, a poster and brochure currently are being developed. The field team will use these materials in outreach programs in rural communities and with pastoral farmers who often encounter the snakes. Future plans include a workshop for teachers in Armenia that will provide them with curricula on ecosystems, conservation, and the plight of the Armenian viper. It will also be important to provide training for future educators. A family in St. Louis, Missouri, interested in assisting our project, has offered to sponsor an Armenian exchange student who will be pursuing a career in environmental education. A search is currently underway and a student should be in place in 2006.

Through the combination of ecological fieldwork, development of management guidelines, and an intensive outreach education program, our goal is to establish a secure future for *M. raddei* in Armenia. In addition to continuing our work in Armenia, the Center for Conservation of Near East Mountain Vipers plans to pursue other collaborative projects involving the other seven species of mountain vipers.

Questions regarding the Armenian Viper Project or Center for Conservation of Near East Mountain Vipers should be directed to Jeff Ettling (e-mail: ettling@stlzoo.org). Further information about the Wildcare Institute and/or its Conservation Centers is available from the Saint Louis Zoo's website (www.stlzoo.org).

LITERATURE CITED

- ETTLING, J. 1996. Natural history, husbandry, and captive reproduction of mountain vipers (*Vipera bornmuelleri* and *Vipera wagneri*). In P. D. Strimple (ed.), *Advances in Herpetoculture*, pp. 139–144. International Herpetological Symposium, Inc.
- , AND A. MARFISI. 2002. Male combat in two species of mountain vipers, *Montivipera raddei* and *M. wagneri*. In G. W. Schuett, M. H  ggren, M. E. Douglas, and H. W. Greene (eds.), *Biology of the Vipers*, pp. 163–166. Eagle Mountain Publishing, Eagle Mountain, Utah.
- NILSON, G., AND C. ANDR  N. 1986. The mountain vipers of the Middle East – The *Vipera xanthina* complex (Reptilia, Viperidae). *Bonn. Zool. Monogr.* No. 20:1–90.
- , AND ———. 2000. Old World Vipers – Natural History/Natural Future. Presentation given at the Biology of Vipers conference in Sweden, May 2000.

LETTERS TO THE EDITOR

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Aspidoscelis Versus *Cnemidophorus* as a Genus of Whiptail Lizards in North America

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A recent announcement of Publications Received [Anonymous, 2004. *Herpetol. Rev.* 35:205] mentioned that Axtell (2003) "... retains usage of *Cnemidophorus sensu lato*, treating *Aspidoscelis* as a subgenus (by extension, *Ameiva* and *Kentropyx* are also regarded as subgenera)..." This raised the questions of what evidence Axtell used and what generic name(s) he intended to use for the subgenera *Ameiva* and *Kentropyx*. We obtained a copy of Axtell (2003) from the author and here we review this matter further.

Axtell (2003:1) reviews aspects of the biology of "*Cnemidophorus (Aspidoscelis) exsanguis* Lowe" in Texas, with emphasis on distribution. He presents no new evidence bearing on the question of which generic name is appropriate for this taxon, or other species of North American whiptail lizards, nor does he present evidence contradictory to the conclusions of Reeder et al. (2002). Instead, he rebuffs these conclusions with the following two sentences: "In this account I have treated *Aspidoscelis* as a subgenus of *Cnemidophorus*, rather than changing that name with its over 200 year nomenclatural history. With this action, I realize that both *Ameiva* and *Kentropyx* would also be reduced to subgeneric rank, but with the molecular data indicating paraphyly among these two groups (Reeder et al. 2002), this may [be] the best option until more is known" (Axtell 2003:9). This is not only a rejection of certain well-supported conclusions of Reeder et al. (2002) in the absence of new data, but it is also a misunderstanding of their comments. In addition, Axtell does not explicitly indicate what generic name he would apply to the subgenera *Ameiva* and *Kentropyx* that he mentions. His writing implicitly suggests that these taxa would represent additional subgenera of *Cnemidophorus*. While this alternate strategy is generally consistent with the phylogeny, such a taxonomic decision would violate Article 23 (principle of priority) of the International Code of Zoological Nomenclature (1999). We write to clarify the situation and restate our conclusion that *Aspidoscelis* is the most appropriate generic name for the North American whiptail lizards.

Reeder et al. (2002) presented an extensive phylogenetic analysis of 39 taxa of teiine macroteiid lizards (representing "*Ameiva*," "*Cnemidophorus*," *Dicrodon*, *Kentropyx*, and *Teius*), using several teiid and non-teiid outgroups. Phylogenetic trees were generated on the basis of combined mitochondrial DNA sequence data,

allozyme data, and morphology, then compared *a posteriori* with karyotypic data for consistency. While various parts of the phylogenies generated had differing levels of support indicating that more research is needed to resolve the relationships among teiines, one aspect of the analyses was clear: the genera *Ameiva* and *Cnemidophorus sensu lato* are paraphyletic.

The South American species in the *Cnemidophorus lemniscatus sensu stricto* species group, containing the type species of the genus, were strongly supported as a clade, with this group being more closely related to *Kentropyx* and most species of *Ameiva* than to the whiptail lizards of North America (Reeder et al. 2002). However, all of the North American species analyzed in the *deppii*, *tigris*, and *sexlineatus* species groups of *Cnemidophorus sensu lato* (and by extension the *cozumela* and *tesselata* species groups) comprised a strongly supported monophyletic group that appears to be distantly related to most of the Neotropical taxa (Reeder et al. 2002).

This left Reeder et al. (2002) with various options to consider with respect to taxonomic changes: (1) suggest no changes in taxonomy, and therefore not even recognize the strongly supported North American clade as a distinct lineage; (2) recognize as a genus the strongly supported clade, but, for stability, make no other changes until the phylogenetic history of the other groups is clarified by future research; or (3) address the widespread paraphyly by combining all species of *Ameiva*, *Cnemidophorus*, and *Kentropyx* into one genus, perhaps applying subgenera in an attempt to preserve some taxonomic stability within this complex and large clade, but in which case, the oldest name would be the generic name *Ameiva* Meyer 1795. Given the strong support for the clade of North American taxa and the remaining levels of uncertainty requiring more research, we chose the second alternative as being a conservative way to apply nomenclature. Placing all species of *Kentropyx* and *Cnemidophorus* into the genus *Ameiva* would be a provisional resolution at best and would obscure the phylogenetic history already retrieved, as would suggesting no taxonomic changes.

Reeder et al. (2002) did not enjoy changing long established names; we prefer nomenclatural stability but require that it be consistent with phylogeny. We made one change of a generic name, thereby adopting the most conservative approach that is consistent with the evidence and based on a philosophy of phylogenetic systematics. This is the same reasoning used in recognizing that snakes and lizards are members of Squamata, although many decades ago this required shifting Serpentes out of Vermes. Change often is the cost of advancing knowledge. The use of *Aspidoscelis* Fitzinger 1843 as the genus for the North American whiptails was not a matter of personal choice. Following Article 23 of the International Code of Zoological Nomenclature (1999), Reeder et al. (2002) used the oldest name available within the synonymy of *Cnemidophorus*.

We note that Axtell (2003) has apparently adopted a nomenclatural approach akin to our option 3 above. Though not explicit, it appears that Axtell (2003) is advocating recognition of several subgenera within an expanded genus *Cnemidophorus*. He explicitly places *Aspidoscelis* as a subgenus of the genus *Cnemidophorus* and implies that *Ameiva* and *Kentropyx* would also be subgenera of *Cnemidophorus*. Axtell does not mention the South American taxa of the *Cnemidophorus lemniscatus* species group (*sensu lato*),

but his recognition of *Aspidoscelis* as a subgenus implies that he would treat the taxa of the *C. lemniscatus* species group as members of a subgenus *Cnemidophorus*. If this is what Axtell is recommending, we note that this would be in violation of Article 23 of the International Code of Zoological Nomenclature (1999), as *Ameiva* would have priority over *Cnemidophorus* as the generic name.

If we have inaccurately assumed Axtell's (2003) intended new subgeneric classification mentioned above, then there are only two other options he might be advocating. The first would be for *Ameiva* and *Kentropyx* to be subgenera within either an expanded genus *Ameiva* (oldest available name) or an expanded genus *Kentropyx*. In both cases, phylogenetic principles would be violated as the species of the subgenus *Kentropyx* (whether considered to be in the genus *Ameiva* or *Kentropyx*) are more closely related to members of the genus *Cnemidophorus* (members of the *C. lemniscatus* species group *sensu stricto* of South America) than to species of *Ameiva*. Alternatively, Axtell (2003) could be recommending the recognition of *Ameiva* and *Kentropyx* as separate genera, each with a single nominate subgenus. If so, not only would this complicate the nomenclatural situation with the erection of redundant taxa (i.e., subgeneric content being equivalent to generic content), but also it would do nothing to correct the paraphyletic nature of *Cnemidophorus sensu lato*.

In Reeder et al. (2002) nomenclatural stability was best served by avoiding additional generic changes (beyond resurrecting *Aspidoscelis*) until future evidence is brought to bear on other parts of the phylogeny, by not lumping all of the taxa into *Ameiva* while awaiting that evidence, and by not erecting formal subgeneric taxa that would be temporary. Stability is not served if the results of Reeder et al. (2002) are rejected or modified without bringing new data or analyses to bear on these issues. New data, however, have been collected recently. With much more mtDNA sequence data (i.e., 2609 bp vs. 876 in Reeder et al. [2002]) and several additional Neotropical teiine taxa (including the type species of *Cnemidophorus*, *C. murinus*), new analyses and results provide additional strong support for the recognition of the North American clade of *Aspidoscelis* (Reeder, Bell, and Cole, unpubl. data). In conclusion, we encourage use of the genus *Aspidoscelis* for North American whiptail lizards as specified by Reeder et al. (2002) and, until further evidence or analyses are brought to bear on this issue, we reject Axtell's (2003) unjustified allocation of *Aspidoscelis* as a subgenus of *Cnemidophorus sensu lato*.

LITERATURE CITED

AXTELL, R. W. 2003. *Cnemidophorus (Aspidoscelis) exsanguis* Lowe. Interpretive Atlas of Texas Lizards 28:1–10 + map 15. Series privately published since 1986 and available from the author.

INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE. 1999. International Code of Zoological Nomenclature, 4th Ed. The International Trust for Zoological Nomenclature c/o The Natural History Museum, London.

REEDER, T. W., C. J. COLE, AND H. C. DESSAUER. 2002. Phylogenetic relationships of whiptail lizards of the genus *Cnemidophorus* (Squamata: Teiidae): A test of monophyly, reevaluation of karyotypic evolution, and review of hybrid origins. *Amer. Mus. Novitates* 3365:1–61.

ARTICLES

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Egg Attendance by Female Frogs in Two Species
of *Eleutherodactylus* from Costa Rica

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Eleutherodactylus crassidigitus and *E. fitzingeri* are common inhabitants of the forest floor of humid lowland and premontane forests from Costa Rica through Colombia, occurring from sea level to 1500 m in elevation (Savage 2002). Although relatively common, little information is available on the reproductive biology of these species. Both species, as well as most members of the genus, lay encapsulated eggs out of water and undergo direct development within the egg bypassing the larval stage and hatching out as miniature adults (Savage 1975). The secretive nature of these and many other species of *Eleutherodactylus* makes collection of detailed ecological observations haphazard and fortuitous at best.

In the only report of egg attendance in *E. crassidigitus*, Taylor (1952) reported finding an adult and 26 eggs under a rock. There are two reports of egg attendance in *E. fitzingeri*. Dunn (1931) found 44 eggs attended by an adult frog, which he identified as a male, but based on size alone, 51 mm snout to vent (SVL), Lynch and Myers (1983) suggested it was a female. Mendoza Quijano et al. (2002) reported a female *E. fitzingeri* attending 85 eggs in a small cavity on the ground. These three observations suggest that *E. crassidigitus* and *E. fitzingeri* may provide parental care to their eggs (Townsend 1996). Egg attendance occurs in at least 48 of the more than 525 species of *Eleutherodactylus* and of these, 24 species exhibit female attendance of eggs (Crump 1996, Townsend 1996). Herein I describe female clutch attendance for *E. crassidigitus* and *E. fitzingeri* with notes on egg deposition sites, clutch size and hatchlings.

I made observations along the south central Pacific coast of Costa Rica at the following localities: Hacienda Baru National Wildlife Refuge, Dominical, Puntarenas (09°16'00"N, 83°52'20"W, 10 m

TABLE 1. Summary of attending female snout–vent length (SVL) and eggs per clutch of *Eleutherodactylus crassidigitus*. Means reported as $\bar{x} \pm 1$ SD.

Date	Female SVL (mm)	Eggs Per Clutch
14 May 2000	39	36
3 June 2000	39	25
28 May 2001	41	42
13 June 2001	43	47
3 July 2001	45	45
	$\bar{x} = 41.4 \pm 2.6$	$\bar{x} = 39.0 \pm 8.8$

elev.); Finca Los Arboles, Tres Piedras, Puntarenas (09°19'30"N, 83°52'0"W, 95 m elev.); and Quebrada Grande, Palmar Norte (08°57'95"N, 83°26'60"W, 90 m elev.). This area is tropical moist forest and receives 2500–4000 mm of rainfall annually, and experiences a dry season from late December through April (Campbell 1999).

During a 26-month period from 19 December 1999 through 15 May 2002, I encountered 11 female *E. fitzingeri* attending clutches and five *E. crassidigitus* attending clutches during quadrat and transect sampling. I measured SVL with a 15 cm plastic ruler and egg diameter with dial vernier calipers. I found all 16 clutches under leaf litter. After I removed and counted eggs I replaced them and attending female within 5 cm of the eggs and replaced the leaf litter on top of both. In two additional cases I obtained egg counts by dissection of gravid *E. fitzingeri*. The eggs of both species were non-pigmented, spherical with yellowish yolk, and were clustered in a grape bunch although not connected by a jelly or foam matrix.

I found 5 female *E. crassidigitus* attending clutches in the months of May (N = 2), June (N = 2), and July (N = 1). In all cases the attending frog was sitting on top of the clutch and were covered by leaf litter. One adult female and a clutch were collected and deposited in the collection of the University of Costa Rica (UCR 14759).

Oviposition sites were associated with shady microhabitats within the forest floor. I found three clutches near the buttresses of large trees: two clutches were found in vertical crevices inside the buttresses of *Brosimum utile*, and one clutch was under deep leaf litter near the root mass of a *Ceiba pentandra*. I discovered a fourth clutch in the crack of a large boulder and a fifth in the deep leaf litter of *Scheelea rostrata* fronds. I found 11 female *E. fitzingeri* attending clutches in the months of January, February, April, June, and September (Table 2). I collected one attendant female and two gravid females and deposited them at UCR (UCR 14714, 16031, 16033).

I recorded seven clutches in primary forest and four clutches along streambeds. All were under leaf litter in deep shade, and nine clutches abutted roots, logs, buttress or boulders. All nests were circular inside a depression in the soil with the eggs flush with the surface of the ground. A small, raised, ridge of soil and debris surrounded the edge of each nest. It appeared that females created or modified these basins by clearing them out of all debris. When a female was brooding, her body completely covered the entire clutch. These females became rigid and flattened when disturbed and remained in this position when handled.

From 9 to 18 February 2002 I marked and monitored one attending female twice daily, once in the morning and once at night, for 10 days. During the day the attending female was always sitting on the eggs. The female attended the clutch everyday, and 8 out of 10 nights, until she disappeared. The eggs were not ready to hatch, and I estimated them to be at approximately stage 9 of development based on tail movements (Townsend and Stewart 1985).

Females attended eggs until they hatched. On three occasions I found females attending nests in the process of hatching. Hatchlings were found hopping on and under the leaf litter. The nests contained the remnant egg capsules. From 1 to 4 June 2001 I monitored a nest of new hatchlings dispersing from the nest. A female frog remained next to the clutch for three days until all hatchlings had dispersed. I observed a similar behavior on two other occasions. Hatchlings of *E. fitzingeri* had a visible yellow yolk sac and a mean SVL of 7.2 ± 0.74 mm (N = 36).

The average clutch size of *E. fitzingeri* was 62.1 ± 18.7 eggs with a range of 24 to 81 (N = 8, Table 2). A positive correlation exists between clutch size and female SVL ($r^2 = 0.54$, $df = 7$, $N = 8$) as has been reported in other *Eleutherodactylus* species (Wake 1978). I dissected two gravid females and counted 84 and 92 eggs, respectively. I excluded these from the analysis because it is unknown whether this species deposits multiple clutches. Egg diameter ranged from 2.80 mm to 5.71 mm for 99 eggs measured of four clutches (Table 2).

TABLE 2. Summary of clutch characteristics of *Eleutherodactylus fitzingeri*. Means reported as $\bar{x} \pm 1$ STD; all measurements are in millimeters.

Date	Female SVL	# Eggs per clutch	# Eggs Measured	Mean Egg Diameter	Nest Dimensions (L x W x H)	# Hatchlings Measured	Mean Hatchling Size	Locality
3 Apr 2000	55	71						Dominical
17 Apr 2000	41	24						Dominical
15 Jun 2000	43	45	9	4.97 ± 0.19	58 x 62 x 18			Dominical
22 Jun 2000	44	69						Dominical
22 Apr 2001	46	62			64 x 70 x 24			Tres Piedras
22 Apr 2001	45	71	72	5.42 ± 0.23	60 x 72 x 23			Tres Piedras
1 Jun 2001						16	7.1 ± 0.65	Tres Piedras
5 Sep 2001	51	74	74	3.10 ± 0.15	63 x 72 x 25			Tres Piedras
15 Sep 2001	57	81	9	3.27 ± 0.18				Palmar Norte
17 Jan 2002						11	7.0 ± 0.74	Tres Piedras
3 Feb 2002						9	7.0 ± 0.88	Tres Piedras
9 Feb 2002	57	84						Tres Piedras
9 Feb 2002	55	92						Tres Piedras
$\bar{x} = 49.4 \pm 6.2$		$\bar{x} = 67.3 \pm 19.8$						

Non-rattling Defensive Tail Display in the Dusky Pygmy Rattlesnake, *Sistrurus miliarius barbouri*: A Previously Undescribed Behavior

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Eggs attendance is the most common form of anuran parental care (Wells 1981) and can serve many functions including: protection against predators and pathogens, aeration of aquatic eggs, hydration of terrestrial eggs, prevention of developmental abnormalities, and to assist hatchlings as they emerge from the nest (Crump 1994). In the case of terrestrial breeding species the principle function of parental care includes hydration of eggs and protection from invertebrate predators (Townsend 1996), which may be the case in *E. crassidigitus* and *E. fitzingeri*. This paper confirms the anecdotal observations of Dunn (1931), Mendoza Quijano et al. (2002), and Taylor (1952), that females of these two species provide parental care to their clutches by egg attendance. 100% of the clutches I found had an attending female present indicating that clutch attendance is obligatory and not facultative.

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LITERATURE CITED

- CAMPBELL, J. A. 1999. Distribution patterns of amphibians in Middle America. In W. E. Duellman (ed.), *Patterns and Distribution of Amphibians: a Global Perspective*, pp. 111–210. Johns Hopkins University Press, Baltimore, Maryland.
- CRUMP, M. L. 1994. Parental care. In H. Heatwole (ed.), *Amphibian Biology*, Vol. II. pp. 518–568. Chipping Norton NSW, Australia.
- . 1996. Parental care among the Amphibia. *Adv. Stud. Behav.* 25:109–144.
- DUNN, E. R. 1931. The amphibians of Barro Colorado Island. *Occ. Pap. Boston Soc. Nat. Hist.* 5:403–421.
- LYNCH, J. D., and C. W. MYERS. 1983. Frogs of the *fitzingeri* group of *Eleutherodactylus* in eastern Panama and Chocóan South America (Leptodactylidae). *Bull. Am. Mus. Nat. Hist.* 15:481–572.
- MENDOZA QUIJANO, F., G. SANTOS-BARRERA, and J. PACHECO-RODRIGUEZ. 2002. *Eleutherodactylus fitzingeri*: clutch size and parental care. *Herpetol. Rev.* 33:125.
- SAVAGE, J. M. 1975. Systematics and distribution of the Mexican and Central American stream frogs related to *Eleutherodactylus rugulosus*. *Copeia* 1975:254–306.
- . 2002. The Amphibians and Reptiles of Costa Rica: a Herpetofauna Between Two Continents, Between Two Seas. University of Chicago Press, Chicago, Illinois.
- TAYLOR, E. H. 1952. A review of the frogs and toads of Costa Rica. *Univ. Kansas Sci. Bull.* 35:577–923.
- TOWNSEND, D. S. 1996. Patterns of parental care in frogs of the genus *Eleutherodactylus*. In R. Powell and R. W. Henderson (eds.), *Contributions to West Indian Herpetology: a Tribute to Albert Schwartz*, pp. 229–239. Society for the Study of Amphibian and Reptiles, Ithaca New York.
- , and M. M. STEWART. 1985. Direct development in *Eleutherodactylus coqui* (Anura: Leptodactylidae): a staging table. *Copeia* 1985:423–436.
- WAKE, M. H. 1978. The reproductive biology of *Eleutherodactylus jasperi* (Amphibia, Anura, Leptodactylidae), with comments on the evolution of live-bearing systems. *J. Herpetol.* 12:121–133.
- WELLS, K. D. 1981. Parental behavior of male and female frogs. In R. D. Alexander and D. W. Tinkle (eds.), *Natural Selection and Social Behavior*, pp. 184–197 Chiron Press, New York.

Defensive tail displays are often exhibited by snakes with bright and/or blunt tails in response to a stressor or a tactile stimulus and depending on the species, these displays can vary in speed, duration, frequency and proportion of tail length used (Greene 1973). Tail displays also make the tail visually obvious to a potential predator and may provide survival value to a snake by intimidating the predator, diverting the predator's attack away from the head and toward the tail, or distracting the predator and thus allowing the snake to strike or escape (Greene 1973). While rattling in rattlesnakes is a well-known defensive tail display used in potentially dangerous situations, non-rattling defensive tail displays might also function either as warning, distraction, or disorientation mechanism as they do in non-rattlesnakes (Greene 1973, 1988, 1992, 1997; Klauber 1972). As part of a larger repertoire of defensive behaviors, non-rattling tail displays might be particularly useful for rattlesnakes with inaudible or barely audible rattle chains or for those rattlesnakes possessing an insufficient number of rattle segments to produce a rattling sound. Here, we document a non-rattling defensive tail display for the first time in the Dusky Pygmy Rattlesnake, *Sistrurus miliarius barbouri*.

Sistrurus miliarius barbouri is a small rattlesnake species, seldom exceeding 55 cm, that has a bright yellow tail as a juvenile and a disproportionately small rattle compared to other rattlesnake species. Rowe et al. (2002) reported high rates of rattle loss in this species, with approximately one-half of all snakes examined possessing fewer than two interlocking segments. Because at least two interlocking segments are needed to produce a rattling sound, approximately one-half of all Pygmy Rattlesnakes are incapable of producing a rattling sound (Rowe et al. 2002). In field observations associated with another study, we noticed that in addition to rattling, this snake undulates its tail when captured. The entire tail is swayed back and forth in large arcs, while the distal half of the tail is wiggled in smaller sinusoidal movements. Both motions occur at a faster speed than those observed when this species caudal lures, and are often interrupted by brief periods of rattling that last approximately one second. Based on these observations and the bright and often rattleless tail of *S. m. barbouri*, we hypothesized that these undulatory (not vibratory) tail movements are a defensive tail display that is part of the typical defensive repertoire in *S. miliarius*. Based on this hypothesis and Greene's (1973) observations, we made two predictions about what we might ex-

pect to see in more detailed field observations of this species. First, if this tail display is a defensive behavior, then it should be used in response to tactile stimuli from a potential predator, as in other species observed by Greene (1973). Second, if tail movements function as a mechanism that compensates for missing rattle segments, then we predicted that *S. miliarius* with fewer than two rattle segments (and thus inaudible rattles) would display tail movements more often than do snakes with longer rattle chains.

Materials and Methods.—To test our hypothesis, we made observations on snakes from Rock Springs Run State Reserve in Lake County, Florida (USA), between June and November of both 2001 and 2002. We located adult (≥ 2 yrs) and juvenile (1–2 yrs) snakes by visual survey and noted if the snake rattled or undulated its tail upon approach and for up to two minutes following capture by gloved hands. We also recorded the duration of tail undulations. We determined age using measures of snout–vent length, tail length, and mass reported for this species by Bishop et al. (1996). We used a two-tailed Fisher’s exact test and a Mann–Whitney *U* test to analyze frequency and duration data, respectively.

Results and Discussion.—We never observed a non-rattling tail display before capture in our study population. Non-rattling tail movements were exhibited only after capture and moreover, they were used in equal frequency to rattling ($\chi^2 = 0.21$, *df* = 1, *P* = 0.65, *N* = 39). The frequency and duration of tail movements were not significantly correlated with number of rattle segments ($\chi^2 = 0.003$, *df* = 1, *P* = 0.96; *U* = 19.6, *P* = 0.74), age ($\chi^2 = 2.92$, *df* = 1, *P* = 0.09; *U* = 16.1, *P* = 0.08) or sex ($\chi^2 = 0.56$, *df* = 1, *P* = 0.45; *U* = 15.5, *P* = 0.47). Median and mean durations of tail display are reported in Table 1.

Crypsis is often the first line of defense for rattlesnakes, with other behaviors exhibited as graded responses to escalating threat (Duvall et al. 1985). Non-rattling defensive tail display occurred in equal frequency to and concomitantly with rattling in this species. This indicates that tail display is part of a larger defensive repertoire typical of this species and because this behavior was only exhibited after tactile stimulation, is probably only used at higher levels of threat and defensive escalation. Greene (1973) suggested that tail displays may provide survival value to the snake by distracting the predator and allowing the snake to strike. In this study, pygmy rattlesnakes often struck while displaying and this observation further supports the hypothesis that this behavior is defensive in nature.

We predicted that *S. miliarius* with fewer than two rattle segments would display tail movements more often than do snakes with longer rattle chains. However, our data did not support this prediction and suggests that tail display might not be used to compensate for inaudible rattles in this species. However, even when adjusted for their small body size, the rattling of *S. miliarius* with two or more rattle segments is much quieter and higher pitched than in other pitvipers (Cook et al. 1994). If the rattle is an ineffective warning device, regardless of chain length, then all Pygmy Rattlesnakes might be expected to exhibit non-rattling tail dis-

TABLE 1. Comparison-wise summary of median time (minutes \pm 1 standard deviation) and mean time (minutes \pm 1 standard error) spent by *Sistrurus miliarius barbouri* displaying tail movements. Observations were made for up to two minutes following capture.

Comparison	N	Median \pm 1 SD	Mean \pm 1 SE
Snakes with < 2 rattle segments	11	0.5 \pm 1.01	0.95 \pm 0.30
Snakes with > 2 rattle segments	28	0.23 \pm 0.92	0.81 \pm 0.17
Adults	23	1.5 \pm 0.96	1.10 \pm 0.2
Juveniles	16	0.00 \pm 0.80	0.47 \pm 0.20
Females	22	0.71 \pm 0.96	0.95 \pm 0.21
Males	17	0.00 \pm 0.92	0.72 \pm 0.22

plays, as was observed in this study. Alternatively, this defensive tail display might reflect an ancestral trait that also occurs in other vipers, or it simply might be a behavioral atavism. Comprehensive and detailed tests covering a range of controlled stimuli and several lineages of snakes are needed to resolve these possibilities. Klauber (1972) suggested that adults often exhibit defensive behaviors more frequently than juveniles and although not statistically significant in this study, there was a trend for adults to exhibit defensive tail displays more often and for longer durations than juveniles. Although the origin and exact role of this tail display remain unclear, its use by *S. m. barbouri* in a defensive context is supported by our observations.

Defensive tail displays were observed in both adult and juvenile snakes but only juveniles exhibit a bright yellow tail color. This suggests that the bright tail color of juvenile *S. m. barbouri* may not contribute to the effectiveness of tail movements as a distraction or disorientation mechanism. Alternatively, this bright color probably enhances the optical attractiveness of the tail when used as a caudal lure (Neill 1960). Caudal luring differs from this defensive tail display in that luring is exhibited exclusively in the presence of prey, is slower in speed of undulations, uses less length of the tail and is affected by age and sex (Rabatsky 2002; Rabatsky and Waterman 2005).

Eryx johnii and *Tropidophis pardalis* are the only two other species thought to use the tail both as a defensive tail display and caudal lure (Greene 1973). Based on our observations of *S. miliarius* in the wild, this snake may be a third species that uses the tail for both behaviors. Although the specific benefits of this defensive tail display are still unclear, having a behavioral repertoire that includes multiple defense mechanisms might enable *S. miliarius* to respond more effectively to a wider variety of potentially dangerous situations, especially considering that the rattle of this species is incapable of sound production or just barely audible in most individuals.

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LITERATURE CITED

- BISHOP, L. A., T. M. FARRELL, AND P. G. MAY. 1996. Sexual dimorphism in a Florida population of the rattlesnake, *Sistrurus miliarius*. *Herpetologica* 52:360–364.
- COOK, P. M., M. P. ROWE, AND R. W. VAN DEVENDER. 1994. Allometric scaling and interspecific differences in the rattling sounds of rattlesnakes. *Herpetologica* 50:358–368.
- DUVALL, D., M. B. KING, AND K. J. GUTZWILLER. 1985. Behavioral ecology and ethology of the prairie rattlesnake. *Nat. Geogr. Res.* 1:80–111.
- GREENE, H. W. 1973. Defensive tail display by snakes and amphisbaenians. *J. Herpetol.* 7:143–161.
- . 1988. Antipredator mechanisms in reptiles. In C. Gans and R. B. Huey (eds.), *Biology of the Reptilia*. Vol. 16, pp. 1–152. Alan R. Liss, New York.
- . 1992. The ecological and behavioral context for pit viper evolution. In J. A. Campbell and E. D. Brodie, Jr. (eds.), *Biology of the Pitvipers*, pp. 107–118. Selva Press, Texas.
- . 1997. *Snakes: The Evolution of Mystery in Nature*. University of California Press, Berkeley, California.
- KLAUBER, L. M. 1972. *Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind*. 2nd edition. University of California Press, Berkeley, California.
- NEILL, W. T. 1960. The caudal lure of various juvenile snakes. *Quart. J. Florida Acad. Sci.* 23:173–200.
- RABATSKY, A. M. 2002. Caudal luring and defensive tail display in the dusky pigmy rattlesnake, *Sistrurus miliarius barbouri*. M.S. Thesis, University of Central Florida, Orlando. 34 pp.
- , AND J. M. WATERMAN. 2005. Ontogenetic shifts and sex differences in caudal luring in the dusky pigmy rattlesnake, *Sistrurus miliarius barbouri*. *Herpetologica* 61:87–91.
- ROWE, M. P., T. M. FARRELL, AND P. G. MAY. 2002. Rattle loss in pigmy rattlesnakes (*Sistrurus miliarius*): Causes, consequences, and implications for rattle function and evolution. In G. W. Schuett, M. Hoggren, M. E. Douglas, and H. W. Greene (eds.), *Biology of the Vipers*, pp. 385–404. Eagle Mountain Publishing, Utah.



Agkistrodon contortrix (Copperhead). USA: Virginia: Greene County. Photographic illustration by Will Brown (www.blueridgebiological.com).

Diet Composition and Microhabitat of *Eleutherodactylus johnstonei* in an Introduced Population at Bucaramanga City, Colombia

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Eleutherodactylus johnstonei Barbour 1914 is an endemic species of many islands of the Lesser Antilles (Frost 1985). It is widely distributed in the Eastern Caribbean (Kaiser and Hardy 1994) and in northern South America (Frost 1985; Kaiser et al. 2002; Ovaska 1991) where it is associated with urban areas. It has been introduced by natural phenomena and by human activity (Kaiser et al. 2002). In Colombia it has been reported in the cities of Barranquilla (Acosta - Galvis 2000; Ruiz-C. et al. 1996), Cali (F. Castro in Kaiser et al. 2002), and Bucaramanga (Ortega et al. 2002).

Diet and microhabitat use of *E. johnstonei* have been studied only in a population of Barbados (Ovaska 1991), where the species is probably indigenous (Marsh 1983). For this population the most abundant prey found was Formicidae, followed by collembolans, dipterans, and homopterans, among others. The individuals of this population use bromeliads, trunks, leaf litter, and small rocks as diurnal refuges, and during the night they are active across the arboreal stratum. In recently colonized areas, these ecological data have not been recorded although such information could contribute to an understanding of why this species is a successful invader. Here, we report on diet composition and microhabitat use in an introduced population of *Eleutherodactylus johnstonei* and compare these data with those from native populations.

Materials and Methods.—The studied population is located in the house gardens of Bucaramanga (Santander, Colombia; 07°07' 28.7"N and 73°06'41.6"W, 1040 m altitude). The area has a nearly constant bimodal regime of rains and a mean temperature of 24°C during the year. The vegetation in the gardens is characterized by a variety of ornamental plants. Individual frogs were collected in gardens in leaf litter and on bushes between 2000 and 2200 h. Additional searches were made in forests bordering the study site, to determine presence adjacent to gardens and whether there has been displacement of native frogs by the introduction of *E. johnstonei*. Initially, we collected 30 frogs and made an analysis of minimum sample size using a saturation curve of consumed prey. We monthly collect 17–20 individuals (May of 2001 through

April of 2002) following the suggestions of this previous analysis. We collected frogs larger than 15 mm snout–vent length (SVL) to facilitate handling in the laboratory. Following the suggestions of Heyer et al. (1994), we recorded SVL, mouth width (MW), substrate type (soil, leaf litter, leaves, trunks, rocks, and grass) and perch height. Individuals were euthanized and fixed in 10% formalin to interrupt the digestive processes and prey decomposition. Specimens were deposited in the Herpetological Collection of the Museo de Historia Natural, Universidad Industrial de Santander (UIS-A).

Leaf litter arthropods were collected with an insect net and Berlesse funnel at the study location. They were preserved in 70% ethanol and were used as reference samples for comparisons and determination of the stomach contents of the collected frogs. Digestive tracts of each individual were removed and their contents preserved in 70% ethanol. Taxonomic determinations of prey were made using the keys of Borror et al. (1989). Fragments that showed identification problems were compared with preserved samples of arthropods. Number and percentage of prey per stomach was recorded. An index of relative importance was calculated to evaluate the contribution of each category to this population's diet (following Pinkas et al. 1971). We tested correlations between frog

SVL and MW and the size and volume (using the ovoid spheroid formula, Caldwell and Vitt 1999) of the ingested prey to see if prey size depends on frog corporal size or mouth size. Chi-square tests were used to investigate whether significant statistical differences existed in the use of the microhabitat and perch height.

Results and Discussion.—We dissected 212 stomachs (140 males and 72 females), revealing 1448 prey items identified to order, and grouped into 22 categories excepting members of Formicidae. Diet was composed of insects and other arthropods such as spiders and isopods (Crustacea), and other prey as gastropods and oligochaetes (Table 1). Although there was some plant material in the diet, these were not included because only two of the 212 dissected stomachs contained these items.

Traditionally it has been thought that anurans have a generalist diet, which reflects the richness and size of the resource (Duellman and Trueb 1986). Our results suggest that *E. johnstonei* is a carnivorous generalist species as determined by the presence of a variety of prey items such as homopterans, orthopterans, thysanopterans, dermapterans, gastropods, formicids, collembolans, and isopods. A generalist diet is likely one of the characteristics (but not the only one) that makes this frog an excellent colonizer.

TABLE 1. Diet composition of males and females of an introduced population of *Eleutherodactylus johnstonei*. Numerical importance (number of prey item in relation to total number of items found in the species), frequency (percentage of prey item number in relation to total number of items found in the species), prey volume (total volume of prey category in all individuals examined), and percentage of relative importance [IRI = % FO (%V + %N), FO, percentage of stomachs containing an specific item, V volumetric importance, and N, numerical importance].

Prey	Numerical Importance		Frequency		Prey volume		% IRI	
	Males	Females	Males	Females	Males	Females	Males	Females
Formicidae	435	260	96	64	248.31	169.13	5780.6	4309.1
Diptera	120	135	58	45	82.73	108.48	1026.9	1657.
Collembola	84	35	24	14	5.34	6.34	200.3	106
Homoptera	16	18	14	14	76.87	41.15	84.7	103
Hymenoptera	13	10	9	9	82.9	12.34	68.3	28.1
Heteroptera	2	7	1	7	2.61	93.54	0.4	69.4
Orthoptera	1	2	1	2	0	3.19	0.1	1.4
Dermaptera	6	3	6	2	16.17	5	10.9	2.1
Nymphs	8	4	5	3	11.57	11.2	8.2	5.4
Caterpillar	22	17	8	7	62.75	462.43	55.2	318.6
Gastropoda-1	10	9	9	6	48.91	83.44	42.3	56.3
Scolopendra	2	2	2	2	1.6	0	0.6	0.8
Larvas	8	7	7	6	15.7	26.35	13.7	22.8
Coleoptera	13	20	10	14	122.97	69.6	106.8	144.5
Gastropoda-2	0	1	0	1	0	48.7	0	4.6
Acari	20	11	14	9	1.75	1.05	28.3	20.6
Blattaria	9	3	5	3	115.48	38.26	48.6	1.2
Isopoda	23	15	11	10	85.69	59.37	96.3	84
Thysanoptera	13	0	2	0	4.34	0	3.1	0
Pseudoscorpion	2	0	2	0	1.46	0	2.6	0
Oligochaete	2	0	2	0	14.03	0	2.5	0
Araneae	11	10	11	9	6.26	6.54	25.2	23.3
TOTAL	820	569	129	88	1007.4	1246.12	7605.6	6958.7

The 22 taxonomic prey categories contribute to the individual's development according to the index of relative importance (IRI). The most important category was Formicidae (54.24%) followed by dipterans (47.16%) and collembolans (19.33%), whereas the categories with a low IRI possibly reflect opportunistic ingestions related to the abundance of these resources in the study place. In other *E. johnstonei* populations, ants were the most important prey (51.4% in Barbados; Ovaska 1991), and in Jamaica, Stewart (1979) reported two introduced species (*E. johnstonei* and *E. planirostris*) and two native species (*E. gossei* and *E. cundalli*) whose main food source was Formicidae. Also, in *E. coqui*, Lavigne and Drewry (1971) found that ants were the most consumed prey, and Duellman (1978) found that for 9 of 15 species of *Eleutherodactylus*, ants were the most consumed prey. The high percentage of ants in the diet might suggest a high availability of this resource in the sampling places not measured by any of these investigators (nor us), or that these species specialize upon ants.

However, other species of *Eleutherodactylus* are not consumers of ants. Arroyo (2002) reported collembolans and coleopterans as the most important prey for an *Eleutherodactylus* assemblage in a cloud forest of the Cordillera Oriental of the Colombian Andes. Gutierrez (2003) reported, for another assemblage of cloud forest *Eleutherodactylus*, that the most common prey items were isopods and coleopterans, in an area south of the location studied by Arroyo (2002). Ants were items that frogs consumed only occasionally in both studies; in fact, ants are typically rare at higher elevations including cloud forests. Thus, prey availability might explain the differences in diet among *Eleutherodactylus* species. Duellman and Trueb (1986) suggest external factors (seasonal abundance of the food and competitors' presence or absence) and intrinsic factors (ecological and morphological tolerances) relating to body size with the election and type of prey consumed, and with use of microhabitats for foraging.

Prey composition of each sex was not significantly different ($Z_{(139,71)} = -0.776212$; $P = 0.4376$). There was also no significant differences among sexes in the numeric importance ($U_{(1,21)} = 209.500$; $P = 0.445$), frequency in the stomachs ($U_{(1,21)} = 221$; $P = 0.622$), volume of the ingested prey ($U_{(1,21)} = 236$; $P = 0.88$) and the relative importance index ($U_{(1,21)} = 226.5$; $P = 0.91$, Table 1).

The adult population of *E. johnstonei* showed a positive relationship between SVL and MW and the size and volume of the consumed prey. There was a significant correlation between SVL and prey size ($r = 0.1983$; $P = 0.0036$; $N = 212$) and prey volume ($r = 0.148$; $P = 0.0308$; $N = 212$). Similarly, there was a significant correlation between MW and prey size ($r = 0.1689$; $P = 0.0135$; $N = 212$) and MW and prey volume ($r = 0.1974$; $P = 0.0038$; $N = 212$) indicating that larger frogs and bigger mouths ingest larger prey. These relationships were also reported in a native population of *E. johnstonei* in Barbados (Ovaska 1991), in *E. coqui* (Woolbright and Stewart 1987), in six sympatric species of anurans the central Amazonian (Lima 1998), and in a subtropical community of anurans (Basso 1990) showing that changes in size and prey types with the sizes of frogs are expected by morphological reasons and for changes in the spectrum of types of prey that can be ingested (Lima and Magnusson 2000). The positive relationship between MW and the size and volume of the prey constitutes an important element supporting the ideas Toft (1980, 1981) that the width of the mouth limits the size of the prey captured by

certain species.

Eleutherodactylus johnstonei used vegetation associated with the herbaceous substrate (families Araceae, Bromeliaceae, Commelinaceae, and Poaceae) as places for calling and perching. Trees taller than 2 m (families Combretaceae and Rutaceae) provided protection against solar radiation/drying and maintained soil moisture. The analysis of substrate use allowed us to establish significant differences for this resource (soil, leaf litter, leaves, trunks, rocks, and grass) intersexually ($\chi^2_{(0,05;5)} = 13.11$; $P > 0.01$) and intrasexually (males, $\chi^2_{(0,05;5)} = 48.3$; $P < 0.001$ and females $\chi^2_{(0,05;5)} = 32.86$; $P < 0.001$, Fig. 1).

Perch height used is also different between the sexes ($\chi^2_{(0,05;6)} = 16.79$; $P < 0.01$); males perch higher than females to call, and females prefer lower perches. Among males there were no significant differences in perch height ($\chi^2_{(0,05;6)} = 9.3$; $P > 0.10$), contrary to from females who showed significantly different perch heights ($\chi^2_{(0,05;5)} = 32.74$; $P < 0.001$) (Fig. 2).

Most of the males were collected calling on the bush substrate whereas females were collected close to the calling sites at lower perch heights. These intersexual differences are presumed to be related with reproductive behaviors: males use higher perches to call before amplexus, but when oviposition occurs they descend to the ground because males care for the eggs, changing their use of the vertical position. Females are more associated with the soil and leaf litter, presumably in relationship with their reproductive behavior and maybe to avoid capture by predators or disturbance. Similar results were obtained in *E. fitzingeri* (Höbel 1999) and in anurans of Anchicayá where the males are arboreal and the females are associated with the soil and leaf litter (Vargas and Castro 1999). Thus, the substrate and perch height used for by frogs may be more closely related to reproduction than with food availability, although these two activities are not completely separated.

At Bucaramanga, *E. johnstonei* is limited exclusively to the vegetation of the gardens. In the forest patches near to the gardens, we did not find *E. johnstonei* nor did we hear their song. In this

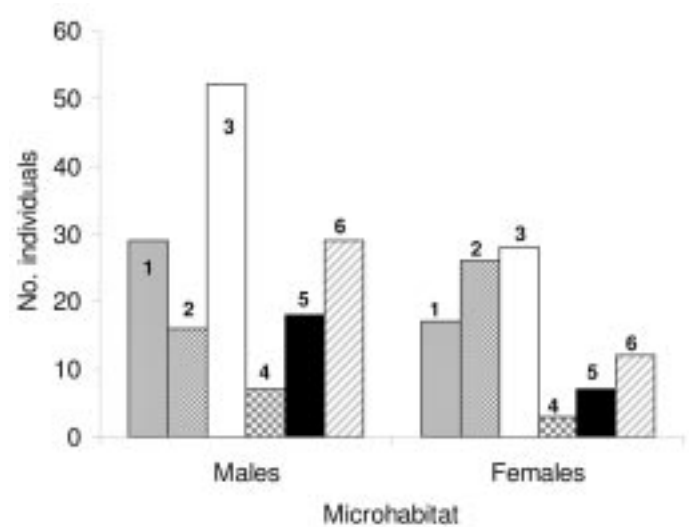


FIG. 1. Substrate used by *Eleutherodactylus johnstonei* (inter and intrasexes). 1) soil, 2) leaf litter, 3) leaves, 4) trunks, 5) rocks, 6) grass. Analysis of substrate use showed that there were significant differences for this resource intersexually and intrasexually.

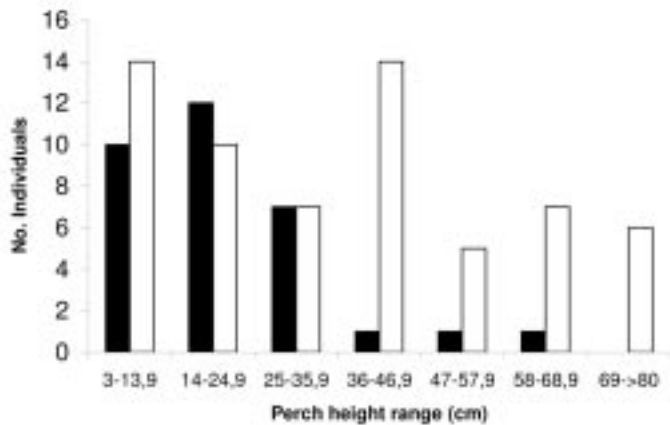


FIG. 2. Perch height used by both sexes of *Eleutherodactylus johnstonei*. Males, white blocks; females, black blocks. Intersexual differences in perch height ranges are presumed to be associated with reproductive behaviors: most males were found calling on leaves of bushes whereas egg-guarding males and females were found at lower perches in different substrates.

zone, we found native species (*E. raniformis* and *E. taeniatus*), which are absent from the gardens of the city. The adjacent vegetation of the neighborhood where the population of *E. johnstonei* is found corresponds to a highly disturbed tropical dry forest on the Andean slopes to the east of the city. Possibly this forest does not have the humidity and microhabitat features required for the survival of the species, similar to those permanently irrigated gardens, which can provide an ideal habitat for reproduction and other physiological aspects. Because native species are absent in the residential areas, *E. johnstonei* enjoys great success in these empty niches. Thus, at present, we have not been able to observe displacement of native species by the arrival of *E. johnstonei*. Although *E. johnstonei* is a generalist species in diet and microhabitat use allowing it to easily colonize new territories, these characteristics do not explain why this species is associated almost exclusively with houses gardens and not other neighboring disturbed areas at this locality.

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LITERATURE CITED

ACOSTA -GALVIS, A. 2000. Ranas, salamandras y caeciliias (Tetrapoda: Amphibia) de Colombia, Biota Colombiana 1:289–319.
 ARROYO, S. B. 2002. Microhábitat, dieta y horas de actividad en un ensamble de anuros del género *Eleutherodactylus* en la Cordillera Oriental. Undergraduate thesis. Escuela de Biología Universidad Industrial de Santander. 68 pp.
 BASSO, N. G. 1990. Estrategias adaptativas en una comunidad subtropical de anuros. Cuadernos de Herpetología. Serie Monográfica No. 1. Asociación Herpetológica Argentina. 70 pp.
 BORROR, D. J., C. A. TRIPLEHORN, AND N. F. JOHNSON. 1989. An Introduc-

tion to the Study of Insects. 6th ed. Harcourt Brace Jovanovich College Publishers, Fort Worth, Texas.
 CALDWELL, J. P., AND L. J. VITT. 1999. Dietary asymmetry in leaf litter frogs and lizards in a transitional rain forest. *Oikos* 84:383–397.
 DUELLMAN, W. E. 1978. The biology of an equatorial herpetofauna in Amazonian Ecuador. Misc. Publ. Mus. Nat. Hist. Univ. Kansas 65:1–352.
 ———, AND L. TRUEB. 1986. Biology of Amphibians. McGraw Hill, New York.
 FROST, D. 1985. Amphibians Species of the world. Association Systematic College. Lawrence, Kansas.
 GUTIERREZ, D. L. 2003. Composición, dieta, microhábitat y horas de actividad de los anuros presentes en dos tipos de bosque dentro del santuario de Fauna y Flora Guanentá, Alto Rio Fonce. Undergraduate thesis. Escuela de Biología. Universidad Industrial de Santander.
 HEYER, W. R., M. DONNELLY, R. MCDIARMID, L. HAYEK, AND M. FOSTER (EDS.). 1994. Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians. Smithsonian Institution Press, Washington D.C.
 HÖBEL, G. 1999. Notes on the natural history and habitat use of *Eleutherodactylus fitzingeri* (Anura: Leptodactylidae). *Amphibia-Reptilia* 20:65–72.
 KAISER, H., C. BARRIO-AMORÓS, J. D. TRUJILLO, AND J. D. LYNCH. 2002. Expansion of *Eleutherodactylus johnstonei* in northern South America: rapid dispersal through human interactions. *Herpetol. Rev.* 33:290–294.
 ———, AND D. HARDY, JR. 1994. *Eleutherodactylus johnstonei*. Cat. Am. Amph. Rept. 581:1–5.
 LAVIGNE, R. J., AND G. DREWRY. 1970. Feeding behavior of the frogs and lizards in the tropical wet forest—preliminary report. In R. G. Clements, G. E. Drewry, and R. J. Lavigne (eds.), The Rain Forest Project Annual Report 147, pp. 64–73. San Juan, Puerto Rico.
 LIMA, A. 1998. The effects of size on the diets of six sympatric species of postmetamorphic litter anurans in Central Amazonia. *J. Herpetol.* 32:392–399.
 ———, AND W. MAGNUSSON. 2000. Does foraging activity change with ontogeny? An assessment for six sympatric species of postmetamorphic litter anurans in Central Amazonia. *J. Herpetol.* 34:192–200.
 MARSH, R. E. 1983. Unquestionable evidence that the whistling frog of Barbados is indigenous. *J. Barbados Mus. Hist. Soc.* 37:68–71.
 ORTEGA, J. E., A. JEREZ, AND M. P. RAMÍREZ-PINILLA. 2002. Geographic distribution: *Eleutherodactylus johnstonei*. *Herpetol. Rev.* 32:269.
 OVASKA, K. 1991. Diet of the frog *Eleutherodactylus johnstonei* in Barbados, West Indies. *J. Herpetol.* 25:486–488.
 PINKAS, L., M. S. OLIPANT, AND Z. L. IVERSON. 1971. Food habits of albacore bluefin, tuna and bonito in California Waters. California Department of Fish and Game (Fish Bulletin No. 152). Sacramento, California. 105 pp.
 RUIZ-CARRANZA, P. M., M. C. ARDILA-ROBAYO, AND J. D. LYNCH. 1996. Lista actualizada de la fauna amphibia de Colombia. *Rev. Acad. Colomb. Cienc. Exactas Fís. Nat.* 20:365–415.
 STEWART, M. M. 1979. The role of introduced species in a Jamaican frog community. In H. Wolda (eds.), Proceedings IV Symposium of Tropical Ecology, pp. 113–146. Panamá City, Panamá.
 TOFT, C. A. 1980. Feeding ecology of thirteen syntopic species of anurans in a seasonal tropical environment. *Oecologia* 45:131–141.
 ———. 1981. Feeding ecology of Panamanian litter anurans: patterns in diet and foraging mode. *J. Herpetol.* 15:139–144.
 VARGAS, F., AND F. CASTRO. 1999. Distribución y preferencias de microhábitat en anuros (Amphibia) en bosque maduro y áreas perturbadas en Anchicayá, Pacífico Colombiano. *Caldasia* 21:95–109.
 WOOLBRIGHT, L. L., AND M. M. STEWART. 1987. Foraging success of the tropical frog *Eleutherodactylus coqui*: the cost of calling. *Copeia* 1987:69–75.

On the Acoustic Communication System of *Eleutherodactylus fitzingeri* (Anura: Leptodactylidae)

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Frogs of the genus *Eleutherodactylus* are the main component of many neotropical herpetofaunas (Scott 1976). However, very little is known about their natural history, and even less information is available on the form and function of their vocalizations. For most species only short call descriptions are published, and for others it is unknown whether they vocalize at all. Yet, the few members of the genus *Eleutherodactylus* whose vocal behavior has been studied in detail show a great diversity of vocalizations: specialized calls for courtship and mating have been reported (Ovaska and Caldbeck 1997), as well as calls for the defense of retreat sites (Stewart and Rand 1991) and even calls produced by females in response to male calls (Schlaepfer and Figueroa-Sandi 1998).

I studied the vocal behavior of *Eleutherodactylus fitzingeri*, a common inhabitant of the tropical lowland forests of Costa Rica (Savage 2002). Although the distribution of *E. fitzingeri* extends from Nicaragua to central Colombia (Lynch and Myers 1983), to date all available information on the vocalizations of this species comes from frogs recorded in Panama (Fouquette 1960; Ibáñez et al. 1999; Lynch and Myers 1983). I provide data on geographic variation of the advertisement calls within Costa Rica and suggest that a vocalization formerly named the “sporadic call” (Ibáñez et al. 1999) is in fact a highly variable aggressive signal.

Material and Methods.—My main study site was at La Selva Field Station, Heredia Province, in the Caribbean lowlands of Costa Rica. I also recorded some frogs from the Pacific lowlands at Marenco Lodge, Puntarenas Province. I used a Sony WM-D6C tape recorder and a Sony ECM 969 microphone to record the calls of males (at ambient temperature of 25–28°C). I either recorded completely undisturbed calling males or I vocally imitated their advertisement call and recorded their vocal response. Whenever possible, I measured the size of the frogs I had recorded (snout–vent length to the nearest 0.1 mm with calipers and weighted them to the nearest mg with a Pesola scale). I digitized the recordings at a sampling rate of 22kHz and analyzed them using the program CoolEdit96 (Syntrillium Co.) on a portable computer. To test whether call variation between populations was statistically significant I calculated Mann-Whitney’s U-tests.

Results.—I recorded two types of calls: an advertisement call that was produced by solitary calling males, and a distinctly different call which was given during antagonistic interactions between males or in response to vocal call imitations.

The advertisement calls (Fig. 1) recorded from Costa Rican frogs were highly variable, and consecutive calls were given in irregular

intervals of several minutes. There was significant geographic variation in several call parameters. Calls from the Pacific population ($N = 6$) contained between 7–11 notes and had a mean \pm SD duration of 1228 ± 301 ms (range: 830–1610 ms). Calls in the Caribbean population ($N = 16$) however contained 12–24 notes and had a mean duration of 2884 ± 597 ms (range: 1700–3900 ms). Both call duration and number of notes per call were significantly different between populations ($P < 0.001$ in both cases). Since the duration of the individual call notes was similar in both sites (mean = 10 ± 2 ms; $P = 0.88$), the difference in call duration results from Caribbean males having more notes per call and having a longer internote interval between consecutive notes (mean = 165 ± 13 ms compared to 138 ± 17 ms; $P < 0.001$). The dominant frequency of the calls of Caribbean frogs was 1931 ± 221 Hz, that of Pacific frogs was 1788 ± 27 Hz. This difference was not statistically significant ($P = 0.27$). Males from the Pacific slope were significantly larger (33 ± 1 mm) and heavier (2.6 ± 0.3 g) than males from the Caribbean site (28 ± 1 mm, 1.7 ± 0.3 g; $P < 0.005$ in both cases).

To loud natural or imitated *E. fitzingeri* advertisement calls males responded with a vocalization that sounded like a series of creaking chirps (Fig. 2). Because I did not make recordings of these vocalizations at Marenco, all data given below refer to Caribbean frogs ($N = 16$). These response calls were produced within 6.3 ± 3.6 seconds after the offset of the rival/imitated call. On average 5.3 ± 3.0 of these calls were produced sequentially (max: 12 calls), with periods of 3.9 ± 3.8 sec of silence between consecutive calls. The mean duration of a complete sequence of response calls thus lasted 17 ± 10 sec. Individual calls contained between 1–4 notes, each of which could last from 3 to 110 ms. The duration of the individual calls was therefore highly variable (31–375 ms). Their build-up, however, followed a common scheme of increasing duration and complexity (Fig. 2). The first call was generally the shortest and consisted of one prolonged note. The following calls often increased in duration and number of notes, and generally here too an increase of note duration from start to end of the call could be observed. The dominant frequency of these calls was

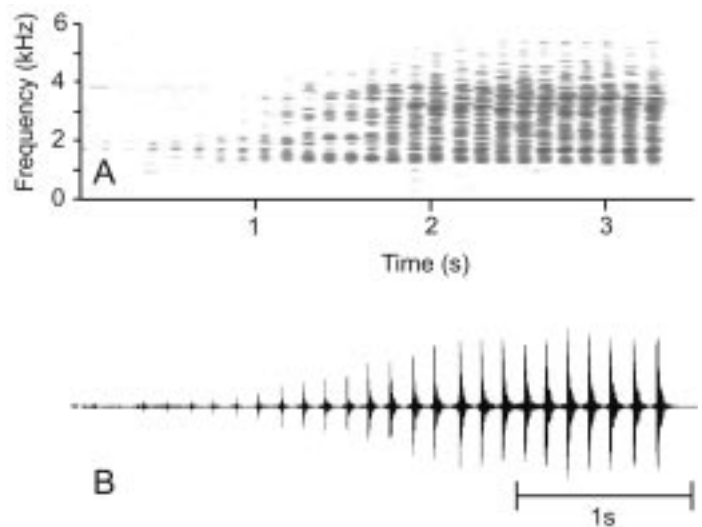


FIG. 1: An advertisement call of *Eleutherodactylus fitzingeri* recorded in Costa Rica. The upper panel (A) shows a sonagram, the lower panel (B) the waveform of the call.

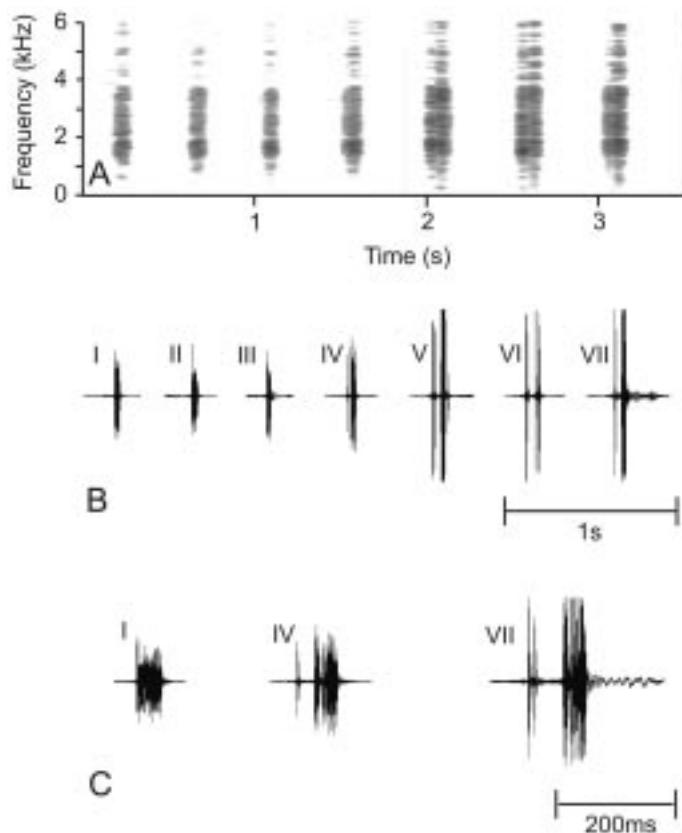


FIG. 2. Aggressive call response of *Eleutherodactylus fitzingeri* consisting of seven consecutive calls. The whole series was 29 sec long, but silent periods between successive calls were deleted in order to show the calls at the same time scale as the advertisement call from Fig. 1. Shown is a sonagram (A) and a waveform (B) of all seven calls. In (C) the waveform of the first, fourth, and last call of the series are shown at expanded time scale. Note how the duration and complexity of the calls increases.

2079 \pm 363 Hz. Some males showed positive phonotaxis, turning to face the source of the imitation call before responding, and certain males even moved towards the source of the call, repeatedly emitting this vocalization. Although these calls could be elicited from the majority of males by means of loud call imitations, they were very infrequently heard in nature.

Discussion.—The short advertisement calls are the most frequently heard vocalizations of *E. fitzingeri*, but because of the often large time lapses between consecutive calls, the frogs are very difficult to locate (Fouquette 1960; Lynch and Myers 1983). This may be interpreted as an avoidance mechanism against audio-orientated predators (Tuttle and Ryan 1981), and ties in with the overall life-history pattern of cryptic coloration (Lynch and Myers 1983) and secretive perch choice (Höbel 1999).

Body size might affect spectral call parameters like dominant frequency, and temperature may affect temporal call parameters like note duration, etc. (Gerhardt and Huber 2002). This should ideally be taken into account when comparing populations and describing geographic variation in call parameters. Unfortunately, my data set was not complete enough to run correlation analyses that would have eliminated these confounding factors. However, the most striking distinction between the advertisement calls of the two populations was the difference in the duration of the call,

which was mainly caused by the different number of notes produced per call. Addition of call notes is to my knowledge not affected by temperature. Also, temperature should affect temporal call parameters in similar ways, e.g., lower temperatures should slow down note duration as well as the duration of the inter-note interval. In my analysis however, I found significant differences between populations in one call parameter (inter-note interval), but not the other (note duration).

Although there is geographic variation in the advertisement calls of *E. fitzingeri*, this variation does not follow a clinal pattern. Calls of Panamanian *E. fitzingeri* comprise 2–18 notes per call (Fouquette 1960; Ibáñez et al. 1999; Lynch and Myers 1983), and are thus intermediate to those of the two sites I investigated in Costa Rica. Also, the general structure of the calls is very similar between different Costa Rican and Panamanian populations (Fouquette 1960; Ibáñez et al. 1999; Lynch and Myers 1983). What is the function of this vocalization? As in most frogs, the advertisement call probably serves a dual purpose of mate attraction and territorial function (Wells 1977). Although direct evidence in form of observations of females performing phonotaxis towards a calling male or a speaker broadcasting an advertisement call is still missing, a role in pair formation is nevertheless suggested by the observation that it is the most frequently given vocalization and that it is more often given in the rainy season, e.g., during the period when reproduction takes place (Höbel 1999; Ibáñez et al. 1999). A territorial function, probably regulating inter-male spacing is suggested by males showing phonotaxis while emitting a special aggressive call (see below) when they perceive very loud advertisement calls.

Calls similar to the response calls reported here have been described for Panamanian *E. fitzingeri*. Ibáñez et al. (1999) reported hearing single one-note calls of this type, and termed this vocalization the “sporadic call.” However, they did not comment on its function. Lynch and Myers (1983) elicited a similar vocalization (series of four chirps) by playing back an advertisement call that they had just recorded from the same male, which led them to suggest that this vocalization might constitute a response to conspecific male intruders. The circumstances under which this call type is given, i.e., when hearing a loud advertisement call of a rival male, together with the observation of males moving towards the source of a rival call while giving this vocalization supports the idea that it may be an aggressive call.

As a rule, the structure of a species’ aggressive call differs markedly from the structure of its advertisement call (Schwartz 2001). In *E. fitzingeri* the number of notes in the aggressive call is greatly reduced compared to the advertisement call, but the duration of the aggressive call notes is increased compared to advertisement call notes. This change in call structure is different from the one found in *Eleutherodactylus* species from the West Indies, where the combination and addition of the two basic notes of the advertisement call form calls used in aggressive signaling. *Eleutherodactylus coqui* converts its advertisement call into an aggressive signal by adding advertisement call like notes to the end of it (Stewart and Rand 1991), and the aggressive signal of *E. antillensis* is comprised of a rapid series of notes that resemble the second note of their advertisement call (Ovaska and Caldbeck 1997). Based on these observations there does not seem to be a general pattern in which aggressive calls differ from advertise-

ment calls in *Eleutherodactylus*, but comparative data on aggressive calls in this frog genus is too scarce to draw any conclusions yet.

Eleutherodactylus coqui has highly variable aggressive calls, and a graded increase in aggressive call duration is related to retreat site defense (Stewart and Rand 1991). In *E. fitzingeri* the variability in duration and structure of the aggressive call suggests that males may be able to respond in a graded fashion to increasing levels of intrusion/competition as well. However, playback experiments with advertisement calls varying in intensity and thus implying varying distance to rival males are needed to elucidate whether *E. fitzingeri* does in fact have a graded aggressive communication system.

For *E. fitzingeri* from Panama a third vocalization has been described. Ibáñez et al. (1999) mention that females occasionally gave repeated screams when seized, suggesting a distress vocalization. I never heard a distress call while catching frogs in Costa Rica (both males and females), but I also did not make an effort to elicit or record distress calls.

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LITERATURE CITED

- FOUQUETTE, M. J., JR. 1960. Call structure in frogs of the family Leptodactylidae. *Texas J. Sci.* 12:201–215.
- GERHARDT, H. C., AND F. HUBER. 2002. Acoustic Communication in Insects and Anurans: Common Problems and Diverse Solutions. University of Chicago Press, Chicago, Illinois.
- HÖBEL, G. 1999. Notes on the natural history and habitat use of *Eleutherodactylus fitzingeri* (Anura: Leptodactylidae). *Amphibia-Reptilia* 20:65–72.
- IBÁÑEZ, R., A. S. RAND, AND C. A. JARAMILLO. 1999. The Amphibians of Barro Colorado Nature Monument, Soberania National Park and Adjacent Areas. Editorial Mizarachi y Pujol. Panama.
- LYNCH, J. D., AND C. W. MYERS. 1983. Frogs of the *fitzingeri* group of *Eleutherodactylus* in Eastern Panama and Chocóan South America (Leptodactylidae). *Bull. Amer. Mus. Nat. Hist.* 175:481–572.
- SAVAGE, J. M. 2002. The Amphibians and Reptiles of Costa Rica. University of Chicago Press, Chicago.
- SCHLAEPFER, M. A., AND R. FIGEROA-SANDI. 1998. Female reciprocal calling in a Costa Rican leaf-litter frog, *Eleutherodactylus podiciferus*. *Copeia* 1998:1076–1080.
- SCHWARTZ, J. J. 2001. Call monitoring and interactive playback systems in the study of acoustic interactions among male anurans. In M. J. Ryan, (ed.), *Anuran Communication*, pp. 183–204. Smithsonian Institution Press, Washington, D.C.
- SCOTT, N. J., JR. 1976. The abundance and diversity of the herpetofaunas of tropical forest litter. *Biotropica* 8:41–58.
- STEWART, M. M., AND A. S. RAND. 1991. Vocalizations and the defense of retreat sites by male and female frogs, *Eleutherodactylus coqui*. *Copeia* 1991:1013–1024.
- TUTTLE, M. D., AND M. J. RYAN. 1981. Bat predation and the evolution of frog vocalization in the neotropics. *Science* 214:677–678.
- OVASKA, K. E., AND J. CALDBECK. 1997. Courtship behavior and vocalizations of the frogs *Eleutherodactylus antillensis* and *E. cochranae* on the British Virgin Islands. *J. Herpetol.* 31:149–155.
- WELLS, K. D. 1977. The social behaviour of anuran amphibians. *Anim. Behav.* 25:666–693.

Seasonal Timing of Follicular Development of the Mud Snake, *Farancia abacura* (Colubridae)

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There is limited information on the seasonality of reproduction of mud snakes, *Farancia abacura*. Observations of reproductive behavior in this species are difficult both in captivity and the wild due to its secretive habits. There are several reports of oviposition and subsequent hatching (Goldstein 1941; Meade 1935b, 1937, 1940a,b, 1945; Reynolds and Solberg 1942), but little is known about seasonally dependent follicle size.

Although complete records of breeding and reproductive habits are limited, Meade (1946) discussed the natural history of *F. abacura*, including reproductive behavior, oviposition, and maternal care. He maintained a live collection of *F. abacura* and produced the first record of breeding habits in *F. abacura* (Meade 1946). Mating and oviposition occurred in July and September, respectively, with the eggs incubating for seven weeks prior to hatching. Hatching of seven clutches occurred between September and October, with incubation periods ranging from seven to nine weeks (Meade 1946). More recently, Robinette and Trauth (1992) investigated both female and male reproductive cycles from mud snakes collected throughout Arkansas. The greatest mean follicle diameter was observed in May and June, synchronal with testicular recrudescence in males.

We examined 129 female *F. abacura* from throughout their range to investigate the seasonal timing of follicular development and discuss the possible relationship between seasonal emergence and the seasonal timing of reproduction.

MATERIALS AND METHODS

Data Collection from Museum Specimens.—Data were collected on oviductal follicle size, snout–vent length (SVL), head width (HW), head length (HL), and total length (TL) of *F. abacura* from adult female museum specimens (Appendix I). Ovarian follicles and oviductal tissue samples were removed through a ventral incision and stored in 70% ethanol for later measurement. Follicles were measured with a Fowler dial caliper and classified based on length according to Betz's (1963) system [Class I = 0.1–5.0 mm; Class II = 5.1–10.0 mm; Class III = 10.1–20.0 mm; and Class IV = 20.1–46.0 mm]. This system allowed for each follicle to be grouped into one of four distinct size classes and is commonly used in studies investigating follicle size and development (e.g., Goldberg 2002; Holycross and Goldberg 2001; Kofron 1979b, 1983; Rosen and Goldberg 2002).

Descriptive Analyses.—We present descriptive data on season-

ally dependent follicle length from 76 of 129 females examined. The number of female specimens collected each month was compared to the number of males and juveniles collected per month, demonstrating the possible influence of follicular development on the differences in seasonal emergence and activity between these demographic groups. Follicle size also was compared among months and regressed against female body size to determine if body size correlates with follicle size.

RESULTS

We examined 129 females for data on morphology and follicle length. Only 76 specimens provided reproductive data that could be used in our analyses, due to damaged follicles (e.g., road killed specimens) or previous dissection. Specimens were sampled primarily from Louisiana and Texas, with some adults from Florida, Mississippi, Oklahoma, South Carolina, and Tennessee (Table 1).

Most museum specimens sampled were collected between March and June, with the greatest number of females collected in April (Fig. 1). All museum specimens collected from September to December were from Louisiana and Texas populations. Museum records indicate that females tended to be captured more often than males and juveniles throughout the year.

Mean follicle lengths for *F. abacura* were compared within their respective months of capture (Fig. 2). Class II follicles were prevalent throughout the year. However, mean follicle length is greatest in June and July, as more Class III follicles were found for these months. Of the 76 females examined, only one follicle (35.3 mm) in one female (SVL = 92.3 cm, TCWC 45620) from Brazos Co., Texas was observed in the developmental stage of Class IV. However, this female's mean follicle length was still within the Class III developmental stage.

Snout-vent length (SVL) in adult female *F. abacura* ranged from 53.4–191.0 cm (mean \pm SE = 93.14 ± 2.556 , $N = 110$); 47.0–122.0 cm in adult males (mean \pm SE = 71.60 ± 1.769 , $N = 62$) and 14.5–45.0 cm in juveniles (mean \pm SE = 27.50 ± 1.346 , $N = 50$). We found no relationship between female body size (SVL) and mean follicle length in *F. abacura*, as SVL explained only 2% ($r^2 =$

TABLE 1. The number of female, male, and juvenile *Farancia abacura* specimens examined with an indication of their respective collection localities by state. Snakes with a SVL < 45.0 cm were considered to be juveniles. Of the 51 juveniles, 18 of these individuals were also identified as females and examined for reproductive condition. Thus a total of 129 adult and sub-adult females were examined.

Locality	Number of Specimens			Total
	Females	Males	Juveniles	
FL	2	1	0	3
LA	59	37	31	127
MS	2	0	3	5
OK	1	1	2	4
SC	1	1	0	2
TN	1	0	0	1
TX	43	21	15	79
Unknown	2	1	0	3
Total	111	62	51	224

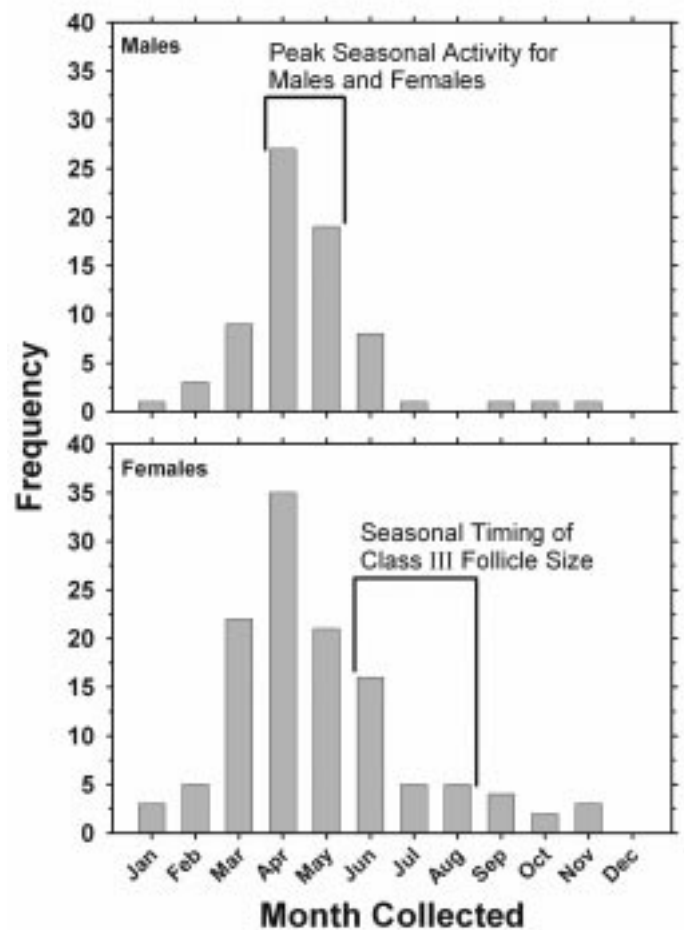


FIG. 1. Seasonal activity patterns determined from the capture records of museum specimens. Most museum specimens examined were collected between March and June, with the greatest number of males and females collected in April. These data may represent less secretive habits of the species during the months associated with seasonal reproduction. Class III follicle sizes were observed from June to August, after the period of peak seasonal activity.

0.0203) of variation in mean follicle size ($F = 1.51$; $df = 1, 74$; $P = 0.223$). However, regression analyses for SVL versus Class I, II, and III follicles lengths indicated a significant relationship between SVL and Class I follicle lengths ($F = 5.39$; $df = 1, 15$; $P = 0.035$; $r^2 = 0.264$). No significant relationship was found between SVL and Class II or III mean follicle lengths (Fig. 3).

DISCUSSION

Several studies report the timing of oviposition and subsequent hatching in *F. abacura* (Goldstein 1941; Meade 1935b, 1937, 1940a, 1945; Reynolds and Solberg 1942), but little is known about seasonally dependent follicle sizes. Most museum specimens examined in this study were collected between March and June with the greatest number for females being found in April. This tendency for higher captures in April could be due to an increase in activity associated with reproductive behavior. This observation is supported by Robinette and Trauth (1992) who examined 22 male and 22 female *F. abacura reinwardtii* from Arkansas and found that reproductive cycles peaked in May and June. Although we might expect that specimen capture in spring is directly due to seasonal activity, we cannot exclude the possibility of sampling

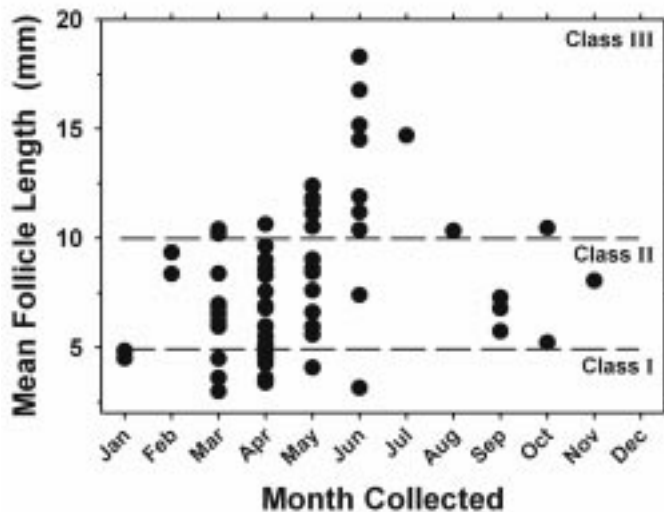


FIG. 2. Monthly distribution of mean follicle length of *Farancia abacura* (N = 76). The greatest proportion (>75%) of individuals demonstrating a Class III mean follicle size was observed in June, July, and August. Class IV was observed only in July.

bias due to greater frequency of collecting trips in spring. However, the observations of road-killed specimens may not show such a collection bias. Of the snakes examined in this study, all 14 road-killed specimens were collected during spring and early summer, thus supporting observations of seasonal activity in *F. abacura* (see also Means and Christman 1998). Lutterschmidt (unpubl. data) conducted a 12-month survey of snake activity in southeastern Louisiana, during which 33 *F. abacura* sampled were found only from April through August, with more than 85% of these captures occurring in April, May, and June. These observations of seasonal activity are similar to observations of juvenile emergence of *F.*

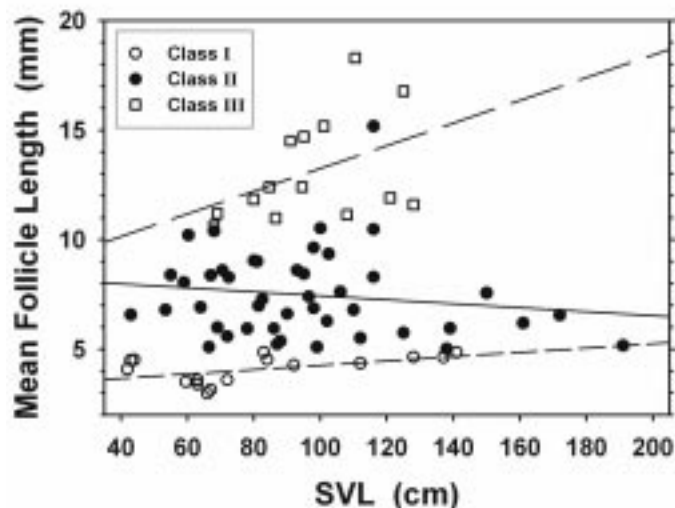


FIG. 3. Relationship between SVL and mean follicle lengths (MFL) of *Farancia abacura*. Regression results and equations: SVL vs. all MFL ($F = 1.51$; $df = 1, 73$; $P = 0.223$; $r^2 = 0.0203$; $MFL = 0.016 \cdot SVL + 6.26$); SVL vs. Class I MFL ($F = 5.39$; $df = 1, 15$; $P = 0.035$; $r^2 = 0.264$; $MFL = 0.010 \cdot SVL + 3.27$); SVL vs. Class II MFL ($F = 3.20$; $df = 1, 42$; $P = 0.081$; $r^2 = 0.071$; $MFL = -0.014 \cdot SVL + 8.54$); SVL vs. Class III MFL ($F = 2.58$; $df = 1, 12$; $P = 0.134$; $r^2 = 0.177$; $MFL = 0.052 \cdot SVL + 8.07$).

abacura in South Carolina where 67 of 98 individuals were captured in April and May (Semlitsch 1988). Although activity is greatest in spring and summer, indicating seasonal emergence and activity, *F. abacura* has been collected throughout the year. However, Meade (1935a; 1946) indicated that they most likely hibernate between November and mid-February. Many of these differences in activity may result from observing different populations over the geographical range of *F. abacura*.

Class II follicles are prevalent throughout the year (March, April, May, August, September, October, and November). However, in June and July follicles increase in length to Class III. After reaching Class III, follicles develop rapidly to Class IV, which are ≥ 2 cm in length and occur just prior to ovulation (Kofron 1979b). Only one specimen (collected in July) of the 129 examined had an ovum in Class IV (Fig. 2). This suggests that when the ova of female mud snakes are in later developmental stages (i.e., III and IV), female snakes may become secretive and less subject to capture. Once *F. abacura* find a mate, they return to their secretive habits. This correlates with Meade's (1937, 1946) observations of July breeding habits. A road-killed gravid female from Florida (collected in August 1997, SVL = 119.0 cm) had three large ova and approximately nine additional vascularized areas in the right oviduct, indicating she had recently oviposited part of her clutch (Means and Christman 1998).

Many studies of snake reproduction have addressed the relationship between female body size and the relationship between clutch mass and clutch size (e.g., Brodie and Ducey 1989; Ford and Seigel 1989; Tinkle 1957; Kofron 1979a, 1983; Santos and Llorente 2001; Voris and Jayne 1979; White et al. 1982), finding reproductive plasticity in female life-history traits. For example, when exposed to periods of low foraging success prior to vitellogenesis, clutch mass and clutch size may decrease (e.g., Seigel and Ford 2001). However, female body size seems to have little effect on mean follicle length. Within a species, mean follicle length is simply a function of development, thus follicle size is a function of time and not female body size. We found no relationship between female body size and mean follicle length during reproduction (Fig. 3). However, upon separating out each developmental size class (i.e., Class I, II, and III), we found a significant relationship between SVL and Class I follicle size. Kofron (1979b) examined reproductive age and ovarian morphology of seven aquatic snake species in south-central Louisiana, not including *F. abacura*. He measured follicles and classified them according to the system that we used here and showed that follicles of all seven species were in Classes I and II at the end of the first reproductive year. Class III follicles were present at the end of the second reproductive year, and then rapidly enlarged to Class IV during the spring of the third reproductive year just prior to ovulation. Although we did not demonstrate a SVL-dependent mean follicle size among females, individual females most likely produce larger follicles with increasing age and body size (Betz 1963; Kofron 1979b). This might explain why we observed a significant relationship between SVL and only Class I follicles. Most of our observation for Class I follicles (56%) were from females less than 80 cm SVL.

We hope the information gathered from museum specimens and presented here aids future investigators studying the seasonal timing of reproduction in *Farancia*.

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LITERATURE CITED

- BETZ, T. W. 1963. The gross ovarian morphology of the diamond-backed water snake, *Natrix rhombifera*, during the reproductive cycle. *Copeia* 1963:692–697.
- BRODIE III, E. D., AND P. K. DUCEY. 1989. Allocation of reproductive investment in the redbelly snake *Storeria occipitomaculata*. *Am. Midl. Nat.* 122:51–58.
- FORD, N. B., AND R. A. SEIGEL. 1989. Phenotypic plasticity in reproductive traits: Evidence from a viviparous snake. *Ecology* 70:1768–1774.
- GOLDBERG, S. R. 2002. Reproduction in the coachwhip, *Mastocophis flagellum* (Serpentes: Colubridae), from Arizona. *Texas J. Sci.* 54:143–150.
- GOLDSTEIN, R. C. 1941. Notes on the mud snake in Florida. *Copeia* 1941:49–50.
- HOLYCROSS, A. T., AND S. R. GOLDBERG. 2001. Reproduction in northern populations of the ridgenose rattlesnake, *Crotalus willardi* (Serpentes: Viperidae). *Copeia* 2001:473–481.
- KOFRON, C. P. 1979a. Female reproductive biology of the brown snake, *Storeria dekayi*, in Louisiana. *Copeia* 1979:463–466.
- . 1979b. Reproduction of aquatic snakes in south-central Louisiana. *Herpetologica* 35:44–50.
- . 1983. Female reproductive cycle of the neotropical snail-eating snake *Sibon sanniola* in northern Yucatan, Mexico. *Copeia* 1983:963–969.
- LEVITON, A. E., R. H. GIBBS, JR., E. HEAL, AND C. E. DAWSON. 1985. Standards in herpetology and ichthyology: Part I. Standard symbolic codes for institutional resource collections in herpetology and ichthyology. *Copeia* 1985:802–832.
- MEADE, G. P. 1935a. Hibernation of *Farancia abacura* in captivity. *Copeia* 1935:99.
- . 1935b. The egg-laying of *Farancia abacura*. *Copeia* 1935:190–191.
- . 1937. Breeding habits of *Farancia abacura* in Captivity. *Copeia* 1937:12–15.
- . 1940a. Maternal care of eggs by *Farancia*. *Herpetologica* 2:15–20.
- . 1940b. Observations on Louisiana captive snakes. *Copeia* 1940:165–168.
- . 1945. Further observations on Louisiana captive snakes. *Copeia* 1945:73–75.
- . 1946. The natural history of the mud snake. *Sci. Monthly* 63:21–29.
- MEANS, D. B., AND S. P. CHRISTMAN. 1998. *Farancia abacura*: Geographic distribution. *Herpetol. Rev.* 29:177.
- REYNOLDS, F. A., AND A. N. SOLBERG. 1942. Notes on the life history of the mud snake. *Copeia* 1942:25–26.
- ROBINETTE, J. W., AND S. E. TRAUTH. 1992. Reproduction in the western mud snake, *Farancia abacura reinwardtii* (Serpentes: Colubridae) in Arkansas. *Proc. Arkansas Acad. Sci.* 46:61–64.
- ROSEN, P. C., AND S. R. GOLDBERG. 2002. Female reproduction in the western diamond-backed rattlesnake, *Crotalus atrox* (Serpentes: Viperidae), from Arizona. *Texas J. Sci.* 54:347–356.
- SANTOS, X., AND G. A. LLORENTE. 2001. Seasonal variation in reproductive traits of the oviparous water snake, *Natrix maura*, in the Ebro Delta of northeastern Spain. *J. Herpetol.* 35:653–660.
- SEIGEL, R. A., AND N. B. FORD. 2001. Phenotypic plasticity in reproductive traits: geographic variation in plasticity in a viviparous snake. *Funct. Ecol.* 15:36–42.
- SEMLITSCH, R. D. 1988. Annual emergence of juvenile mud snakes (*Farancia abacura*) at aquatic habitats. *Copeia* 1988:243–245.
- TINKLE, D. W. 1957. Ecology, maturation, and reproduction of *Thamnophis sauritus proximus*. *Ecology* 38:69–77.
- VORIS, H. K., AND B. C. JAYNE. 1979. Growth, reproduction, and population structure of a marine snake, *Enhydrina schistosa* (Hydrophiidae). *Copeia* 1979:307–318.
- WHITE, D. R., J. C. MITCHELL, AND W. S. WOOLCOTT. 1982. Reproductive cycle and embryonic development of *Nerodia taxispilota* (Serpentes: Colubridae) at the northeastern edge of its range. *Copeia* 1982:646–652.

APPENDIX I

Specimens of *Farancia abacura* examined. Standard museum symbolic codes for institutional resource collections follow Leviton et al. (1985).

USA:

Florida: Dade Co.: TNHC 50103, Lake Co.: OMNH 18993, Putnam Co.: OMNH 34414

Louisiana: Avoyelles Co.: LSUMZ 2724, LSUMZ 75894, L S U M Z 75914, Beauregard Co.: LSUMZ 22552, Bossier Co.: LSUMZ 24247, Caddo Co.: LSUMZ 4838, Cameron Co.: TCWC 17417, East Baton Rouge Co.: LSUMZ 2723, LSUMZ 5959, LSUMZ 11895, LSUMZ 20331, LSUMZ 20332, LSUMZ 24248, LSUMZ 24249, LSUMZ 31246, LSUMZ 38093, LSUMZ 38959, LSUMZ 39191, LSUMZ 44913, LSUMZ 65908, LSUMZ 83190, LSUMZ 83386, LSUMZ 83390, LSUMZ 84521, East Feliciana Co.: LSUMZ 2725, LSUMZ 6109, LSUMZ 9121, LSUMZ 18296, LSUMZ 34306, Evangeline Co.: LSUMZ 29097, LSUMZ 58466, LSUMZ 58467, LSUMZ 74846, LSUMZ 75895, Franklin Co.: LSUMZ 43537, Grant Co.: LSUMZ 74849, Iberbville Co.: LSUMZ 18770, LSUMZ 46868, LSUMZ 75888, LSUMZ 75889, Jefferson Co.: LSUMZ 9163, LSUMZ 9164, LSUMZ 18282, LSUMZ 58389, LSUMZ 58454, LSUMZ 58455, Jefferson Davis Co.: LSUMZ 59063, Lafayette Co.: LSUMZ 74848, LSUMZ 75909, Lafouche Co.: LSUMZ 19178, Livingston Co.: LSUMZ 12884, LSUMZ 13008, LSUMZ 55927, LSUMZ 79283, LSUMZ 80501, LSUMZ 80503, Natchitoches Co.: LSUMZ 75896, LSUMZ 83451, LSUMZ 83485, LSUMZ 83504, LSUMZ 84597, LSUMZ 84674, Orleans Co.: LSUMZ 9162, LSUMZ 14154, Plaquemines Co.: LSUMZ 75900, Pointe Coupee Co.: LSUMZ 4149, LSUMZ 18295, Rapides Co.: LSUMZ 74853, LSUMZ 75869, LSUMZ 75893, Richland Co.: LSUMZ 42524, St. Landry Co.: LSUMZ 20330, LSUMZ 74850, LSUMZ 75862, LSUMZ 75868, TCWC 38241, St. John the Baptist Co.: LSUMZ 39805, LSUMZ 58438, LSUMZ 59624, LSUMZ 80948, St. Martin Co.: LSUMZ 74843, LSUMZ 74844, LSUMZ 74845, LSUMZ 74847, LSUMZ 74851, LSUMZ 75866, LSUMZ 75891, LSUMZ 75892, LSUMZ 75897, LSUMZ 75898, LSUMZ 75907, LSUMZ 75913, LSUMZ 75915, LSUMZ 75916, LSUMZ 75917, LSUMZ 75910, LSUMZ 75911, LSUMZ 75912, LSUMZ 79053, St. Mary Co.: LSUMZ 75890, LSUMZ 75899, St. Tammany Co.: LSUMZ 24098, LSUMZ 24099, LSUMZ 28816, LSUMZ 58518, LSUMZ 80255, LSUMZ 80898, LSUMZ 81207, Tangipahoa Co.: LSUMZ 17674, LSUMZ 23175, LSUMZ 47458, LSUMZ 57956, LSUMZ 57959, LSUMZ 57960, LSUMZ 80507, LSUMZ 80508, LSUMZ 80509, LSUMZ 80510, LSUMZ 80511, Terrebonne Co.: TCWC 74150, Terrebonne Co.: TCWC 71458, Vernon Co.: LSUMZ 20174, Washington Co.: LSUMZ 21026, West Carroll Co.: LSUMZ 20333

Mississippi: Attala Co.: LSUMZ 75989, Hancock Co.: LSUMZ 41368, LSUMZ 19176, Jackson Co.: LSUMZ 57957, Sharkey Co.: LSUMZ 47883

Oklahoma: McCurtain Co.: OMNH 30111, OMNH 38351, OMNH 24380, OMNH 30706

South Carolina: Charleston Co.: LSUMZ 36919, Jasper Co.: LSUMZ 74432

Tennessee: Lake Co.: LSUMZ 74856

Texas: Anderson Co.: TCWC 64992, TCWC 81207, Angelina Co.: SFA 654, Aransas Co.: TCWC 81205, Austin Co.: TCWC 4583, TCWC 6453, Burleson Co.: TCWC 18279, Brazoria Co.: TCWC 53155, Brazos Co.: TCWC 5164, TCWC 13838, TCWC 45620, Chambers Co.: TCWC 60707, Colorado Co.: TCWC 64322, Dewitt Co.: TCWC 82477, Fort Bend Co.: TCWC 81641, Galveston Co.: TCWC 27368, Grimes Co.: TCWC 64991, TNHC 36319, Hardin Co.: TNHC 4534, TNHC 19800, TNHC 21940, TNHC 28728, Harris Co.: TCWC 183, TCWC 8711, TCWC 18278, Harrison Co.: TCWC 79273, Houston Co.: TCWC 67299, Jackson Co.: TCWC 29467, Jasper Co.: SFA 2896, TCWC 48425, TCWC 78732, Jefferson Co.: TCWC 8710, TCWC 16178, Leon Co.: TCWC 2614, TCWC 5158, TCWC 5159, TCWC 5160, TCWC 5161, TCWC 5162, TCWC 5163, TCWC 5177, TCWC 8709, TCWC 8712, Liberty Co.: TNHC 21846, Madison Co.: TCWC 17389, TCWC 49322, Morris Co.: TCWC 78731, Montgomery Co.: TCWC 57916, TCWC 68233, TCWC 68237, TCWC 81209, TCWC 82476, Nacodoches Co.: SFA, SFA 1216, SFA 1233, SFA 2033, SFA 2291, SFA 2309, Newton Co.: TCWC 48426, Orange Co.: TCWC 33646, TNHC 21963, Refugio Co.: TNHC 20583, TNHC 32202, San Jacinto Co.: LSUMZ 34289, Tyler Co.: TCWC 78730, TCWC 81204, Victoria Co.: TCWC 70080, Walker Co.: TCWC 67234, TCWC 82818, Wharton Co.: TCWC 4757, TCWC 81206

Unknown Locality: SFA, SFA, TCWC 31956

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Aquatic Chytrid Pathogen Detected in Terrestrial Plethodontid Salamander

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A conservative estimate by Stuart et al. (2004) identified declines in 43% of all amphibian species worldwide. Three major causes were recognized as underlying these rapid global declines: overexploitation, habitat reduction, and enigmatic agents (Stuart et al. 2004). Enigmatic agents (mainly pathogens) may be responsible for driving nearly a quarter of the world's amphibian species towards rapid extinction (Stuart et al. 2004). The main relationship currently recognized between a pathogen and amphibian declines has been with the chytrid fungus *Batrachochytrium dendrobatidis* (Chytridiomycota) (Carey et al. 2003). This emerging fungal pathogen causes the disease chytridiomycosis and is responsible for amphibian declines, die-

offs, and possible extinctions (Berger et al. 1998; Bosch et al. 2001; Carey et al. 2003; Daszak et al. 1999; Green et al. 2002; Muths et al. 2003). *Batrachochytrium dendrobatidis* has been considered an aquatic pathogen because it requires water to transmit zoospores (Longcore et al. 1999) and cannot survive desiccation (Johnson et al. 2003). In wild populations of amphibians, chytridiomycosis has only been associated with aquatic habitats and surface water. We report here the first case of chytridiomycosis in a wild-caught, strictly terrestrial salamander. Our discovery expands the known ecological occurrence of this deadly pathogen into the terrestrial community, and indicates that many more amphibians, not just those associated with aquatic habitats, are potentially vulnerable to the disease.

We observed a *B. dendrobatidis* infection through histological examination in wild-caught terrestrial Jemez Mountains Salamander (*Plethodon neomexicanus*, Plethodontidae), a species endemic to the relatively dry slopes of the Jemez Mountains, New Mexico, USA. A single gravid adult female (specimen 18810; U.S. Geological Survey, National Wildlife Health Center, Madison, Wisconsin; mass: 2.57 g; SVL: 63.3 mm) was collected in a meadow with a few aspen trees (*Populus tremuloides*) (2950 m elev.). The infected salamander had typical foci of infection around the vent containing multiple zoosporangia of *B. dendrobatidis* and black flakes of unshed skin around the vent (Fig. 1A), characteristic of abnormal ecdysis (Berger et al. 1998). Cytological and histological examinations of the abnormal molt and epidermis revealed thalli and zoosporangia of *B. dendrobatidis* (Fig. 1B, 1C). In addition, a PCR-based assay, which amplifies the internal transcribed spacer regions of the rDNA cassette specific to *B. dendrobatidis* (Annis et al. 2004), confirmed the presence of DNA of *B. dendrobatidis* in skin of the ventrum and tail.

This first report of chytridiomycosis in a wild-caught, strictly terrestrial species suggests that *B. dendrobatidis* survives in terrestrial habitats. The persistence and transmission mechanisms of the pathogen in terrestrial communities remain largely unknown. It is possible that the fungus was transmitted to this salamander either by direct or indirect contact with sympatric infected aquatic amphibians. Other sympatric amphibians include Tiger Salamanders (*Ambystoma tigrinum*) and Boreal Chorus Frogs (*Pseudacris maculata*).

Although Stuart et al. (2004) concluded that enigmatic agents are primarily affecting Neotropical montane stream-associated species, it is generally accepted that surface water-associated amphibian species on all continents are at serious risk from *B. dendrobatidis*. Despite suspected declines in some terrestrial salamanders (Parra-Olea et al. 1999), and a report of chytridiomycosis in a captive terrestrial salamander (Pasmans et al. 2004), this pathogen has not been a major concern in strictly terrestrial frogs, salamanders, or caecilians because of their dissociation from surface water. The discovery of chytridiomycosis in a wild-caught terrestrial salamander significantly expands the potential host-range of *B. dendrobatidis*, suggesting that many more amphibians are at risk than previously thought.

Terrestrial communities might play a heretofore unrecognized, but important role, in the distribution, persistence, or dispersal of this epizootic pathogen. Whereas effective methods of control of *B. dendrobatidis* in sites of natural amphibian populations are unknown, attention should be directed towards limiting the spread

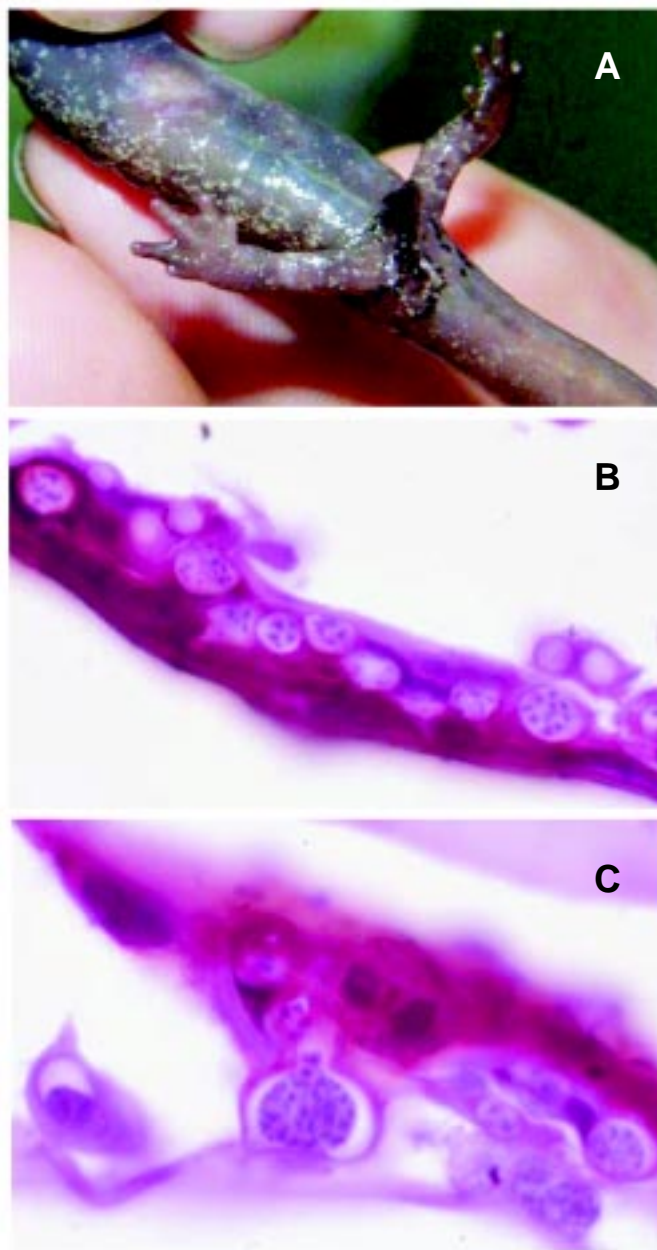


FIG. 1. Infection of *Batrachochytrium dendrobatidis* in terrestrial Jemez Mountains Salamander (*Plethodon neomexicanus*). A) Infected female with abnormal (black) spots around vent as it appeared after 11 days at 4°C. The black foci were limited to ventral skin and consisted of abnormally retained flakes of molt (dys-ecdysis). B) Histological section (hematoxylin and eosin [H&E] stain, 1000x) of abnormal molt showing numerous spherical zoosporangia of *B. dendrobatidis*. C) the larger flask-shaped chytrid thallus at bottom center is filled with zoospores and shows a characteristic discharge pore at the 12 o'clock position (H&E stain, 1000x).

of the agent by strict biosecurity measures in the field to prevent anthropogenic transmission and dispersal. Continued and expanded efforts to monitor the status of amphibian populations worldwide, to understand the biology of this pathogen, and to investigate the complex interactions of this host-pathogen system are urgently needed to reduce global losses of amphibian species.

- ANNIS, S. L., F. P. DASTOOR, H. ZIEL, P. DASZAK, AND J. E. LONGCORE. 2004. A DNA-based assay identifies *Batrachochytrium dendrobatidis* in amphibians. *J. Wildlife Dis.* 40:420–428.
- BERGER, L., R. SPEARE, P. DASZAK, D. E. GREEN, A. A. CUNNINGHAM, C. L. GOGGIN, R. SLOCOMBE, M. A. RAGAN, A. D. HYATT, K. R. McDONALD, H. B. HINES, K. R. LIPS, G. MARANTELLI, AND H. PARKES. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. *Proc. Natl. Acad. Sci. USA* 95:9031–9036.
- BOSCH, J., I. MARTÍNEZ-SOLANO, M. GARCÍA-PARÍS. 2001. Evidence of chytrid fungus infection involved in the decline of the common midwife toad (*Alytes obstetricans*) in protected areas of central Spain. *Biol. Conserv.* 97:331–337.
- CAREY, C., D. F. BRADFORD, J. L. BRUNNER, J. P. COLINS, E. W. DAVIDSON, J. E. LONGCORE, M. OUELLET, A. P. PESSIER, AND D. M. SCHOCK. 2003. Biotic factors in amphibian population declines. In G. Linder, S. K. Krest, and D. W. Sparling (eds.), *Amphibian Decline: An Integrated Analysis of Multiple Stressor Effects*, pp. 153–207. Society of Environmental Toxicology and Chemistry, Pensacola, Florida.
- DASZAK, P., L. BERGER, A. A. CUNNINGHAM, A. D. HYATT, D. E. GREEN, AND R. SPEARE. 1999. Emerging infectious diseases and amphibian population declines. *Emerg. Infect. Dis.* 5:735–748.
- GREEN, D. E., K. A. CONVERSE, AND A. K. SCHRADER. 2002. Epizootiology of sixty-four amphibian morbidity and mortality events in the USA, 1996–2001. *Ann. New York Acad. Sci.* 969:323–339.
- JOHNSON, M. L., L. BERGER, L. PHILIPS, AND R. SPEARE. 2003. Fungicidal effects of chemical disinfectants, UV light, desiccation and heat on the amphibian chytrid *Batrachochytrium dendrobatidis*. *Dis. Aquat. Org.* 57:255–260.
- LONGCORE, J. E., A. P. PESSIER, AND D. K. NICHOLS. 1999. *Batrachochytrium dendrobatidis* gen. et sp. nov., a chytrid pathogenic to amphibians. *Mycologia* 91:219–227.
- MUTHS, E., P. S. CORN, A. P. PESSIER, AND D. E. GREEN. 2003. Evidence of disease-related amphibian decline in Colorado. *Biol. Conserv.* 110:357–365.
- PARRA-OLEA, G., M. GARCÍA-PARÍS, AND D. B. WAKE. 1999. Status of some populations of Mexican salamanders (Amphibia: Plethodontidae). *Rev. Biol. Trop.* 47:217–223.
- PASMANS F., P. ZWART, AND A. D. HYATT. 2004. Chytridiomycosis in the Central American bolitoglossine salamander (*Bolitoglossa doleini*). *Vet. Rec.* 154:153.
- STUART S. N., J. S. CHANSON, N. A. COX, B. E. YOUNG, A. S. L. RODRIGUES, D. L. FISCHMAN, AND R. W. WALLER. 2004. Status and trends of amphibian declines and extinctions worldwide. *Science* 306:1783–1786.

Description of the Tadpole of *Pseudopaludicola boliviana* (Anura: Leptodactylidae)

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The genus *Pseudopaludicola* consists of frogs of small size (< 20 mm SVL [snout–vent length]) and they are distributed in the oriental region of South America, from the north of Colombia to the Province of Buenos Aires in Argentina. Frost (2004) recognized 12 species of *Pseudopaludicola*: *Pseudopaludicola boliviana*, *P. canga*, *P. ceratophryes*, *P. falcipes*, *P. llanera*, *P. mirandae*, *P. mineira*, *P. mystacalis*, *P. pusilla*, *P. riopiedadensis*, *P. saltica*, and *P. ternetzi*. Lynch (1989) and Lobo (1994, 1995, 1996) studied the systematics of the genus exhaustively. In Argentina, the species of the genus *Pseudopaludicola* are *P. falcipes* (Hensel 1867); *P. mirandae* (Mercadal de Barrio y Barrio 1994); *P. mystacalis* (Cope 1867) and *P. boliviana* Parker 1927 (Lavilla and Cei 2001). The first citation of *P. boliviana* for Argentina was for the Province of Chaco (Lobo 1989, 1990).

Pseudopaludicola boliviana belongs to the *Pseudopaludicola pusilla* group, in which the included species (*P. boliviana*, *P. canga*, *P. ceratophryes*, *P. llanera*, and *P. pusilla*) have toes with T-shaped terminal phalanges. The distribution of these species in South America is widespread. *Pseudopaludicola boliviana* is distributed in disjunct regions of eastern Colombia, northern Brazil (Roraima), and southern Venezuela through Guyana to Surinam and French Guiana, eastern Bolivia, Paraguay, southwestern Brazil, and northern Argentina; *P. canga* is known only from the type locality, Serra dos Carajás, municipality of Marabá, state of Pará, Brazil; *P. ceratophryes* is known only from Leticia, Colombia; *P. llanera* in northeastern Colombia and adjacent Venezuela in the drainage of the Río Orinoco, and *P. pusilla* is distributed in the lower and middle Magdalena River valley and the Caribbean lowlands of northern Colombia and adjacent Venezuela.

In Argentina, *P. boliviana* is distributed in the provinces of Formosa, Chaco and northern Santa Fé (Lobo 1992). Recently, Duré et al. (2004) also cited this species for the Province of Corrientes, the first record east of the Paraná River. Until the present, tadpoles of species belonging to the *Pseudopaludicola pusilla* group have not been described. In this paper, we describe *P. boliviana* tadpoles from Corrientes, Argentina.

Materials and Methods.—The tadpole description of *P. boliviana* is based on specimens collected in a rice field located 30 km NE of the city of Corrientes (27°30'S; 58°45'W), Province of Corrientes, Argentina. Specimens (N = 16) were collected by us on 4 December 2003. A subset of those individuals (N = 10) was raised in the laboratory through metamorphosis to confirm the species identification. The remaining tadpoles (N = 6) were preserved in 10% formalin.

Descriptive terminology follows that of Altig and McDiarmid

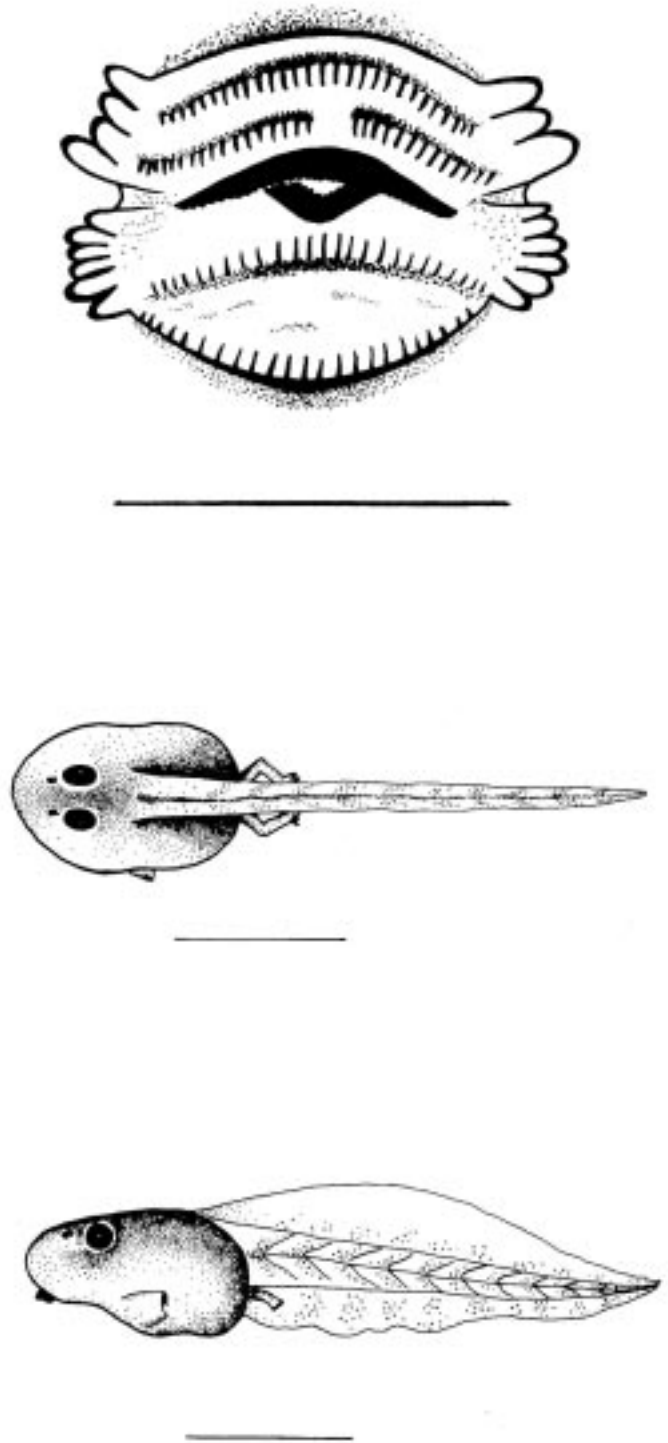


FIG. 1. Oral disc, dorsal and lateral views of *Pseudopaludicola boliviana* tadpole, CECOAL 005, from Corrientes, Argentina. Gosner stage 36. Scale line: 1 mm, 5 mm, and 5 mm (top to bottom).

(1999) and Kehr and Williams (1990). The morphometric variables considered are those suggested by Kehr et al. (2004). Measurements were taken with dial caliper and recorded to the nearest 0.1 mm; these variables are abbreviated as follows: TL (total length), BL (body length), TaL (tail length), BW (body maximum width), BWE (body width at eyes), BWN (body width at nostrils), BH (body

maximum height), FH (fin height), TMH (tail muscle height), RSD (rostr–spiracular distance), SPD (spiracular–posterior distance), FN (fronto–nasal distance), NO (narial–ocular distance), N (nostril diameter), E (eye diameter), EN (extranarial distance), IN (internarial distance), EO (extraorbital distance), IO (interorbital distance), ODW (oral disc width), RG (rostral gap), MG (mental gap). Tadpoles were staged using Gosner's table of normal development (Gosner 1960). Drawings were made with the aid of a camera lucida attached to a Wild M3C stereomicroscope.

Results and Discussion.— The specimen illustrated (CECOAL 005) (Fig. 1) is at Gosner stage 36 and has the following measurements in mm: TL = 18.8, BL = 7.0, TaL = 11.8, BW = 4.8, BWE = 4.3, BWN = 3.4, BH = 3.8, FH = 4.2, TMH = 1.7, RSD = 4.5, SPD = 2.8, FN = 1.0, NO = 0.4, N = 0.1, E = 1.0, EN = 1.0, IN = 0.8, EO = 2.4, IO = 0.9, ODW = 1.3, RG = 0.9, MG = 0.9. Table 1 summarizes the measurements of tadpoles in different stages collected at the same time with the tadpole described here.

Tadpoles of *P. boliviana* have an ovoid body, wider than high (BW/BH = 1.3). Snout rounded in lateral and dorsal views; nostrils dorsal, located nearer eyes than snout; eyes dorsolateral. Spiracle single, sinistral, and ventrolateral, visible in dorsal view; vent tube 1.8 mm long, positioned and opening medially; tail 63% of total length; the maximum tail fin height is greater than that of the body; dorsal fin extending slightly onto body, and is higher than ventral fin; tail tip pointed-rounded.

Oral disc positioned anteroventral to ventral; single row of 3–4 large marginal papillae on each side of the rostral gap and six large marginal papillae on each side of the mental gap, with a small gap separating the two groups of marginal papillae on each side; mental gap 0–0.6 times lower than rostral gap; labial tooth row formula 2(2)/2 (Fig. 1); labial teeth, with two to four cusps; length of tooth rows: A1 = 0.9 mm, A2 = 1.0 mm, gap of A2 = 0.2 mm; P1 = 1.1 mm, P2 = 0.9 mm; upper jaw sheath approximately 0.7 mm long; upper jaw sheath and lower jaw sheath serrated; upper jaw sheath broadly arch-shaped, lower jaw sheath V-shaped.

In life, dorsally, the body is brown with scattered dark spots; small dark spots start at the caudal musculature; two dark spots on each eyelid; iris with scattered golden spots; laterally, body pale brown, and base of spiracle pigmented; the caudal musculature with small bands darker among each muscular package; the dorsal fin clearer than ventral fin; ventral fin with scattered golden spots and melanic bands; ventrally, intestinal coils not visible, intestinal area with golden color; throat with scattered golden spots. In preservative, body light olive or gray with small dark and reticulate spots; throat semitransparent and intestinal coils barely visible through skin; tail fins transparent with small, black patches of melanin mainly on the ventral fin.

This is the first tadpole described for a species of the *Pseudopaludicola pusilla* group. In Corrientes, in the same area

TABLE 1. Measurements (in millimeters) of *Pseudopaludicola boliviana* tadpoles from Corrientes, Argentina. The individuals (N = 5) were collected together with the tadpoles described in the text. Tadpoles were staged according to Gosner (1960).

Morphometric variables	Stage				
	30	31	41	41	41
TL (total length)	9.6	10.4	19.3	18.4	19.6
BL (body length)	3.8	4.2	7.0	6.8	7.1
TaL (tail length)	5.8	6.2	12.3	11.6	12.5
BW (body maximum width)	2.7	2.7	5.2	4.7	4.8
BWE (body width at eyes)	2.3	2.5	4.3	4.1	4.2
BWN (body width at nostrils)	1.8	2.0	3.2	2.9	3.2
BH (body maximum height)	2.1	2.3	4.0	3.6	3.5
FH (fin height)	1.6	1.6	3.4	3.7	3.9
TMH (tail muscle height)	0.6	0.8	1.8	1.6	1.3
RSD (rostr–spiracular distance)	2.2	2.9	4.3	4.4	4.6
SPD (spiracular–posterior distance)	1.3	1.2	2.5	2.4	2.5
FN (fronto–nasal distance)	0.5	0.7	1.0	0.9	1.0
NO (narial–ocular distance)	0.2	0.2	0.2	0.4	0.3
N (nostril diameter)	0.1	0.2	0.3	0.2	0.2
E (eye diameter)	0.6	0.6	1.2	1.1	1.2
EN (extranarial distance)	0.6	0.6	1.5	1.2	1.2
IN (internarial distance)	0.5	0.4	0.8	0.8	0.9
EO (extraorbital distance)	1.5	1.4	2.9	2.7	3.0
IO (interorbital distance)	0.5	0.5	1.0	0.9	1.0
ODW (oral disc width)	0.6	0.7	1.3	1.2	1.1
RG (rostral gap)	0.5	0.6	1.0	0.9	1.0
MG (mental gap)	0.3	0.6	0.7	0.6	0.6

where *P. boliviana* is very common, there were also developing tadpoles of *P. falcipes*. Lamentably, information is scarce about the morphology of *P. falcipes* tadpoles and only the oral disc features are well detailed (Barrio 1945, 1953; Cei 1980). The differences between the tadpoles of these two syntopic species are: (1) *P. falcipes* without mental gap (*P. boliviana* present) and, (2) *P. falcipes* with labial tooth row formula 2(2)/3 (*P. boliviana* 2(2)/2). Lavilla and Cei (2001) cited two additional species occurring in the Province of Corrientes: *Pseudopaludicola mystacalis* (Cope 1867) and *P. mirandae* Mercadal de Barrio and Barrio (1994). The tadpoles of these species are unknown.

Until now, considering the tadpole described here, there are only three species of the genus *Pseudopaludicola* with the tadpoles described: *P. boliviana* (described here), *P. falcipes* (Barrio 1945, 1953) and *P. ternetzi* (Lobo 1991). In reality, the tadpole described by Lobo (1991) was considered a posteriori as *P. ternetzi* (Lobo 1994) because this author described this tadpole as *P. mystacalis*. It is probable that *P. ternetzi* is not present in Argentina as its known range is otherwise restricted to Goias, Brazil; nevertheless we will compare the morphological features between *P. boliviana* and *P. ternetzi* tadpoles: (1) both tadpoles share the same labial tooth row formula 2(2)/2; (2) *P. ternetzi* lacks a mental gap (*P. boliviana* present) and, (3) total length and body lengths are similar in the two tadpoles (stages 36–37) (*P. ternetzi*: 20.8

mm and 7.3 mm respectively; *P. boliviana*: see Table 1).

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LITERATURE CITED

- ALTIG, R., AND R.W. McDIARMID. 1999. Body plan: development and morphology. In R. W. McDiarmid and R. Altig (eds.), *Tadpoles: the Biology of Anuran Larvae*, pp. 24–51. The University of Chicago Press, Chicago, Illinois.
- BARRIO, A. 1945. Contribución al estudio de la etología y reproducción del batracio *Pseudopaludicola falcipes*. *Rev. Argentina de Zoogeografía* 5:37–43.
- . 1953. Sistemática, morfología y reproducción de *Physalaemus hensellii* (Peters) y *Pseudopaludicola falcipes* (Hensel) (Anura, Leptodactylidae). *Physis* 20:379–389.
- CEI, J. M. 1980. Amphibians of Argentina. *Monitore Zoologico Italiano (N.S.) Monografie* 2: 609 pp.
- DURÉ, M. I., E. F. SCHAEFER, M. I. HAMANN, AND A. I. KEHR. 2004. Consideraciones ecológicas sobre la dieta, reproducción y el parasitismo de *Pseudopaludicola boliviana* (Anura: Leptodactylidae) de Corrientes, Argentina. *Phyllomedusa* 3:121–131.
- FROST, D. R. 2004. Amphibian Species of the World: an Online Reference. Version 3.0 (22 Aug. 2004). Elec. Database at <http://research.amnh.org/herpetology/amphibia/index.html> American Museum of Natural History, New York.
- GOSNER, K. L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica* 16:183–190.
- KEHR, A. I., AND J. D. WILLIAMS. 1990. Larvas de anuros de la República Argentina. *Monografía Asociación Herpetológica Argentina* 2:1–44.
- , E. F. SCHAEFER, AND M. I. DURÉ. 2004. The tadpole of *Physalaemus albonotatus* (Anura: Leptodactylidae). *J. Herpetol.* 38:145–148.
- LAVILLA, E. O., AND J. M. CEI. 2001. Amphibians of Argentina. A Second Update, 1987–2000. *Monografie XXVIII*, Museo Regionale di Scienze Naturali-Torino, Italy. 177 pp. + 8 plates.
- LOBO, F. 1989. Primera cita de *Pseudopaludicola boliviana* para la República Argentina. *Bol. Asoc. Herpetol. Argentina (AHA)* 5(3):11.
- . 1990. *Pseudopaludicola boliviana*. *Herpetol. Rev.* 21:38.
- . 1991. Descripción de la larva de *Pseudopaludicola mystacalis* (Anura: Leptodactylidae). *Bol. Asoc. Herpetol. Argentina* 7(2):22–24.
- . 1992. Distribución y lista de localidades de *Pseudopaludicola* (Anura: Leptodactylidae) en la República Argentina. *Cuad. Herpetol.* 7:30–37.
- . 1994. Revisión del Género *Pseudopaludicola* (Anura: Leptodactylidae). Tesis Doctoral inédita. Facultad de Ciencias Naturales, Universidad Nacional de Tucumán. 318 pp.
- . 1995. Análisis filogenético del género *Pseudopaludicola* (Anura: Leptodactylidae). *Cuad. Herpetol.* 9:21–43.
- . 1996. Evaluación del status taxonómico de *Pseudopaludicola ternetzi* Miranda Ribeiro, 1937; *P. mystacalis* y *P. ameghini* (Cope, 1887). Osteología y distribución de las especies estudiadas. *Acta Zool. Lilloana* 43:327–345.
- LYNCH, J. D. 1989. A review of the leptodactylid frogs of the genus *Pseudopaludicola* in northern South America. *Copeia* 1989:577–588.

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Glueboards for Estimating Lizard Abundance

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Trapping animals without the use of bait reflects the density of the captured species and the level of that species' activity on the surface sampled. Trap capture with bait additionally reflects the attraction of the bait, environmental conditions affecting bait sensory cue detection, and the motivation level of the animal, among other variables. When the variable of interest is population density, the other factors (activity level, habitat, motivation, etc.) are nuisance variables that increase variance, but do not necessarily bias the relationship between the chosen index (typically captures/trap h) and the phenomenon of interest (population density). The strength of each such relationship is a crucial methodological attribute. Unfortunately, the precision of the statistical correlation between trap capture success and population density is rarely known. We are not aware of any study that has quantified the precision of population estimation using trap capture of reptiles. The development of total removal sampling (Rodda et al. 2001a) has made possible the estimation of this relationship for small herpetofaunal assemblages. Using total removal sampling, we sampled the herpetofauna of islands of the Pacific Ocean, Indian Ocean, and the West Indies in small (10 × 10 m) plots. By preventing immigration/emigration while removing all aboveground vegetation, we were able to completely enumerate (census) the absolute density of each species in the plots. We estimated relative population densities for small lizards on the basis of glueboard capture rates obtained concurrently from traps set in a ring surrounding each total removal plot. Given the close geographic correspondence between the sample areas, we expected a tight correlation between glueboard capture rates and absolute population densities.

The precision of a bivariate relationship is traditionally characterized by r^2 , the squared correlation coefficient. We report this value, but in addition report a new metric of population estimation precision: percentile range of the population densities corresponding to the 95% confidence limits of a midrange relative population density estimate. One weakness of r^2 as a metric of precision is that it is a ratio that reflects changes in both the numerator and denominator. Without changing the precision of a relationship, r^2 can be increased by extending the range of values being correlated. A more intuitive weakness of r^2 in this case is that it is measured in units that do not relate directly to the feature being estimated. That is, it does not express uncertainty about popula-

tion density estimate in terms of population density.

For a specific system, confidence limits can be expressed in terms of absolute density (e.g., 8–14/ha). Unfortunately, such ranges cannot be used to compare the precision of estimates among different species or habitats. Typical measures of dispersion, such as standard errors, assume normality. Densities are unlikely to be normally distributed—ours were not. Percentile ranks, because they make no assumptions about the shape of the underlying distribution, are more general.

Consider an ideal linear relationship between a relative and absolute population abundance measure. In a hypothetical example, trap capture yield varies 0–100 captures/trap h. At midrange, about 50 captures/trap h, the true density of our hypothetical taxon is about 10/ha, which is the 50th percentile of known abundance (which in this example ranges 0–25/ha). Furthermore, the 95% upper and lower confidence limits (CL) of our estimate are 8/ha and 14/ha, which are the 40th and 60th percentiles of known abundance respectively. Thus a midrange relative population estimate provides us with the knowledge that 95% of the time the true density of a population producing 50 captures/trap h will fall within the 40th–60th percentile range, and the single best estimator is at the 50th percentile, or 10/ha. A less precise relationship might have indicated only that the true value was in the range of 25th–75th percentiles, and a worthlessly imprecise measure would cover the full range of possibilities: 0–100th percentile. The central question of our study was: what percentile range of true densities is associated with the 95% confidence limits on a relative population measure at midrange?

The answer to this question is, unfortunately, context specific. We consider three possible sources of variance—species, habitat, and island—within the context of our specific sample size. A different sample size would produce different degrees of precision, but our sample sizes are typical and can therefore be used to illustrate the types of challenges facing an effective relative population measure.

Relative population estimators, indices, or counts are assumed to be proportional to true density. That is, if a later count were three times that of an earlier count, we could assume that the true density has increased threefold. If that condition is met for all possible changes, the regression of true density on sample density will form a straight line that passes through the origin, the slope reflecting the detectability of the species. The slope represents average detection multiplier ($= \hat{N} / \bar{n}$); alternately, the inverse of slope represents average detection fraction or \hat{p} ($= \bar{n} / \hat{N}$), where \hat{N} is the best estimator of absolute abundance and \bar{n} is the average index value (in our case, glueboard capture rate). If the detection fraction (\hat{p}) is constant over the range of densities considered, the points will lie along a line radiating from the origin. A y-intercept deviating significantly from zero indicates inconstancy in the detection fraction, and therefore a relative population estimator that will not be proportional. In our experience, the detection fraction tends to be reduced at low population densities, leading to a positive y-intercept. Inconstancy in the detection fraction will produce bias in population estimates, but the bias can be eliminated if the form and magnitude of the detection fraction inconstancy is quantified. We begin this process by quantifying the direction and magnitude of y-intercept deviations from zero.

The estimation of absolute population density is implicit rather

than explicit in many population studies. Often, temporal or spatial differences in relative abundance are of greater interest than is population density per se. A temporal change is often expressed as a ratio of follow-up count or index divided by the baseline index or count. Suppose that a later trap capture rate is twice that of an earlier one: we would like to infer that the target species has doubled in density. The confidence limits on this inference can be approximated by regressing known ratios of absolute population densities on the corresponding ratios of relative population estimates. For example, we might find that the absolute population density changed from 1400/ha to 1700/ha, a ratio of 1.21. This is not exactly the expected ratio of 2.0, but some error is expected. In the absence of error, all corresponding ratios would be equal and therefore would lie on the line $Y = X$. If the points lie along a different slope, we can infer that the underlying conceptual model (i.e., constant detectability) is in error. Note that any comparison between two estimates involves at least two opportunities for inferential or estimation errors. Confidence limits on a comparison of estimates will therefore always be wider than the confidence limits on a single inference. In this paper we regress the ratios of all pairs of absolute abundances on the corresponding relative population measures to inspect the form of the relationship and quantify the precision of such inferences for each species.

Our data were collected during 1995–2000 with 38 total removal plots; 22 on the island of Guam, six on Rota, four on Saipan (Mariana Islands, western Pacific), two on Ile aux Aigrettes (Mauritius outlier, Indian Ocean), and four on Guana (north of Tortola, British Virgin Islands, West Indies). Total removal yields were partially reported in Rodda et al. (2001b), Rodda and Campbell (2002), and Rodda et al. (2005). Four of the 38 total removal plots were 5×5 m (0.0025 ha) and 33 others were 10×10 m (0.01 ha). The four small plots were obtained from the same area at the same time and, for the purposes of this study, were pooled to represent a single 10×10 -m plot. The number of individuals captured per species per total removal plot ranged 0–676; nonzero captures per species averaged 21.5/plot (median = 6; sum of total removal captures = 4612). However, many of the lower species counts were omitted from consideration because of small sample size (see below).

We grouped all data into four habitat types: *Leucaena* forest, grassland, *Pandanus* forest, and broadleaf forest (Mueller-Dombois and Fosberg 1998). *Leucaena* forest is notable for the small size and translucency of leaves. *Leucaena* forests are relatively well lit, even in the shadows. *Pandanus* has very large, thick tangled leaves, which inhibit light penetration and create dark mesic forests. The broadleaf forest category included all other forestlands, which exhibited more average light and moisture conditions (unpubl. data).

Glueboard procedures followed Rodda et al. (1993). Glueboards were placed in a circular array of twelve traps on the ground in a ring concentric with the total removal plot at a distance of 5–10 m from the plot perimeter. Ground traps were spaced about 7 m apart. When used, 12 arboreal traps were stapled to a trunk or large limb at approximately breast height, one on the tree nearest each terrestrial trap. Traps were monitored for 24 h beginning at around 0830, but we found that relatively few captures were obtained from ground traps after the first 3 h of trapping. Therefore the capture results from ground traps reported here reflect three morning hours;

arboreal trap results reflect 24 h. Arboreal traps were omitted from three grassland plots and 17 other removal plots. The median placement of glueboards occurred within 19 days (range 1–78 d) of the total removal sample, generally afterwards. Total glueboard sample size for the three well-documented terrestrial species (see below) was 1025 captures in 1982 trap h. Glueboards were far less effective in

trees, producing only 88 captures among four reasonably well-documented species in 19,252 trap h. Arboreal lizards were occasionally captured on ground traps; for example, the arboreal *Anolis cristatellus* was captured 9 times in 141.5 ground trap h.

Twenty-four species of lizards, snakes, and frogs were obtained by total removal, but only seven lizard species had sufficient glueboard captures to merit comparison between the techniques. Several of the omitted species warrant mention here: *Anolis carolinensis* was captured 35 times in total removal plots on Saipan, Rota, and Guam, but was caught only once on glueboards. This species thus appears refractory to glueboard capture, perhaps as a consequence of its excellent vision and deliberate movements as a sit-and-wait predator. Data from this species were analyzed through the ANOVA mentioned below, but not otherwise considered. *Bufo marinus* was taken on 45 occasions in total removal plots, but only once on glueboards. Our impression is that this species can routinely disable the glue in glueboards, perhaps by urination. The nocturnal arboreal gecko *Gehyra oceanica* was taken only once on glueboards, despite a sample of 90 individuals in total removal plots. This species ordinarily uses the surfaces on which we place arboreal glueboards and it is firmly grasped by glueboards; its scarcity among captures is therefore perplexing and may be related to its relatively deliberate locomotion. There was no evidence, such as skin remnants on traps, that this species freed itself from the glueboards. Glueboard capture data from *Lepidodactylus lugubris* were included in the following analysis despite our failure to capture it on glueboards in the vast majority of sites (detected by glueboards in only 4 of 31 sites where its presence was confirmed by 625 captures in total removal plots). This species is easily snared by glueboards, but it routinely travels over leaves and other very small diameter perches (Rodda et al. 2005), where placement of glueboards is difficult or impossible. Thus, the following analyses are based on the subset of species that are relatively easy to sample with glueboards.

We performed ANOVAs to identify the factors that influence glueboard capture rate. To be consistent with the proposed use as a metric of relative abundance, we forced the model intercept to pass through the origin (i.e., when the species was absent, capture rate was zero). Because we used a different time period for arbo-

TABLE 1. Results of our analysis comparing absolute population estimates obtained from total removal plots to glueboard capture rates. The slope of best no-intercept regression indicates the detection rate multiplier ($1/\hat{p}$) achieved by glueboard sampling (lower values represent more complete sampling). The y-intercept indicates the constancy in detection over the ranges of densities sampled (higher y-intercept signifies reduced constancy).

Species	Relationship between absolute and relative abundance	Slope of best no-intercept regression	y-intercept (individuals/ha)
<i>Anolis cristatellus</i>	$r^2 = 0.88$, NS	15,840 (SE = 2900)	250 (NS)
<i>Carlia fusca</i>	$r^2 = 0.65$, $P < 0.0001$	4560 (SE = 680)	1511 ($P = 0.072$)
<i>Emoia caeruleocauda</i>	$r^2 = 0.55$, $P < 0.0001$	13,800 (SE = 2570)	1780 ($P = 0.028$)
<i>Gehyra mutilata</i>	$r^2 = 0.27$, $P = 0.016$	212,400 (SE = 78,600)	1330 ($P = 0.043$)
<i>Hemidactylus frenatus</i>	$r^2 = 0.83$, $P < 0.0001$	72,700 (SE = 8520)	350 (NS)
<i>Lepidodactylus lugubris</i>	$r^2 = 0.04$, NS	100,800 (SE = 24,800)	2930 ($P < 0.0001$)
<i>Sphaerodactylus macrolepis</i>	$r^2 = 0.82$, $P = 0.02$	368,300 (SE = 83,400)	10,400 (NS)

real than terrestrial glueboards, we performed separate analyses for arboreal and terrestrial species. Furthermore, because we wanted to consider the role of island, we eliminated from ANOVAs all species that we recorded on only one island (i.e., *Sphaerodactylus macrolepis* and *Anolis cristatellus*).

We also regressed the absolute population density on the relative capture rates for each habitat sampled to inspect the form of the relationship and to identify 95% confidence limits for samples of the seven species with sufficient data (*A. cristatellus*, *Carlia fusca*, *Emoia caeruleocauda*, *Gehyra mutilata*, *Hemidactylus frenatus*, *Lepidodactylus lugubris*, and *S. macrolepis*). We had sufficient data for the two terrestrial skinks (*C. fusca* and *E. caeruleocauda*) to further consider the variability of capture rates within a single habitat type, *Leucaena* forest, on two and three islands, respectively. For all seven lizard species we also regressed logs of all pairwise permutations of ratios between non-zero absolute abundances on the corresponding log ratios of non-zero glueboard capture rates to inspect the form of the relationship and identify 95% confidence limits for samples. If each ratio between densities was exactly reflected in the corresponding ratio between trap capture rates, the ratios would lie on the line $Y = X$. Because the ratios were collected from pairs of plots, the number of ratios differs from the sample size of plots. For example, there are six pairs possible from four nonzero plots.

The ANOVA for terrestrial species indicated that density was associated with glueboard capture rate ($F_{1,35} = 7.99$, $P = 0.0077$), which also exhibited significant interactions with species ($F_{1,35} = 24.38$, $P < 0.0001$), species and habitat ($F_{1,35} = 3.34$, $P = 0.014$), and species and island ($F_{1,35} = 4.81$, $P = 0.0066$). Thus to obtain the most precise estimate of population density from glueboard captures, it would be necessary to calibrate the relationship separately for each habitat*island*species condition.

Five arboreal species were analyzed with ANOVA (*A. carolinensis*, *G. mutilata*, *G. oceanica*, *H. frenatus*, and *L. lugubris*). These did not collectively exhibit a significant relationship between total removal density and glueboard capture rate, although they did exhibit significant effects for habitat ($F_{1,35} = 7.32$, $P_{2,45} = 0.0018$), species ($F_{1,35} = 18.72$, $P_{4,45} < 0.0001$), and habitat*species ($F_{1,35} = 3.12$, $P_{7,45} = 0.009$).

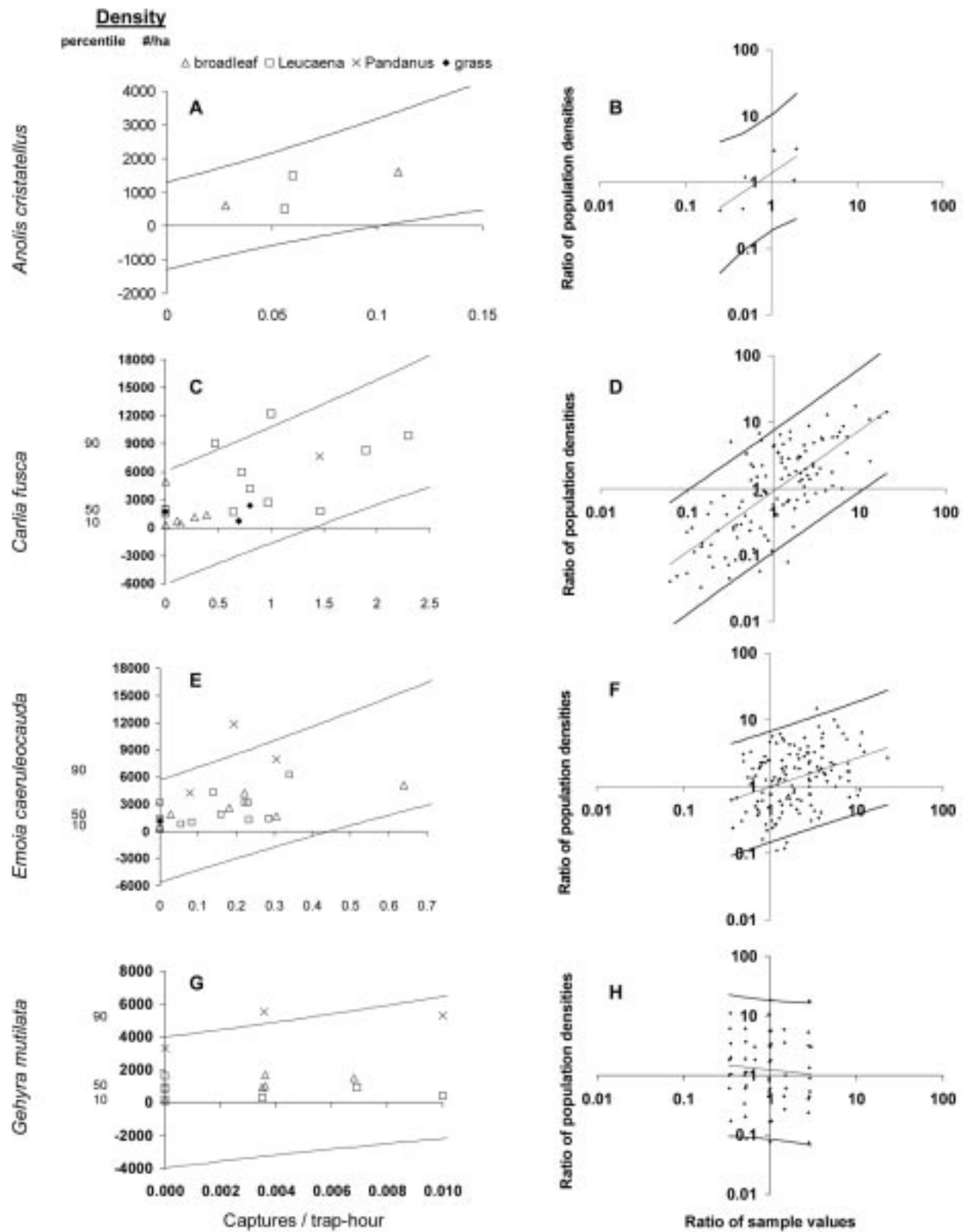


FIG. 1. Glueboard capture rates based on 12 traps for three morning hours for diurnal lizards (A–F), and 12 traps for 24 h for the nocturnal species (G–H). Left-hand graphs relate absolute densities to glueboard capture rates. Right-hand graphs relate pairwise ratios in absolute densities to pairwise ratios in glueboard capture rates. Because each possible pairing of points in the left-hand graphs yields a point in the right-hand graphs, the sample sizes are unequal, although based on the same information. The right-hand graphs are comparable among species, and are scaled identically to facilitate comparison. Outer lines in all panels represent 95% confidence limits for samples. (A) The relationship between absolute density (determined by 10 x 10-m total removal plots) and glueboard capture rate for *Anolis cristatellus* in two habitat types. (B) The relationship between pairwise ratios of *A. cristatellus* total removal population densities and the corresponding ratios of glueboard capture rates. (C–H) Other species as indicated by row headings.

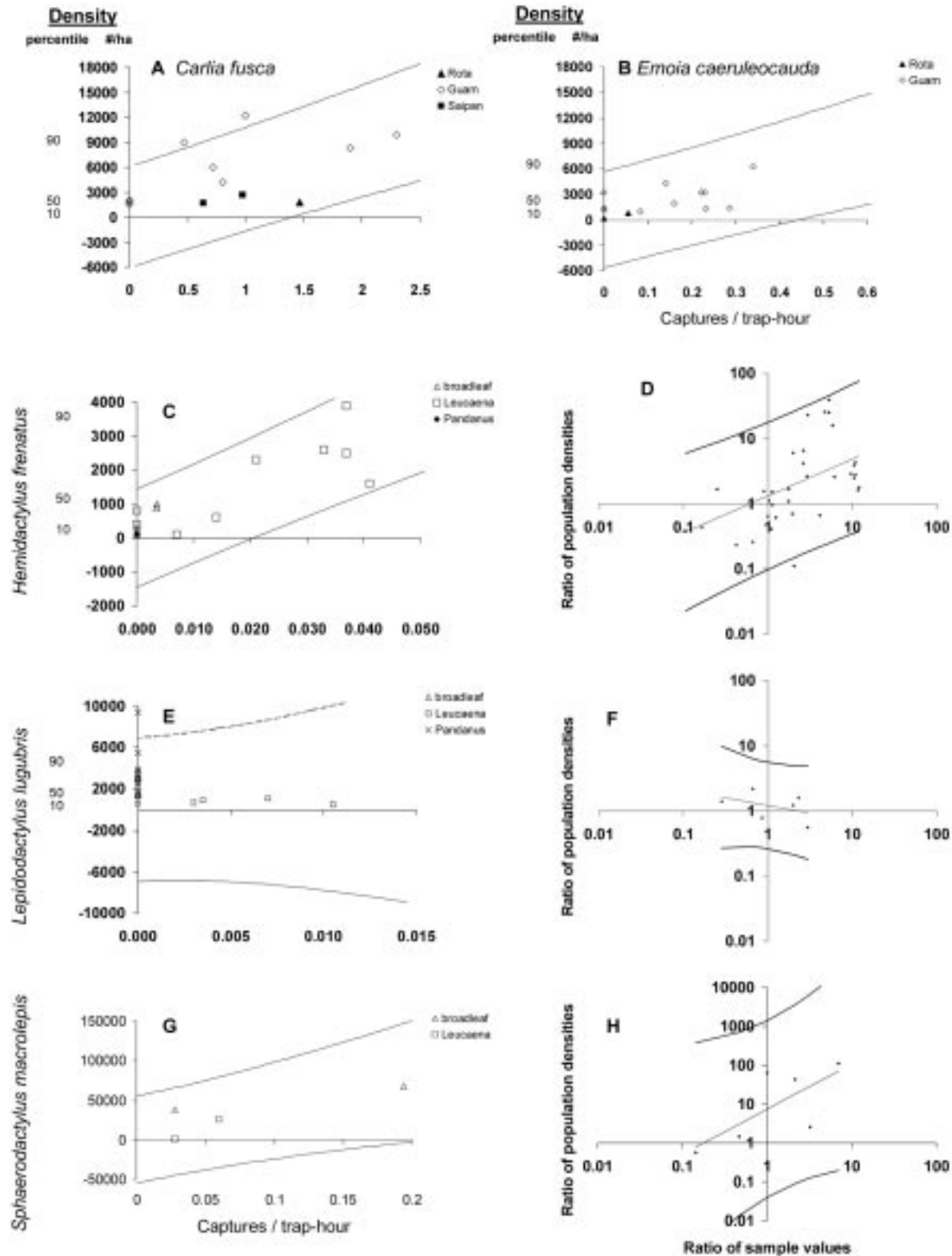


FIG. 2. (A) Relationship between absolute density and glueboard capture rates for *Carlia fusca* in a single habitat type (*Leucaena* forest) on three islands. See Fig. 1 left-hand column for graphical conventions. (B) Same relationship as A for *Emoia caeruleocauda* on two islands. The remainder of Fig. 2 follows the graphical conventions of Fig. 1. Note different scaling on ordinate for H.

The relationship between absolute and relative measures was significant for all but two species (*A. cristatellus* and *L. lugubris*), suggesting a reasonable correlation between methods (Table 1; Figs. 1, 2). However, of the five that were significant, three taxa (*C. fusca*, *E. caeruleocauda*, and *G. mutilata*) were relatively imprecise ($r^2 < 0.7$). Although an r^2 of 0.7 is satisfactory for many ecological studies, it does not produce adequate precision for correlated population densities estimates. This is most clearly seen from the percentile ranks associated with 95% confidence limits for mid-range capture rates (Table 2). Two of the seven taxa studied (*Anolis* and *Sphaerodactylus*) had confidence limits at mid-range that spanned the entire known range of densities for the species (0–100th percentiles). Four of the remaining five species covered 0–90th percentile or more. At mid-range glueboard capture rates, the best species as ranked by percentile range, *H. frenatus*, covered 0–84th percentiles of abundance, allowing only the inference that the highest population densities could be excluded on the basis of an intermediate glueboard capture rate. Thus, substantially larger sample sizes would be needed to make inferences about the density of these species from glueboard sampling.

The y-intercepts of the absolute/relative correlations (Table 1) reflect the appropriateness of using glueboard capture rates to quantify the relative densities of populations within a single species, a comparison that assumes index values reflect a constant proportion of the sampled populations. The y-intercepts deviated significantly from the origin for four of seven taxa (*Emoia*, *Gehyra*, *Hemidactylus*, and *Lepidodactylus*), implying inconstancy in capture probability over the observed range of population densities. While not significant (based on $N = 2$), the large y-intercept for *Sphaerodactylus* (10,400 individuals/ha at zero glueboard captures) suggests that capture probability may be variable for this species as well (Table 1).

If index values such as glueboard capture rates are used to compare populations of a single species among different habitats, the y-intercepts associated with those different habitats must be close to zero and the absolute/relative regression slopes must be the same. Both ANOVAs (above) generally falsified this assumption. Too few data were obtained to test this hypothesis rigorously for individual species. However, inspection of Figs. 1 and 2 suggests that the main sources of the significant species*habitat effects may be *Carlia* in *Leucaena* habitat (Fig. 1C), and *Emoia* (Fig. 1E), *Gehyra* (Fig. 1G), and *Lepidodactylus* (Fig. 2E) in *Pandanus* habitat. Each of these anomalies was associated with relatively reduced detectability (high absolute densities for low glueboard capture rates). The role of “island” in detectability was inspected with reference to *Carlia* (Fig.

TABLE 2. Confidence limits at midrange on the computed relationship between absolute population density and glueboard capture rates. The 95% CL are in units of absolute population density and the ranks give the corresponding percentiles from the observed range of densities for that species.

Species	Midrange capture rate (captures/trap h)	95% CL (individuals/ha)	Percentile range
<i>Anolis cristatellus</i>	0.06	0–2360	0–100
<i>Carlia fusca</i>	1.0	0–10,800	0–97
<i>Emoia caeruleocauda</i>	0.2	0–8500	0–97
<i>Gehyra mutilata</i>	0.005	0–4100	0–90
<i>Hemidactylus frenatus</i>	0.02	0–2940	0–84
<i>Lepidodactylus lugubris</i>	0.005	0–8070	0–97
<i>Sphaerodactylus macrolepis</i>	0.07	0–88,300	0–100

2A) and *Emoia* (Fig. 2B). Although there was no apparent difference between islands for *Emoia* trapping in *Leucaena* forests, detectability of *Carlia* in *Leucaena* habitat appears to be appreciably higher on Guam than on other islands. On the basis of the small number of comparisons conducted, inter-island relative population estimates may be appropriate for *Emoia* but not *Carlia*.

The ratio plots (Figs. 1B, D, F, and H; Fig. 2D, F, and H) address the use of glueboard capture rates for detecting single population changes over time. Only three of the seven comparisons exhibited r^2 values > 0.25 (*Anolis*, *Carlia*, and *Sphaerodactylus*) but none was > 0.6 (Table 3). Six of the seven species had confidence limits that spanned about two orders of magnitude in abundance, but the limits for *Sphaerodactylus* were exceptionally wide (ca. six orders of magnitude). To be of any value for predicting population density trajectories from the observed change in glueboard capture rates, a ratio plot must have a slope of about 1.0, and a y-intercept passing through the origin (ratio = 1.0). *Anolis* and *Carlia* pass this standard and have relatively narrow confidence limits (spanning ca. two orders of magnitude). However, with such confidence limits one must observe a tenfold change in glueboard capture rates to be 95% certain of rejecting the null hypothesis of no population change.

Constancy of detectability between species is required for in-

TABLE 3. Characteristics of the relationships between absolute population density ratios and relative population density ratios. In these ratio diagrams, an axis value of 1 corresponds to population density equality or, for repeated samples, no temporal change.

Species	Relationship between absolute and relative ratios	Slope (significance test of slope = 1)	y-intercept (significance test of y-intercept = 1)
<i>Anolis cristatellus</i>	$r^2 = 0.60$, $P = 0.07$	0.87 (NS)	1.37 (NS)
<i>Carlia fusca</i>	$r^2 = 0.53$, $P < 0.0001$	0.92 (NS)	0.90 (NS)
<i>Emoia caeruleocauda</i>	$r^2 = 0.13$, $P < 0.0001$	0.99 (NS)	0.43 ($P < 0.0001$)
<i>Gehyra mutilata</i>	$r^2 = 0.007$, NS	Negative	—
<i>Hemidactylus frenatus</i>	$r^2 = 0.25$, $P = 0.002$	0.57 ($P = 0.011$)	1.3 (NS)
<i>Lepidodactylus lugubris</i>	$r^2 = 0.18$, NS	Negative	—
<i>Sphaerodactylus macrolepis</i>	$r^2 = 0.52$, NS	1.16 (NS)	7.4 ($P = 0.049$)

terspecific comparisons of glueboard capture rates. There was an 80-fold range in the glueboard detectability among well-sampled species (Table 1 slopes; Fig. 3). *Carlia* was the easiest to detect, followed by *Emoia* and *Anolis*. *Sphaerodactylus* and *Lepidodactylus* were nearly undetectable by glueboard sampling. No two of the tested species had detection multipliers that were sufficiently similar to support direct interspecific comparisons.

The general features of this comparison between glueboard capture rates and absolute population densities mirror those obtained from a similar analysis of the relationship between visual encounter rates and absolute population densities (Rodda et al. 2005). In both, high and moderately high r^2 values were associated with negligible precision in some population estimates. With both visual and glueboard detections we found that detectability sometimes differed appreciably among habitats. Furthermore, with both types of detections, species differed substantially in their detectability and in their suitability for single-species monitoring by means of relative population estimates. One hopeful note is that the rank order of detectability for tested species was the same for both methods. Whether detected by glueboards or visual searching, the five species with the most data were ranked (from most detectable to least) in the order *Carlia*, *Emoia*, *Hemidactylus*, *Lepidodactylus*, and *Gehyra*. In both cases *Carlia* was judged reasonably suitable for relative population estimation and *Lepidodactylus* was judged unsuitable. This correspondence of results suggests that some species will be easily sampled through a variety of methods, but it leaves no obvious avenue for estimating the abundance of problematic species such as *L. lugubris*. In contrast to the consistency between methods in relative detectability, visual quantification of *G. mutilata* was found to be especially favorable, whereas this species was found to be unsuitable for population estimation using glueboards. Thus given a choice between visual searching and trapping for population estimation of *G. mutilata*, visual searching is a clear preference.

A result such as that above may provide decisive guidance on selection of a monitoring program for a tested species, but it leaves open the question of whether one can extrapolate from these results to species or systems that have not undergone the costly validation tests performed here. The detectability differences summarized in Fig. 3 reinforce the generalization that no single unadjusted sampling method can be used interspecifically.

Even if small lizards differ in detectability among species, habitats, islands, and densities, it may be possible to use relative population estimators (index values) if the detection biases are predictable. Do basic niche dimensions clarify the range of detection possibilities? The first four species illustrated in Fig. 3 are arboreal, the latter three are terrestrial. The first species (*A. cristatellus*) and the last three (*Carlia*, *Emoia*, and *Sphaerodactylus*) are diurnal, the others nocturnal. Neither of these ecological distinctions appears to offer strong guidance on detectability (Fig. 3) or suitability for glueboard monitoring (Figs. 1, 2). Perhaps studies of additional species will clarify general patterns. In that regard, we find it notable that the two species of *Anolis* we tested differed so dramatically in detectability, despite the species being closely related, of similar dietary habits and size, and occupying similar positions in their habitats (both are primarily trunk dwellers where they were tested: *A. carolinensis* occupies canopy positions in its native range, but is typically found much lower on the small trees sampled in

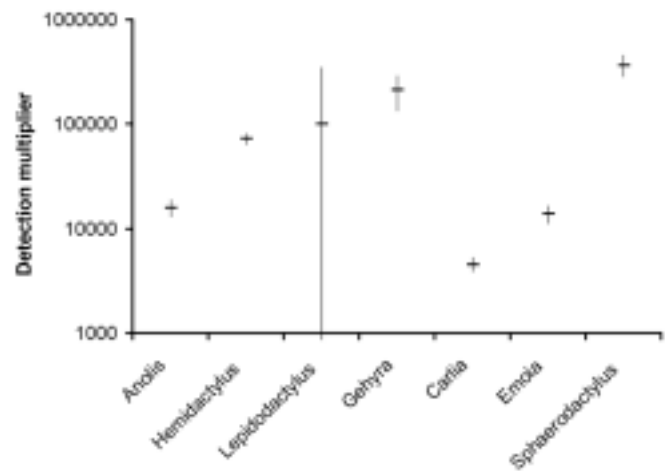


FIG. 3. Detection multipliers ($(1/\hat{p}) \pm \text{SE}$) for the seven best-studied species.

the Mariana Islands; unpubl. data). *Anolis cristatellus* was the most detectable arboreal species that we sampled, and *A. carolinensis* was collected by glueboards so infrequently that we were unable to quantify its detectability. It seems likely that the relatively deliberate locomotion of *A. carolinensis* reduces its vulnerability to glueboard capture, but it is disheartening to recognize that general principles of detectability are unlikely to be discernible from knowledge of phylogeny, size, diet, and ecomorphology. Future generalizations about detectability may require data, such as the speed and mode of locomotion that are not routinely collected by researchers interested in estimating population size.

Analyses of detectability, proportionality, and precision are helpful in designing monitoring programs. With additional validation studies it may be possible to suggest some general guidelines for predicting the validity of specific sampling techniques. For example, our data hint that arboreal species may be less well suited than terrestrial species for glueboard estimates. Likewise, slow-moving species may be less suitable than species that run quickly. Simple arboreal habitats may be more suitable than dense, complex ones (e.g., *Pandanus* forest). Furthermore, arboreal species that are most often found on twigs and leaves appear less well suited than species that habitually use trunks. These patterns may prove to be illusory when additional sampling strategies are studied and validated, but they illustrate the types of generalities that should become available after further study. More work along these lines is needed to establish the precision of population estimates for specified samples of these species in the habitats under consideration. For the vast majority of herpetofaunal species, validation studies are needed for all circumstances under which relative population estimates might be used.

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LITERATURE CITED

- MUELLER-DOMBOIS, D., AND F. R. FOSBERG. 1998. Vegetation of the Tropical Pacific Islands. Springer, New York. 733 pp.
- RODDA, G. H., AND E. W. CAMPBELL. 2002. Distance sampling of forest snakes and lizards. *Herpetol. Rev.* 33:271–274.
- , E. W. CAMPBELL, III, AND T. H. FRITTS. 2001a. A high validity census technique for herpetofaunal assemblages. *Herpetol. Rev.* 32:24–30.
- , T. H. FRITTS, AND C. S. CLARK. 2005. The predictive power of visual searching. *Herpetol. Rev.* 36:259–264.
- , M. J. MCCOY, AND T. H. FRITTS. 1993. Adhesive trapping II. *Herpetol. Rev.* 24:99–100.
- , G. PERRY, R. J. RONDEAU, AND J. LAZELL. 2001b. The densest terrestrial vertebrate. *J. Trop. Ecol.* 17:331–338.

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The Predictive Power of Visual Searching

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Validation of relative population estimates has rarely been attempted for reptiles (Rodda, *in press*). Validity is expensive and time consuming to test. However, the scarcity of validation examples is due, in part, to the absence of a discrete threshold for success. Across density extremes (zero to superabundance), it is difficult to imagine how a relative measure would fail to be at least loosely correlated with density. Precision, however, depends on the strength of the correlation.

In many situations, bias is more problematic than imprecision. A relative population estimator will give a biased result if the detected fraction of the population varies systematically among the conditions of interest. Species to be compared must have the same detectability; habitats to be compared must allow equal detect-

ability of the target species, etc. The simplest situation, a single species in a single habitat type at a single time, will yield an unbiased comparison of density only if the detection fraction is constant across the range of densities sampled. This factor is rarely considered, but can be troublesome. For example, searchers detect a lower fraction of horned lizards when the animals or signs of their presence are scarcer (Henke 1998). At low densities, a higher proportion of the animals are overlooked.

These factors suggest that a relative population measure cannot be considered “validated” in an absolute sense; an estimator will be more or less accurate depending on context. In this paper we consider visual encounter surveys (Crump and Scott 1994) as a relative population estimator for brown treesnakes (*Boiga irregularis*), skinks (*Carlia fusca* and *Emoia caeruleocauda*), and geckos (*Gehyra mutilata*, *Hemidactylus frenatus*, and *Lepidodactylus lugubris*) in forest on Guam, Mariana Islands. For each species we quantified the precision of the relative estimator from the correlation between visual searching and a validated absolute density estimator. To assess the contexts in which use of a relative estimator would be appropriate, we tabulated the constancy of the detection fraction among and within species and present evidence on the constancy of the detection fraction between habitats.

Attributes of a good estimator.—A good relative population measure will not only be correlated with true density, it will also be proportional. That is, if the population doubles, the relative measure should also increase two fold. If the regression of true population density on visual encounter rate has a positive y-intercept, the detection fraction is not constant, and a minimum density of animals must be present, on average, before the species becomes visually detectable (Fig. 1). This condition indicates a reduction in detection fraction at low densities. Conversely, a negative y-intercept indicates a reduction in detection fraction at high densities.

Another approach to assessing proportionality is to inspect the correspondence between pairwise ratios of absolute population estimates against the ratios obtained from a prospective index of abundance such as visual sighting rate. Unbiased and precise estimators will produce an exact correspondence (i.e., all points will lie on the line $Y = X$).

A relative population estimator that is “valid” in the sense of being correlated with absolute density may nonetheless be of no use if the confidence limits associated with the correlation span all or most possible population densities. For example, consider a species that occasionally achieves absolute population densities as high as 2500/ha. If a moderate visual encounter rate (e.g., 2 sightings/h) corresponds to an estimated absolute population density of 900/ha, but that estimator is bracketed by confidence limits of 0–2400/ha, the relative estimator is not useful.

To provide a common metric for confidence limits of species of varying abundances, we introduce the use of confidence limits expressed as percentile ranks of density. Percentile ranks are good for characterizing non-normal distributions or comparing distributions of unknown shape. Single-species abundances are rarely normally distributed—ours were not. Use of percentile ranks makes it possible to compare the utility of visual encounter rates among species of differing density.

Validation studies compare the performance of a proposed

method (the test method) against a proven reference method. For the lizard species considered, we compared the visual encounter rates (test method) to total removal samples (Rodda et al. 2001) obtained concurrently from an adjacent area (reference method). For the snake species considered, we compared the visual encounter rates to mark-recapture population estimates obtained concurrently from the same 1-ha plots. The validity of mark-recapture was established for this system by comparing mark-recapture population estimates to two total trap-outs of all snakes from 1-ha areas surrounded by snake-proof fencing (Campbell 1996). Comparing a test method to a reference method on a slightly different geographic area entails some sampling error, which should be manifest in reduced precision of the estimation. In the case of the snake sampling (identical areas), there is some loss of precision associated with estimating rather than measuring the absolute population density with the reference method. Nonetheless, these comparisons are among the first to rigorously measure the bias and precision of a relative sampling technique.

Sites.—Time-constrained visual encounter surveys (Crump and Scott 1994) and total removal sampling (Rodda et al. 2001) were conducted in three regions of Guam, Mariana Islands, 1993–97. Compared to a “region,” a “site” was a small (~ 1 ha) area within which visual surveys were conducted and one or more very small (~ 0.01 ha) total removal “plots” were laid out. Because visual surveys required more space than total removal plots, the geographic correspondence between these two methods was only partial, although an effort was made to establish sample plots and visual survey routes in habitat that was representative of the entire

site (see below).

Mark-recapture population estimation for snakes was performed quarterly at four sites in one of these regions (N 13.63, E 144.86) from 1993–94 (Campbell 1996). This habitat was scrubby secondary growth forest, consisting primarily of *Leucaena leucocephala*, an introduced legume tree having short stature (canopy heights 5–6.5 m) and tiny leaflets (3–4 x 5–8 mm). The three other sites were located in two regions of native forest, which supported a diverse array of trees, many of which had large leaves (e.g., *Pandanus* leaves up to 150 x 2000 mm; the dissected leaves of coconut palms may exceed 13 m in length). Visibility was reduced to a greater extent by the dense foliage in the large-leaved forest. Measured canopy heights were 9–15 m in the northern native-forest plots (N 13.65, E 144.86), and 5 m in the southern native-forest plots (N 13.35, E 144.67). For the purposes of our habitat analysis, sites were grouped into small-leaved forest and large-leaved forest.

Species.—Three small (1.0–2.2 g) arboreal nocturnal species of gecko were sighted with sufficient frequency for analysis: *Gehyra mutilata*, *Hemidactylus frenatus*, and *Lepidodactylus lugubris*. Two small (1.6–3.1 g) diurnal terrestrial skinks were sighted often enough for limited analysis: *Carlia* cf. *fusca* and *Emoia caeruleocauda*. The single snake studied, *Boiga irregularis*, is nocturnal and arboreal (Rodda et al. 1999b). It reached highest densities in the small-leaved habitat (Rodda et al. 1999c).

Reference population estimation.—Lizard abundance was estimated from total-removal plots (Rodda et al. 2001). This method involved erection of a lizard-proof fence during times when the species were inactive, and removal of all vegetation down to mineral soil while inspecting each item of vegetation for the presence of lizards (none of the sampled species permanently evaded capture by hiding below the surface). Thus the lizards were censused rather than surveyed in the sample plots. Of the seven sites under consideration, one was sampled by four 5 x 5 m plots, five were sampled with one 10 x 10 m plot, and one was sampled by two 10 x 10 m plots. The total number of lizards (of the five focal species) sampled per site averaged 147 (range 53–244).

Mark-recapture was used to obtain 29 estimates of absolute population densities of snakes (four sites sampled quarterly for two years). Sites were sampled daily for 15–32 d. Snakes were captured by hand and in standard brown treesnake traps (Rodda et al. 1999a), marked with PIT tags and released. Abundance estimates were obtained using the program MARK (White and Burnham 1999) under a size-stratified open model, using the relationship $N = \bar{n} / \hat{p}$, where \bar{n} is the size-stratified mean number of daily captures, and \hat{p} is the model’s best estimator for that size class’ average capture probability per day. Capture probability did not exhibit heterogeneity over time or by sex. As these plots were surrounded on all sides by 3–4 m swaths of mowed grass, and perimeter traps did not generally exhibit elevated capture probabilities, the nominal trap area (1 ha) was used for the estimation of density from abundance.

Test population estimation based on visual encounter surveys.—Experienced (> 100 h of previous surveys for these species in these habitats) reptile searchers conducted all visual encounter surveys. Observers walked forest transects at a slow speed (ca. 0.5 km/h), recording all reptiles seen on one side of a road or trail during surveys lasting 1–4 h. Nighttime surveys were conducted under

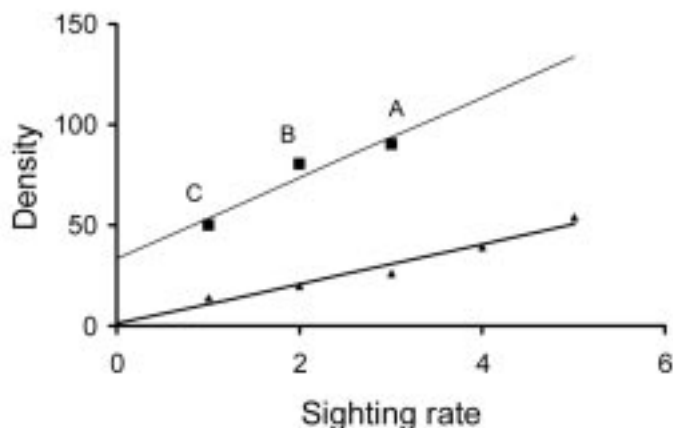


FIG. 1. Two hypothetical data sets expressing the relationship between relative and absolute population estimates. The detection fraction associated with each point is the point’s X value/Y value (or sighting rate/true density). Point A’s detection fraction, $3/90 = 0.033$, is higher than the detection fraction at B, $(2/40 = 0.025)$, which is in turn higher than the detection fraction at C ($1/50 = 0.020$). In a case such as this, in which detection fraction is reduced at progressively lower absolute population densities, the y-intercept of the associated regression line will be positive. In contrast, if the detection fraction is essentially constant vis-à-vis density (e.g., triangle points), the regression will pass through the origin (y-intercept = 0). The inverse of detection fraction (detection multiplier = Y value/X value) for a given point is equal to the slope of an imaginary line drawn from the point through the origin. Data sets composed of points with a constant detection fraction will therefore all lie along the same radial line and that line will pass through the origin.

the illumination of a headlamp (various manufacturers). Each comparison between an absolute population density and a visual encounter survey mean represents 2.5 km of transect (snakes) or 5.6–76.5 person hours of lizard searching (mean 31.1 h). The transect lines used for the small-leaved habitats were serpentine paths at 25 m intervals through the 1 ha sites from which mark-recapture estimates were obtained (total removal plots were placed near the middle of the 1 ha plots, in representative vegetation). Vegetation was judged to be representative on the basis of plant species composition, canopy height, and canopy closure. The large-leaved habitats did not have suitable paths through the middle of the study sites; instead, primitive road edges passing to within 100 m of the total removal plots were surveyed for a distance of about 1 km. The roads passed through similar habitat, although the preference of *Carlia fusca* for disturbed habitat no doubt biased upwards the abundance of that species in the vicinity of the large-leaved habitat transects.

Analyses.—We asked six questions: (1) Are relative and absolute measures of abundance correlated?; (2) Are detection fractions relatively constant at different densities within a species?; (3) Is the detection fraction constant among species of small lizards?; (4) Is the detection fraction constant between habitats?; (5) What range of population densities correspond to the confidence limits at moderate visual sighting rates (i.e., how precise are the observed correlations)?; and (6) What confidence limits best describe the relationship between ratios of absolute densities and ratios of sighting rates?

In assessing the strength of the correlations between absolute and relative measures, we used a no-intercept model. We report a sample-size adjusted r^2 , with the associated probability that the slope equals zero. To be conservative, all reported probability values are two-tailed, even for one-sided contrasts. We computed the regression of absolute population density on relative population estimator, because this is the direction of inference normally used for estimates of population abundances.

We did not have direct measurements of the detection fraction; therefore we could not directly test whether the detection fraction was different at higher or lower population densities. Instead, we tabulated the y-intercept values for unconstrained regressions of absolute population density on relative population estimators. A positive y-intercept would reflect a reduced detection fraction at lower population densities and a negative y-intercept would indicate the converse. The associated probability indicates the likelihood that the true value is zero for a given sample size. In addition, we express the y-intercept value in percentile scores of population density based on a mean of 28 (range 21–32) 10×10 m removal plots having non-zero densities. For example, the 90th percentile abundances of the study species, in ascending order, were *H. frenatus* (3500/ha), *L. lugubris* (4400/ha), *G. mutilata* (5300/ha), *E. caeruleocauda* (6300/ha), and *C. fusca* (9000/ha).

To address the question of whether the detection fraction was constant among species, we used the slope estimate (and SE) from the no-intercept regressions. The slope of the regressions is the inverse of detection fraction; therefore a high slope reflects a low detection fraction. It is perhaps easiest to think of the slope values as “detection multipliers.” They are “multipliers” in the sense that one can estimate an absolute population density by multiplying the relative measure of abundance by the detection multiplier. For

example, if the relative measure of abundance is 5 sightings/h and the applicable detection multiplier is 10, the estimated absolute density would be $5 \times 10 = 50$ individuals/ha. Thus detection multipliers are a convenient way to convert relative to absolute measures of abundance. Detection fraction captures the same information, but in less tangible quantities, usually small fractions.

In the case of the small-leaved habitats, our visual surveys were conducted entirely within the 1 ha sites, on trails having 1 km of trail edges (each survey was conducted on one side of a 0.5 km trail). Because the visual sighting rate was based on searches of exactly 1 ha, the same unit for which the absolute density is estimated, the detection multiplier in this case also expresses the number of individuals that were present for each individual seen. The number of overlooked individuals is the number present minus the number seen. A detection multiplier of 12 indicates that 11 unseen individuals existed in the area for each one sighted (detection fraction = 0.083). In the large-leaved habitats, the layout of 1 km visual search transects did not correspond to a 1 ha study plot, but the slope parameter reflects the same conceptual multiplier (each additional sighting corresponds to a density increase expressed by the slope value).

Sample sizes for quantifying detectability by habitat were sufficient for only *Hemidactylus* and *Lepidodactylus*. Because those species abundances were on different scales, reflecting different values in different habitats, we studentized (SAS Institute 1990) the residuals from each regression and compared the values of the z-scores between large and small-leaved habitats using a *t*-test after testing for equality of variances ($F = 3.84$; $P = 0.2$). To characterize the magnitude of the abstract scores in understandable units, we also report the mean detection multiplier for each species-by-habitat combination.

To characterize the precision of a relationship, we report the range of abundance percentiles corresponding to a midrange visual encounter rate. Confidence limits corresponding to negative population densities were truncated to zero.

The regression of \log_{10} absolute abundance ratios on \log_{10} sighting rate ratios produced confidence limits, slopes, and intercepts. Ratios were obtained for every pairwise permutation of nonzero values within a species. A proportional relative estimator will produce a slope of 1; therefore the slope was tested against the null hypothesis that it was equal to 1. The intercept has a less decisive interpretation, but proportionality requires that the $Y = X$ line pass through the origin; we tested the null hypothesis that the y-intercept was equal to 0. The computed y-intercept appears in the figure at an axis value of 1, as log values were back transformed for easier visualization.

We were concerned that the very small sample sizes obtained for the two skink species would result in potentially misleading correlation coefficients and confidence limits. To assess the magnitude of the small sample bias, we randomly extracted 10 subsamples of various small sizes ($N = 2, 3, 4, 5, 10, 20$, and 50) from a 100-point random distribution having the slope, range, intercept, and r^2 values characteristic of our empirical data sets. Using ten simulations of each sample size we computed the mean and variance of range of confidence limits (at mid slope), adjusted r^2 , and slope.

Were absolute densities correlated with sighting rates?—A positive relationship was evident for all species except brown

treesnakes (Fig. 2), for which the relationship was insignificant ($r^2 = 0.005$, NS). Although the regression is strongly influenced by two outliers (Fig. 2), the relationship is comparably weak with those outliers removed. The correlation between absolute and relative estimators was equivalent between observers (Fig. 2).

Four of the five lizard species exhibited a tight correlation ($r^2 > 0.9$), and three of these five were statistically significant (Table 1). However, the sample sizes ($N = 2$) for *Carlia* and *Emoia* were small. Based on our simulations of equivalent ($N = 2$) samples, the bias associated with r^2 in such small samples is trivial (our simulations produced an average r^2 0–2% less than the full data set).

Was the detection fraction constant at different densities within a species?—All six species exhibited a positive value for the y-intercept, although the difference was slight and statistically significant only for *Lepidodactylus*. Our simulations of small sample sizes indicated a small (5–7.5%) bias towards steeper slope at sample sizes of $N = 2$. This implies that large-sample y-intercepts for the skinks would be larger than that observed. The significant discrepancy for *Lepidodactylus* was the greatest observed (60th percentile). On average, about 2065 individuals of this species would be present in a hectare before the first *Lepidodactylus* was seen.

The regression of absolute population density ratios on sighting rate ratios (Fig. 3) had a slope of 0.40, significantly less than the desired slope of 1 ($P < 0.0001$). The intercept (0.62) also deviated significantly from zero ($P = 0.0037$). These results indicate that the detection fraction was lower at lower densities.

Was detection fraction constant among species?—The average detection multiplier for each species ranged from the relatively detectable *C. fusca* (mean detection multiplier = 12.88 (SE = 2.80); detection fraction = 0.0776) to the rarely seen *G. mutilata* (mean detection multiplier = 6105 (SE = 412.9); detection fraction = 0.00016). In descending order of detectability the three other species were *E. caeruleocauda* = 91.8 (SE = 14.1), *H. frenatus* = 143 (SE = 17.7), and *L. lugubris* = 848 (SE = 271.7). The wide gaps between detection multipliers (relative to SEs) reinforce the inference that detection is grossly different among species.

Was detection fraction constant between habitats?—Tests comparing large-leaved and small-leaved habitats for *Hemidactylus* and *Lepidodactylus* indicated that both geckos were seen significantly less often in the large-leaved habitat ($t = 2.55$, $df = 11$, $P = 0.027$). For *Hemidactylus*, the mean detection multiplier in small-leaved habitats was 163 (SD = 54), about an order of magnitude less than that for large-leaved habitats, 1511 (SD = 703). *Lepidodactylus* was seen less often than *Hemidactylus* (higher detection multipliers on average), but exhibited a similar tenfold difference between habitats. In small-leaved habitats its detection multiplier averaged 984 (SD = 618), whereas that in large-leaved habitats averaged 9914 (SD = 5372).

How wide were the density confidence limits?—At moderate sighting rates *Lepidodactylus* and *Emoia* had density confidence limits that covered the full range of known densities (0–100th percentile) for the species. *Hemidactylus* and *Carlia* exhibited confidence limits that covered most of the known densities (0–90th percentile and 0–60th percentile, respectively). *Gehyra mutilata* was exceptional: a moderately successful visual survey (0.25 sightings/h) corresponded to a reasonably precise characterization of the

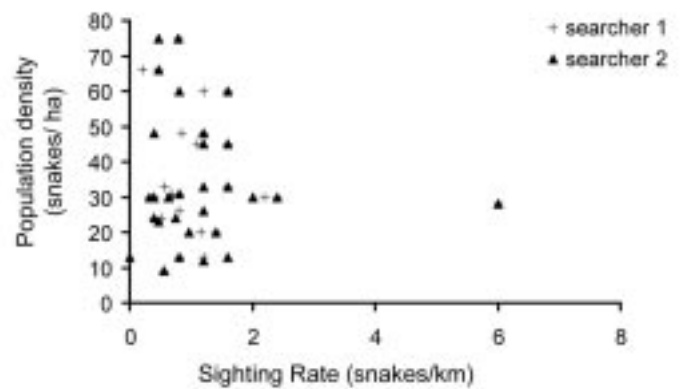


FIG. 2. The relationship between population density of *Boiga irregularis* in 1-ha *Leucaena leucocephala* forest, Guam, 1993–94 and snake sighting rates of two searchers searching each plot five times (total 2.5 km of searching per datum).

absolute density (50–70th percentile). The confidence limits for skinks are undoubtedly inflated by the small number of samples evaluated. Our simulations of two-sample regressions indicates that confidence limits for such small samples are 4.8–5.7 fold those based on 100 points; thus the width of the confidence limits for *Carlia* and *Emoia* need to be revisited when larger samples of comparisons become available. The other species have sample sizes that yield confidence limits only marginally larger than asymptotic values.

What confidence limits best describe the relationship between ratios of absolute densities and ratios of sighting rates?—The confidence limits associated with ratios were large, in keeping with the double inference being made (that both baseline and follow-up measurements were accurate reflections of true population density). For example, if the second measurement had been tenfold that of the baseline value, the naïve expectation would be that the population had increased tenfold. Instead the confidence limits range 0.33–7.5, indicating that the population could have shrunk by as much as threefold (ratio: 0.33) or increased by as much as 7.5-fold, although the most likely change was of a modest increase of about 60% (1.6-fold). The failure of the confidence limits to include the naïve expectation highlights the observed deviation from constant detection at different population densities. The wide confidence limits highlight the weakness of the double inference associated with ratios. Note that the absolute density ratio of 1 (no population change) is within the confidence limits for all of the sighting rate ratios considered (0.1–100 fold).

The overall analysis suffers from small sample sizes and incomplete geographic correspondence between test and reference plots. Thus it is encouraging that five of six species exhibited reasonably tight ($r^2 > 0.5$) positive correlations and four of five lizards exhibited very tight ($r^2 > 0.9$) correlations between absolute and relative population estimators. The presumption underlying single species relative abundance measures appears generally valid. The apparent exception is brown treesnakes, for which no correlation was evident. Our prior experience (e.g., Rodda et al. 1999c) using larger samples of visual sightings of brown treesnakes suggests that the fundamental premise is correct for brown treesnakes, but the effort contributing to each individual datum in the present study was inadequate (Rodda and Fritts 1992). Although each da-

TABLE 1. Correspondence of absolute population estimates obtained from mark-recapture (*Boiga*) or total removal plots (all lizards) to visual encounter surveys. An ideal visual survey would exhibit $r^2 = 1$, 95% confidence limits (CL) at midrange that were very narrow and near 50%, and a y-intercept near zero in both absolute density and percentile of abundance.

Species	Relationship between absolute and relative abundance	N	95% CLs at Midrange Sight Rate (percentiles)	Y-intercept	
				Individuals/ha	Percentile
<i>Boiga irregularis</i>	$r^2 = 0.005$, NS	58	Not applicable	36 (NS)	28
<i>Carlia fusca</i>	$r^2 = 0.91$, NS	2	0–60	216 (NS)	7
<i>Emoia caeruleocauda</i>	$r^2 = 0.95$, $P = 0.097$	2	0–100	137 (NS)	12
<i>Lepidodactylus lugubris</i>	$r^2 = 0.56$, $P = 0.021$	7	0–100	2065 ($P = 0.01$)	60
<i>Hemidactylus frenatus</i>	$r^2 = 0.90$, $P < 0.0002$	7	0–90	487 (NS)	45
<i>Gehyra mutilata</i>	$r^2 = 0.97$, $P < 0.0002$	4	50–70	114 (NS)	14

tum summarized five passes by each observer (2.5 km of visual searches), and although the snake is exceptionally abundant in the study habitat, 2.5 km of visual searches appears to be insufficient to accurately characterize density. The higher density of lizards, combined with the more extensive surveying effort for them ($\bar{x} = 31.1$ h) apparently sufficed to produce strong positive correlations between relative and absolute population measures, although confidence limits were excessively wide in four of five cases. Additional validation work is needed to establish the sample size needed for an adequate level of precision.

Based on all six species exhibiting positive y-intercepts, and the low slope and nonzero intercept exhibited by the regression of ratios, we conclude that reduced detection fraction at low population densities may be a widespread problem with visual encounter surveys. Further investigation of this problem seems warranted, especially in light of the large magnitude of the intercept in some species (e.g., *Lepidodactylus*), and the high level of statistical uncertainty. On the basis of the information presented in this paper, we would not be comfortable with the assumption of proportionality for either *Hemidactylus* or *Lepidodactylus*. Further study into

the magnitude and shape of the low-density decline in detection probabilities for those species may allow a correction factor to be incorporated for unbiased estimates.

The gross differences in detection multipliers or detection fractions among the species we studied indicate that relative population measures should not be used interspecifically to characterize abundances. Even species with similar sizes and habits (e.g., *Hemidactylus* and *Gehyra*) exhibited substantial differences in detectability within a single habitat type. We conclude that interspecific population density comparisons should not be based on visual survey data in the absence of validation studies that quantify the detection probabilities in the system of interest.

The difference in detectability of small geckos between habitats was about tenfold. The generality of this value is of great interest. Are habitats usually more or less similar in visibility of reptiles? Some rules of thumb would be useful for planning inventory and monitoring efforts.

We were discouraged by the wide confidence limits associated with the visual surveys we conducted. Based on the information presented, we would select visual surveys as an adequate sampling tool only for *G. mutilata*. Unfortunately, it is difficult to assess whether the reported confidence limits would be appreciably smaller if based on exhaustive visual surveys having a perfect geographic correspondence between test and reference methods. Further comparisons would be of interest, not only for the species we reviewed, but for other visually sampled species as well. It is perhaps notable that the species with the lowest detection rate, *G. mutilata*, was also the species with the most precise correlation between visual sightings and absolute density. The effective sample size was small, even for inferences limited to this species. Also, the bulk of the data for this species came from a single habitat type. Further study is needed to determine whether highly precise correlations are characteristic of certain species or habitats.

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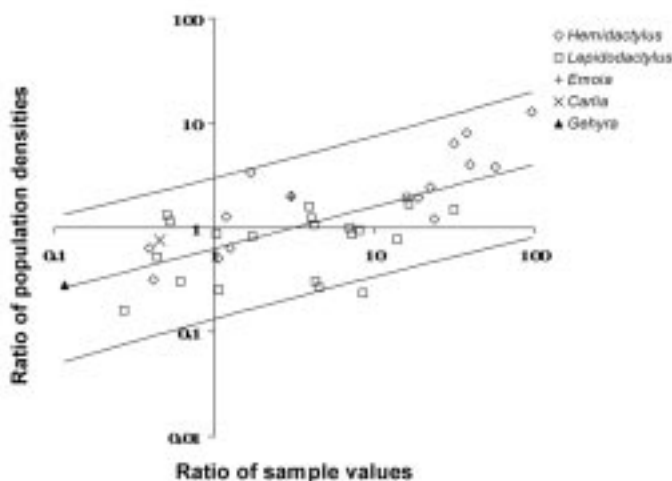
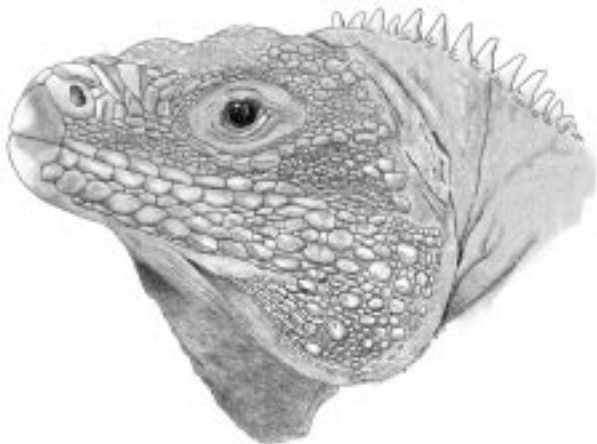


FIG. 3. The relationship between ratios of population densities and ratios of visual sighting rates for five species of lizard. All pairwise comparisons for non-zero values within a species are given, with the associated regression line and 95% confidence limits.

LITERATURE CITED

- CAMPBELL, E. W., III. 1996. The effect of brown tree snake (*Boiga irregularis*) predation on the island of Guam's extant lizard assemblages. Unpubl. Ph.D. Diss. Ohio State Univ., Columbus, Ohio.
- CRUMP, M. L., AND N. J. SCOTT, JR. 1994. Visual encounter surveys. In W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, and M. S. Foster (eds.), *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians*, pp. 84–92. Smithsonian Inst. Press, Washington, DC.
- HENKE, S. E. 1998. The effect of multiple search items and item abundance on the efficiency of human searchers. *J. Herpetol.* 32:112–115.
- RODDA, G. H. In press. Comparison of techniques. In M. S. Foster, R. W. McDiarmid, C. Guyer, J. W. Gibbons, and N. Chernoff (eds.), *Measuring and Monitoring Biological Diversity: Standard Methods for Reptiles*. Smithsonian Inst. Press, Washington, DC.
- , E. W. CAMPBELL, III, AND T. H. FRITTS. 2001. A high validity census technique for herpetofaunal assemblages. *Herpetol. Rev.* 32:24–30.
- , AND T. H. FRITTS. 1992. Sampling techniques for an arboreal snake, *Boiga irregularis*. *Micronesica* 25:23–40.
- , ———, C. S. CLARK, S. W. GOTTE, AND D. CHISZAR. 1999a. A state-of-the-art trap for the brown treesnake. In G. H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka (eds.), *Problem Snake Management: the Habu and the Brown Treesnake*, pp. 268–305. Cornell Univ. Press, Ithaca, New York.
- , ———, M. J. MCCOID, AND E. W. CAMPBELL, III. 1999b. An overview of the biology of the brown treesnake, *Boiga irregularis*, a costly introduced pest on Pacific Islands. In G. H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka (eds.), *Problem Snake Management: the Habu and the Brown Treesnake*, pp. 44–80. Cornell Univ. Press, Ithaca, New York.
- , M. J. MCCOID, T. H. FRITTS, AND E. W. CAMPBELL, III. 1999c. Population trends and limiting factors in *Boiga irregularis*. In G. H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka (eds.), *Problem Snake Management: the Habu and the Brown Treesnake*, pp. 236–253. Cornell Univ. Press, Ithaca, New York.
- SAS INSTITUTE. 1990. *SAS/STAT User's Guide. Volume 2, GLM-VARCOMP*. SAS Institute, Cary, North Carolina. 1686 pp.
- WHITE, G. C., AND K. P. BURNHAM. 1999. Program MARK: survival estimation from populations of marked animals. *Bird Study* 46 (Suppl.):120–138.



Cyclura lewisi (Grand Cayman Blue Iguana). Adult male, born 1993, held in captivity at the Shedd Aquarium in Chicago. Illustration by John Bendon (Lizardwizard@btinternet.com).

An Effective New Radio Transmitter Attachment Technique for Lizards

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Radio telemetry is a valuable method for acquiring important ecological information such as home range, habitat preference, and dispersal distance for many types of wildlife (White and Garrott 1990). One of the limitations with using telemetry is the difficulty of developing a reliable and safe transmitter attachment technique to facilitate consistent research. Multiple transmitter attachment methods are available for a variety of lizards, with additional approaches being introduced as telemetry becomes increasingly popular and techniques are refined through trial and error (see Richmond 1998; Ussher 1999).

Using radio telemetry on saxicolous lizards living among jagged, xeric limestone conditions presents serious challenges for wildlife researchers. West Indian iguanas (genus *Cyclura*) are particularly difficult because they inhabit areas of sharp limestone and squeeze into small retreat openings, often causing the loss of externally affixed transmitters. Attaching external transmitters to hatchling or subadult iguanas also is problematic because of their small size and potential for rapid growth. Numerous radio transmitter attachment methods have been attempted, with variable results, on adults of this genus (reviewed in Goodman 2005), but none have been successful for hatchlings or juveniles.

We devised a technique for attaching radio transmitters to recently hatched Andros Iguanas (*Cyclura cychlura cychlura*) during a study of natal dispersal, survival, and habitat preferences. Data on these parameters are crucial for developing a science-based management program for this endangered lizard, especially since little ecological information is available for hatchlings of this species or its congeners.

We conducted our study from 12 August to 9 October 2003, and 3 August to 14 September 2004 on Andros Island, Bahamas, primarily in pine woodland, scrub, and mangrove habitats. Forty-one hatchlings in 2003 and 36 hatchlings in 2004 were collected for radio tracking directly from nests or from incubated eggs. Hatchlings ranged from 31 to 57 g in body mass (mean = 44; S.D. = 5.56), 84–106 mm in snout–vent length (mean = 97; S.D. = 0.41), and 122–171 mm in vent–tail length (mean = 153; S.D. = 0.97). To radio track lizards we used BD-2 (17 × 8.5 × 5.5 mm) and PD-2 (23 × 12 × 5.5 mm) model transmitters (Holohil Systems Ltd., Ontario, Canada). The average battery lifespan for the

BD-2 and PD-2 transmitters was 12 and 16 weeks, respectively. The BD-2 (1.9 g) and PD-2 (2.7 g) transmitters after encapsulation represented between 4.1 and 9.0% (mean = 6.0%; S.D. = 0.7) of hatchling body mass.

To test the efficacy of the attachment technique on another lizard species, we attached transmitters during the 2004 field season to three adult Curlytail Lizards (*Leiocephalus carinatus coryi*) inhabiting the same study sites and tracked them between 16 and 30 days. The lizards ranged from 39–45 g in body mass (mean = 42.7), 91–98 mm in SVL (mean = 95), and 127–151 mm in vent–tail length (mean = 139). The transmitters were between 4.9 and 6.0% (mean = 5.7%) of adult body mass.

The transmitters and batteries were encapsulated in an inert waterproof epoxy with tubes attached laterally through the anterior and posterior ventral edges. The antenna was a 20 cm long flexible stainless steel wire covered with a black nylon coating and shrink tubing to reinforce the base. Using a hand-held 3-element Yagi directional antenna and a Wildlife Materials, Inc. (Carbondale, Illinois, USA) TRX-48S receiver, we obtained a signal range of 500 m over open, flat terrain that was reduced to 200 m in closed forest conditions.

To attach a transmitter, two 15 cm pieces of 20 lb test monofilament line were cut (length may vary depending on personal preference and size of animal) and one piece inserted through the anterior and the other through the posterior tube of the transmitter. The transmitter was placed on the dorsal side of the pelvic girdle, the anterior monofilament line was wrapped around the lizard's body (anterior to the hind limbs) and tied with two square knots in the lateral inguinal region using needle-nose pliers. A dab of ethylcyanoacrylate glue gel was then applied to the knot to prevent it from slipping. The posterior monofilament line was then wrapped loosely around the tail, tied, and glued as above. All extra line was trimmed (Fig. 1). The antenna protruded farther than the tail tip, but appeared to have no effect on the animals. Although antennas can be trimmed, this will limit the maximum signal detection distance.

An assumption of radio tracking investigations is that animal movements are not affected by researcher techniques (White and Garrott 1990). Although not quantified, our method appears to have no significant effect on iguana behavior or movement. All hatchling iguanas ran, jumped, swam, and climbed trees without apparent difficulty. Lizards were found in pine trees 10 m above the ground, in underground (and at times underwater) limestone

retreats, and within mangrove islands which required overwater movement. The Curlytail Lizards also appeared unaffected by the transmitters. The inert waterproof epoxy was gray in color and was relatively cryptic in our study environment. The epoxy can be painted to either facilitate detection by the researcher or to offer additional camouflage for the lizard.

Although no transmitters detached from the animals during the study, this technique does have limitations. Abrasions developed after two weeks in the inguinal region of five (12%) iguana hatchlings in 2003. When this occurred, we recaptured the lizard and reattached the transmitter on the ventral surface directly posterior to the cloaca using the method described above. Repositioning the transmitter removed pressure from the ventral inguinal region where the abrasions were occurring. Abrasions healed after one week and the new ventral transmitter placement appeared to have no effect on the movements, activity, or defecation ability of the hatchlings.

During the 2003 study, we noted that the posterior (tail) monofilament line often snagged on jagged limestone surfaces or tree bark as the lizards moved, thereby increasing cutting pressure on the

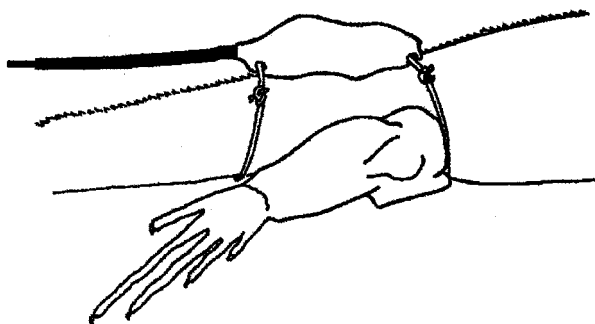


FIG. 1. Lateral view of PD-2 transmitter attachment method with both the anterior and posterior monofilaments lines tied.

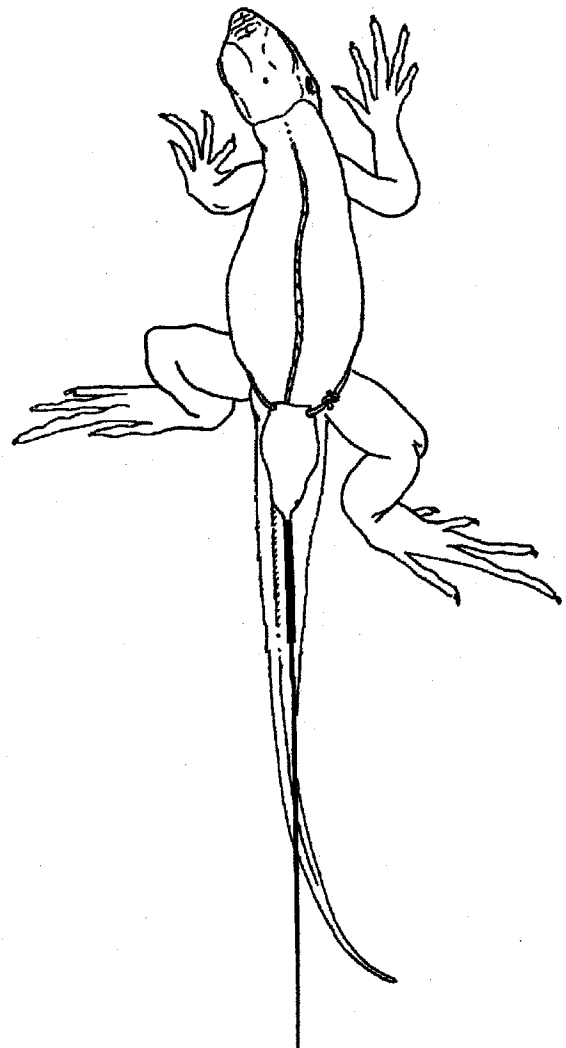


FIG. 2. Dorsal view of PD-2 transmitter attachment method with only the anterior monofilament line tied.

inguinal region. Therefore, we attached the last ten transmitters in 2003 and all the transmitters in 2004 without using the posterior monofilament line and secured the anterior (inguinal region) line more loosely (Fig. 2). This method also was effective, and in our opinion, was the better of the two options, as it allowed the transmitter to move slightly as the lizard moved, thereby reducing pressure on the inguinal region. The transmitter rotated on the body at times and occasionally flipped back and forth as the animals moved backwards then forwards in enclosed spaces. However, no abrasions were found during the remaining four weeks of the project in 2003 or throughout most of 2004. All surviving hatchlings in 2003 (N = 2) and 2004 (N = 8), as well as the three *Leiocephalus* in 2004, were recaptured at the end of this study and transmitters were removed. All recaptured iguanas had maintained, or gained body mass, were free of abrasions, and appeared healthy. One curlytail lizard, which was not recaptured until 30 days after initial attachment, exhibited slight cutting abrasions in the inguinal region.

No lizards died during this study directly as a result of the attachment method. Because very little material is required for this convenient and easy procedure, lizards can be harnessed in the field within minutes using only minimal equipment. However, we encourage using this technique only if lizards can be reliably recaptured. The monofilament line may not present a significant problem for adult lizards of equivalent size, but long-term survival of growing hatchlings will be affected if the line is not removed. Additionally, 83% and 61% of radio-tagged hatchlings were visually confirmed to be eaten by snakes in 2003 and 2004, respectively. Although we feel time of release after hatching may have influenced the higher than expected predation rates in 2003, we cannot exclude the possibility that the transmitter attachment played a role. The potential benefits of using this technique warrants further study with results being disseminated in the literature. A future modification could include inserting the monofilament line through low-diameter Tygon® tubing so that the potential for long-term cutting into the inguinal region of adult lizards is further reduced. In conclusion, use of this method allowed us to elucidate many previously unknown aspects of the behavior and ecology of *Cyclura* hatchlings (Knapp and Owens 2004), and should be applicable to other lizards of similar size.

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LITERATURE CITED

- GOODMAN, R. M. 2005. Attachment of radio transmitters in a rock iguana, *Cyclura nubila lewisi*. *Herpetol. Rev.* 36:150–152.
- KNAPP, C. R., AND A. K. OWENS. 2004. Diurnal refugia and novel ecological attributes of the Bahamian Boa, *Epicrates striatus fowleri* (Boidae). *Carib. J. Sci.* 40:265–270.
- RICHMOND, J. Q. 1998. Backpacks for lizards: A method for attaching radio transmitters. *Herpetol. Rev.* 29:220–221.

USSHER, G. T. 1999. Method for attaching radio transmitters to medium-sized reptiles: trials on tuatara (*Sphenodon punctatus*). *Herpetol. Rev.* 30:151–153.

WHITE, G. C., AND R. A. GARROTT. 1990. Analysis of Wildlife Radio-tracking Data. Academic Press, New York. 383 pp.

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A New Technique for Capturing Pacific Pond Turtles (*Actinemys marmorata*) and a Comparison with Traditional Trapping Methods

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Various techniques have been used to capture freshwater turtles in the field, including hand collecting, dipnetting, snorkeling, fyke nets, baited hoop nets, collapsible traps, basking traps, and funnel traps (Iverson 1979; Kennett 1992; Kuchling 2003; Legler 1960; Vogt 1980). Pacific Pond Turtles (*Actinemys marmorata*) occur in slow-moving or stagnant aquatic habitats from British Columbia south to northwestern Baja California. The most common techniques used to capture *A. marmorata* have been snorkeling, basking traps, and funnel traps (Bury 1972; Germano and Bury 2001; Reese 1998).

I used capture-recapture methods for estimating population size, structure, and population density of the western pond turtle at Sunol Regional Wilderness, Alameda Co., California, USA. Sites were small to medium-sized (< 400 m²) artificial stockponds, with a silt and clay substrate, and devoid of emergent vegetation. To optimize my capture and recapture rate, I tested four capture methods: funnel traps, basking traps, hand collecting, and a new technique, baited wires.

Funnel traps measured 0.8 m in length and 0.5 m in width and height. Each trap was made using 2 cm mesh of non-stretch, metallic netting painted dark green. The mouth of the trap was an elliptical funnel decreasing in diameter towards the bait. The mouth of the trap was large enough to allow adult turtles to enter (carapace width of the largest individuals is about 130 mm). Funnel traps were baited with fresh beef attached on a string to the center of the trap.

Basking traps had a rectangular shape and measured 0.8 m in length and 0.6 m in width and depth. A net was held afloat at its perimeter with a PVC pipe of 0.1 m in diameter. Two wood ramps allowed turtles to climb over the PVC pipe and to bask on a platform (0.8 m in length and 0.20 m in width) in the center of the trap.

Hand collecting consisted of walking slowly along the shoreline of the pond. When turtles were observed near the shoreline from a distance of 0.3 m, I used a dipnet to capture individuals before they escaped to deep water.

The baited wires consisted of bait attached to a heavy non-corrosive metallic wire, 0.1–0.2 m long, firmly anchored to a rock or other heavy object along the shoreline of the pond. Yellow vinyl marking flags were attached to the baited wires to locate

TABLE 1. Capture efficiency of three traditional capture techniques for Pacific Pond Turtles, *Actinemys marmorata*, compared to a new technique, baited wires. Data were collected during May 2002, at the Sunol Regional Wilderness, Alameda County, California.

Capture technique	Bait	Number of Traps	Trap days*	Number of Captures	Captures/trap day
Hand	None	None	4	4	1.0
Baited Wires	Beef	4	16	340	21.3
Basking Traps	None	3	12	20	1.7
Funnel Traps	Beef	3	12	5	0.4

*A trap-day consists of one trap set for 3 h between 1000 h and 1600 h.

them from a distance. A bait of fresh stew beef worked very well, even after multiple turtle bites. Sardines or other small fish disintegrated too rapidly in the water and therefore did not work as well. The bait was placed in shallow water usually < 0.25 m from the shoreline. Baited wires were placed around the pond at intervals of 2–5 m and checked every 10 minutes from a distance. When turtles were observed feeding on the bait, they were approached slowly and captured by hand or with a small dipnet. An average of 10 turtles could be caught without changing the bait. My assistant, who had never caught turtles before, tested the baited wires during a three-hour session. Her capture rate was about the same as mine.

The four capture techniques were tested during four days in May and June 2002, with at least seven days between each testing day. These tests were conducted at the beginning of the study in order to find the most effective capture method for my study sites. During each testing day, I exclusively used three basking traps for the first three hours (in about 1.5 h my capture rates dropped to zero). By using only basking traps, I intended to limit basking behavior disturbance that could be associated with the simultaneous use of other trapping techniques. After three hours, I used baited funnel traps and baited wires in addition to basking traps. During this period, I also captured turtles by hand when they were encountered. Three baited funnel traps, three basking traps, and four baited wires were set at haphazard intervals along the banks of a 300 m² stockpond known to have a large density of pond turtles. There was no emergent vegetation and the shoreline sloped gradually. The study periods were between 1000 and 1600 h under sunny skies and little wind (< 7 m/sec). Air temperatures were 22–28°C, and water temperatures at a depth of 0.1 m were 22–27°C.

The baited wire technique captured more than 20 times the number of turtles captured by the next best technique (Table 1). Using the baited wires, I captured 1–3 turtles every 15 min. This technique created less disturbance than the other methods when turtles were removed.

Turtles caught by hand were mostly hatchlings and small juveniles, which do not feed on beef baits (Bury 1986). All of the hatchlings were captured by hand, either in the water in algae or on land when moving from their nest to the water.

Funnel traps captured few individuals (0.4 per trap day), perhaps because the pond was small and removing turtles and replacing the bait in traps created too much disturbance. Also, turtles appeared to have trouble finding the entrance to the traps.

Basking traps captured turtles during the first part of each daily trapping session (1.7 per trap day), but, in most cases, capture rates dropped to zero during the later half of the trapping session.

It appeared that the disturbance caused by removing turtles from the basking traps caused other turtles to avoid the basking traps.

In the proper habitat, baited wires are very efficient, cheap in cost (< US \$0.50/wire), and require minimal equipment. Their placement takes very little time. Furthermore, the technique precludes injury to sympatric, threatened or endangered amphibians and reptiles (e.g., California Red-legged Frogs [*Rana draytonii*], California Tiger Salamanders [*Ambystoma californiense*], or Giant Garter Snakes [*Thamnophis gigas*]).

Baited wires work well in ponds with open banks and a low gradient. If the shoreline is too steep, it might be difficult to catch turtles, even with a dipnet. I have never tested the baited wire technique in a stream, but it could also work where the banks are open and the water is shallow.

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LITERATURE CITED

- BURY, R. B. 1972. Habits and Home Range of the Pacific Pond Turtle, *Clemmys marmorata*, in a Stream Community. Unpublished Ph.D. dissertation. University of California at Berkeley. 205 pp.
- . 1986. Feeding ecology of the turtle, *Clemmys marmorata*. J. Herpetol. 20:515–521.
- GERMANO, D. J., AND R. B. BURY. 2001. Western pond turtles (*Clemmys marmorata*) in the Central Valley of California: status and population structure. Trans. West. Sect. Wildl. Soc. 37:22–36.
- IVERSON, J. B. 1979. Another inexpensive turtle trap. Herpetol. Rev. 10:55.
- KENNETT, R. 1992. A new trap design for catching freshwater turtles. Wildl. Res. 19:443–445.
- KUCHLING, G. 2003. A new underwater trap for catching turtles. Herpetol. Rev. 34:126–128.
- LEGLER, J. M. 1960. A simple and inexpensive device for trapping aquatic turtles. Proc. Utah Acad. Sci. 37:63–65.
- REESE, D. A. 1998. Comparative demography of *Clemmys marmorata* populations in the Trinity River of California in the context of dam-induced alterations. J. Herpetol. 32:505–515.
- VOGT, R. C. 1980. New methods for trapping aquatic turtles. Copeia 1980:368–371.

Use of Native Dominant Wood as a New Coverboard Type for Monitoring Eastern Red-backed Salamanders

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The Eastern Red-backed Salamander (RBS, *Plethodon cinereus*), probably the most abundant salamander in many forests of eastern North America (Burton and Likens 1975; Conant and Collins 1991; Jaeger 1980), has been widely used as an indicator of forest disturbance in recent years (deMaynadier and Hunter 1998; Harpole and Haas 1999; Moore et al. 2002). Because RBS are ectotherms and lungless, they may be affected by forest canopy loss because of changes in temperature and humidity that result (deMaynadier and Hunter 1998; Harpole and Haas 1999). Furthermore, Welsh and Droegge (2001) have proposed the use of plethodontid salamanders (family Plethodontidae) for monitoring biodiversity and ecosystem integrity in North American forests.

The use of artificial coverboards is one of the most popular techniques for monitoring plethodontid salamander populations (Table 1; Fellers and Drost 1994). Coverboards simulate decaying logs or woody debris, under which salamanders can be found (Heatwole 1962; Marsh and Goicochea 2003; Moore et al. 2000). Coverboards are often preferred to other sampling methods, such as pitfall traps and drift fences, night transects, and unit-effort searches of natural cover objects, because they represent a non-disruptive technique, impose little risk of mortality to both salamanders and non-target species, and minimize observer bias and errors (DeGraaf and Yamasaki 1992; Enright et al. 1998; Fellers and Drost 1994; Harpole and Haas 1999). Moreover, coverboards are a time- and cost-effective method for obtaining an index of salamander population size (Enright et al. 1998).

To test the effectiveness of wood from a native dominant tree species to monitor RBS, slices of sugar maple (*Acer saccharum* Marsh.) logs were used as coverboard material in a northern hardwood forest of Québec (Lake Clair Watershed: LCW, Canada). Small boards were used (36 to 42 cm in diameter) because it was easier to transport and install them throughout the watershed. Although several types of wood were used for coverboards in other studies (Table 1), none, to my knowledge, has used wood from a native dominant tree species to monitor salamanders.

The LCW (226 ha, 46°57'N, 71°40'W, elevation: 270 to 390 m) is located approximately 50 km northwest of Québec City, Québec, Canada. The overall vegetation is dominated by deciduous species (83%) with small patches of conifers (17%). The deciduous species consist mainly of sugar maple in association with yellow birch (*Betula alleghaniensis* Britton) and American beech (*Fagus grandifolia* Ehrh.). The coniferous component includes balsam fir (*Abies balsamea* (L.) Mill.), red spruce (*Picea rubens* Sarg.), and white birch (*Betula papyrifera* Marsh.). The soil is a sandy loam of the Ste-Agathe series (Raymond et al. 1976) and is classified as an Orthic Ferro-Humic Podzol according to *The Canadian Sys-*

tem of Soil Classification (Canada Soil Survey Committee 1992). The humus is of mor type, and the main surface deposit is a very acidic and stony till (stone content of 25%, 1–3 m depth) on an underlying granite and syenite bedrock. Average slope is approximately 10%. Mean annual temperature is 3.4°C, and annual precipitation is 1300 mm.

In August 2001, a sugar maple tree with a diameter of 42 cm at breast height was felled. A chainsaw was used to make 104 circular sections of 4 cm thickness from the tree trunk. Boards had a diameter and surface area varying from 36 to 42 cm, and 0.09 to 0.14 m², respectively. Thirteen transects were established around the lake, perpendicular to the slope. Sugar maple coverboards were placed in early September 2001 along these transects at distances varying between 0 and 200 m (0, 5, 10, 20, 40, 60, 100, 150, 200 m) from the shore of the lake edge. Boards were allowed to weather for approximately nine months (September to May) prior to sampling. Coverboards were sampled during daylight hours, five times in 2002 and four times in 2003 at approximately six-week intervals from the end of May through mid-October. All boards were checked on a single rainless day (sunny or cloudy). Salamander species were recorded and snout–vent length (SVL) was measured in the field to the nearest 0.1 mm with dial calipers. Salamanders were weighed to the nearest 0.1 g with a 10 g Pesola® spring scale. No attempt was made to sex salamanders. Salamanders were handled in a transparent plastic bag sprayed with lake water. After measurements were taken, salamanders were immediately released at the edge of the coverboard.

Correlation analysis was used to evaluate the relationship between coverboard surface areas and three characteristics of RBS (weight, snout–vent length and number found under each board). Outlier analysis and normality of the data were assessed with residuals. Statistical procedures were performed using SAS v. 8.01 (SAS Institute Inc. 2000).

During the two sampling years, 285 RBS, 23 *Eurycea bislineata* (Two-lined Salamander) and one *Notophthalmus viridescens* (Eastern Newt) were found, for a total of 309 salamanders. Coverboards with solitary salamanders totalled 219, 36 coverboards had 2 salamanders, 3 had 3 and 2 had 4. Eight of the captures were with two-lined salamanders. Such simultaneous captures were also observed in other studies for RBS (Bonin and Bachand 1997; DeGraaf and Yamasaki 1992; Monti et al. 2000), and suggest that RBS are not excluding conspecifics (Monti et al. 2000). These coverboards were used by RBS for reproduction, since egg clusters were occasionally found (~3 egg clusters per year for 104 coverboards).

The encounter rate per boards was 28% and 27% for all salamanders and RBS, respectively. These rates are the highest reported for coverboards in the literature (Table 1). These results confirm the effectiveness of coverboards (Bonin and Bachand 1997; Davis 1997; DeGraaf and Yamasaki 1992; Stewart and Bellis 1970), particularly those used in the present study, for surveying plethodontid salamander species. These encounter rates are higher than expected due to the low pH of the upper soil at LCW (pH = 2.8 to 3.6: Houle et al. 1997; Moore, unpubl. data). Previous studies have demonstrated the influence of soil pH on the occurrence of RBS (Wyman 1988; Wyman and Hawksley-Lescault 1987). Red-backed salamanders prefer neutral or basic environments over acidic areas (Mushinsky and Brodie 1975; Vernberg 1955; Wyman

TABLE 1. Studies having used coverboards for monitoring plethodontid salamanders in North America.

Author	Study area and forest type	Coverboard material	Coverboard dimension L x W x H (cm)	Most abundant salamander or salamander studied	Mean encounter rate of most abundant salamander found under coverboard (%) ¹
Bonin and Bachand 1997	Québec, Canada Northern Hardwood	Chipboard	30 x 30 x 1	<i>Plethodon cinereus</i> <i>Eurycea bislineata</i>	11
DeGraaf and Yamasaki 1992	New Hampshire Northern Hardwood	Pine ²	100 x 20 x 2	<i>Plethodon cinereus</i>	10
DeGraaf and Yamasaki 2002	New Hampshire Northern Hardwood	Hemlock ² (air-dried)	200 x 25 x 2.5	<i>Plethodon cinereus</i>	16.9
Davis 1997	Vancouver, Canada Westcoast Conifer	Cedar ² (untreated, rough-cut)	Modified coverboard	<i>Plethodon vehiculum</i>	n.a.
Grant et al. 1992	South Carolina Diverse forest types	Plywood chipboard	133 x 66 x 2	<i>Plethodon glutinosus</i> <i>Eurycea quadridigitata</i>	7 ³
Harpole and Haas 1999	Virginia Hardwood	<i>Liriodendron tulipifera</i> (rough-cut)	60 x 30 x 5	<i>Plethodon cinereus</i>	16.8
Mathis 1990	Virginia Mixed Deciduous	Pine ²	23 x 24 x 2 11 x 11 x 2	<i>Plethodon cinereus</i>	n.a.
Monti et al. 2000	Maine Red oak-white pine	Cedar ²	25 x 10 x 2	<i>Plethodon cinereus</i>	2.4
Ryan et al. 2002	South Carolina Diverse forest types	Plywood chipboard	120 x 60 x 1.3	None specified	n.a.
Stewart and Bellis 1970	Pennsylvania Diverse forest types	Pine ²	23 x 19 x 2	<i>Desmognathus f. fuscus</i>	4.2
Sugar et al. 2001	Ontario, Canada Diverse forest types	Spruce, pine, fir ²	Modified coverboard	<i>Plethodon cinereus</i>	n.a.
Taub 1961	New Jersey Hardwood	Pine ²	30 x 25 x 3	<i>Plethodon cinereus</i>	n.a.
This study	Québec, Canada Northern Hardwood	Sugar maple	Diverse (tree slices)	<i>Plethodon cinereus</i>	27

Notes:

n.a. = not available

¹ Estimate made from study's data. Data came from mature stands.² Scientific name and/or origin not specified.³ Diverse habitats.

and Jancola 1992). Wyman and Hawksley-Lescault (1987) observed that very few individuals of this species were found on forest soils with pH < 3.7. More studies will be needed at the LCW to explain this phenomenon. One explanation for the high encounter rate of RBS under coverboards could be that if woody debris is limited, adding refugia may attract salamanders to an area regardless of other habitat variables (Monti et al. 2000). However, sugar maple decline has occurred for more than a decade at LCW (Duchesne et al. 2003), resulting in a relatively large amount of woody debris on the forest floor. Another explanation could be

the younger age of coverboards in the present study (1 to 2 years) when compared to other woody debris. However, a comparison of sampling results from 2002 (137 RBS in five inventories) and 2003 (148 RBS in four inventories) does not support this hypothesis at this time, although longer monitoring will be needed to understand the effect of coverboard maturation and to exclude inter year variation. Other studies also found that the difference between the number of salamanders found under old and new coverboards was not significant (Grant et al. 1992; Monti et al. 2000). One of the most probable explanations for the high encounter rate of RBS

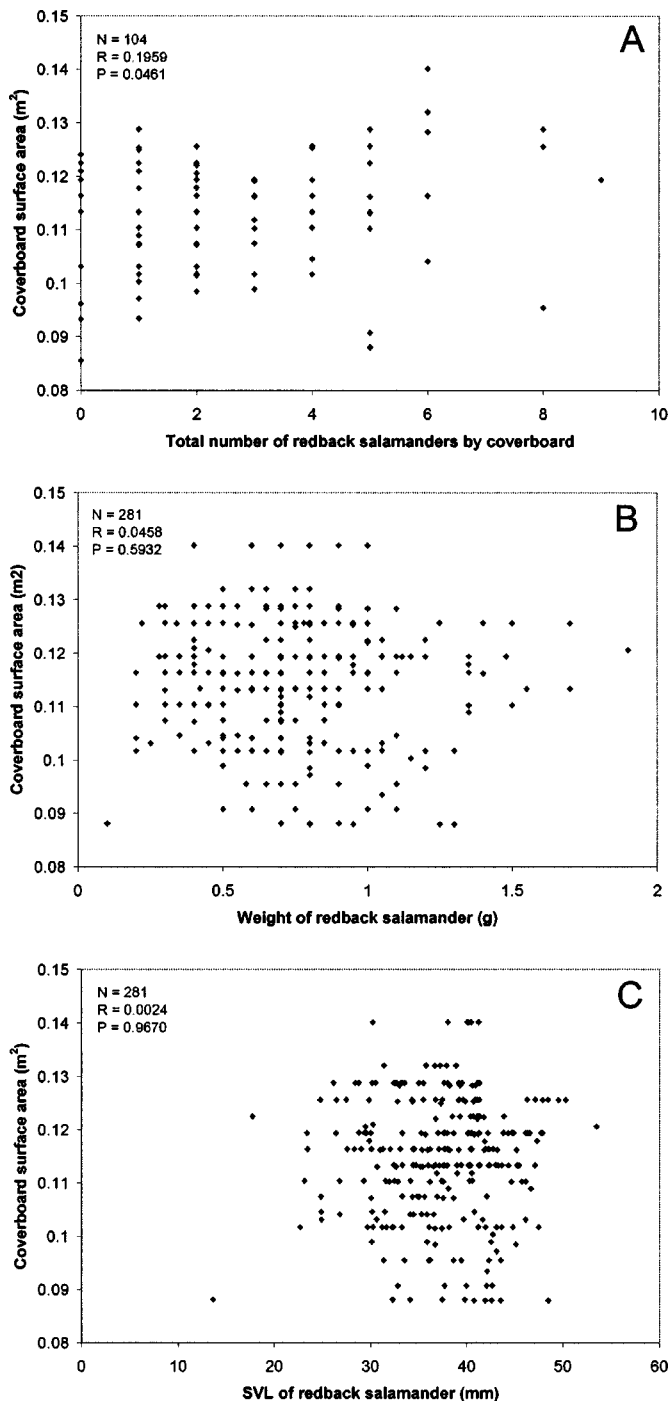


FIG. 1. Regression analysis between coverboard surface area and RBS A) number, B) weight, and C) SVL.

could be the weather prevailing before and at the time of sampling. Coverboard inventories were done, most of the time, during rainless periods (no precipitation the day of the sampling and at least one or two days before), probably forcing salamanders to retreat under coverboards to escape dry conditions. Jaeger (1980) found that the percentage of RBS under logs increased with decreasing rainfall, while simultaneously the percentage of RBS in the leaf litter decreased. This emphasizes the need to monitor RBS during rainless periods so as to maximize coverboard efficiency and, consequently, capture rate.

The relationship between the surface area of coverboards and the number of RBS found under them was significant ($P = 0.0461$; Fig. 1A). However, the weak R value (0.1959) and the relative narrow range of coverboard surface area for each number of salamanders suggests that this parameter was independent of the dimension range of coverboards used at LCW (855 to 1400 cm²). No relationship was found between the surface area of coverboards and the weight ($R = 0.0458$; $P = 0.5932$) and SVL ($R = 0.0024$; $P = 0.9670$) of RBS during the two-year sampling period (Fig. 1B,C). Similar results were found in Virginia by Faragher and Jaeger (1997) for the size of RBS in spite of a greater range of coverboard sizes (10 to 5000 cm²) studied. Other studies found, however, that size or weight of RBS was correlated with cover item size (Mathis 1990; Moore et al. 2000) but in these cases, cover size effect was attributed to seasonal influence.

Although no studies have been published that have documented a preference among the salamanders for one type of coverboard over another, it is possible that the wood composition of coverboards (e.g., wood species, chipboard or plywood vs rough-cut) may influence their use by salamanders due to, for example, their wood chemistry and leachate, decomposition rate and moisture retention (Droede et al. 2003). Given the close relationship of salamanders with soil features (Frisbie and Wyman 1991, 1992; Grover 1998; Heatwole 1962; Wyman 1988; Wyman and Hawksley-Lescault 1987), such factors may harm or repel salamanders. The present study was not designed to detect differences among coverboard types. However, the coverboards used at LCW could mitigate this possible phenomenon, given that they were made with *in situ* wood (dominant tree species). Also, in a recent study dealing with potential bias associated with the use of wood coverboard arrays, Marsh and Goicochea (2003) observed that samples from under artificial coverboards contained higher proportions of adult RBS and lower proportions of juveniles and hatchlings than did natural objects. There was, however, no difference in sex ratios or in SVL within stage classes. In this context, more studies will be needed to determine if this new coverboard type accurately indexes the RBS population at LCW.

This study indicates that the use of wood from a native dominant tree species to make coverboards is an efficient tool for surveying and monitoring plethodontid salamanders. Preparation can be done *in situ*, reducing transport and cost. The results suggest that, under a relatively narrow range (0.09 to 0.14 m²), variability in coverboard surface area has no effect on salamander encounter rate, weight and snout-vent length. More studies will be needed at LCW to explain the high encounter rate of RBS in this acidic habitat.

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LITERATURE CITED

- BONIN, J., AND Y. BACHAND. 1997. The use of artificial covers to survey terrestrial salamanders in Québec. *Herpetol. Conserv.* 1:175–179.
BURTON, T. M., AND L. E. LIKENS. 1975. Salamander populations and biomass in the Hubbard Brooks Experimental Forest, New Hampshire.

- Copeia 1975:541–546.
- CANADA SOIL SURVEY COMMITTEE. 1992. The Canadian System of Soil Classification. 2nd ed. Can. Dep. Agric. Publ. 1646., Ottawa, Ontario. 170 pp.
- CONANT, R., AND J. T. COLLINS. 1991. A Field Guide to Reptiles and Amphibians: Eastern and Central North America. 3rd ed. Houghton Mifflin Co., Boston, Massachusetts. 450 pp.
- DAVIS, T. M. 1997. Non-disruptive monitoring of terrestrial salamanders with artificial cover objects on Southern Vancouver Island, British Columbia. *Herpetol. Conserv.* 1:161–174.
- DEGRAAF, R., AND M. YAMASAKI. 1992. A nondestructive technique to monitor the relative abundance of terrestrial salamanders. *Wildl. Soc. Bull.* 20:260–264.
- , AND ———. 2002. Effects of edge contrast on redback salamander distribution in even-aged northern hardwoods. *For. Sci.* 48:351–363.
- deMAYNADIER, M. L., AND P. G. HUNTER. 1998. Effects of silvicultural edges on the distribution and abundance of amphibians in Maine. *Conserv. Biol.* 12:340–352.
- DROEGE, S., L. MONTI, AND D. LANTZ. 2003. The terrestrial salamander monitoring program, <http://www.im.nbs.gov/sally/>.
- DUCHESNE, L., R. OUMET, AND C. MORNEAU. 2003. Assessment of sugar maple health based on basal area growth pattern. *Can. J. For. Res.* 33:2074–2080.
- ENRIGHT, L., B. ROCHE, AND R. J. BROOKS. 1998. Amphibian Monitoring in Ontario: Proposed Site Selection Criteria and Data Collection Protocol. A report to the Ontario Ministry of Natural Resources. 35 pp.
- FARAGHER, R. G., AND R. JAEGER. 1997. Distributions of adult and juvenile red-backed salamanders: testing new hypotheses regarding territoriality. *Copeia* 1997:410–414.
- FELLERS, G. M., AND C. A. DROST. 1994. Sampling with Artificial Cover. In W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, and M. S. Foster (eds.), *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians*, pp. 146–150. Smithsonian Institution Press, Washington D.C.
- FRISBIE, M. P., AND R. L. WYMAN. 1991. The effects of soil pH on sodium balance in the red-backen salamander, *Plethodon cinereus*, and three other terrestrial salamanders. *Physiol. Zool.* 64:1050–1068.
- , AND ———. 1992. The effect of soil chemistry on sodium balance in the red-back salamander: A comparison of two forest types. *J. Herpetol.* 26:434–442.
- GRANT, B. W., A. D. TUCKER, J. E. LOVICH, A. M. MILLS, P. M. DIXON, AND J. W. GIBBONS. 1992. The Use of Coverboards in Estimating Patterns of Reptile and Amphibian Biodiversity. In D. R. McCullough, and R. H. Barrett (eds.), *Wildlife 2001: Populations*, pp. 379–403. Elsevier Science Publ. Inc., London, England.
- GROVER, M. C. 1998. Influence of cover and moisture on abundance of the terrestrial salamanders *Plethodon cinereus* and *Plethodon glutinosus*. *J. Herpetol.* 32:489–497.
- HARPOLE, D. N., AND C. A. HAAS. 1999. Effects of seven silvicultural treatments on terrestrial salamanders. *For. Ecol. Manage.* 114:349–356.
- HEATWOLE, H. 1962. Environmental factors influencing local distribution and activity of the salamander (*Plethodon cinereus*). *Ecology* 43:460–472.
- HOULE, D., R. PAQUIN, C. CAMIRÉ, R. OUMET, AND L. DUCHESNE. 1997. Response of the Lake Clair Watershed (Duchesnay, Quebec) to change in precipitation chemistry (1988–1994). *Can. J. For. Res.* 27:1813–1821.
- JAEGER, R. G. 1980. Microhabitats of a terrestrial forest salamander. *Copeia* 2:265–268.
- MARSH, D. M., AND M. A. GOICOCHEA. 2003. Monitoring terrestrial salamanders: Biases caused by intense sampling and choice of cover objects. *J. Herpetol.* 37:460–466.
- MATHIS, A. 1990. Territoriality in a terrestrial salamander: The influence of resource quality and body size. *Behavior* 112:162–174.
- MONTI, L., M. HUNTER, AND J. WITHAM. 2000. An evaluation of the artificial cover object (ACO) method for monitoring populations of the redback salamander *Plethodon cinereus*. *J. Herpetol.* 34:624–629.
- MOORE, A. L. AND C. E. WILLIAMS. 2000. Influence of season, geomorphic surface and cover item on capture, size and weight of *Desmognathus ochrophaeus* and *Plethodon cinereus* in Allegheny Plateau riparian forests. *Am. Midl. Nat.* 145:39–45.
- MOORE, J.-D., R. OUMET, C. CAMIRÉ, AND D. HOULE. 2002. Effects of two silvicultural practices on soil fauna abundance in a northern hardwood forest, Québec, Canada. *Can. J. Soil Sci.* 82:105–113.
- MUSHINSKY, H. R., AND E. D. BRODIE. 1975. Selection of substrate pH by salamanders. *Am. Midl. Nat.* 93:440–443.
- RAYMOND, R., G. LAFLAMME, AND G. GODBOUT. 1976. Pédologie du Comté de Portneuf. Bulletin Technique 18, MAPAQ, Service des sols, Sainte-Foy, Québec, Canada.
- RYAN, T. J., T. PHILIPPI, Y. A. LEIDEN, M. E. DORCAS, T. B. WIGLEY, AND J. W. GIBBONS. 2002. Monitoring herpetofauna in a managed forest landscape: Effects of habitat types and census techniques. *For. Ecol. Manage.* 167:83–90.
- SAS Institute Inc. 2000. SAS/STAT User's Guide, Version 8. SAS Institute Inc., Cary, N.C.
- STEWART, G. D., AND E. D. BELLIS. 1970. Dispersion patterns of salamanders along a Brook. *Copeia* 1:86–89.
- SUGAR, A., T. BELLHOUSE, D. PHOENIX, N. DAWSON, AND G. HOLBORN. 2001. A Sampling Protocol for Red-Backed Salamander (*Plethodon cinereus*) Populations in Ontario: the 2nd pilot study. Wildlife Assessment Program, Ontario Ministry of Natural Resources WAP-2001-01. 23 pp.
- TAUB, F. B. 1961. The distribution of the red-backed salamander, *Plethodon c. cinereus*, within the soil. *Ecology* 42:681–698.
- VERNBERG, J. F. 1955. Correlation of physiology and behavior indexes of activity in the study of *Plethodon cinereus* (Green) and *Plethodon glutinosus* (Green). *Am. Midl. Nat.* 54:382–393.
- WELSH Jr., H. H., AND S. DROEGE. 2001. A case for using plethodontid salamanders for monitoring biodiversity and ecosystem integrity of North American forests. *Conserv. Biol.* 15:558–569.
- WYMAN, R. L. 1988. Soil acidity and moisture in the distribution of amphibians in five forests of southcentral New York. *Copeia* 1988:394–399.
- , AND D. S. HAWKSLEY-LESCAULT. 1987. Soil acidity affects distribution, behavior and physiology of the salamander *Plethodon cinereus*. *Ecology* 68:1819–1827.
- , AND J. JANCOLA. 1992. Degree and scale of terrestrial acidification and amphibian community structure. *J. Herpetol.* 26:392–401.



Hyla versicolor (Gray Treefrog) metamorph, first day on land. USA: Virginia: Greene County. Photographic illustration by Will Brown (www.blueridgebiological.com).

A Comparison of Approaches to Counting Spotted Salamander (*Ambystoma maculatum*) Egg Masses in Vernal Ponds

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In 2003, a long-term program to monitor pond breeding amphibians at Cape Cod National Seashore, Barnstable County, Massachusetts (Paton et al. 2003) was initiated. One aspect of this program involves the use of egg mass counts for monitoring long-term population trends of the vernal pond breeding wood frog (*Rana sylvatica*) and spotted salamander (*Ambystoma maculatum*). Crouch and Paton (2000) found that counts of egg masses in ponds were the most cost-effective means of monitoring wood frog populations. Egg mass counts may also be used to estimate abundance and monitor populations of spotted salamanders (Brodman 1995, 2002; Egan and Paton 2004; Jung 2002; Petranks et al. 2003).

While there is a general agreement that egg mass counts are an effective and accurate way to estimate abundance and monitor populations of spotted salamanders (See Shoop 1974 for a contrary opinion), researchers have employed a number of approaches. Brodman (1995, 2002) used random transects across a pond to estimate egg mass density. Others have attempted to count all the egg masses present, based on either a single count of egg masses (e.g., Rowe and Dunson 1993) or multiple counts. One method of multiple counts involves marking egg masses or groups of egg masses to generate a cumulative total (Egan and Paton 2004), hereafter called the locus method (Paton et al. 2003). A second approach to multiple counts is to count (but not mark) all egg masses in the pond on a series of sample dates spanning the breeding season, and use the maximum count as the measure of abundance (Albers and Prouty 1987; Petranks et al. 2003; Petranks et al. 2004). A third, more recently employed multiple count method is the dependent double observer approach. This applies the double observer method of Cook and Jacobson (1979) to estimate the number of egg masses present on a series of counts based on their probability of detection. It then uses the maximum estimate as the measure of abundance (Grant et al. 2005). As with the other multiple count methods, this technique allows better estimates of the maximum number of spotted salamander females breeding at a site than a single count. Including additional observers allows less biased estimates of this variable (Nichols et al. 2000).

In 2003, we compared the maximum count and locus methods for counting egg masses of spotted salamanders in breeding ponds. The maximum count method involves carefully and systematically counting all the egg masses found in a breeding pond on a series of dates during the breeding season. The largest of these counts is then used as the measure of egg mass abundance for that pond that year. The locus method (Paton et al. 2003) is based on the fact that egg masses of wood frog and spotted salamander are often clustered together in a group or locus. The locus method

involves counting the number of egg masses in a group (locus), and identifying and marking each locus with flagging. Single, isolated egg masses are also treated as a locus and marked. Each locus and the number of egg masses it contains is recorded. On a subsequent visit, each locus is recounted and the number of egg masses present recorded. Differences in the number of egg masses recorded in a locus from one count to the next may be due to predation, displacement (dislodging an egg mass from vegetation), the laying of additional egg masses, overcounting, or undercounting egg masses that were present during a survey. New (unmarked) loci encountered are also marked, counted, and recorded during subsequent surveys. These new loci may also represent egg masses deposited after the previous visit, or egg masses that were present during the last survey but overlooked. After repeat visits, the maximum count for each individual locus is selected and all loci in a pond summed, providing a total count of the egg masses deposited in that pond.

Methods.—In spring 2003 we conducted two rounds of spotted salamander egg mass counts at 18 ponds in Cape Cod National Seashore. The first count was conducted between 14 April 2003 and 21 April 2003, and the second, between 28 April 2003 and 5 May 2003. This is generally the period of greatest egg mass abundance. Since data collected on a given day as part of the locus method can also be treated as a count in the maximum count method, we used these data to compare the results obtained by these two different methods. For each pond, the highest of the two daily counts was the maximum count, whereas the locus count was obtained by taking the highest of the two counts of each locus and summing for all the loci in a pond.

Results.—The maximum daily count method underestimated the locus method, on average by 2.7% (range 0–12%; Table 1). Maximum count values were significantly less than those obtained by the locus method (paired t-test $t = -3.46$; $df = 17$; $P = 0.003$), but were highly correlated with them ($R = 0.9996$; $P < 0.000000$; $N = 18$). The mean field time for data collection using the maximum count method was 29 minutes/pond and for the locus method it was 80 minutes/pond. Thus, relative to the locus method, the maximum count method systematically underestimated the number of egg masses present, on average by 2.7%, required 36% the field time, and provided highly correlated results.

Discussion.—Implementation of the locus method was problematic. Determining what constituted a “locus” was often difficult. While many egg masses form discrete loci, many egg masses are also laid singly or in small groups. Egg masses may be spread over a large area rather than concentrated in a small one. When single egg masses were near a larger group of masses, we had to decide whether to consider it a separate locus or group it with a larger neighboring locus. Moreover, since egg mass deposition takes place over the course of a few weeks, seemingly distinct loci early in the season become less so as the space in between them fills in with additional egg masses. To deal with this problem, we had to delineate boundaries between what initially were distinct loci with flagging, labeled to indicate which locus it defined. Using this method, we could be sure we were counting the same locus as in the prior sample and could determine whether egg masses were added or lost. However, defining, labeling, delineating, and recording each locus was a very time consuming process. In addition, the locus method took more time to enter and tabulate

TABLE 1. Comparison of maximum count versus locus method values for spotted salamander egg masses in 2003.

Pond	2003 Max Count	2003 Locus	Difference	% Deviation
E02	50	51	1	2%
E03	38	41	3	7%
E04	633	639	6	1%
E05a	315	321	6	2%
E05main	767	790	23	3%
E06	575	601	26	4%
E07	269	273	4	1%
E08	250	263	13	5%
E11	254	261	7	3%
E11east	24	25	1	4%
E21	261	264	3	1%
T01	544	549	5	1%
T15	22	25	3	12%
W01	489	521	32	6%
W06	27	29	2	7%
W07	338	338	0	0%
W15	64	66	2	3%
W18	44	46	2	4%
Total	4964	5103	139	2.7%

data.

The advantage of the locus method is that, by tracking the number of egg masses in a locus over sampling visits, egg masses once counted but then lost to predation or displaced during counting are still counted, as are newly deposited egg masses. This provides a more complete count of the total number of egg masses deposited. In contrast, maximum counts do not allow for tracking the disappearance of older or the appearance of newer egg masses, and may underestimate the total number of egg masses laid. While we found this to be true, egg mass counts based on the maximum count method provided nearly identical data as the locus method, but in a more time efficient and economical fashion. Increasing effort 276% to detect, on average, 2.7% more egg masses, is not worth the additional effort.

Of these two methods, we would recommend use of the maximum count method, provided that at least three counts are conducted during the appropriate time period. On Cape Cod, we conduct three counts, with the first occurring the last week of March–first week of April, the second in mid-April, and the third in the last week of April–first week of May. This ensures that regardless of whether it is an “early” or “late” spring, counts will occur during the time of peak egg mass presence. Elsewhere, sampling would need to be adjusted for local phenology.

While our results indicate that the maximum count method provides data comparable to the locus method for less effort, neither method addresses the issue of egg mass detectability raised by (Grant et al. 2005). Shoop (1974) felt that egg mass counts underestimated the numbers of spawning females due to the inability to detect egg masses in deep (> 2 m), turbid water. Egan and Paton

(2004) also noted that deeper (>1.5 m) sections of ponds are hard to survey.

The dependent double observer method of egg mass counts (Grant et al. 2005) attempts to account for differences in the detectability of egg masses due to such factors as observers, sites, vegetation, pond size and depth. In its implementation, the primary observer counts egg masses in groups out loud, and the secondary observer records the primary observer’s counts and silently records any egg masses the primary observer missed (Jung 2002). Halfway around the pond, the observers switch roles. In our experience with this method in vernal ponds at Cape Cod National Seashore, it is not always feasible in practice. A fundamental assumption of this method is that the sighting ability of an observer does not change as they shift from the role of primary to secondary observer (Southwell 1996). But, suspension of silt, differences in the visibility of egg masses to the observers due to differences in glare and view angle, and the fact that the primary observer often must handle egg masses below the water’s surface to count them frequently makes it impossible for the secondary observer to follow along in the count with the primary observer. Thus the secondary observer is often less able to detect egg masses than the primary, resulting in a systematic undercount by the secondary observer and a violation of the above assumption.

While we concur with Grant et al. (2005) on the desirability of modeling detectability to obtain unbiased estimates of the number of spotted salamander egg masses in a pond, our experiences suggest that it may not always be feasible. A more optimal method to assess detectability of egg masses has not yet been developed. In situations where conditions lead to violation of the assumptions of the dependent double observer method, the only reasonable recourse to estimating egg mass abundance, particularly when more than a few ponds are being monitored, seems to be single observer counts, such as the maximum count method described above. We acknowledge that the maximum count method is less than perfect, but believe it provides a meaningful index of spotted salamander breeding effort (e.g., see Petranka et al. 2004) and represents the best currently available compromise among the competing factors of accuracy and precision, ease and economy of implementation in a long term monitoring program, and minimizing monitoring impacts to pond vegetation and wildlife.

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LITERATURE CITED

- ALBERS, P. H., AND R. M. PROUTY. 1987. Survival of spotted salamander eggs in temporary woodland ponds of coastal Maryland. *Environ. Pollution* 46:45–61.
- BRODMAN, R. 1995. Annual variation in breeding success of two syntopic species of *Ambystoma* salamanders. *J. Herpetol.* 29:111–113.
- . 2002. Twelve-year study monitoring two species of pond-breeding salamanders in Northeast Ohio. *Ohio J. Sci.* 102:123–127.
- COOK, R. D., AND J. O. JACOBSON. 1979. A design for estimating visibility bias in aerial surveys. *Biometrics* 35:735–742.
- CROUCH, W. B., AND P. W. C. PATON. 2000. Using egg-mass counts to monitor wood frog populations. *Wildl. Soc. Bull.* 28:895–901.

EGAN, R. S., AND P. W. PATON. 2004. Within-pond parameters affecting oviposition by wood frogs and spotted salamanders. *Wetlands* 24:1–13.

GRANT, E. H. C., R. E. JUNG, J. D. NICHOLS, AND J. E. HINES. 2005. Double-observer approach to estimating egg mass abundance of vernal pond breeding amphibians. *Wetlands Ecol. Manage.* 13:305–320.

JUNG, R. E. 2002. Wood frog and spotted salamander egg mass counts and percent vernal pools occupied by amphibian species on DOI lands in the northeastern United States. US Geological Survey Amphibian Research and Monitoring Initiative (ARMI) in the Northeast Region, USGS Patuxent Wildlife Research Center, Laurel, Maryland.

NICHOLS, J. D., J. E. HINES, J. R. SAUER, F. FALLON, J. FALLON, AND P. J. HEGLUND. 2000. A double-observer approach for estimating detection probability and abundance from avian point counts. *Auk* 117:393–408.

PATON, P. W., B. TIMM, AND T. TUPPER. 2003. Monitoring pond breeding amphibians. A protocol for the long-term ecosystem monitoring program at Cape Cod National Seashore. U.S.D.I. 113 pp.

PETRANKA, J. W., C. A. KENNEDY, AND S. S. MURRAY. 2003. Response of amphibians to restoration of southern Appalachian wetland: a long-term analysis of community dynamics. *Wetlands* 23:1030–1042.

———, C. K. SMITH, AND A. F. SCOTT. 2004. Identifying the minimal demographic unit for monitoring pond-breeding amphibians. *Ecol. Appl.* 14:1065–1078.

ROWE, C. L., AND W. A. DUNSON. 1993. Relationships among biotic parameters and breeding effort by three amphibians in temporary wetlands of central Pennsylvania. *Wetlands* 13:237–246.

SHOOP, C. R. 1974. Yearly variation in larval survival of *Ambystoma maculatum*. *Ecology* 55:440–44.

SOUTHWELL, C. 1996. Multiple dependent observers. In D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster (eds.), *Measuring and Monitoring Biological Diversity: Standard Methods for Mammals*. pp. 202. Smithsonian Institution Press, Washington, D.C.

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A Novel Arboreal Pipe-Trap Designed to Capture the Gray Treefrog (*Hyla versicolor*)

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Drift fences with pitfall traps are a common and effective method of censusing amphibian populations (Dole 1971; Gibbons and Bennett 1974; Gibbons and Semlitsch 1982; Shoop 1965). However, drift fence arrays are ineffective for capturing hylid frogs because of their ability to climb vertical surfaces (Dodd 1991; Gibbons and Bennett 1974). The difficulty of capturing treefrogs using drift fences has led to the development of alternative sampling techniques for hylid frogs including open-ended polyvinyl chloride (PVC) pipes, elevated inverted tin cans, and modified drift fences (Boughton et al. 2000; Goin and Goin 1957; Moulton et al. 1996; Murphy 1993). Currently, the most widely used of these methods consists of constructing artificial refugia from PVC pipe. Several studies have found that varying pipe-trap designs and configurations lead to differences in species composition and size classes of captured individuals (Bartareau 2004; Boughton et al. 2000; Moulton et al. 1996), suggesting that no single pipe-trap design is appropriate for all species in all locations. Here I report on the design and effectiveness of a novel pipe-trap designed to simulate natural arboreal retreats and capture the gray treefrog (*Hyla versicolor*).

The pipe-traps used in this study consisted of 60 cm long sections of 3.8 cm inside diameter black acrylonitrile butadiene styrene (ABS) pipe (Fig. 1). A 10 cm upper and 15 cm lower section of 5.0 cm inside diameter black ABS pipe were attached to trees with bungee cord and wire (Fig. 2). The smaller diameter pipe slid freely up and down during monitoring (Fig. 3), and the flexibility of the bungee cord allowed the 5.0 cm diameter sections of pipe to twist during monitoring, while remaining at the correct position on the tree. Utility wire was used to increase tension of the bungee cord on the upper and lower sections of the trap (Fig. 2) and to provide a pivot point during monitoring (Fig. 3B). Traps were sealed at the bottom with 5.0 cm diameter black ABS caps to allow for rainwater to fill the lower sheath of the 5.0 cm diameter pipe (Fig. 1). Water levels remained constant within the pipe-trap because the inside pipe sat loosely within the bottom capped portion, and excess rainwater flowed out. Frogs were able to enter and leave the pipe-trap freely at the upper opening (Fig. 1).

The pipe-trap design outlined here is similar to some PVC pipe designs evaluated by Boughton et al. (2000). However, I modified their designs in three ways. First, black ABS pipe was used rather than white PVC pipe to provide more realistic (i.e., dark) refugia sites (Lohoefer and Wolfe 1984). Other possible advantages of the dark material may include warmer internal temperatures and greater camouflage from potential predators. ABS pipe is typically used for residential plumbing applications and is similar to the polyvinyl chloride (PVC) piping used in previous studies of artificial arboreal refuge use by treefrogs. Second, I eliminated

the need to nail pipe-traps directly onto trees, which avoids damage to trees and can be an important consideration in old growth forests, or on public lands that discourage the permanent disturbance of habitat. Lastly, this pipe-trap design maintains a constant

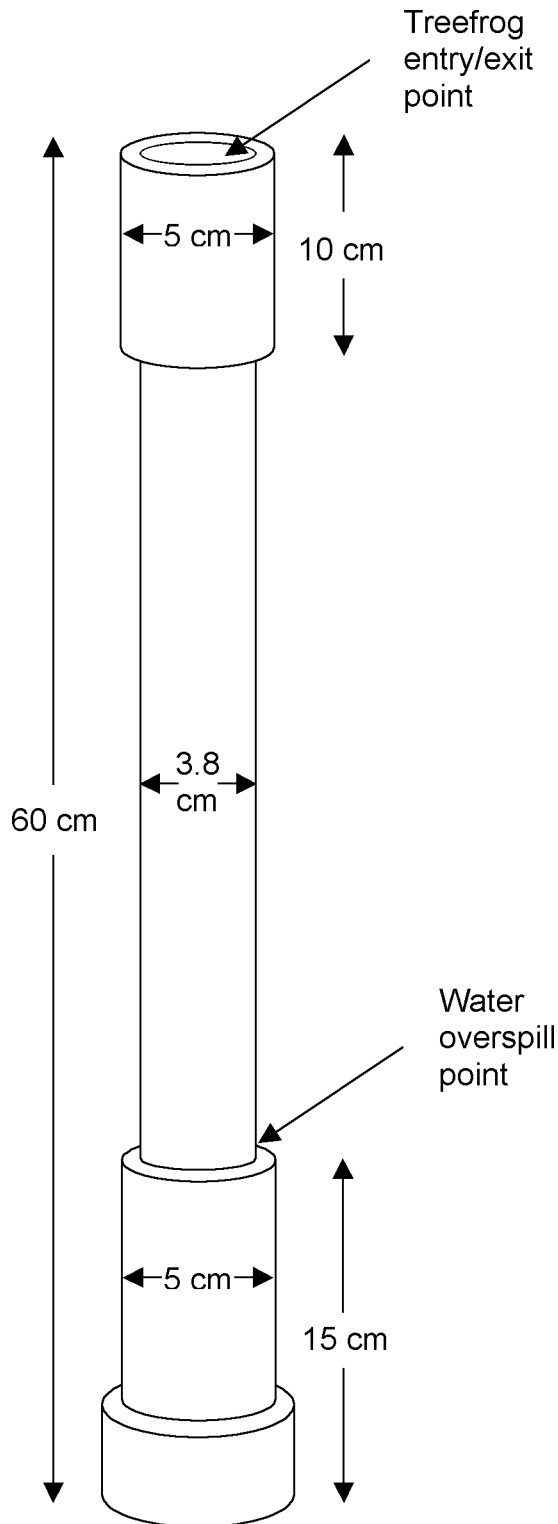


FIG. 1. Pipe-trap design. The smaller diameter inside pipe slides freely through the larger diameter top sheath and rests inside the capped bottom portion of large diameter pipe. The gap between the small and large diameter pipe maintains water level at a constant depth.

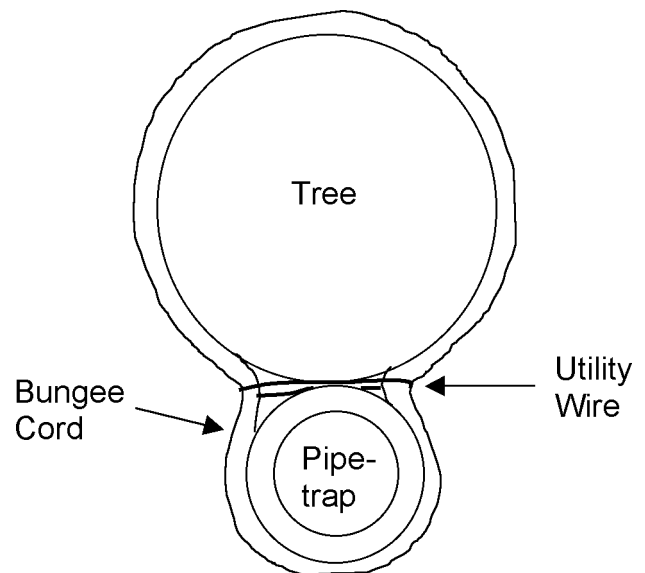


FIG. 2. Top view of a pipe-trap attached to a tree. Not shown is a second bungee cord and utility wire attachment on the bottom segment of the 5 cm diameter pipe.

water depth within the pipe-trap. If frogs are attracted to pipe-traps because of the water they contain, it is important to standardize water level among traps.

The pipe-trap refugia described in this report were constructed for an ongoing study of gray treefrog dispersal distances and terrestrial habitat requirements. To date, pipe-traps have been monitored during two fall emigrations as frogs move towards overwintering sites, two spring immigrations as frogs move towards breeding sites, and two summer breeding seasons (Table 1). Here I present data regarding the effectiveness of these traps for capturing gray treefrogs in a midwestern U.S. deciduous forest.

During the fall of 2002 and the spring of 2003, I placed 28 pipe traps at two adjacent gray treefrog breeding sites located within the Thomas Baskett Wildlife Research Area near Ashland, Boone County, Missouri. The pipe-traps were placed with the upper opening 3 m above ground on large diameter deciduous trees (mean DBH 21.8 cm) and arranged at fixed distances from breeding ponds along four transects. Each transect extended from the breeding sites 200 m into secondary growth (~100 yr) oak/hickory (*Quercus* spp./*Carya* spp.) forest with sugar maple (*Acer saccharum*) understory. During the summer of 2003, the existing transects received an additional pipe-trap at each distance and three paired transects were added to a third gray treefrog breeding site, for a total of 98 pipe-traps in seven paired transects extending 200 m from three breeding ponds into the adjacent forest. An additional pipe-trap was placed 200 m from each of the two breeding sites for a grand total of 100 pipe-traps. During monitoring, pipe-traps were checked during daylight hours for the presence of treefrogs. Frogs were extracted from the pipes by forcing a sponge through one end until the frog could be reached at the opposite end (Boughton et al. 2000; Fig. 3C). Individuals were sexed, given unique toe-clip identifications and snout-vent length (SVL) was measured with a plastic ruler. After processing, frogs were returned to the pipes and placed back on the tree.

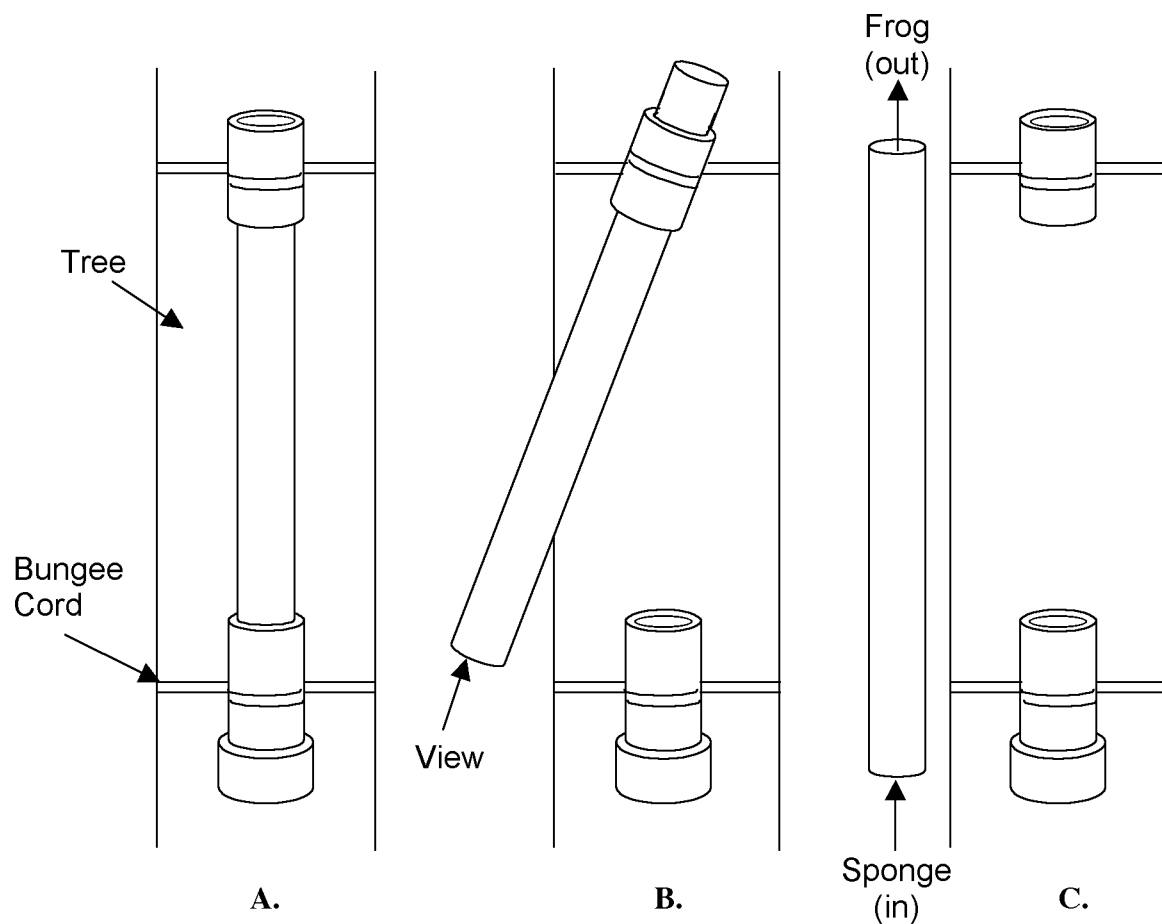


FIG. 3. Overview of pipe-trap monitoring procedure. A. Normal pipe-trap position. B. Inside pipe is slid upwards and top sheath twists on bungee cord so the observer can detect frogs from below. C. If a frog is present, the inside pipe is removed and the frog is extracted.

In total, pipe-traps captured 111 Gray Treefrogs (60 males, 36 females, and 15 juveniles) a total of 565 times (Table 1). The size range was 17–56 mm SVL, which encompasses the entire range of adult gray treefrog lengths (Conant and Collins 1998). The SVL data indicate that these pipes are capable of capturing all size classes of *Hyla versicolor*; however, without size frequency distribution data for the population, it remains unclear if these data display a bias in capture rates generated by the internal pipe diameter (see Bartareau 2004; Martin et al. 2003).

Other vertebrate species captured in the traps include one adult Spring Peeper (*Pseudacris crucifer*), one adult Five-lined Skink (*Eumeces fasciatus*), eight mice (*Peromyscus sp.*), and seven fly-

ing squirrels (*Glaucomys volans*). I observed no amphibian mortality within the pipes, however 12 of the 15 mammals encountered were dead. Prior studies using pipe-trap refugia for monitoring amphibians have not reported mammalian mortality. Use of this pipe-trap design might not be appropriate in areas in which incidental small mammal mortality is of concern, unless the open end of the pipe-trap can be modified to reduce the frequency of mammalian intruders without affecting treefrog access.

Previous studies using PVC pipe refugia have been conducted primarily in the southeastern U.S. to monitor other species of hylids (e.g., *H. avivoca*, *H. cinerea*, *H. femoralis*, *H. gratiosa*). These artificial refugia studies have been successful in capturing treefrogs

TABLE 1. Summary of monitoring sessions and captures.

Season	# of pipe-traps	Monitoring period	# of days monitored	# of recaptures	# of males	# of females	# of juveniles
Fall 2002	28	30 Sept. to 15 Oct.	4	7	3	1	1
Spring 2003	28	17 Apr. to 05 May	10	20	4	1	1
Summer 2003	100	17 June to 08 July	11	20	3	10	2
Fall 2003	100	11 July to 22 Oct.	42	290	31	16	21
Spring 2004	100	09 April to 14 May	18	83	18	13	14
Summer 2004	100	18 May to 11 July	28	145	29	17	8

in pipe-traps inserted upright into the ground, placed open-ended or capped at varying heights on trees, and in "T" configurations (see Bartareau 2004; Boughton et al. 2000; Moulton et al. 1996). However, in more northerly locations (Michigan; J. Ball, pers. comm.; New York, Tregger 2004) similar pipe-trap designs have not succeeded in capturing large numbers of treefrogs. The large number of captures reported in this study indicate that this new pipe-trap design may be more appropriate than previous designs for sampling populations of hylid frogs in areas outside of the southeastern U.S. Additional data regarding the factors that drive the use of artificial refugia would be beneficial to the development of pipe-traps designed to optimize captures of particular species in specific locations. For example, the height at which a pipe-trap is placed, the internal diameter and the depth of water retained within the pipe-trap could easily be adjusted to fit the specific requirements of the hylid species under investigation. While the use of pipe-trap refugia to generate estimates of treefrog density or abundance may be complicated by biases of pipe diameter and design configuration, artificial pipe-trap refugia may be especially useful for delineation of terrestrial core habitat used by hylid frogs during both the breeding and non-breeding seasons when traditional methods of capturing amphibians are inadequate.

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LITERATURE CITED

- BARTAREAU, T. M. 2004. PVC pipe diameter influences the species and sizes of treefrogs captured in a Florida coastal oak scrub community. *Herpetol. Rev.* 35:150–152.
- BOUGHTON, R. B., J. STAIGER, AND R. FRANZ. 2000. Use of PVC pipe refugia as a sampling technique for hylid treefrogs. *Am. Mid. Natur.* 144:168–177.
- CONANT, R., AND J. T. COLLINS. 1998. *A Field Guide to Reptiles and Amphibians of Eastern and Central North America*. 4th ed. Houghton Mifflin Co., New York, New York. 616 pp.
- DOLE, J. W. 1971. Dispersal of recently metamorphosed leopard frogs, *Rana pipiens*. *Copeia* 15:221–228.
- DODD, C. K. JR. 1991. Drift fence-associated sampling bias of amphibians at a Florida sandhill temporary pond. *J. Herpetol.* 25:296–301.
- GIBBONS, J. W., AND D. H. BENNETT. 1974. Determination of anuran terrestrial activity patterns by a drift fence method. *Copeia* 1974:236–243.
- , AND R. D. SEMLITSCH. 1982. Terrestrial drift fences with pitfall traps: an effective technique for quantitative sampling of animal populations. *Brimleyana* 7:1–16.
- GOIN, C. J., AND O. B. GOIN. 1957. Remarks on the behavior of the squirrel treefrog, *Hyla squirella*. *Ann. Carnegie Mus.* 35:27–35.
- LOHOEFENER, R., AND J. WOLFE. 1984. A 'new' live trap and a comparison with a pit-fall trap. *Herpetol. Rev.* 15:25–26.
- MARTIN, F. D., L. D. WIKE, AND M. H. PALLER. 2003. PVC pipe samplers for hylid frogs: a cautionary note. World Wide Web <http://sti.srs.gov/fulltext/ms2004128/ms2004128.pdf>. Accessed 06 June 2004.
- MOULTON, C. A., W. J. FLEMING, AND B. R. NERNEY 1996. The use of PVC pipes to capture hylid frogs. *Herpetol. Rev.* 27:186–187.
- MURPHY, C. G. 1993. A modified drift fence for capturing treefrogs. *Herpetol. Rev.* 24:143–145.
- SHOOP, C. R. 1965. Orientation of *Ambystoma maculatum*: Movements to and from breeding ponds. *Science* 149:558–559.
- TREGGER, N. 2004. Evaluation of PVC pipe as a trap and evaluation of transmitter harness for hylidae species. World Wide Web <http://www.schoharie-conservation.org/scholarships/html/TreeFrogs.html>. Accessed 06 June 2004.

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A New Method of Temporarily Marking Lizards

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Labeling individual animals with unique and distinct markers is necessary in many ecological studies, including population density assessments, estimates of home range or territory areas, and behavioral observations. Researchers have developed many techniques for identifying individuals, but few allow convenient field identification of individuals from a distance. The ability to distinguish among individuals without repeatedly disturbing them is especially important in studies of behavioral ecology where the goal is to determine natural patterns of behavior. The most appropriate marking techniques for these studies are therefore quickly and easily implemented, clearly distinguishable from a distance, and not harmful to the marked individual (Murray and Fuller 2000; Nietfeld et al. 1994). I have developed a new method for temporarily marking small lizards that meets these criteria.

Individually marking reptiles presents a special challenge for field workers in that reptiles frequently shed their skin and with it any external markers. The bead-tagging method of Fisher and Muth (1989) avoids this problem by sewing unique combinations of beads into the most proximal region of a lizard's tail muscle. This is a permanent marker that works well for lizards that have a snout-vent length (SVL) of greater than 40–45 mm, but one that is difficult and often impossible to use for smaller lizards and for those with very slender tails. Other common methods of marking lizards have shortcomings as well. Many researchers use toe-clipping to distinguish among individuals (Ferner 1979). However, there are several problems with using this method in short-term behavioral studies. First, it may take a substantial amount of time for a toe-clipped lizard to recover from the injury caused by the clipping, which may further inhibit normal behavioral and movement patterns. Second, lizards sometimes naturally lose toe joints (Hudson 1996; Middelburg and Strijbosch 1988), which can make identifications difficult. Finally, toe clips cannot easily be seen without handling the animal. Other researchers have used non-toxic paint on the dorsum or colored acrylic polymers inserted under the skin, but these are also difficult to administer and distinguish on small lizards. For studies that can be completed in less than the average interval between natural sheddings of the species, I recommend the use of queen bee marking kits for smaller lizards. These kits, available from The Bee Works of Orillia, Canada (www.bee-works.com) for US \$17.50 each, contain cardboard dots in five colors (white, blue, yellow, green, and orange) numbered 1–99 in each color. Each kit also includes phial glue and an applicator for adhering the dots to the animal.

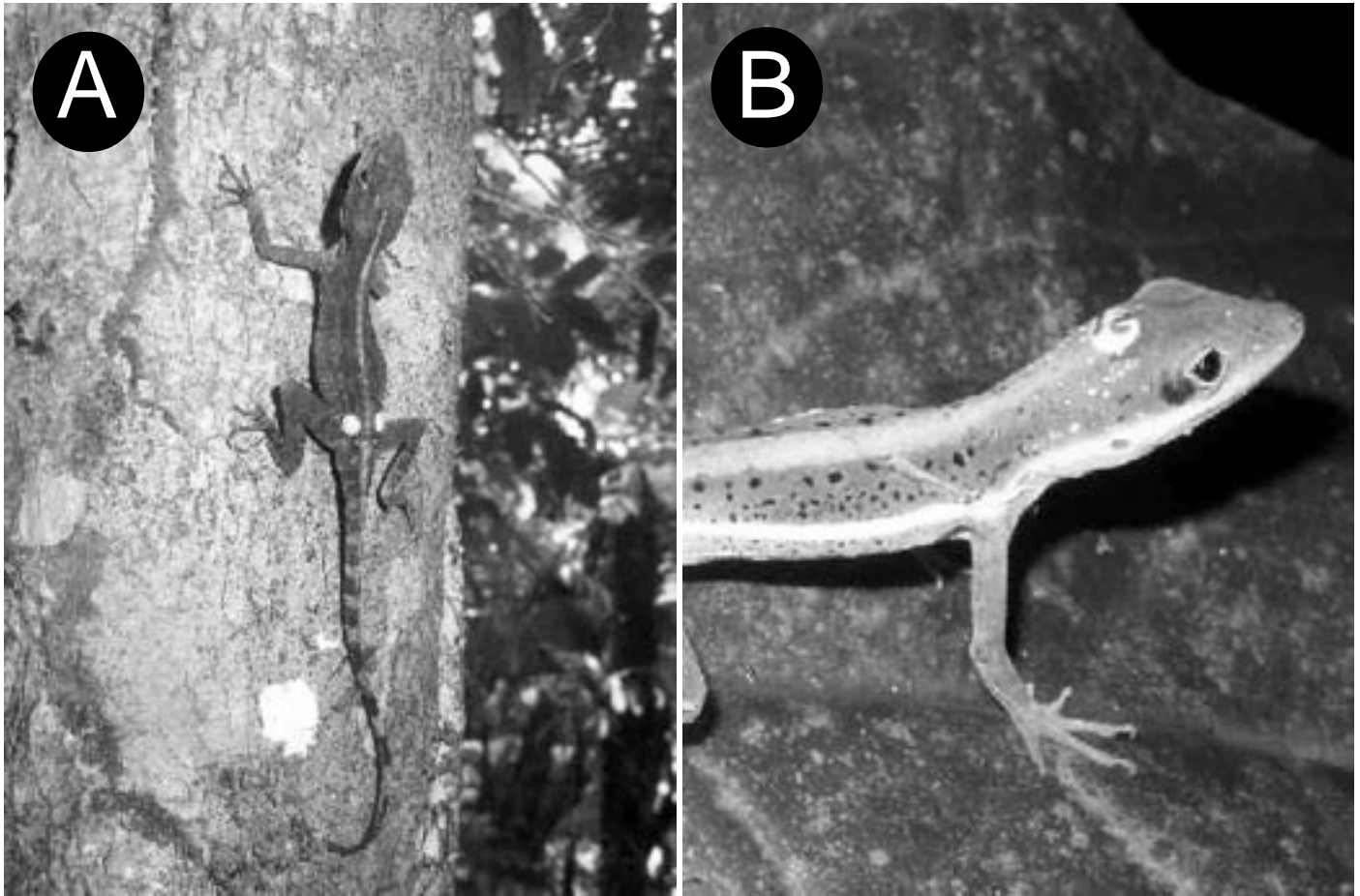


FIG. 1. A) Female *Anolis gundlachi* with two bee tags attached to its lower dorsum. B) Female *Anolis krugi* with bee tag (numbered 21) attached to its head.

We have used bee tags for marking four species of diurnal lizards: *Anolis cristatellus*, *A. gundlachi*, *A. krugi*, and *Sceloporus undulatus*. These four species have different habitat requirements and different scale types, and bee tags have proven to work well for each. *Anolis gundlachi* and *A. krugi* occur in the montane rainforests of Puerto Rico (Rand 1964; Schoener and Schoener 1971), *A. cristatellus* occurs in lowland dry forests and disturbed areas in Puerto Rico (Rand 1964; Schoener and Schoener 1971), and *S. undulatus* is found in North American woodland areas and glades (Stebbins 1954). During our behavioral studies of these species, we found that bee tags were dependable markers for approximately three weeks in the natural habitats of these species. We marked males and large females with the bead-tagging method described above (Fisher and Muth 1989), and smaller females and juveniles with bee tags. Bee tags are remarkably easy to attach; after catching a lizard we handled it for approximately two minutes to measure its SVL, take a small tissue sample from its tail, attach a bee tag combination, and allow the glue to dry. In contrast, almost twice that time was needed to attach a bead tag. Another primary advantage of the bee tag technique is its flexibility; the dots can be glued on almost any part of the dorsal surface of the lizard (Fig. 1). In our studies, we glued 2-3 bee tags on the head, the upper dorsum, or the lower dorsum of the lizards using the colors, numbers, and location of the tags to identify individuals. While the colors and position of the tags are often visible with

the naked eye, close-focus binoculars were needed to read the numbers on the tags. When a tag was occasionally missing from a lizard, we were almost always able to identify the individual by the remaining tags on that individual, or by a process of elimination in which other lizards of known identification were ruled out.

Marking lizards with bee tags provided short-term results comparable to those of the bead tagging technique (Fisher and Muth 1989). Of the 166 lizards of the four species we have marked using the bee tag method, we were able to conduct behavioral observations on 141, or 85%, in a three-week period. Likewise, of the 75 lizards marked with permanent bead tags for the same studies, we were able to observe 66, or 88%. It therefore appears that these two methods have similar "success" rates. There are many reasons we may fail to repeatedly observe a lizard other than loss of its tags, including death by predation or disease. It is also logical to assume that some lizards may be captured in a rare foray from their normal home range into the study area. However, we did observe one lizard (a female *A. krugi*) shed its entire skin and eat its dots immediately after being marked with bee tags, and the dots of one female *A. cristatellus* were found in its feces. These occurrences appear to be rare in the field, but when *Anolis* lizards were placed in the animal care facility at Washington University almost every individual shed and ate its bee tags.

In many circumstances, marking small lizards with queen bee marking kits is preferable to other marking techniques, as it is

inexpensive, relatively non-intrusive, and an easily visible way to identify particular individuals. The technique is also useful for larger lizards when temporary highly visible markers are preferred to permanent ones, particularly in studies in which the researcher wishes to avoid disturbing the focal individuals as much as possible.

Acknowledgments.—Many thanks to J. Chase for the original suggestion of bee tags for use in my behavioral studies, and to R. Kirby and S. Wang for their enthusiastic assistance in the field. J. Kolbe, J. Losos, K. McIntyre, and N. Calder provided helpful comments on an earlier draft of this manuscript. This work was supported by a grant from the National Science Foundation (DEB 9982736).

LITERATURE CITED

- FERNER, J. W. 1979. A review of marking techniques for amphibians and reptiles. *SSAR Herpetol. Circ.*, No. 9. 41 pp.
- FISHER, M., AND A. MUTH. 1989. A technique for permanently marking lizards. *Herpetol. Rev.* 20:45–46.
- HUDSON, S. 1996. Natural toe loss in southeastern Australian skinks: Implications for marking lizards by toe-clipping. *J. Herpetol.* 30:106–110.
- MIDDELBURG, J. J. M., AND H. STRIJBOSCH. 1988. The reliability of the toe-clipping method with the common lizard (*Lacerta vivipara*). *Herpetol. J.* 1:291–293.
- MURRAY, D. L., AND M. R. FULLER. 2000. A critical review of the effects of marking on the biology of vertebrates. In L. Boitani and T. K. Fuller (eds.), *Research Techniques in Animal Ecology: Controversies and Consequences*, pp. 15–64. Columbia University Press, New York.
- NIETFIELD, M. T., M. W. BARRETT, AND N. SILVY. 1994. Wildlife marking techniques. In T. A. Bookhout (ed.), *Research and Management Techniques for Wildlife and Habitats*, pp. 140–168. Wildlife Society, Bethesda, Maryland.
- RAND, A. S. 1964. Ecological distribution in anoline lizards of Puerto Rico. *Ecology* 45:745–752.
- SCHOENER, T. W., AND A. SCHOENER. 1971. Structural habitats of West Indian *Anolis* lizards II. Puerto Rican uplands. *Breviora* 375:1–39.
- STEBBINS, R. C. 1954. *Amphibians and Reptiles of Western North America*. McGraw-Hill Book Company, Inc., New York.



Hyla valancifer (USNM 319780) (Fringe-limbed Treefrog). Belize: Toledo: Gloria Camp. Palmar view of the hand. Illustration by Julian C. Lee.

A Refined Method for Culturing Reptilian Cells with Comments on Aggregations of Reptilian Melanomacrophages

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Many herpetologists are using cell culture to answer questions ranging from cell and tissue function to studies of the aging process. This paper reports a culture technique improved from that of Rund et al. (1998), especially a method of concentrating cells such as melanomacrophages (MMs). We became interested in these cells with the discovery that they formed aggregations in spleen, liver, and other organs in mud turtles, *Kinosternon flavescens*, and that these aggregations increase in number and size with turtle age (Christiansen et al. 1996). Aggregations of MMs have been reported in fishes (Aguis 1985), amphibians (Sichel et al. 1997), and some reptiles (Duncker 1968) among others. The basics of our methods were similar to those of Clark and Karzon (1967), Clark et al. (1970), and Koment and Haines (1982). Ulsh et al. (2000) used autologous turtle serum instead of fetal bovine serum to facilitate culture of reptilian lymphocytes.

In our studies of the advantages these cells provide turtles in low temperature environments (Johnson et al. 1999), we observed that our cultures became overrun with fibroblast-like cells. Our need to obtain nearly pure cultures of MMs for this study as well as our need for nearly pure fibroblast-like cell cultures for our current studies of aging and the aging process in reptiles, necessitated development of the purification techniques we report here. In addition, our MM cultures have provided evidence for a potential reason for the hepatic aggregations.

Culture Technique.—Liver and spleen from Western Painted Turtles (*Chrysemys picta bellii*) were used for preparation of MMs and these tissues along with skin and lung provided cells for fibroblast cultures. The turtles were collected and sacrificed under scientific collecting permit SC255 0101 and others issued to JLC by procedures approved by the Drake University Animal Care Committee as reported in Rund et al. (1998). Approximately 10 mm cubes of tissue were placed in RPMI-1640 (Sigma-Aldrich, Inc., St Louis, Missouri) containing penicillin, streptomycin, and neomycin (100 IU/ml: 100 mg/ml; 200 mg/ml, respectively, all from Sigma-Aldrich, Inc.). Tissues were rinsed three times in 40 ml RPMI-1640 with antibiotics to remove clotted blood and debris. Washed tissues were transferred to petri dishes and crossed scalpels were used to divide them into 2–3 mm cubes. The cubes of friable organs were pushed through a 1.0 mm stainless steel screen with a spoonula but skin was shredded further with crossed scalpels. The tissue fragments, cell aggregates, and individual cells

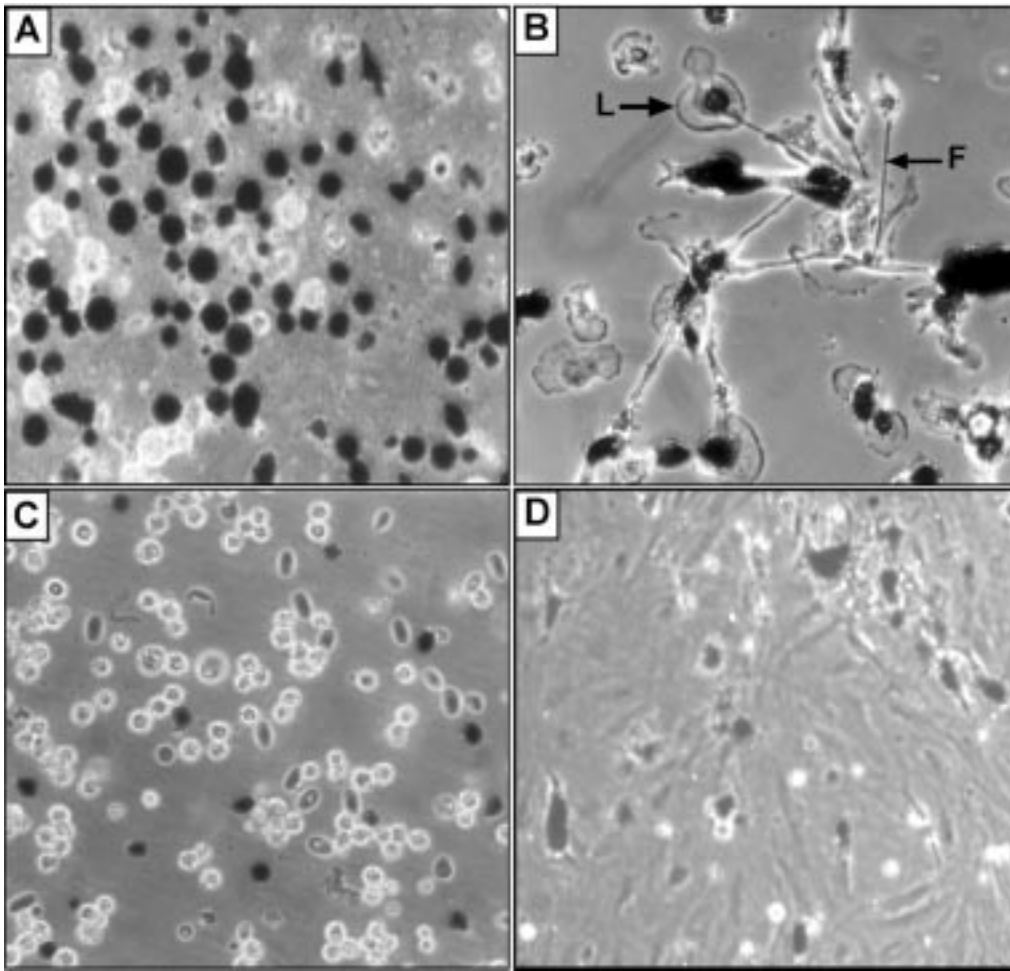


FIG. 1. Purification of reptilian cells for culture by selective trypsinization and differential settling. Initial plates (A and C) have app. 30,000 cells per plate. A = Selectively tryptonized and settled cells one hour post plating showing nearly pure culture of melanomacrophages (cells with black pigment). B = Same culture 25 days post plating. L indicates feeding lamellapodia; F indicates one of many forms of filapodia forming a network. C = Cells prepared by standard technique (Rund et.al. 1998) one hour post plating showing few melanomacrophages and abundant other cells. D = Same plate 15 days post plating showing culture overrun with fibroblast-like cells. We have used selective trypsinization to prepare nearly pure fibroblast cultures as well as melanomacrophage cultures. Blood cells do not attach and are eliminated when the cultures are fed.

were collected in complete medium (CM), RPMI-1640 with 7.5% fetal bovine serum (Gibco Inc. Grand Island, New York) and penicillin, streptomycin, and neomycin at half the concentrations used above. The cells and aggregates were allowed to settle for 8 min through a 40 ml column of CM in a sterile centrifuge tube. The pellet was collected, trunulated (repeatedly pulled in and out of a 10 ml pipette) in fresh CM to resuspend and separate the cells, and the cells were resettled as before. This procedure removed much of the cellular debris. The pellet was then resuspended in CM and transferred to ten 75cm² T flasks as described in Rund et al. (1998). Individual viable cells and aggregates of either MMs or fibroblasts or both attached to the substratum and spread within 3–5 days post-plating during incubation at 29°C in a humidified incubator operating at 5% CO₂. CM was decanted and replaced with fresh CM after one week. Additional cultures were started from the decantates that contained viable cells and aggregates that had not yet fully attached. These cells and aggregates were centri-

fuged, resuspended in CM, and then vigorously trunulated to further separate cells before depositing cells in T flasks. MMs and other cells including many fat droplet-bearing cells were obtained by this procedure and their viability was demonstrated by their ability to attach to the flask substratum and spread.

Approximately 28 days after establishment of these primary cultures containing mixtures of cells, MMs were collected by selective trypsinization. Unattached cells such as RBCs and fragments of tissue were removed by gentle shaking and decantation. A warm 1:5 dilution of 0.25% trypsin-EDTA (Sigma-Aldrich, Inc.) in sterile PBS (10 mM phosphate buffer, pH 7.2, 137 mM NaCl) was added to the flasks and incubated for 5–7 minutes. Most fibroblasts, fat droplet-bearing cells, and hepatocytes rounded up and detached from the substrate with gentle shaking. These could be cultured in other flasks if desired. A few fibroblasts always remained but this procedure could be repeated when relatively pure MM cultures were desired. The MMs rounded and detached after approximately 15 minutes or with the addition of fresh trypsin-EDTA. The enriched MM fraction was collected by centrifugation for three minutes at 1000 x g and cultured at plating densities of 0.5–3.0 x 10³ cells/cm² in T flasks. The enriched MM fraction consisted mostly of MMs with some debris and a few

hepatocytes (Fig. 1A). Cells were maintained at 29°C in CM with media replacement at weekly intervals. Cultures were selectively trypsinized if overgrowth by fibroblasts occurred. Overgrowth of MMs did not occur because these apparently end-stage, differentiated cells rarely, if ever, divided in culture. Selective trypsinization and settling as described herein, typically resulted in cultures that were greater than 90% MMs based upon microscopic determinations of melanin in attached and spreading cells (Fig. 1B). These cultures could be maintained free of fibroblast overgrowth for many weeks depending on the burden of fibroblasts in the selectively trypsinized cell fraction.

Fibroblast and other cells in preparations that were not selectively trypsinized (Fig. 1C) would grow into colonies and further multiplied to form confluent cultures of mostly fibroblasts in 10–20 days depending upon plating densities, species, age of the culture (number of times the culture had been passaged), and age of the animal from which the culture was obtained (Fig. 1D).

MM Aggregations.—Melanomacrophages tended to adhere to each other. The MM centers in the liver and spleen were resistant to trypsinization and disaggregation and clumps of MMs were lost during culturing as they did not bind sufficiently well to the plastic substratum to resist decantation during media replacements. Upon selective trypsinization, MMs tended to reaggregate to form collections of 2–6 cells that appear as the larger spherical clusters in Fig 1A. These would often settle to form clusters of MMs (Fig. 1B). MMs that had aggregated or individual MMs that otherwise found themselves in relatively close proximity to each other in culture, used a variety of cellular processes to form networks. These processes are continuing to develop at 25 days post plating (Fig. 1B). This *in vitro* evidence suggests that MMs may aggregate in sinusoids or elsewhere with the effect of forming a similar network of processes potentially to trap foreign particles or organisms moving through the vessel. Johnson et al. (1999) demonstrated that MMs in culture phagocytized red blood cells and bacteria, and that they attached to parasites.

LITERATURE CITED

- AGUIS, C. 1985. The melanomacrophage centers of fish: a review. In M. J. Manning and F. M. Tatner (eds.), *Fish Immunology*, pp. 85–105. Academic Press, Orlando, Florida.
- CHRISTIANSEN, J. L., J. M. GRZYBOWSKI, AND R. A. KODAMA. 1996. Melanomacrophage aggregations and their age relationships in the yellow mud turtle, *Kinosternon flavescens* (Kinosternidae). *Pigment Cell Res.* 9:185–190.
- CLARK, H. E., AND D. T. KARZON. 1967. Terrapene heart (TH-1), a continuous cell line from the heart of the box turtle *Terrapene carolina*. *Exp. Cell Res.* 48:263–268.
- , M. H. COHEN, AND D. T. KARZON. 1970. Characterization of reptilian cell lines established at incubation temperatures of 23 to 36 degrees. *Proc. Soc. Exp. Biol. Med.* 133(3):1039–1047.
- DUNCKER, H. R. 1968. Die extracutane Melanocyten der Echsen (Sauria). *Ergeb. Anat. Entwickl. Gesch.* 40:7–55.
- JOHNSON J. C., T. SCHWIESOW, A. K. EKWALL, AND J. L. CHRISTIANSEN. 1999. Reptilian melanomacrophages function under conditions of hypothermia: observations on phagocytic behavior. *Pigment Cell Res.* 12:376–382.
- KOMENT, R. W., AND H. HAINES. 1982. Characterization of a reptilian epithelioid skin cell line derived from the green sea turtle, *Chelonia mydas*. *In Vitro.* 1982 18 (3 Pt 1):227–232.
- RUND C. R., J. L. CHRISTIANSEN, AND J. C. JOHNSON. 1998. In vitro culture of melanomacrophages from the spleen and liver of turtles: comments on melanomacrophage morphology. *Pigment Cell Res.* 11:114–119.
- SICHEL, G., M. SCALIA, F. MONDIO, AND C. CORSARO. 1997. The amphibian kupffer cells build and demolish melanosomes: an ultrastructural point of view. *Pigment Cell Res.* 10:271–287.
- ULSH, B. A., J. D. CONGDON, T. G. HINTON, F. W. WHICKER, AND J. S. BEDFORD. 2000. Culture methods for turtle lymphocytes. *Methods Cell Sci.* 22(4):285–97.

The Use of PIT Tags in Capture-Recapture Studies of Frogs: A Field Evaluation

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Marking animals so that they can be individually identified is an essential component of many animal studies. However, the same animals must be observed on two or more occasions for patterns of growth, development, movement and other parameters to be determined (e.g., Donnelly et al. 1994; Schemintz 1980; Skalski and Robson 1992). Capture-recapture of individuals may also be required for estimation of population size and patterns of population dynamics (e.g., Begon 1979; Caughley 1984; Seber 1982; Southwood 1978).

To be useful in these contexts the marks applied to animals should be able to uniquely identify the individual, should be permanent (at least over an animal's lifetime) and accurately discernable, and should not affect survival, reproduction or behavior (e.g., Seber 1982). Additionally, if marked animals are less likely to be captured than unmarked animals then estimates of population size based on capture-recapture analysis will be biased away from the true population size (e.g., Seber 1982). Any process of marking animals must also be logistically and economically viable (e.g., IUCN/CBSG on Permanent Animal Identification 1991).

For the use of marks to be justified, any associated pain or suffering experienced by the animals should be minimized (e.g., Anonymous 1992). Aside from being reasonably humane, such an approach is now a legal requirement in many areas for research activities that involve non-human animals.

In the case of frogs, no reliable and completely pain-free technique for marking individuals has been found. Identifying individuals on the basis of unique color patterns is sometimes possible, but only when the total number of individuals is reasonably small (e.g., Berrill et al. 1992; Bertram and Berrill 1997; Doody 1995). It is difficult or impossible to permanently attach anything external to the body of a frog (e.g., Elmberg 1989; Woodbury 1956), and therefore the most commonly used technique for marking frogs has been toe-clipping (e.g., Donnelly et al. 1994). In this technique, one or more toes are removed and a unique pattern of toe removal is assigned to each individual (e.g., Donnelly et al. 1994). It is hard to imagine that this would not be painful for the animals involved. Branding, where a mark is induced in the skin of a frog through the application of intense but localized heat or cold (e.g., Clark 1971; Ehmann 2000), seems also likely to be painful for the individuals involved.

Since 1983 it has been possible to mark individual animals with small passive integrated transponders that are generally referred to as PIT tags or microchips (e.g., Barnard 1989; Camper and Dixon 1988; Fagerstone and Johns 1987; Prentice and Park 1983). The transponder is an integrated unit consisting of an electromagnetic coil, tuning capacitor and microchip, all sealed in a cylindrical glass enclosure that is typically 1.8–2.2 mm in diameter and 10–

12 mm long (e.g., Elbin and Burger 1994; Fasola et al. 1993; Keck 1994; Ott and Scott 1999). The transponder is passive in that it contains no power supply and does not emit any signal until stimulated (e.g., Germano and Williams 1993; Jehle and Hoedl 1998; Schooley et al. 1993). The chip is inserted internally into the animal and is programmed with a unique alphanumeric code that can be read by a scanner (e.g., Christy 1996; Jehle and Hoedl 1998; Schooley et al. 1993).

This methodology has many advantages of alternative methods for marking animals. As there are high rates of scanner accuracy (Gibbons and Andrews 2004), PIT-tagged individuals can consistently be identified with little or no error. PIT tags are reliable and relatively easy to use, durable and afford an immense number of possible different codes, estimated at about 34 billion (Elbin and Burger 1994). Insertion of a tag into an animal requires no more than five minutes (Christy 1996) and often much less time (G. Pyke, pers. obs.). Tag life is considered to be 15–20 years (Germano and Williams 1993), 50–100 years (Pope and Matthews 2001), indefinite (Christy 1996; Fasola et al. 1993; Keck 1994) or ‘permanent’ over the lifetime of an animal (Ott and Scott 1999).

Due to these advantages and the small size of PIT tags, they have been increasingly used to individually mark all classes of vertebrate animals (Elbin 1991). They have been used with fish (e.g., Adam and Schwevers 1994; McCutcheon et al. 1994; Peterson et al. 1994), mammals (e.g., Ball et al. 1991; Schooley et al. 1993; Thomas et al. 1987), reptiles (e.g., Germano and Williams 1993; Parmenter 1993; Jemison et al. 1995), amphibians (e.g., Brown 1997; Donnelly et al. 1994; Zulich et al. 1992), and birds (e.g., Ballard et al. 2001; Elbin and Burger 1994). They have also been used with relatively large invertebrates, such as crabs (e.g., Pengilly and Watson 1994).

The consequences of the PIT tagging process for the animals involved have been considered in a number of studies. For example, relative merits of using PIT tags in relation to alternative methods for individually marking animals have been assessed (e.g., Brown 1997; Jehle and Hoedl 1998; Jemison et al. 1995; Ott and Scott 1999; Perret and Joly 2002), as have effects of PIT tagging on individual survival, growth, movement and health (e.g., Christy 1996; Fasola et al. 1993; Keck 1994; Ombredane et al. 1998). In general, PIT tagging has minimal adverse impacts on tagged animals (Gibbons and Andrews 2004).

Our own use of PIT tags to mark frogs provides an additional opportunity to consider some of the consequences of employing this technique. As part of an ongoing research program that focuses on the Green and Golden Bell Frog (*Litoria aurea*) and the Striped Marsh Frog (*Limnodynastes peronii*) my colleagues and I have been using PIT tags to mark frogs at several sites in New South Wales, Australia since March 1998 (Pyke and Miehs 2003; Pyke and White, unpubl.). We have PIT tagged over 3000 individual frogs and had multiple recaptures of many of these. We have, therefore, made a number of observations that are relevant in the context of evaluating the outcomes of the technique.

FIELD STUDIES

General Methodology.—Field studies have been carried out by teams of people that have varied in composition. These teams have been coordinated by the author, who has been present on all occasions.

We have used PIT tags supplied by Trovan in individually-packaged needles inside hermetically sealed packages. Inside each needle is a metal rod that can push the tag from the open end of the needle. We have implanted these tags subcutaneously by pinching the skin along the side of the body a short distance behind the front limb, inserting the needle through the pinched skin parallel to the body axis toward the base of the hind limb, and then pushing the tag through and out of the needle with the aid of a plunger mechanism inside a syringe that is attached to the needle. We have not anaesthetized frogs before this procedure. To seal the wound area we have used Vetbond, an n-butyl cyanoacrylate adhesive that quickly polymerizes from liquid to solid state when applied to the skin. We have adopted a minimum snout-vent length of 40 mm for PIT tagging. The alphanumeric codes for the PIT tags supplied to us have not been sequential and have varied greatly from one to the next.

We have been able to evaluate PIT tags of two different ages since manufacture. We have used PIT tags within two years of their receipt and well before the stated expiry date, which has been about seven years after we received them. These tags would have been less than two years old when used by us. We also have some PIT tags with an expiry date of 1996, but have not used them. These tags were considerably older when we examined them, probably about 15 years since manufacture (see below).

Effects of PIT Tagging on Frogs.—During field studies in Australia over a period of 6 years we have implanted PIT tags under the skin of almost 3000 frogs of nine species. One species, the Green and Golden Bell Frog (*Litoria aurea*) has accounted for most (89.2%, $N = 2950$) of the frogs we have micro-chipped, followed by the Striped Marsh Frog (*Limnodynastes peronii*; 8.9%) and small numbers of the other species.

The behavior of frogs while we have microchipped them suggests that any pain involved must be minimal, except when an animal is injured during the process. Although capable of emitting a distress call, the frogs that we have PIT tagged have rarely (i.e., <1% of the time) made such calls while we have handled and tagged them (pers. obs.). They have also rarely flinched or otherwise struggled during the microchipping. On the other hand, on three occasions when frogs have clearly been injured during tagging (see below) they have made loud and obvious distress calls. I assume here that distress calls and struggling movements of hand-held animals are possible signs of pain they experience, and that the absence of such behaviors suggests a lack of pain.

On only three occasions has any noticeable injury occurred to a frog during the tagging process. In each of these cases the implanting needle must have penetrated the body wall, because part of the lungs exuded from the body and out into the air almost as soon as the needle was withdrawn, and the frog emitted loud distress calls starting when the needle began to penetrate the body wall. In one case the injured frog was taken from the wild into captivity, given sutures, antibiotics and food, and subsequently released back into the wild. In another case, the lungs naturally and reasonably quickly retracted back into the frog's body and remained there after application of tissue glue to the wound, and this frog was then released where it had been captured. In the third case the frog was euthanized. Neither of the injured frogs that were released alive has subsequently been recaptured, but overall recapture rates at the associated sites have been close to zero (Pyke,

unpubl.).

No longer-term effects of our tagging on the health of individual frogs have been apparent. Whenever frogs have been recaptured about 24 h after initial tag insertion, a thin layer of Vetbond around the wound site has often been observed but the wound itself has never been visible and there have been no signs of swelling, infection or other damage to the area ($N = 420$). Frogs that have been recaptured about 6 weeks or longer after initial tag insertion have never shown any signs of the wound or other damage to the area ($N = 1099$). Our field schedule has been such that recaptures after intervals of between 2 days and 6 weeks have not been possible.

The proportion of tagged frogs among those found dead has not been significantly different from the proportion among those captured alive, suggesting that mortality is no different between tagged and untagged frogs. At Broughton Island over the period from 1999 to 2003 four dead frogs (3 *L. aurea*; 1 *L. peronii*) have been found, of which three (i.e., 75%) were tagged. Over this period, which omits the first year of the study when recapture rates were rapidly increasing, and during which recapture rates were relatively stable, the overall recapture rate across the two species was almost identical at 74.5% ($N = 5379$). Similarly, at North Avoca over the same period, 33.3% ($N = 9$) of *L. aurea* frogs found dead had been tagged compared with 48.1% ($N = 497$) of this species captured alive ($P = 0.5$; Fisher Exact Test).

If tagged frogs are less likely to mate than untagged frogs then the proportion of tagged frogs among those found in amplexus should be lower than the proportion among unmated frogs, and a significant trend in this direction was found. On Broughton Island, during spring and summer when almost all amplexing *L. aurea* are found, 60.9% of the males ($N = 46$) and 37.0% of the females ($N = 46$) were tagged while among unmated frogs, 80.0% of males and 62.4% of females were tagged (males: $P = 0.003$; females: $P = 0.001$; Fisher Exact Test). Amplexing pairs of this species have not been recorded at other sites.

However, the frogs in amplexus were significantly younger than those that were unmated. For those *L. aurea* that had been previously captured and tagged, the average number of captures per individual was significantly higher for unmated frogs than for frogs in amplexus (i.e., unmated: mean = 5.45, $N = 4229$; amplexing frogs: mean = 3.76, $N = 54$; F-ratio = 9.11 $r^2 = 0.002$, $P = 0.003$, ANOVA). For all captured *L. aurea*, including both new captures and recaptures, the average number of captures per individual was about 92% higher for unmated frogs than for frogs in amplexus (i.e., unmated: mean = 4.32, $N = 5661$; amplexing frogs: mean = 2.24, $N = 120$; F-ratio = 31.7, $r^2 = 0.005$, $P < 0.001$, ANOVA). Assuming the probability of capture for a frog of this species is independent of age once the frogs have reached maturity, the average age of the unmated frogs must have been about 92% higher than that of the amplexing frogs.

Taking this age difference into account, there were no significant differences in recapture rates of amplexing and unmated frogs. If the probability of an individual of age "X" being tagged is " P_x " and the probability of an animal being captured is assumed constant throughout its life, then the probability of an individual of age "A times X" being tagged, where A is any constant, is $1 - (1 - P_x)^A$. Hence the recapture rates of 0.609 and 0.370 for amplexing males and females respectively are equivalent to 0.835 and 0.588 among frogs that are 92% older (e.g., $1 - (1 - 0.609)^{1.92} = 0.835$). These

proportions are not significantly different from those observed for unmated males and females (P 's = 0.8 and 0.5, respectively; Fisher Exact Test). Allowing for the likelihood that capture probability does not remain constant would not alter this conclusion.

During our study some PIT-tagged frogs of *L. aurea* have lived for many years, some individuals have been captured many times, and recapture rates have reached high levels. Based on recaptures, about 7% of tagged individuals have lived at least 3 years since first capture and several frogs have been alive for the 5-year duration of the study. About 8% have been captured at least 10 times and about 1% have been captured over 20 times. Recapture rates have peaked during winter each year at about 90% for males and 75% for females (Pyke, unpubl.).

Permanence of Tag Code and Accuracy of Recording Codes.—No tag failures have been detected during the present study. For most tagged individuals the tag can be seen as an elongated bump under the skin and there has not yet been a case where a tag was visible but undetected by the scanner. In a relatively small number of cases the scanner has detected a tag that was not noticed during visual inspection of the frog. Tag failures have, however, been apparent in tags that were about 15 years old. Out of a total of 75 tags that all have an expiration date of 1996 printed on the sealed container and were supplied together, 5 (i.e., 7%) could not be read by a scanner in 2004, while the remainder could be read correctly.

There has probably been negligible error with regard to the alphanumeric codes associated with the PIT tags when they have been implanted into frogs. In our case the PIT tags come supplied with stick-on labels bearing the code and we have used these labels to record the code without scanning and hence without any scanning error. We occasionally scanned the PIT tags at the time of implantation and always found agreement between the code detected by the scanner and the code on the label. We have also been able to compare the codes associated with the tags we have used with a master list for tags supplied to us, and so far found no discrepancy.

On the other hand, we have detected incorrect codes in our data when codes that are recorded for a recaptured frog only appear once in our records and have never been recorded in association with an initial capture of any animal. About 1.8% of recorded codes for frogs on Broughton Island have shown such errors ($N = 5020$). Such errors might also be detected if recorded microchip codes do not correspond to the entries in the master list of all codes that have been used.

We have found that these errors can generally be attributed to human error associated with recording microchip codes, with usually just one character being omitted or incorrectly recorded. Most cases of mistaken character identity can be attributed to visual or auditory similarity between the correct and incorrect characters when written or spoken respectively (e.g., visual: B vs. 8; auditory: D vs. B). Some mistakes have no obvious explanation.

We have taken steps to minimize recording errors. Typically one person scans and calls out the code to a second person that does the recording. Lighting may be poor and there may be significant background noise. To minimize recording error the person doing the scanning uses a headlamp to illuminate the scanner. To minimize auditory misinterpretation, words rather than letters are called out (e.g., 'alpha' instead of 'a'). Errors could be further

reduced if the recording person called out the recorded code to the scanning person who checked this against the code on the scanner, but this would add to the time required.

Through the diversity, as supplied, of alphanumeric codes for PIT tags and the above steps to minimize human error, we have been able to achieve a marking system that is essentially error-free. There is much noticeable variation among the alphanumeric codes for PIT tags, both within batches of supplied tags (we get them in batches of 40) and between these batches. It is this diversity of codes that permits us to detect and correct any errors that do occur, despite our attempts to minimize them. Such errors might also be eliminated where it is possible to transmit detected codes directly from scanner to computer and match these codes with other recorded information about individual frogs.

DISCUSSION

Our field observations provide further evidence that marking frogs with PIT tags has little immediate impact, does not significantly affect long-term survival or reproductive behavior, and can be used with almost no error (see Gibbons and Andrews 2004). The behavior of frogs while we have microchipped them suggests that any pain involved must be minimal, they have rarely suffered noticeable injury during the tagging process, and no longer-term effects of our tagging on the health of individual frogs have been apparent. There have been no apparent differences between tagged and untagged frogs in terms of survival or ability to mate. Some tagged frogs have lived for many years, some individuals have been captured many times, and recapture rates have reached high levels. The diversity of alphanumeric codes for PIT tags and our steps to minimize human error have essentially eliminated errors. Hence there are many benefits associated with the use of PIT tags to mark amphibians and other animals.

Our observations, however, are more consistent with claims that tag life is 15–20 years (Germano and Williams 1993) than with reported tag longevities of 50–100 years or indefinite (Christy 1996; Fasola et al. 1993; Keck 1994; Pope and Matthews 2001). Assuming that our older tags were initially obtained in about 1989, then 7% have stopped working after about 15 years. Of course, it is also possible that longevity has increased through improved technology. Authors (e.g., Keck 1994) seldom comment regarding tag failure and so presumably this has rarely occurred. However, there has not yet been a comprehensive evaluation of tag longevity.

Acting as impediments to more widespread use of PIT tags for marking frogs are their size and cost. With a minimum snout–vent length threshold of 40 mm, given the smallest size tags currently available, there are many frogs that cannot be marked in this manner. As financial resources will always be limiting, the high cost of PIT tags relative to other methods of marking frogs also restricts their use (e.g., Elbin and Burger 1994; Germano and Williams 1993; Gibbons and Andrews 2004; Ireland et al. 2003; Ott and Scott 1999). However, given the considerable benefits associated with their use for marking animals, they are likely to be increasingly used in this manner, especially with decreases in either their size or cost.

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LITERATURE CITED

- ADAM, V. B., AND U. SCHWEVERS. 1994. New marking method for fish - initial trials with micro transponders. *Anim. Res. Devel.* 40:78–87.
- ANONYMOUS. 1992. Use of coded microchip implants for marking live animals in trade. *CBSG News* 3(2): 21–22.
- BALL, D. J., G. ARGENTIERI, R. KRAUSE, M. LIPINSKI, R. L. ROBINSON, R. E. STOLL, AND G. E. VISSCHER. 1991. Evaluation of a microchip implant system used for animal identification in rats. *Lab Anim. Sci.* 41:185–186.
- BALLARD, G., D. AINLEY, C. RIBIC, AND K. R. BARTON. 2001. Effect of instrument attachment and other factors on foraging trip duration and nesting success of Adelie penguins. *Condor* 103: 481–490.
- BARNARD, S. M. 1989. The use of microchip implants for identifying big brown bats (*Eptesicus fuscus*). *Anim. Keepers' Forum* 16:50–52.
- BEGON, M. 1979. *Investigating Animal Abundance: Capture-Recapture for Biologists*. Edward Arnold, London.
- BERRILL, M. S., S. BERTRAM, D. BRIGHAM, AND V. CAMPBELL. 1992. A comparison of three methods of monitoring frog populations. In C. A. Bishop and K. E. Pettit (eds.), *Declines in Canadian Amphibian Populations: Designing a National Monitoring Strategy*. Occasional Paper 76, pp. 87–93. Canadian Wildlife Service, Ottawa, Ontario, Canada.
- BERTRAM, S., AND M. BERRILL. 1997. Fluctuations in a northern population of gray treefrogs, *Hyla versicolor*. In D. M. Green (ed.), *Amphibians in Decline: Canadian Studies of a Global Problem*, pp. 57–63. Society for the Study of Amphibians and Reptiles, St. Louis, Missouri.
- BROWN, L. J. 1997. An evaluation of some marking and trapping techniques currently used in the study of anuran population dynamics. *J. Herpetol.* 31:410–419.
- CAMPER, J. D., AND J. R. DIXON. 1988. Evaluation of a microchip marking system for amphibians and reptiles. *Texas Parks Wildl. Dept. Rep.* 7100-159:1–22.
- CAUGHLEY, G. 1984. *Analysis of Vertebrate Populations*. Wiley, New York.
- CHRISTY, M. 1996. The efficacy of using Passive Integrated Transponder (PIT) tags without anaesthetic in free living frogs. *Aust. Zool.* 30:139–142.
- CLARK, D. R. 1971. Branding as a marking technique for amphibians and reptiles. *Copeia* 1971:148–151.
- DONNELLY, M. A., C. GUYER, J. E. JUTERBOCK, AND R. A. ALFORD. 1994. Techniques for marking amphibians. In W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster (eds.), *Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians*, pp. 277–284. Smithsonian Institution Press, Washington, D.C.
- DOODY, J. S. 1995. A photographic mark-recapture method for patterned amphibians. *Herpetol. Rev.* 26:19–20.
- EHMANN H. 2000. Microbranding: a low impact permanent marking technique for small reptiles and frogs as an alternative to toe clipping. *ANZCCART News* 13(2):6–7.
- ELBIN, S., AND J. BURGER. 1994. Implantable microchips for individual identification in wild and captive populations. *Wildl. Soc. Bull.* 22:677–683.
- ELMBERG, J. 1989. Knee-tagging—a new marking technique for anurans.

- Amphibia-Reptilia 10:101–104.
- FAGERSTONE, K. A., AND B. E. JOHNS. 1987. Transponders as permanent identification markers for domestic ferrets, black-footed ferrets, and other wildlife. *J. Wildl. Mgmt.* 51:294–297.
- FASOLA, M., F. BARBIERI, AND L. CANOVA. 1993. Test of an electronic individual tag for newts. *Herpetol. J.* 3:149–150.
- GERMANO, D. J., AND D. F. WILLIAMS. 1993. Field evaluation of using passive integrated transponder (PIT) tags to permanently mark lizards. *Herpetol. Rev.* 24:54–56.
- GIBBONS, J. W., AND K. M. ANDREWS. 2004. PIT tagging: Simple technology at its best. *BioScience* 54(5):447–454.
- INTERNATIONAL UNION FOR CONSERVATION OF NATURE/ CAPTIVE BREEDING SPECIALIST GROUP (IUCN/CBSG) ON PERMANENT ANIMAL IDENTIFICATION 1991. Final report on transponder system testing and product choice as a global standard for zoological specimens. *CBSG News* 2(1):3–4.
- IRELAND, D., N. OSBOURNE, AND M. BERRILL. 2003. Marking medium- to large-sized anurans with passive integrated transponder (PIT) tags. *Herpetol. Rev.* 34:218–220.
- JEHLE, R., AND W. HOEDL. 1998. PITs versus patterns: effects of transponders on recapture rate and body condition of Danube crested newts (*Triturus dobrogicus*) and common spadefoot toads (*Pelobates fuscus*). *Herpetol. J.* 8:181–186.
- JEMISON, S. C., L. A. BISHOP, P. G. MAY, AND T. M. FARRELL. 1995. The impact of PIT-tags on growth and movement of the rattlesnake, *Sistrurus miliaritus*. *J. Herpetol.* 28:129–132.
- KECK, M. B. 1994. Test for detrimental effects of PIT tags in neonatal snakes. *Copeia* 1994:226–228.
- MCCUTCHEON, C. S., E. F. PRENTICE, AND D. L. PARK. 1994. Passive monitoring of migrating adult steelhead with PIT tags. *N. Amer. J. Fish. Mgmt.* 14:220–223.
- OMBREDANE, D., J.-L. BAGLINIÈRE, AND F. MARCHAND. 1998. The effects of passive integrated transponder tags on survival and growth of juvenile brown trout (*Salmo trutta* L.) and their use for studying movements in a small river. *Hydrobiology* 371/372:99–106.
- OTT, J. A., AND D. E. SCOTT. 1999. Effects of toe-clipping and PIT-tagging on growth and survival in metamorphic *Ambystoma opacum*. *J. Herpetol.* 33:344–348.
- PARMENTER, C. J. 1993. A preliminary evaluation of the performance of passive integrated transponders and metal tags in a population of the flatback sea turtle (*Natator depressus*). *Wildl. Res.* 20:375–381.
- PENGILLY, D., AND U. WATSON. 1994. Automated detection of internally injected tags in red king crabs at crab processing facilities. *Fisheries Res.* 19:293–300.
- PERRET, N., AND P. JOLY. 2002. Impacts of tattooing and PIT-tagging on survival and fecundity in the alpine newt (*Triturus alpestris*). *Herpetologica* 58:131–138.
- PETERSON, N. P., E. F. PRENTICE, AND T. P. QUINN. 1994. Comparison of sequential coded wire and passive integrated transponder tags for assessing overwinter growth and survival of juvenile Coho salmon. *N. Amer. J. Fish. Mgmt.* 14:870–873.
- POPE, K. L., AND K. R. MATTHEWS. 2001. Movement ecology and seasonal distribution of mountain yellow-legged frogs, *Rana muscosa*, in a high elevation Sierra Nevada basin. *Copeia* 2001:787–793.
- PRENTICE, E. F., AND D. L. PARK. 1983. A Study to Determine the Biological Feasibility of a New Fish Tagging System. Quarterly Progress Report, April–June 1983. Seattle: Coastal Zone and Estuarine Studies Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA.
- PYKE, G. H., AND A. MIEHS. 2003. Effects of stomach flushing on recapture rates for *Litoria aurea* and *Limnodynastes peronii*. *Herpetofauna* 34:81–83.
- SCHEMINTZ, S. D. 1980. *Wildlife Management Techniques Manual*. 4th Edition. Wildlife Society, Washington.
- SCHOOLEY, R. L., B. VAN-HORNE, AND K. P. BURNHAM. 1993. Passive integrated transponders for marking free-ranging Townsend's ground squirrels. *J. Mammal.* 74:480–484.
- SEBER, G. A. F. 1982. *The Estimation of Animal Abundance and Related Parameters*. New York: MacMillan.
- SKALSKI, J. R., AND D. S. ROBSON. 1992. *Techniques for wildlife investigations: design and analysis of capture data*. Academic Press, San Diego.
- SOUTHWOOD, T. R. E. 1978. *Ecological Methods with Particular Reference to the Study of Insect Populations*. 2nd Edition. Chapman Hall, London.
- THOMAS, J. A., L. H. CORNELL, B. E. JOSEPH, T. D. WILLIAMS, AND S. DREISCHMAN. 1987. A transponder chip used as a permanent tag for sea otters (*Enhydra lutris*). *Marine Mammal Sci.* 3:271–274.
- WOODBURY, A. M. 1956. Uses of marking animals in ecological studies: Marking amphibians and reptiles. *Ecology* 37:670–674.
- ZULICH, A. W., D. HAMPER, B. CLARK, AND T. PEITZ. 1992. A report on the use of implanted transponders for permanent identification of reptiles and amphibians. *Rept. Amphib. Mag. Sept./Oct.*:60–62.

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Coelomic Response and Signal Range of Implant Transmitters in *Bufo cognatus*

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Radio telemetry is a useful technique in ecological studies to determine habitat use, survival, and dispersal of organisms (Faccio 2003; Lamoureux et al. 2002; Millspaugh and Marzluff 2001). For amphibians, radio transmitters are attached externally using a belt harness or implanted into the coelomic cavity (Muths 2003; Werner 1991). External attachment of transmitters may affect amphibian dispersal or other life cycle events (e.g., breeding, feeding; Richards et al. 1994). Also, external transmitters are not feasible for amphibians that estivate underground, because they could interfere with digging and concealment. Alternatively, implanting transmitters requires invasive surgery that might affect body condition and survival (Madison and Farrand 1998), or damage vital organs within the coelomic cavity. Also, information on aboveground signal range of transmitters after implantation has not been published. Our goal was to describe the general effects of implant transmitters on coelomic response of a common amphibian (*Bufo cognatus*) in the Great Plains (Gray et al. 2004), and measure aboveground signal distance over four months, which was the expected battery life of the transmitters.

Materials and Methods.—We collected 14 Great Plains Toads

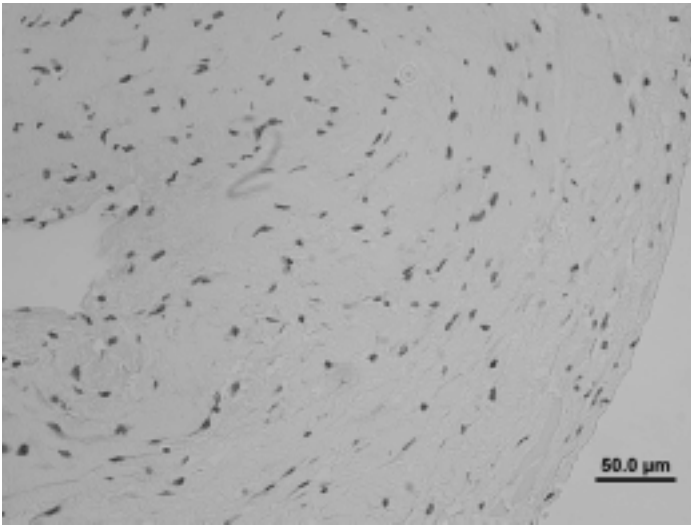


FIG. 1. Four months post-surgery microscopic view of the connective tissue encapsulating transmitters implanted in the coelomic cavity of 9 *Bufo cognatus*.

(*Bufo cognatus*) along roads at night during intense rain on 12 May 2001 northwest of Lubbock, Texas (33°39'–33°51'N, 101°49'–102°10'W) in the Southern High Plains. We placed all toads in separate 38-liter aquariums and fed them native crickets and beetles *ad libitum* for the duration of the study. Each aquarium contained 10 cm of soil substrate and a 500 cm³ plastic water reservoir that was flush with the substrate surface to allow natural burrowing and water absorption by the toads.

We used SM1-H transmitters manufactured by AVM Instrument Company. These transmitters were single-staged (150 MHz) and powered by a CR2040 lithium manganese dioxide cell with an internal-loop antenna that encircled the battery. Signal strength and pulse rate of our transmitters at the beginning of the study were between -21 and -25 dBm and 58 and 68 BPM, respectively. The expected battery life given the power output (0.065 mA) was 4 months. The transmitter, battery, and antenna were encapsulated in RTV plastic and coated with clear dental acrylic. The final mass and volume of the transmitter package were 6.63 g (5–10% of individual toad body mass, 60–118 g) and 2.45 cm³, respectively.

We implanted transmitters into 10 of the 14 toads on 2 June 2001. The four remaining toads did not receive transmitters and were maintained in captivity simultaneously. These toads were used as controls so we could

compare histological responses to the transmitters at the end of the study. Our surgical procedures were similar to Madison (1997) and Seebacher and Alford (1999). We soaked transmitters and surgical instruments ≥ 30 minutes in chlorhexadine then rinsed them with sterile water. Toads were anesthetized by placing them into a solution of distilled water and tricaine methanesulfonate (1000 mg/L, Faccio 2003); sedation occurred within 10–32 minutes (mean = 18.5, SD = 6.8). After anesthetization, we made a 20-mm skin incision in the left caudoventrolateral quadrant of the abdomen with a sterile #20 scalpel. Next, we punctured through the abdominal wall and into the coelomic cavity with closed pointed surgical scissors. After puncturing the wall, the scissors were opened to separate the muscular fibers creating an opening into the coelomic cavity. The opening was maintained with thumb forceps then the transmitter was placed into the cavity. The incision was closed in two layers with 3-0 absorbable suture material. First, we sutured the abdominal wall with 3 stitches 5 mm apart in a simple interrupted pattern. Next, we closed the skin in a similar fashion. The incision was dried using sterile 4 × 4 gauze sponges. Finally, we applied surgical glue along the entire length of the incision to provide a temporary sealant. The entire surgical procedure lasted 8–10 minutes. Toads were then placed in distilled water containing antibacterial tetracaine powder (1% solution) for recovery (mean = 40.6, SD = 11.7 minutes). After anesthetic recovery, we returned toads to aquariums.

We measured aboveground signal distance (m) and body mass (g – transmitter package mass) twice per month from 2 June to 2 October 2001. We used a fully charged R2100 Advanced Telemetry Systems receiver and a 3-element AF Antronics Yagi antenna (model #F152-3FB) tuned specifically for 150–152 MHz to measure signal distance. Aboveground distance was determined by placing each toad in a plastic bucket and traversing a linear transect until the signal was not received. We considered these measure-

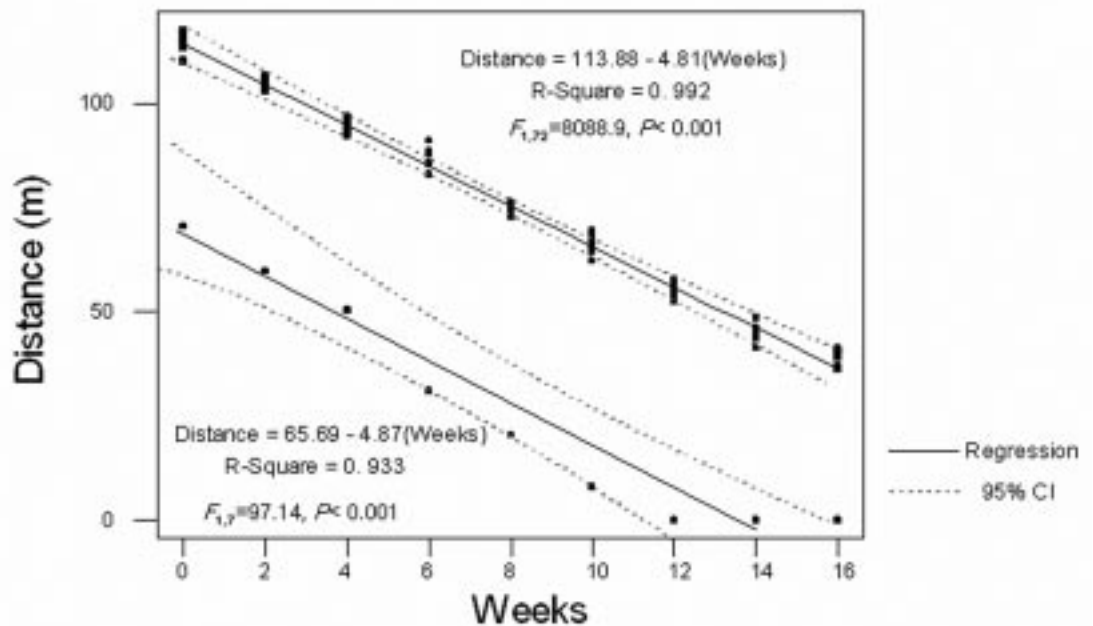


FIG. 2. Aboveground signal distance in two-week increments (2 June [week = 0] – 2 October 2001 [week = 16]) of SM1-H internal-loop antenna transmitters implanted into 10 Great Plains Toads (*Bufo cognatus*). The bottom regression is for a prototype transmitter that lost battery strength prior to the study.

ments maximum signal distances under ideal conditions because toads were aboveground and no obstructions existed between them and the receiver. Individual toad survival also was recorded.

At completion of the study, we sent all live toads (controls and ones with transmitters) to the University of Georgia Tifton Veterinary Diagnostic and Investigational Laboratory where they were euthanized and necropsied. Macroscopic inspections included surgical site condition, coelomic response to transmitters, and general organ condition. Tissue sections of all organs (including skin) were collected, processed, and examined microscopically.

Aboveground signal distance and toad body mass were regressed against post-surgery duration in two-week increments from the initiation until the end of the study (0, 2, 4, ..., 16 weeks) to compare signal range and body mass through time. We performed two separate regressions for signal distance because maximum distance of one transmitter was markedly less throughout the study compared to the other nine transmitters. This transmitter was sent as a prototype six months prior to the study and used twice; all other transmitters had batteries at full strength at the beginning of the study. Also, one toad died during the study on 5 July 2001 thus its signal distance was not measured afterward nor used in the regression after week 4. Proportion of toads surviving until the end of the study was tested against a constant proportion ($p_0 = 0.5$) using a one-sample binomial test to determine if the overall survival rate differed ($\alpha = 0.05$) from the mortality rate (Milton and Arnold 1995:322). Necropsy results are presented as summary statistics.

Results.—Pathological examinations were performed on 9 of the 10 toads with transmitters and the 4 control toads. The deceased toad could not be analyzed because of advanced autolysis. Surgical sites of all toads were healed with minimal scarring. Granulation tissue existed at the surgical site of all toads and few mixed inflammatory cells (heterophils, macrophages, and lymphocytes) were present in one toad (11.1%). All transmitters were in the right caudoventrolateral coelome except one, which was in the left caudoventrolateral coelome. Each transmitter was encapsulated in a smooth, transparent connective tissue <1 mm thick (Fig. 1); few inflammatory cells and occasional vascularization were noted in the capsule of one transmitter. Six of 9 transmitters (67%) were adhered to the coelomic wall only or to the coelomic wall and 1–2 nearby organs by a strand of fibrous tissue (hereafter adhesion) that was ≤ 1 mm diameter \times 1–4 mm in length. Organs of attachment included the liver, ovary, and mesentery. Histological analyses and comparison with control toads revealed no damage to the organs of attachment or other organs (i.e., lungs, spleen, kidneys, large and small intestines) in the coelomic cavity.

Aboveground signal distance decreased predictably through the study (Fig. 2). Mean aboveground signal distance at the initiation and completion of the study for the 9 transmitters was 114.2 m (SD = 2.7) and 39.4 m (SD = 1.9), respectively. The maximum distance of the prototype transmitter at the initiation of the study was 70.4 m with no signal by week 12. Toad body mass did not change ($F_{1,7} = 0.03$ – 5.10 , $P = 0.06$ – 0.86) throughout the study. The proportion of toads surviving was 0.90, which differed ($P = 0.011$) from $p_0 = 0.5$. Mortality of the one toad was due to post-surgery complications; one suture pulled through the skin causing secondary infection.

Discussion.—Our results suggest that intracoelomic placement

of radio transmitters does not negatively affect survival, body mass, and coelomic condition of amphibians. Post-surgery survival was 90% and body mass of all individuals was stable for the duration of the study. Previous studies also have suggested that survival and body mass are unaffected by implant transmitters (Madison 1997; Madison and Farrand 1998; Werner 1991).

Intracoelomic placement of transmitters was within the left caudoventrolateral quadrant, but at postmortem examination, 8 of 9 transmitters were found in the right caudoventrolateral quadrant. Although the exact mechanism for transmitter displacement is unknown, it may have been a consequence of stomach expansion. The stomach is located within the left middle coelome (Duellman and Trueb 1994). During feeding and subsequent stomach expansion, the stomach may have extended into the left caudal region, displacing the transmitter to the right. Once displaced, the transmitter may not have returned to the left caudal position after gastric emptying.

Coelomic response to the transmitters was similar for all toads. A thin transparent connective tissue capsule formed around all transmitters, which is a typical histological response to implants (Butler et al. 1997; Eltze et al. 2003; Kellar et al. 2002; Laitung et al. 1987; Shannon et al. 1997; Walboomers et al. 1998; Walboomers and Jansen 2000; Zhao et al. 2000). One capsule had minimal vascularization and inflammatory cell infiltrates, which was consistent with local irritation. Most toads developed one or more fibrous adhesions that resulted in anchoring the transmitters within the coelome. Adhesions are common surgical complications in all species, and they result from local trauma as well as constant irritation (Alimoglu et al. 2003; Goodwin and Grizzle 1991; Herzog et al. 1970; Montz et al. 1991). In general, adhesions are not considered beneficial structures; however in our toads, the adhesions may have aided in preventing mechanical trauma to nearby organs or preventing cranial migration during normal body movements by anchoring the transmitters locally.

Coelomic and body mass response to implants likely would be similar for other large anurans (e.g., > 60 g in body mass). Mortality of one toad occurred secondary to dehiscence of the surgical site, which has been documented previously (Werner 1991). Thus, we recommend external sutures encompass > 2 mm of skin on each side of the incision. This may be especially important for species that are fossorial such as *Bufo cognatus*.

Average aboveground signal distance at the beginning of the study was 114 m and decreased linearly over the 4 months to 40 m. This initial signal distance was 23% of the manufacturer's claim of 500 m. Only 1 of 10 transmitters lost signal in < 4 months (the expected battery life); this transmitter was the prototype and may have been operating at a reduced power capacity at the initiation of the study.

Considering that average aboveground signal distance of our implant transmitters was approximately 100 m, researchers may need to monitor amphibians frequently (1–2 times/day) in the field so they are not lost. Also, implant transmitters might not be reasonable for amphibian species that disperse long distances over short duration. New multi-staged transmitters (e.g., G3-1V) may have greater signal range than the SM1-H transmitters used in our study (B. Corbett-Kermeen, AVM Instrument Company, pers. comm.). Signal distance also might be reduced by environmental variables that we did not measure, such as aboveground vegeta-

tion and substrate (if amphibians become fossorial, Madison 1997). Thus, our distance estimates likely represent best-case scenarios of signal range for SM1-H implant transmitters.

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LITERATURE CITED

- ALIMOGLU, O., A. AKCAKAYA, M. SAHIN, Y. UNLU, O. V. OZKAN, E. SANLI, AND R. ERYILMAZ. 2003. Prevention of adhesion formations following repair of abdominal wall defects with prosthetic materials (an experimental study). *Hepatogastroenterology* 50:725–728.
- BUTLER, K., H. BENGHUZZI, M. TUCCI, AND Z. A. CASON. 1997. Comparison of fibrous tissue formation surrounding intraperitoneal and subcutaneous implantation of ALCAP, HA, and TCP ceramic devices. *Biomed. Sci. Instrum.* 34:18–23.
- DUCELLMAN, W. E., AND L. TRUEB. 1994. *Biology of Amphibians*. John Hopkins, Baltimore, Maryland.
- ELTZE, E., O. BETTENDORF, A. RODY, C. JACKISH, F. HERCHENRODER, W. BOCKER, AND B. PFLEIDERER. 2003. Influence of local complications on capsule formation around model implants in a rat model. *J. Biomed. Mater. Res.* 64A:12–19.
- FACCIO, S. D. 2003. Postbreeding emigration and habitat use by Jefferson and spotted salamanders in Vermont. *J. Herpetol.* 37:479–489.
- GOODWIN, A. E., AND J. M. GRIZZLE. 1991. Granulomatous inflammation and monstrous giant cells in response to intraperitoneal hormone implants in channel catfish (*Ictalurus punctatus*). *J. Comp. Pathol.* 104:147–160.
- GRAY, M. J., L. M. SMITH, AND R. BRENES. 2004. Effects of agricultural cultivation on demographics of Southern High Plains amphibians. *Con. Biol.* 18:1368–1377.
- HERZOG, M., W. K. LINDSAY, AND W. G. MCCAIN. 1970. Effect of beta-aminopropionitrile on adhesions following digital flexor tendon repair in chickens. *Surg. Forum.* 21:509–511.
- KELLAR, R. S., L. B. KLEINERT, AND S. K. WILLIAMS. 2002. Characterization of angiogenesis and inflammation surrounding ePTFE implanted on the epicardium. *J. Biomed. Mater. Res.* 61:226–233.
- LAMOUREUX, V. S., J. C. MAERZ, AND D. M. MADISON. 2002. Premigratory autumn foraging forays in the green frog, *Rana clamitans*. *J. Herpetol.* 36:245–254.
- LAITUNG, J. K., J. MCCLURE, AND C. A. SHUTTLEWORTH. 1987. The fibrous capsules around static and dynamic implants: their biochemical, histological, and ultrastructural characteristics. *Ann. Plast. Surg.* 19:208–216.
- MADISON, D. M. 1997. The emigration of radio-implanted spotted salamanders, *Ambystoma maculatum*. *J. Herpetol.* 31:542–551.
- , AND L. FARRAND, III. 1998. Habitat use during breeding and emigration in radio-implanted tiger salamanders, *Ambystoma tigrinum*. *Copeia* 1998:402–410.
- MILLSPAUGH, J., AND J. MARZLUFF. 2001. *Radio tracking and animal populations*. Academic, New York.
- MILTON, J. S., AND J. C. ARNOLD. 1995. *Introduction to probability and statistics*. McGraw-Hill, New York.
- MONTZ, F. J., J. M. FOWLER, A. J. WOLFF, S. M. LACEY, AND M. MOHLER. 1991. The ability of recombinant tissue plasminogen activator to inhibit post-radical pelvic surgery adhesions in the dog model. *Am. J. Obstet. Gynecol.* 165:1539–1542.
- MUTHS, E. 2003. A radio transmitter belt for small ranid frogs. *Herpetol. Rev.* 34:345–348.
- RICHARDS, S. J., U. SINSCH, AND R. A. ALFORD. 1994. Radio tracking. In W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek, and M. S. Foster (eds.), *Measuring and monitoring biological diversity: standard methods for amphibians*, pp. 155–158. Smithsonian Institution, Washington D.C.
- SEEBACHER, F., AND R. A. ALFORD. 1999. Movement and microhabitat use of a terrestrial amphibian (*Bufo marinus*) on a tropical island: seasonal variation and environmental correlates. *J. Herpetol.* 33:208–214.
- SHANNON, C., R. THULL, AND A. VON RECUM. 1997. Types I and III collagen in the tissue capsules of titanium and stainless-steel implants. *J. Biomed. Mater. Res.* 34:401–408.
- WALBOOMERS, X. F., H. J. CROES, L. A. GINSEL, AND J. A. JANSEN. 1998. Microgrooved subcutaneous implants in the goat. *Biomed. Mater. Res.* 42:634–641.
- , AND J. A. JANSEN. 2000. Microgrooved silicone subcutaneous implants in guinea pigs. *Biomaterials* 21:629–636.
- WERNER, J. K. 1991. A radiotelemetry implant technique for use with *Bufo americanus*. *Herpetol. Rev.* 22:94–95.
- ZHAO, S., E. M. PINHOLT, J. E. MADSEN, AND K. DONATH. 2000. Histological evaluation of different biodegradable and non-biodegradable membranes implanted subcutaneously in rats. *J. Craniomaxillofac. Surg.* 28:116–122.

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Observations on Problems with Using Funnel Traps to Sample Semi-Aquatic Snakes

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Funnel traps have been shown to be an effective method for sampling snakes in many different aquatic habitats (Fitch 1999; Greene et al. 1999; Karns et al. 2000; Keck 1994). However, any technique can have biases which need to be considered when choosing an appropriate sampling method. In this note I report problems encountered using funnel traps to sample snakes. These problems include: 1) predation upon trapped Banded Watersnakes (*Nerodia fasciata fasciata*) by Eastern Cottonmouths (*Agkistrodon piscivorus piscivorus*); 2) potentially biased sex ratios of *N. fasciata* and *A. piscivorus*; and 3) predation upon trapped snakes by red imported fire ants (*Solenopsis invicta*).

I used both commercially available minnow traps of dimensions 42 cm long by 22 cm in diameter (Cuba Specialty Manufacturing Co., Filmore, New York; funnel openings enlarged to 3 cm with a rake handle), and funnel traps made from hardware cloth that were 41 x 22 cm with 5-cm funnel openings (Fitch 1987) to sample *N. fasciata* and *A. piscivorus*. The study site was the Pee Dee Research and Education Center (PDREC), a 972-ha experimental farm owned by Clemson University, located in the upper coastal plain of Darlington County, South Carolina, USA. Traps were

placed in shallow water (water depth < trap diameter) along logs, in emergent vegetation, and along short drift fences. The drift fences consisted of 5-m lengths of aluminum flashing oriented perpendicular to the shoreline with two traps placed at each end. Because of low capture rates (0.007 captures/trap day [TD] in 1998 to 0.011 captures/TD in 2002), traps were checked at 48-h intervals and not on weekends. Beginning in 1998 I sampled 11 ponds, a swamp, a lake, and several drainage ditches. Sampling occurred from July–October 1998 (960 TD), May–October 1999 (4108 TD), May–July 2000 (994 TD), April–June 2001 and 2002 (810, 994 TD, respectively), and May–June 2003 (757 TD). Means are followed by ± 1 SD. An $\alpha \leq 0.05$ is considered significant in all statistical tests.

Ten female *N. fasciata* ranging from 362 to 738 mm snout–vent length (SVL, mean = 600.8 ± 102.7) were found dead in traps with live Cottonmouths, including three (19% of captures) in 1998, two (7% of captures) in both 1999 and 2000, two (18% of captures) in 2002, and one (12.5% of captures) in 2003. The largest dead specimen was found in a minnow trap with a live male conspecific (390 mm SVL) and a live *A. piscivorus*. Of six adult *A. piscivorus* trapped with dead watersnakes, four were male and all ranged from 521 to 810 mm SVL (mean = 706 ± 115.7). Necropsies of 10 dead *N. fasciata* revealed paired puncture wounds surrounded by necrotic tissue on the dorsum of eight. I was unable to find bite marks on two specimens that were in an advanced state of decomposition. Bite marks (paired puncture wounds) were located 85–502 mm (mean = 223.75 ± 156.59) posterior to the snout. One 680 mm SVL specimen was bitten twice (two pairs of puncture wounds) located 502 and 585 mm posterior to the snout. *Nerodia fasciata* has been reported in the diet of Cottonmouths (Palmer and Braswell 1995), but only two of the watersnakes (362, 595 mm SVL) appeared to have been ingested and regurgitated as evidenced by saliva on the body of the dead *Nerodia*. Upon checking the trap, the larger of these was being ingested headfirst with only the posterior 10 cm protruding from the mouth of the *A. piscivorus* (617 mm SVL male) but was regurgitated when the trap was picked up. It is unclear why not more of the *N. fasciata* were ingested, although it is possible that cottonmouths either regurgitated the *Nerodia* after becoming agitated in the traps or did not have enough space to maneuver the *Nerodia* into proper swallowing position. However, it is also possible that the *Nerodia* were bitten as a stress response.

Sex ratios are an important part of population structure. Females dominated the samples of Banded Watersnakes and Eastern Cottonmouths. The 67 *N. fasciata* sampled from this population exhibited a 1.68:1 female-biased sex ratio, which was significantly different from 1:1 ($\chi^2 = 4.83$, $df = 1$, $P = 0.028$). The primary sex ratio of 66 neonate *N. fasciata* from three litters in this population was 1.2:1, which was not significantly different from 1:1 ($\chi^2 = 4.684$, $df = 2$, $P = 0.096$; unpubl. data). I believe this female bias to be a sampling artifact because of the primary sex ratio and because observations based upon radiotelemetry suggest that male *N. fasciata* in this population frequent deeper water more often than females (pers. obs., 2002) and therefore might be less likely to encounter funnel traps restricted to the littoral zone of aquatic habitats. Secondary sex ratios for a Texas population of *N. fasciata* sampled with funnel traps also showed a female bias (Keck 1994). I found a similar trend in 63 *A. piscivorus* from the Pee Dee popu-



FIG. 1. Remains of a female Eastern Cottonmouth (*Agkistrodon piscivorus piscivorus*) attacked by red imported fire ants (*Solenopsis invicta*) while caught in a funnel trap at the Pee Dee Research and Education Center in Darlington, Co. South Carolina found on 9 June 1999.

lation, as my sample yielded a 1.52:1 sex ratio that was not significantly different from 1:1 ($\chi^2 = 3.11$, $df = 1$, $P = 0.078$). Three other populations of *A. piscivorus* had balanced or male-biased sex ratios (Blem 1981; Ford 2002; Zaidan 2001).

Red imported fire ants (*Solenopsis invicta*) are problematic for many species of North American wildlife (Mount 1981). On 9 June 1999, a female *A. piscivorus* ca. 495 mm in length (skull and remaining vertebral column length) was found in a trap that was swarming with fire ants. The snake was reduced to a skeleton with only a small amount of viscera and the medial portions of some of the ventral scales remaining (Fig. 1). As no other cause of death was evident, it is likely that the snake was killed and devoured by fire ants. The trap had been placed perpendicular to the bank over a hole in very shallow water on 7 June 1999. If the trap had been placed in deeper water the ants probably would not have been able to attack the snake. Although fire ant predation on reptile eggs and hatchlings has been well documented for crocodilians, lizards, and turtles (Allen et al. 1994; Epperson and Heise 2003; Landers et al. 1980; Martin 1989; Moloney and Vanderwoude 2002; Mount 1981), I could find no evidence of fire ant predation on snakes in the literature. However, Tuberville et al. (2000) implicated fire ant predation in the decline of the Southern Hog-nosed Snake (*Heterodon simus*).

In conclusion, funnel traps can be an effective way to sample semi-aquatic snakes but frequent monitoring of traps, trap placement away from fire ant mounds, and possible bias in sex ratios should be considered when employing this technique.

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Evaluation of a New Method for Measuring Salamanders

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- ALLEN, C. R., S. DEMARAIS, AND R. S. LUTZ. 1994. Red imported fire ant impact on wildlife: an overview. *Texas J. Sci.* 46:51–59.
- BLEM, C. R. 1981. Reproduction in the eastern cottonmouth *Agkistrodon piscivorus piscivorus* (Serpentes: Viperidae) at the northern edge of its range. *Brimleyana* 5:117–128.
- EPPERSON, D. M., AND C. D. HEISE. 2003. Nesting and hatchling ecology of gopher tortoises (*Gopherus polyphemus*) in southern Mississippi. *J. Herpetol.* 37:315–324.
- FITCH, H. S. 1987. Collecting and life-history techniques. In R. A. Seigel, J. T. Collins, S. S. Novak (eds.), *Snakes: Ecology and Evolutionary Biology*, pp. 143–164. Macmillan, New York.
- . 1999. A Kansas Snake Community: Composition and Changes over 50 years. Krieger Publ. Co., Malabar, Florida. 165 pp.
- FORD, N. B. 2002. Ecology of the western cottonmouth (*Agkistrodon piscivorus leucostoma*) in northeastern Texas. In G. W. Schuett, M. Hoggren, M. E. Douglas, H. W. Greene (eds.), *Biology of the Vipers*, pp. 167–177. Eagle Mountain Publ., Eagle Mountain, Utah.
- GREENE, B. D., J. R. DIXON, M. J. WHITING, AND J. M. MUELLER. 1999. Reproductive ecology of the Concho water snake, *Nerodia harteri paucimaculata*. *Copeia* 1999:701–709.
- KARNS, D. R., H. K. VORIS, T. CHAN-ARD, J. C. GOODWIN, AND J. C. MURPHY. 1999/2000. The spatial ecology of the rainbow water snake *Enhydrys enhydrys* (Homalopsinae) in southern Thailand. *Herpetol. Nat. Hist.* 7:97–115.
- KECK, M. B. 1994. A new technique for sampling semi-aquatic snake populations. *Herpetol. Nat. Hist.* 2:101–103.
- LANDERS, J. L., J. A. GARNER, AND W. A. McRAE. 1980. Reproduction of gopher tortoises (*Gopherus polyphemus*) in southwestern Georgia. *Herpetologica* 36:353–361.
- MARTIN, R. P. 1989. Notes on Louisiana gopher tortoise (*Gopherus polyphemus*) reproduction. *Herpetol. Rev.* 20:36–37.
- MOLONEY, S., AND C. VANDERWOUDE. 2002. Red imported fire ants: A threat to eastern Australia's wildlife? *Ecol. Manag. Restoration* 3:167–175.
- MOUNT, R. H. 1981. The red imported fire ant, *Solenopsis invicta* (Hymenoptera: Formicidae), as a possible serious predator on some native southeastern vertebrates: direct observations and subjective impressions. *J. Alabama Acad. Sci.* 52:71–78.
- PALMER, W. M., AND A. L. BRASWELL. 1995. *Reptiles of North Carolina*. University of North Carolina Press, Chapel Hill, North Carolina. 412 pp.
- TUBERVILLE, T. D., J. R. BODIE, J. B. JENSEN, L. LACLAIRE, AND J. W. GIBBONS. 2000. Apparent decline of the southern hog-nosed snake, *Heterodon simus*. *J. Elisha Mitchell Sci. Soc.* 116:19–40.
- ZAIDAN, F. III. 2001. Western cottonmouth (*Agkistrodon piscivorus leucostoma*) sexual dimorphism and dichromatism in northwestern Arkansas. *Herpetol. Nat. Hist.* 8:79–82.

Collection of morphometric data is essential to many field studies of amphibian populations. One of the most common measurements obtained from salamanders is snout-to-vent length (SVL), a parameter useful in studies of sexual dimorphism (Bovero et al. 2003), demography (Semlitsch 1985), and systematics (Carlin 1997). Measuring salamander lengths in the field is challenging because of their small size, slimy texture, and propensity to maintain a nonlinear body position. Time expenditure is another concern, especially when researchers process large numbers of salamanders. Different measurement techniques vary in accuracy and precision, limiting the reliability of the data so that comparisons cannot be easily performed. Here, we compare a new method of obtaining salamander SVL measurements to other commonly used methods.

To restrict salamander movement and maintain a linear body orientation, we constructed a device (the “Salamander Stick”) using two equally sized polyvinyl chloride (PVC) pipes (40-cm long, with 2.5 cm outer diameter). We wrapped duct tape around both ends of one PVC piece such that a gap of 2 mm separated the two pieces when positioned parallel to each other. We then wrapped duct tape around both ends of the device, which secured the 2 mm gap. After assembly, we could pass a 23-cm wide plastic sandwich bag through the gap while prohibiting the passage of objects larger than 2 mm thick (Fig. 1a).

To obtain salamander SVL measurements, we placed a salamander into a plastic sandwich bag and fed the bag opening through the gap between the two PVC pipes. We pulled the bag through the gap until the salamander (at the bottom of the bag) reached the gap. We then manipulated the salamander through the walls of the bag to straighten it along the cranio-caudal axis and ensure that its ventral surface could be viewed. Once this was accomplished, SVL measurements were obtained with dial calipers (Fig. 1b).

We compared the precision and accuracy of the Salamander Stick to two other methods. In Method 1 (hereafter, “Freehand”; adopted from Phillips et al. 2002), a salamander was set on a table, straightened, and the SVL was measured with a plastic ruler. In Method 2 (hereafter, “Tube”; adopted from Mathis 1991), a salamander was placed into a clear plastic tube (inner diameter = 1.7 cm) and the SVL was measured by placing a ruler against the outside of the tube.

In March 2004, we captured 20 adult smallmouth salamanders (*Ambystoma texanum*) from a breeding pond in Coles County, Illinois, USA. During measurements, we housed all salamanders individually in 2 L plastic tubs in the laboratory. Salamanders were randomly selected and measured (SVL \pm 1.0 mm) once with a

randomly chosen method. We repeated this process until each salamander was measured 4 times for each method. A plastic ruler was used to measure salamanders from the tip of the snout to the posterior margin of the vent. To reduce bias, one of us (LJW) measured all subjects. We determined the amount of time (± 0.1 sec.) required for each measurement to evaluate the efficiency of the three methods. We completed all measurements over a five-day period and released salamanders at their capture site.

We determined measurement precision using the coefficient of variation (CV; Zar 1999). Salamanders have a tendency to contort their bodies when manipulated (Wise and Buchanan 1992), often reducing their body lengths. Because of this tendency, we assumed that the method providing the smallest mean SVL would be the least accurate representation of the “true” SVL. In contrast, the most accurate method should provide the greatest mean SVL. The precision and accuracy of each method were analyzed using one-way analyses of variance (ANOVA). All data conformed to assumptions of parametric statistics and analyses were conducted using SPSS 12.0 (SPSS, Inc. 2003).

There was a difference in the mean SVL ($F_{2,59} = 5.79$, $P = 0.005$) and CV ($F_{2,59} = 5.75$, $P = 0.005$) among the three measurement methods (Table 1). Bonferroni post-hoc tests indicated that measuring salamander SVL with the Salamander Stick was more ac-

TABLE 1. Accuracy (mean SVL ± 1 SE) and precision (CV ± 1 SE) for 20 Smallmouth Salamanders (*Ambystoma texanum*) measured by the three methods in March 2004. Measurement time (sec, mean ± 1 SE) is the amount elapsed between initially manipulating the salamander and the moment at which the measurement was obtained.

Method	Mean SVL (mm)	CV%	Time (s)
Freehand	76.7 \pm 1.3	4.2 \pm 0.4	56.5 \pm 4.0
Tube	77.9 \pm 1.5	4.4 \pm 0.4	37.0 \pm 1.3
Salamander Stick	82.7 \pm 1.2	2.7 \pm 0.3	34.7 \pm 1.2

curate and precise than the Freehand and Tube methods. The Freehand and Tube methods did not differ in precision or accuracy. While our results obtained from the Tube and Freehand methods do not differ, neither method was more accurate or precise than the Salamander Stick. This is likely because the Tube and Freehand methods do not restrict salamander movement and straighten its vertebral column as well as the Salamander Stick. As another testament to its efficiency, we found that the Salamander Stick allowed measurements to be obtained with the least time expended (Table 1). Other techniques to obtain salamander measurements may not be as efficient as the Salamander Stick. For instance, using a plastic sandwich bag alone (without the stick) is another method used to immobilize salamanders and obtain morphometric measurements (“Baggie” method; Bury and Corn 1991). Although we did not compare the Baggie method and the Salamander Stick, we suspect that the PVC pipes decrease the time spent measuring individuals and the likelihood that a subject will contort its body as the measurement is taken.

The Salamander Stick is an accurate, precise, and time-efficient method for obtaining standardized salamander measurements. The device is simple in design, durable, and easily transported and used in the field. It can be used to measure salamander SVL as well as total length, and the width of the device is easily modified to accommodate salamanders of different sizes including large larvae (> 3 mm girth) or neotenic species. It is inexpensive, costing less than US \$6.00 to manufacture. The plastic sandwich bags used in measurements can be replaced after wear and can be easily cleaned. We have used this device in the field to measure breeding adult *A. texanum* in the spring of 2004 ($N = 986$), without any injury to the study organisms. Similarly, we witnessed no ill effects of repeated use of this device on the salamanders measured in this study.

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LITERATURE CITED

- BOVERO, S., G. SOTGIU, S. CASTELLANO, AND C. GIACOMA. 2003. Age and sexual dimorphism in a population of *Euproctus platycephalus* (Caudata: Salamandridae) from Sardinia. *Copeia* 2003:149–154.
- BURY, R. B., AND P. S. CORN. 1991. Sampling methods for amphibians in streams in the Pacific Northwest. U.S. Dept. Agric. For. Serv. Gen. Tech. Rep. PNW-GTR-275.



FIG. 1. The Salamander Stick, a device for obtaining precise and accurate measurements of salamander snout–vent length. A) The device shown with a plastic bag passing through the gap between the two polyvinyl chloride (PVC) pieces. B) The lateral view of an adult Smallmouth Salamander (*Ambystoma texanum*) immobilized in the device.

- CARLIN, J. L. 1997. Genetic and morphological differentiation between *Eurycea longicauda* and *E. guttolineata* (Caudata: Plethodontidae). *Herpetologica* 53:206–217.
- MATHIS, A. 1991. Territories of male and female terrestrial salamanders: costs, benefits, and intersexual spatial associations. *Oecologia* 86:433–440.
- PHILLIPS, C. A., J. R. JOHNSON, M. J. DRESLIK, AND J. E. PETZING. 2002. Effects of pond hydroperiod on recruitment of mole salamanders (genus *Ambystoma*) at a temporary pond in Vermilion County, Illinois. *Trans. Illinois State Acad. Sci.* 95:131–139.
- SEMLITSCH, R. D. 1985. Reproductive strategy of a facultatively paedomorphic salamander *Ambystoma talpoideum*. *Oecologia* 65:305–313.
- SPSS, Inc. 2003. Statistical Package for the Social Sciences, Version 12.0. SPSS, Inc., Chicago, Illinois.
- WISE, S. E., AND B. W. BUCHANAN. 1992. An efficient method for measuring salamanders. *Herpetol. Rev.* 23:56–57.
- ZAR, J. H. 1999. Biostatistical Analysis, 4th ed. Prentice-Hall, Englewood Cliffs, New Jersey.

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Husbandry and Captive Reproduction in *Carlia aylanpalai* (Scincidae)

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The skink *Carlia aylanpalai* is introduced (Zug 2004) on the southernmost islands of the Mariana archipelago (Guam, Rota, Tinian, and Saipan) and reaches dense populations on Guam (mean population estimate of 9150 *Carlia*/ha for certain areas; Campbell 1996). It is likely that the species was introduced in the late 1950s to early 1960s (McCoid 1993, 1999). On Guam, the species is medium-sized and exhibits a negligible sexual dimorphism in size (males reach at least 63 mm and females 62 mm SVL) and in coloration (both sexes have a uniform light brown dorsum with cream venter grading to a slight peach on the ventral aspect of the tail). It has been suggested that *C. aylanpalai* might negatively impact native scincids (McCoid 1995, 1997). The biology of *C. aylanpalai* has not yet been reported.

We are unaware of information on long-term captive maintenance of small Australasian scincids. Available information on captive maintenance of small scincids comes from short-term studies on behavior (Done and Heatwole 1977; Perrill 1980; Torr and Shine 1994; Whittier 1993; Whittier and Martin 1992; Zwickel

and Allison 1986).

As part of a larger study on the colonization biology and interactions of two western Pacific skink species (*C. aylanpalai* and *Emoia caeruleocauda*), we established a colony of these species in Kingsville, Texas. We maintained this colony for approximately 20 months until we voluntarily ceased observations. On 30 June 1995 we received 14 adult *C. aylanpalai* (6 male: 8 female; 45–55 mm SVL) and 10 subadult to adult *E. caeruleocauda* (5 male: 5 female; 35–45 mm SVL) from Guam, Mariana Islands. Observations on captive maintenance of *E. caeruleocauda* are presented elsewhere (McCoid et al. 1997). Size at maturity was determined by the presence of secondary yolk follicles revealed by dissection of preserved material (McCoid 1997). Sexes can be easily distinguished as adult males have a markedly swollen tail base. Initially, all *C. aylanpalai* were housed in a single 75 L (20 gal) aquarium. This aquarium had a sand substrate with three flat rocks for basking and cover. A shallow water dish was placed in the tank along with a small potted ivy plant (*Pothos* sp.). The aquarium was kept in a curtained, secluded room and supplied with fluorescent lighting set in an aquarium reflector. The room was air-conditioned and daily air temperatures in the aquarium ranged between 20 and 32.2°C while daily humidity ranged between 60 and 90%. Crickets were fed twice weekly and we maintained the *C. aylanpalai* under these conditions for approximately nine months. There was no mortality during this period.

Beginning in April 1996, for the next seven months of this study, we divided the 14 lizards into four 75 L (20 gal) screen-covered aquaria. Two females were placed in each tank and two males in two of the tanks. The remaining two tanks each received a single male. A 50:50 mixture of potting soil and sand was provided as a substrate and a potted ivy plant was placed in each tank. Several small flat rocks were placed in each tank as cover and basking sites. A small shallow tray in each tank was kept filled with distilled water and tanks were hand-misted twice daily. Approximately once a week, about 0.5 L of distilled water was poured into the substrate. A 300 ml dirt-filled rectangular Tupperware, container with a hole cut in the top was supplied as an egg-laying chamber. We replaced the 48-inch fluorescent lamp with a full-spectrum Vita-Lite fluorescent lamp (Duro-Test Corp.) set in a reflector and installed an additional 50 W basking-lite heat lamp (Duro-Test Corp.). The heat lamp was suspended within the aquarium ca. 20 cm above the substrate and over a basking rock. Heat lamps and fluorescent lamps were turned on at 0700 h. At 1000 h, heat lamps were turned off. At approximately 1800 h heat lamps were turned on again and left on until 1900 h when all illumination was discontinued for the evening. Daily temperatures ranged between 20 and 32.2°C with the basking spot under the heat lamp reaching 55°C.

Throughout the study period, the photo regime was kept at 12L: 12D to approximate conditions on Guam (which vary seasonally between 13L: 11D and 12L: 12D). Lizards were fed *ad libitum* with crickets every other day. Two feeding regimens were attempted. Initially, for the first week, crickets were dusted with Tetra® Reptical calcium/vitamin powder but all lizards refused 'white' crickets. In order to provide the lizards with a vitamin supplement, for the remainder of the study, we then fed the crickets powdered (prepared with a coffee grinder) T-Rex® Calcium Plus cricket food, essentially 'gut-loading' crickets with nutrients

and calcium. Crickets also were fed dry oatmeal and given water *ad libitum*. The 14 *C. ailanpalai* would consume ca. 1000 two- to three-week-old 'gut-loaded' crickets in 10 days.

In November 1996, we combined the remaining 13 (we sustained a single fatality due to an accidental rock crush) adult *C. ailanpalai* into three 75 L (20 gal) screen-covered aquaria. All other conditions mentioned previously remained the same. Captive husbandry was terminated in March 1997 and no fatalities occurred during this period.

Reproduction can be a measure of the success of captive husbandry. During the initial phase of husbandry when all 14 adults were housed in a single aquarium, only three clutches (over a nine-month span) were discovered (*C. ailanpalai* lays an invariant clutch of two, McCoid 1997). Only one of these clutches had not desiccated and, after incubation, yielded two viable offspring. In strong contrast, the later husbandry housing configurations and feeding with nutrient-enhanced crickets yielded many more clutches. The four-aquarium configuration (eight females) produced 76 clutches over a seven-month period and the three-aquarium configuration (seven females) yielded 16 clutches over a four-month period. The total number of clutches produced over the 20-month husbandry period was 95. For individual females, intervals between clutches were computed using the four-aquarium (eight females) configuration that produced 76 clutches. Mean interval time between clutches for all eight females was 17.71 days with a range of 10–38 days.

Females seemed to repeatedly choose the same oviposition site. We recovered eggs by searching specific areas in the aquaria when gravid females were expected to oviposit. Eggs were transferred to small screw-top jars containing a dampened paper towel folded to fit the bottom of the jar. The jar lid was lightly fastened and the jar was placed in a darkened room (daily temperature range 21–32°C). Incubation periods (34–35 days) were identical to those reported by McCoid (1994) for wild-collected eggs. With the exception of the initial two desiccated clutches, all clutches were fertile and hatched. A single clutch from the three-aquarium configuration had viable, but malformed offspring.

The eight P generation females produced a total of 186 viable hatchlings during the 20-month study. Just prior to the termination of this study, we hatched the first F2 generation. We noted no decline in fecundity of the P generation through time and our results suggest that the F1 generation was healthy and fertile. Since the original lizards received from Guam were adults and all survived 20 months (with the exception one individual), we can assume that the species can live a minimum of two to three years in captivity. This adult longevity, coupled with ease of maintenance, high fecundity, and hatchling survivorship, suggests that this species might be a candidate for large-scale breeding efforts for those requiring large numbers of lizards.

This information also suggests reasons for success as colonizers in the southern Mariana Islands.

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- CAMPBELL, E. W. III. 1996. The Effect of Brown Tree Snake (*Boiga irregularis*) Predation on the Island of Guam's Extant Lizard Assemblages. Unpubl. Ph.D. Dissertation, Ohio State University, Columbus, Ohio. 91 pp.
- DONE, B. S., AND H. HEATWOLE. 1977. Social behavior of some Australian skinks. *Copeia* 1977:419–430.
- MCCOID, M. J. 1993. The 'new' herpetofauna of Guam, Mariana Islands. *Herpetol. Rev.* 24:16–17.
- . 1994. Eggs, hatchling sizes, and oviposition sites of lizards on Guam, Mariana Islands. *Herpetol. Rev.* 25:98–100.
- . 1995. *Carlia cf. fusca* (NCN). Behavior. *Herpetol. Rev.* 26:35.
- . 1997. Interactions of *Carlia cf. fusca* (Scincidae) with the herpetofauna of Guam. Unpubl. Masters Thesis, Texas A&M University-Kingsville, Kingsville, Texas. 98 pp.
- . 1999. Established exotic reptiles and amphibians of the Mariana Islands. In G. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka (eds.), *Problem Snake Management. The Habu and Brown Treesnake*, pp. 453–459. Cornell University Press.
- , S. E. Henke, R. A. Hensley, and C. Clark. 1997. *Eomoia caeruleocauda* (Pacific Blue-tailed Skink). Captive reproduction. *Herpetol. Rev.* 28:202.
- PERRILL, S. A. 1980. Social communication in *Eumeces inexpectatus*. *J. Herpetol.* 14:129–135.
- TORR, G. A., AND R. SHINE. 1994. An ethogram for the small scincid lizard *Lampropholis guichenoti*. *Amphibia-Reptilia* 15:21–34.
- WHITTIER, J. M. 1993. Behavioural repertoire of *Carlia rostralis* (Scincidae) in the wet tropics of Queensland, Australia. pp. 305–310. In D. Lunney and D. Ayers (eds.), *Herpetology in Australia*, pp. 305–310. Surrey, Beatty & Sons. Chipping Norton, NSW.
- , AND J. MARTIN. 1992. Aspects of social behaviour and dominance in male rainbow skinks *Carlia rostralis*. *Aust. J. Zool.* 40:73–79.
- ZUG, G. R. 2004. Systematics of the *Carlia* "fusca" lizards (Squamata: Scincidae) of New Guinea and nearby islands. *Bishop Mus. Bull. Zool* 5. 84 pp.
- ZWICKEL, F. C., AND A. ALLISON. 1986. Inter- and intra-sexual interactions in a New Guinea skink, *Eomoia physicae*. *Can. J. Zool.* 64:752–755.



Ninia diademata (EAL 3637) (Ring-necked Coffee Snake). México: Chiapas: 3 km SW Palenque. Illustration by Julian C. Lee.

NATURAL HISTORY NOTES

Instructions for contributors to Natural History Notes appear in Volume 36, Number 1 (March 2005).

CAUDATA

AMBYSTOMA MACULATUM (Spotted Salamander). **REPRODUCTION.** Baseline phonological and reproductive success information on amphibian species is important in determining the decline, stability, or increase in population. Herein we document the reproductive life history of the spotted salamander from seven breeding ponds and vernal pools (3 permanent beaver ponds fed by small streams, 3 vernal pool complexes, and 1 ephemeral stream) during the 1999 breeding season. All of these breeding pools are found within the confines of Powhatan Lakes Wildlife Management Area, in Powhatan County, Virginia, USA. The first adult discovered in or near one of the seven breeding areas was on 16 February. This animal was dead, possibly frozen the night before. There was no sign of predation or scavenging. Spermatophores were first observed in breeding pools on 21 February. Egg masses were discovered three days later. Egg masses discovered in breeding pools were counted, flagged, and tracked for hatching success over the course of the breeding season. Each breeding pool was checked at least three times per week. Egg deposition lasted over a period of 50 days (24 Feb–14 April). Number of eggs per mass ranged from 8 to 177 (mean \pm SD = 71.9 ± 35.4 , $N = 158$). The depth (cm) egg masses were deposited ranged from 0–23 (4 ± 3.8 , $N = 99$). The mass (g) of the wet swollen weight of the egg masses ranged from 10 to 380 (111 ± 68 , $N = 140$). The percent of eggs hatching ranged from 0 to 100 (89 ± 23.6 , $N = 93$). Fungal hyphae were seen covering dead embryos under microscopic examination, even in intact egg masses. It is not known if this was the cause of mortality or just normal decomposition. All but one egg mass were of the clear jelly type, $N = 140$. Masses were found attached to various substrates at the following rates: blades of grass (43 masses), submerged sticks (37), hardwood leaves (*Acer rubrum*, *Fagus grandifolia*, *Liquidambar styraciflua*, *Quercus alba*, *Q. falcata*, *Q. palustris*, *Q. rubra*, and *Salix* sp.) (34), unattached (34), underwater plant stems (not grass) (5), *Juncus* sp. (4), metal flagging pole (1), *Carex* sp. (1), $N = 159$. Twenty-one percent of the egg masses were unattached to substrate. This strategy may help in the survival of this species in ponds and ephemeral breeding areas that dry up early. The last adult spotted salamanders found at breeding pools was on 28 April.

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AMBYSTOMA MACULATUM (Spotted Salamander). **PREDATION.** The known predators of *A. maculatum* include aquatic invertebrates and several vertebrates (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, DC.). Petranka (1998. *op. cit.*) listed only one bird as a predator of *A. maculatum*, the least sandpiper (*Calidris pusilla*),

which was observed feeding on the larvae of *A. maculatum* (Stangel 1988. Herpetol. Rev. 14:112). Here I report an adult female Common Grackle (*Quiscalus quiscula*) preying on a partially exposed *A. maculatum* egg mass in a vernal pool on 15 May 2004 at 1320 h. The vernal pool, dominated by a button bush (*Cephalanthus occidentalis*) scrub association, was located at ca. 20 m elev in Willowdale State Forest, Town of Ipswich, Essex County, Massachusetts USA (42.68379°N, 070.90342°W). The egg mass had been deposited earlier in the season (likely late March) on a fully submerged button bush branch.

Peer and Bollinger (1997. The Birds of North America, No. 271. Acad. Nat. Sci. Philadelphia, Pennsylvania and American Ornithologists' Union, Washington, DC), state that the Common Grackle is an opportunistic forager. Among the small vertebrates taken, Peer and Bollinger (1997, *op. cit.*) listed salamanders, having cited Hamilton (1951. Auk 68:213–217), who determined over a two-year period that salamanders were an important dietary component of common grackles in central New York, especially in the food brought to their nestlings. The grackle that I observed feeding on salamander eggs was one of several observed foraging amongst the button bush and cattail (*Typha latifolia*) growing in the pond. The grackle was observed for a only a short time before my presence likely disturbed it while it was feeding on the eggs, plucking and consuming several from the exposed part of the egg mass above waterline. The grackle appeared to be undeterred by the gelatinous outer coating of the Spotted Salamander's egg mass, which has been shown to protect against predation and desiccation (Nyman 1987. Herpetol. Rev. 18:15). Common Grackles were observed nesting in the area and it is possible that the grackle I observed feeding on the Spotted Salamander eggs was out gathering food for one or more of its nestlings. No other grackles or other birds were directly observed feeding on other similarly exposed egg masses in the area. To my knowledge this is the first observation of a bird feeding on the eggs of *A. maculatum*, and it might also represent the first record of a bird feeding on the eggs of any salamander.

The Massachusetts Division of Fisheries and Wildlife funded this work. Jonathan Regosin administered the work. I thank Mark Grgurovic, Department of Natural Resources and Conservation, University of Massachusetts, Amherst, who supervised all fieldwork and Jacob Kissel who assisted in the field.

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AMBYSTOMA MACULATUM (Spotted Salamander). **PREDATION.** Since 1999, annual surveys have been conducted at 46–70 vernal pools in New London County, Connecticut USA. These surveys are conducted to quantify *Ambystoma maculatum* and Wood Frog (*Rana sylvatica*) egg masses as well as to document the presence of fairy shrimp and Marbled Salamander (*A. opacum*) larvae. From 1999 to 2003, no Snapping Turtles (*Chelydra serpentina serpentina*) were observed during these surveys. While conducting surveys in 2004, however, I observed 7 snapping turtles in 5 different vernal pools over four days. I witnessed both direct

and indirect signs of Snapping Turtles feeding on salamander eggs.

While conducting egg mass surveys on 18 April 2004, I observed a large (ca. 400 mm carapace length) Snapping Turtle submerged in the water of a pool. The turtle had Spotted Salamander eggs hanging out of its mouth and small fragments were floating in the vicinity of the turtle's head. The snapping turtle did not move when I approached. No other intact egg masses were observed in the vicinity of the turtle. On 19 April, I observed a Snapping Turtle (ca. 300 mm carapace length) floating near a large conglomeration of egg masses in another vernal pool. As the turtle approached me, small fragments of Spotted Salamander eggs were observed floating in the vicinity of the turtle. On 19 April and 21 April, I observed two additional Snapping Turtles (ca. 420 mm and 100 mm carapace lengths) in two vernal pools. No predation on eggs was observed. On 20 April, I observed three Snapping Turtles in a small vernal pool. The estimated carapace lengths of these turtles were 100, 330, and 420 mm. Although no turtles were observed eating eggs, fragments of Spotted Salamander egg masses were observed floating throughout the pool.

Although Snapping Turtles are not usually associated with vernal pools, it has been reported that adults prefer permanent bodies of water whereas younger individuals (150–250 mm carapace length) may be found in vernal pools (Klemens 1993. *Amphibians and Reptiles of Connecticut and Adjacent Regions*. State Geological and Natural History Survey of Connecticut. Bull. No. 112). Aquatic plants and fish were the major food items in the stomachs of 470 snapping turtles collected in Connecticut (Alexander 1943. *J. Wildl. Manag.* 7:278–282). I found no previous reports of Snapping Turtles eating Spotted Salamander egg masses.

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AMPHIUMA MEANS (Two-toed Amphiuma). **PREDATION.** Known avian predators of *Amphiuma means* include various large wading birds (Dye 1982. *Florida Field Nat.* 10:76; Kilham 1984. *Colonial Waterbirds* 7:143–145). At 2350 h on 11 June 2004, I observed an adult Barred Owl (*Strix varia*) subduing a prey item in a shallow roadside ditch (floodplain of Drowning Creek, 3.5 km N of Hoffman, Richmond County, North Carolina, USA). The owl's legs were immersed in several cm of water and its wings were spread for balance as it struggled with the unidentified prey. I exited my vehicle and shone a flashlight on the owl, which presently hopped from the water onto the ditch bank, striking with its bill at an object held in its talons. I was able to approach to within a few meters and identify the prey as a small *A. means* (ca. TL 30–40 cm). After several seconds, the owl flew into a nearby tree with the amphiuma and apparently finished killing it there before carrying it out of my view into thick woods. Barred Owls are opportunistic predators, known to take a wide range of terrestrial and aquatic prey, including various amphibians (Bent 1938. *Life Histories of North American Birds of Prey*, Part II. Dover Publishing, Inc., New York, NY. 482 pp.). To my knowledge, this represents the first record of predation on *A. means* by an owl.

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DICAMPTODON ATERRIMUS (Idaho Giant Salamander). **REPRODUCTION.** The natural history of *Dicamptodon aterrimus*, whose distribution is limited to the Northern Rocky Mountains of Idaho, is poorly known (Nussbaum et al. 1983. *Amphibians and Reptiles of the Pacific Northwest*. Univ. Idaho Press, Moscow.). On 20 June 2004, we visited Mountain Gulch, a tributary of the North Fork of the Palouse River in Latah County, Idaho (47°01'N, 116°31'W). At ca. 1330 h, we located a clutch of ca. 20–30 white eggs attached to the lower surface of a large, flat rock submerged in about 15 cm of relatively slow-moving water. No obvious signs of embryonic development were apparent, suggesting that the eggs had been laid recently. A *D. aterrimus* (109 mm SVL) was associated with the clutch, and we assumed her to be a brooding female. The presence of distinct gills indicates that this individual was paedomorphic. We know of no other direct observations that indicate breeding by paedomorphs in *D. aterrimus*.

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PLETHODON ALBAGULA (Western Slimy Salamander). **VOCALIZATION.** Several species of salamanders are known to vocalize (Brodie 1977. *Copeia* 1977:523–535; Brodie 1978. *Copeia* 1978:127–129; Davis and Brattstrom 1975. *Herpetologica* 31:409–412; Duellman and Trueb 1994. *Biology of Amphibians*. John Hopkins Univ. Press, Baltimore, Maryland. 670 pp; Mansutei 1941. *Copeia* 1941:266–267; Marshall 1997. *Herpetol. Rev.* 28:145; Neill 1952. *Copeia* 1952:195–196; Smith and Barichivich 2001. *Herpetol. Rev.* 32:246–247; Wyman and Thrall 1978. *Herpetologica* 28:210–212). The few sounds noted have been correlated with defense and anti-predatory behavior (Davis and Brattstrom 1975, *op.cit.*). *Plethodon albagula* has not been documented to vocalize. The following describes vocalization in five *P. albagula* adult females.

An abandoned mineshaft in Garland County, Arkansas USA, was visited between 27 June and 1 Aug 2004 and 122 adult *P. albagula* were captured. All animals were taken along the walls inside the mineshaft; air temperature was 16°C. On 27 June 2004, 122 adults (114 females and eight males) were photographed and placed in a plastic bag to be sexed and measured. On 17 and 18 July 2004, 79 animals (77 females and two males) were photographed and placed in a plastic bag to be sexed, measured, weighed, and injected with subcutaneous fluorescent Visual Implant Elastomer (VIE) markings (Northwest Marine Technology Inc., Shaw Island, Washington). None was injected more than two times, and 8 had been previously injected (all females); therefore, these salamanders underwent an abbreviated handling process.

Vocalizations were observed on 27 June and 17–18 July 2004. On 27 June between 1200 and 1900 h, vocalizations were wit-

nessed in an undocumented number of animals as a series of chirping noises. The chirping noises were audible enough to be heard 5–7 m away and greatly resembled the sound of a cricket. The vocalizations were also observed and documented on 17 July between 1100 and 1600 h by three adult females. The sounds were identical to the previous noises on 27 June. Of the three females heard vocalizing, one female (62 mm SVL) was gravid and had undergone the entire handling process including the injection of two VIE marks. Another female (55 mm SVL) was not gravid and also underwent the entire handling process, and one non-gravid female (59 mm SVL) was injected on 26 Oct 2001, but still underwent the handling process. This female was also captured on 1 Aug 2004 and did not vocalize. On 18 July 2004 between 0900 and 1200 h two more females were noted producing the noise. Both females had undergone the entire handling procedure. One female (64 mm SVL) was gravid and the other (69 mm SVL) was not gravid. In all cases, the salamander's mouth was closed; however, their gular region was pulsating. It is unclear whether the pulsating of the throat was related to the vocalization. All sounds were repetitive and stopped after a few seconds. In all but one case, in which the animal produced the sound while in a plastic bag, the vocalizations were observed after the animals were released and did not appear to be associated with any defense posture or behavior.

The function of the chirping noise is unknown. The noises were only observed in females; however, only a small number of males were handled ($N = 10$). This behavior apparently was not an anti-predatory response. The simple handling of the salamanders may have elicited the sound production. The injection of fluorescent VIE was probably not the stimulus for the noise, as one individual was not injected prior to the vocalization. This population of salamanders has been handled on a number of occasions in the past, but no other observations of vocalization have been recorded.

The chirping noises might be used as a warning, as the vocal salamanders were in close proximity. Two were within 3 m of each other, and two were within 9 m; in every instance, each produced the noise after they were handled. Furthermore, a non-gravid female (captured and injected on 26 Oct 2001), vocalized on 17 July 2004, but did not vocalize 1 Aug 2004 after being handled once again. Brodie's (1978, *op. cit.*) suggestion that vocalization was a means of warning predators of noxious skin secretions might have support in this instance. Every *P. albagula* handled secreted a sticky discharge. Further studies on vocalization as a means of warning in Plethodontidae are warranted.

We thank the United States Forest Service for funding and Brian Caldwell for field assistance.

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PLETHODON CINEREUS (Eastern Red-backed Salamander). **EARLY NESTING.** Breeding in *Plethodon cinereus* is either annual (southern populations) or biennial (northern populations) (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Inst. Press, Washington, DC. 587 pp.). Females typically oviposit an egg cluster in late spring or early summer, al-

though rare late summer oviposition may occur, and the females remain with the eggs during their developmental period (Bishop 1941. New York St. Mus. Bull. 324:1–363, Petranka 1998, *op. cit.*). In Virginia, Eastern Red-backed Salamanders typically nest in June (Martof et al. 1980. Amphibians and Reptiles of the Carolinas and Virginia. Univ. North Carolina Press, Chapel Hill. 264 pp.), but Ernst et al. (1997. Bull. Maryland Herpetol. Soc. 33:1–62) reported oviposition in northern Virginia from late May to June (25 May–10 June, unpubl. data).

On 7 April 2004 at 1420 h, we found a female, lead-backed morph *P. cinereus* coiled over an egg cluster under a large wooden tie at the edge of an open mesic woodland at the Mason Neck National Wildlife Refuge, Fairfax, Virginia. Six eggs were exposed, but the female was reclining on several additional eggs. The egg cluster was directly on the soil under the tie.

This is the earliest recorded date for oviposition in *Plethodon cinereus*.

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PLETHODON CINEREUS (Eastern Red-backed Salamander). **PREDATION.** The Creek Chub, *Semotilus atromaculatus* (Cyprinidae), is a common inhabitant of forested streams and is broadly sympatric with the Eastern Red-backed Salamander, *Plethodon cinereus*.

On 11 July 2003 in Boston Run (Summit County, Ohio, USA), we captured an adult *S. atromaculatus* that had ingested an adult *P. cinereus*. The creek chub had a standard length of 166 mm, a total length of 170 mm, and a wet mass of 54.7 g. The *P. cinereus* was partially digested and in generally poor condition, thus we measured its length from the snout to base of the hind limb, following Szuba et al. (2002. Herpetol. Rev. 33:187–189). Snout to base of hind limb length was 35.9 mm. Dissection of the *P. cinereus* revealed the following stomach contents: one mite (Acari: Oribatida), fly wings (Diptera: Ceratopogonidae and Sciaridae), and segments of at least 13 ants (Hymenoptera: Formicidae).

Throughout the Boston Run watershed, we have found numerous *P. cinereus* under woody cover and in the leaf litter of small ravines that only carry water during periods of heavy rain. The *P. cinereus* discussed within this note was likely washed into the stream during severe storms that resulted in flash floods throughout the region. This hypothesis is supported by the terrestrial nature of the stomach contents of the salamander.

To the best of our knowledge, this is the first published report of *S. atromaculatus* consuming an adult terrestrial salamander as well as the first report of *P. cinereus* being preyed upon by a fish.

This research was conducted at the Woodlake Environmental Field Station within the Cuyahoga Valley National Park. The Cuyahoga Valley National Park provided the necessary permits to conduct this research, and we are grateful for their continued support. Funding for this work was provided through the National Science Foundation Research Experiences for Undergraduates program.

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TARICHA TOROSA TOROSA (Coast Range Newt). **OVERWINTERING LARVAE.** We present observations of overwintering behavior in *Taricha torosa torosa* larvae at two independent sites. We define overwintering larvae as newts that spend the entire winter season in the larval form. The winter season (December, January, and February) represents the average three coldest months for the southern California coastal region (Felton 1965. California's Many Climates. Pacific Books. 169 pp.).

From Dec 2001 through July 2002, daytime and/or nocturnal visual encounter surveys were conducted in pools in Adobe Creek (Santa Rosa Plateau Ecological Reserve, Murrieta, Riverside County, California USA) at least once per month for a phenology study of *T. t. torosa*. Larval *T. t. torosa* were captured with a dipnet, measured, and on occasion voucher specimens were collected. (Preserved specimens are currently in the collection of US Geological Survey, Biological Resource Discipline, San Diego Field Station [RNF]).

On 25 April 2001, breeding adults and over 50 egg masses were observed in a pool in Adobe Creek. In addition to the breeding activity, three *T. t. torosa* larvae (37–40 mm TL) approaching the size for metamorphosis (50–60 mm TL) (Bishop 1943. A Handbook of Salamanders. Comstock Publishing. 555 pp.) were also captured and examined. Most notable is the considerable size of the three premetamorphic larvae in comparison to the average size of recently hatched *T. t. torosa* larvae at 11–12 mm (Bishop 1943, *op. cit.*). We recognized the three large larva present at the commencement of the 2001 breeding season as larvae from the previous year that spent the winter season in the larval form, hence overwintered.

On 01 May 2002, a single larva collected measured 53 mm TL and was found in a pool containing breeding adults and egg masses (voucher number: RNF 2552). However, during the previous year egg masses were only observed on Adobe Creek in April and May. Consequently, cohorts of the April/May 2001 embryos should have transformed sometime between early Aug and mid Dec 2001 (based on the natural history of *T. t. torosa*) if growth and development had not been delayed during the fall and winter months (see Petranks 1998. Salamanders of the United States and Canada. Smithsonian Institution Press. 587 pp.). We recognize the large larva (53 mm TL) present at the commencement of the 2002 breeding season as a larva that overwintered.

While conducting a review of the published literature we came across only one previous report of overwintering *T. t. torosa* larvae (Storer 1925. Univ. California Publ. Zool. 27:1–342).

Our recent observations of overwintering *T. t. torosa* larvae reported herein and Storer's (1925, *op. cit.*) historical record represents observations from two locations separated by a distance of ca. 90 km. Despite the documentation of two consecutive years of overwintering *T. t. torosa* larvae on Adobe Creek, we suspect this phenomenon does not occur often because of the paucity of previous reports or published records (Jennings and Hayes 1994. Amphibian and Reptile Species of Special Concern in California. Fi-

nal Rept. to California Dept. Fish and Game. 225 pp.; Petranks 1998, *op. cit.*; Storer 1925, *op. cit.*).

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ANURA

AMOLOPS CREMNOBATUS (Rough-backed Torrent Frog). **ENDOPARASITES.** *Amolops cremnobatus* was described from specimens collected in Khammouan Province, Laos (Inger and Kottelat 1998. Raffles Bull. Zool. 46:29–34) and was reported in Vietnam by Bain and Truong (2001. Herpetol. Rev. 32:269). To our knowledge there are no reports of endoparasites from this species. The purpose of this note is to report the nematode *Falcaustra trilokiae* from *A. cremnobatus*.

Three *A. cremnobatus* (SVL 33 mm \pm 3 mm SD, range: 29–35 mm) were collected 21 April 1999 from Ha Tinh Province, Huong Son District (18°20'N, 105°14'E), Vietnam and deposited in the herpetology collection of the Natural History Museum of Los Angeles County, Los Angeles, California as LACM 146884–146886. The esophagus, stomach, small intestine, large intestine, lungs and urinary bladder were opened and examined separately for helminths under a dissecting microscope. The body was also searched. Each frog was found to harbor individuals of Nematoda in the small or large intestines. The nematodes were cleared in a drop of concentrated glycerol, identified as *Falcaustra trilokiae*, and deposited in the United States National Parasite Collection, Beltsville, Maryland as USNPC 94898. Prevalence of infection (number infected frogs/number frogs examined) \times 100 and mean intensity of infection (mean number of infected individuals) \pm 1 SD and range were: 100%, 4.3 \pm 3.2, 2–8.

Falcaustra trilokiae was originally described from specimens taken from *Euphylyctis cyanophlyctis* (Ranidae) collected in Andhra Pradesh State, India (Singh 1958. J. Helminthol. 32:132–138). *Amolops cremnobatus* represents the second host for *Falcaustra trilokiae*. Vietnam is a new locality record.

We thank Robert F. Inger (Field Museum of Natural History, Chicago, Illinois) for identification of *A. cremnobatus* and Amanda Woolsey (Whittier College) for assistance with dissections.

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ATELOGNATHUS PATAGONICUS (NCN). **PREDATION.** Various species prey on larval and post-metamorphic anurans, such as spiders, aquatic insects, fishes, birds, and mammals (Duellman and Trueb 1994. *Biology of Amphibians*. The Johns Hopkins Univ. Press, Baltimore. 670 pp. and references therein). *Atelognathus patagonicus* is a leptodactylid occurring in Laguna Blanca National Park and the surrounding area of Neuquén Province, Argentina. This frog is highly adapted for aquatic life with enlarged interdigital membranes and lateral and ventral skin folds (Cei and Roig 1968. *Physis* 27:265–284; Duellman and Trueb 1994, *op. cit.*). The species is listed as endangered in Argentina (Lavilla et al. 2000. *Categorización de los Anfibios y Reptiles de la República Argentina*. Asociación Herpetológica Argentina. 97 pp.). The habitat of *A. patagonicus* is semi-permanent to permanent ponds and lakes. Numerous species of aquatic and semi-aquatic birds also live at these sites.

We report field observations of predation on *A. patagonicus* by four species of birds. During a survey along the northwest shore of Laguna Verde—a permanent pond of 0.17 km² (39°0'S, 70°23'W; 1282 m elev.) in Laguna Blanca Park—we observed predation by the Silvery Grebe (*Podiceps occipitalis*) and the White-tufted Grebe (*P. rolland*) on tadpoles and post-metamorphic *A. patagonicus*. Between 1120 and 1220 h on 28 Dec 2003, we observed 22 captures by the birds. Seven Silvery Grebes captured 6 tadpoles and 15 post-metamorphic frogs. One White-tufted Grebe captured one post-metamorphic *A. patagonicus*. We watched individual birds and could track the number of prey consumed by each one. During these observations, one bird caught three *A. patagonicus*. A grebe would dive underwater, for as long as two minutes, and then emerge with a prey item in its beak. Birds held the tadpoles by their tails and the frogs by one of their legs. Then the bird would slap the prey against the water surface before swallowing it head first. We observed similar acts of predation by these two species on 29 and 30 Dec 2003, between 900 and 1700 h. At Laguna el Hoyo—another permanent pond in the national park—two other birds, the Brown-hooded Gull (*Larus maculipennis*) and the Andean Ruddy Duck (*Oxyura ferruginea*), were observed preying on *A. patagonicus* on 15 Jan 2002. In these two lagunas the most common predators are birds, and they can capture at least three frogs per hour. Hence, it is important to fully understand the interaction between bird predation and *A. patagonicus* populations.

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BUFO AMERICANUS (American Toad) and **RANA CATESBEIANA** (Bullfrog). **MICROHABITAT.** Use of burrows by amphibians has been documented for several species. During a field study, adult *B. americanus* (21 April 2001) and juvenile *R. catesbeiana* (9 March 2002) were observed using crayfish bur-

rows at a breeding pond in Union City, Madison County, Kentucky. Use of burrows occurred as the pond was receding during dry conditions, suggesting burrows may have been used as refugia to avoid desiccation.

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BUFO AMERICANUS CHARLESMTITHI (Dwarf American Toad). **MAXIMUM SIZE.** Conant and Collins (1998. *A Field Guide to Reptiles and Amphibians of Eastern and Central North America*. Third Ed., Expanded. Houghton Mifflin, Boston. 616 pp.) report the record size for *Bufo americanus charlesmtithi* as 6.4 cm. Herein, we report on a new maximum body size for this subspecies from Arkansas.

On the night of 17 April 2004, we collected an adult female *B. a. charlesmtithi* crossing St. Hwy 88, ca. 0.2 km W Queen Wilhelmina State Park, on the top of Rich Mountain (Polk County; 34°41.240'N, 94°23.143'W; elev. 768 m). The specimen measured 10.2 cm SVL at the time of preservation on 20 April 2004 and 9.5 cm SVL upon a more recent measurement on 14 June 2004.

The specimen was deposited in the Arkansas State University Museum of Zoology herpetological collection (ASUMZ 28453) and collected under the authority of an Arkansas Game & Fish Commission scientific collection permit.

Submitted by **STANLEY E. TRAUTH** (e-mail: strauth@astate.edu), **MICHELLE N. MARY**, and **JACOB A. SAWYER**, Department of Biological Sciences, Arkansas State University, State University, Arkansas 72467, USA.

BUFO MARINUS (Cane Toad). **PREDATION.** *Bufo marinus* is a widespread anuran native to central and tropical South America that has been introduced into several other countries for pest control (Easteal 1981. *Biol. J. Linn. Soc.* 16:93–113). In these countries, the uncontrolled expansion of *B. marinus* is causing a negative impact upon native species (Catling et al. 1999. *Wildl. Res.* 26:161–185). Although it has been documented that eggs and tadpoles are toxic to a wide range of aquatic predators including invertebrates, fish, and other anurans (Crossland and Azevedo-Ramos 1999. *Herpetologica* 55:192–199; Punzo and Lindstrom 2001. *J. Herpetol.* 35:693–697), there is little information about natural predators of larval stages of this species (Hutchings 1979. *N. Queensland Nat.* 45:4–5; Crossland 1998. *Herpetologica* 54:364–369). Snakes of the genus *Liophis* inhabit mesic habitats and their diet consists largely of anurans and their larvae. At least one species, *L. epinephelus*, feeds on *B. marinus*, and *L. melanotus* has been reported as a predator of *Bufo granulatus* (Michaud and Dixon 1989. *Herpetol. Rev.* 20:39–41). On 18 Feb 2004 near Chichiriviche, Vargas State, Venezuela (10°32'N, 67°14'W, 135 m elev.), we observed an adult male *L. melanotus* on the shore of the Río Chichiriviche, 3 km SW of Chichiriviche, in a shallow margin of the river that was also occupied by a few hundred *B. marinus*

tadpoles. When captured, the snake regurgitated 8 large *B. marinus* tadpoles that appeared to have been recently swallowed. Voucher specimens are deposited in the Museo de La Estación Biológica de Rancho Grande (EBRG), Ministerio del Ambiente y de los Recursos Naturales, Venezuela as EBRG 4460 (*L. melanotus*) and EBRG 4939 (*B. marinus* tadpoles).

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BUFO OCELLATUS (NCN). **DEATH FEIGNING.** Death feigning or thanatosis (Edmunds 1974. Defense in Animals. Longman, New York, 357 pp.), is a common behavior among frogs (Sazima 1974. J. Herpetol. 8:376–377; Duellman and Trueb 1986. Biology of Amphibians. McGraw-Hill, New York; Azevedo-Ramos 1995. Rev. Bras. Biol. 55: 45–47). On 7 Aug 2003, in Unaí Municipality (46°7'W; 16°9'S) when handling an adult male *Bufo ocellatus* (42.8 mm SVL), I observed death feigning behavior in this species. The specimen adopted a motionless posture, keeping his limbs close to the body and eyes closed. After 45 sec. in this position, the frog started moving, attempting to escape. However, when restrained it reinflated the lungs and released bladder liquid. Both behaviors are similar to those described for *B. paracnemis* (Zamprognio et al. 1998. Herpetol. Rev. 29:96–97) and probably are widespread among other species of this genus. The function of death feigning might be related to increasing the chances of being lost by a predator and/or to minimization injuries when seized by a predator (Sazima, *op. cit.*). A voucher specimen (AAG-UFU 2484) is housed in the Museu of Biodiversidade do Cerrado, Universidade Federal de Uberlândia, Minas Gerais, Brazil.

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BUFO PROBOSCIDEUS (NCN). **PREDATION.** *Bufo proboscideus* occurs in the Amazon River region from Ecuador to Manaus, Brazil (Frost 2002. Amphibian Species of the World: An Online Reference V2.21, April 2003). This species is diurnal, but is often seen at night when it rests off the ground on small seedlings and shrubs (Zimmerman and Bogart 1988. J. Herpetol. 22:97–108). Here, I report predation of *B. proboscideus* by the colubrid snake *Xenoxybelis argenteus*.

On 11 April 2003 (1930 h), at Reserva Florestal Adolpho Ducke (02°55'S, 59°59'W), Manaus, Amazonas, Brazil, I found a juvenile *X. argenteus* (ca. 800 mm TL) ingesting a juvenile *B.*

proboscideus (35 mm SUL). At the moment of observation, only the hind limbs of *B. proboscideus* protruded from the snake. The snake was on a shrub 1.0 m above the ground and when disturbed, regurgitated the dead frog and escaped into the vegetation.

Xenoxybelis argenteus is considered to be a strictly diurnal species that sleeps on low vegetation at night (Martins and Oliveira 1998. Herpetol. Nat. Hist. 6[2]:78–150). Their diet consists of small lizards and frogs, which are captured while the snake forages on low vegetation (Martins and Oliveira, *op. cit.*). The present observation shows that *X. argenteus* may forage opportunistically at night when frogs, such as *B. proboscideus*, sleep on vegetation.

I thank W. E. Magnusson, A. P. Lima, and D. J. Rodrigues for critically reading this manuscript; fellowship by CAPES to MM.

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BUFO SPECIOSUS (Texas Toad). **MAXIMUM SIZE.** The record size reported for *Bufo speciosus* is 92 mm SVL (Conant and Collins 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Third Ed., Expanded. Houghton Mifflin, Boston. 523 pp.). Herein, we report on a new maximum size for this species.

On 7 July 2004, a female *Bufo speciosus* was collected as we road cruised in Brewster County, Texas, USA. The toad was collected at ca. 2330 h on St. Hwy 118, 32.6 km N Terlingua. The highway was damp following a brief rain shower, air temperature was 27.8°C. In the field the specimen measured 98 mm SVL, mass was 127 g. The specimen was deposited in the Arkansas State University Museum of Zoology herpetology collection (ASUMZ 28696). The specimen was re-measured following preservation and was 97 mm SVL. Collection of the specimen was under the authority of the Texas Parks and Wildlife Department permit (SPR-0704-398) issued to SET.

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ELEUTHERODACTYLUS PLANIROSTRIS (Greenhouse Frog). **COLD TOLERANCE.** On 3 March 2004, a healthy adult *Eleutherodactylus planirostris* was found inside a sealed 3 cu. ft bag of cypress mulch at the Detroit Zoo, Oakland County, Michigan. According to a representative of the manufacturer this bag originated at a packing plant in Trenton, Gilchrist County, Florida 1–2 weeks prior to its arrival in Michigan on 11 July 2003. The bag was kept outside until it and several others were relocated to the zoo on 29 Jan 2004. All the bags appeared to be frozen solid at that time. The bags remained outside at the zoo until 29 Feb 2004 when the bag containing the frog was brought inside to thaw. The ability of some ectotherms to endure freezing climates results from freeze avoidance (selecting a microclimate that does not freeze), freeze resistance (supercooling), or freeze tolerance (accumula-

tion of intracellular antifreeze and nucleation of extracellular freezing (Pinder et al. 1992. In Feder and Burggren [eds.], *Environmental Physiology of the Amphibians*, pp. 250–274. University of Chicago Press). Freeze avoidance cannot be ruled out in this case: it is possible that the bag of mulch (12 cm thick) provided a thermally protected microclimate, particularly if the bag had been ensconced within a pile of bags. Freeze resistance is not an option for amphibians due to their low supercooling capacity and water-permeable skin (Pinder et al., *op. cit.*). Freeze tolerance has been documented in certain extreme temperate amphibians, including some ranid and hylid frogs and a hynobiid salamander (Pinder et al., *op. cit.*); it has not been documented in leptodactylids. As we did not observe the frog until after the mulch had thawed, we are unable to state for certain if what we observed was freeze avoidance or freeze tolerance. However, the frog likely experienced freezing temperatures during some of its time in Michigan. During the 32 days the bag was kept outside at the zoo, maximal outdoor daily temperatures in the Metro Detroit region were below freezing on 15 days; average daily temperatures were below freezing on 23 days. *Eleutherodactylus planirostris* is native to the West Indies and has been introduced into Florida, Hawaii, Jamaica, Louisiana, Mexico (Frost 2002. *Amphibian Species of the World* online), and Georgia (Winn et al. 1999. *Herpetol. Rev.* 30:49). This species was first detected on the mainland US in southern Florida in 1875 (Cope 1875. *Bull. U.S. Nat. Mus.* 1:i–xi, 1–104.) and since has been spreading northward (Ashton and Ashton 1988. *Handbook of Reptiles and Amphibians of Florida* pt. 3, The Amphibians. Windward Publ. Inc., Miami. 191 pp.). Although it is typically thought that the northward range expansion of tropical species introduced into the southern US will be limited by cold or freezing temperatures, our observation of cold tolerance in *E. planirostris* suggests that macro-environmental temperature *per se* might not be a limiting factor for this species. Moreover, that this individual survived for ca. 8 months sealed in a bag of mulch speaks to the extreme tolerance of the species and its potential for inadvertent anthropogenic dispersal. The presence of extreme cold tolerance, or possibly freeze tolerance, in a tropical species is intriguing, especially in light of the freeze intolerance of several temperate species more closely related to freeze-tolerant species (Pinder et al., *op. cit.*), and raises questions about the origin(s) and phylogenetic distribution of the underlying physiological mechanisms.

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GASTROPHRYNE OLIVACEA (Great Plains Narrow-mouthed Toad). **PREDATION.** At Yécora, Sonora, Mexico (28°22'4.0"N, 108°55'32.6"W), 1545 m, a large chorus of *Gastrophryne olivacea* was found the night of 25 July 2004, in temporary pools as much as 25 cm deep that had formed earlier that day. The chorus was an attraction for at least 3 *Thamnophis c. cyrtopsis* that were observed foraging in and around the pools. Each was watched for a time as it appeared to be directed toward one specific calling toad, none of which made any attempt to avoid the approaching snake. The head and neck of each snake were held well above the water, as

though guided by vision toward the prey, although it is not likely that the snakes were attracted to the site by vision. Most pools in the area contained breeding choruses of *Hyla wrightorum* as well as *Gastrophryne*, but all snakes observed were in pools containing only the latter genus. It is possible they selectively sought the smallest anurans of the congress, which were the male *Gastrophryne*. Apparently *T. cyrtopsis* is one of the main predators of *Gastrophryne* in this area.

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GASTROPHRYNE OLIVACEA (Great Plains Narrow-mouthed Toad). **REPRODUCTION.** At Yécora, Sonora, Mexico (28°22'4.0"N, 108°55'32.6"W), 1545 m, during the day on 25 July 2004 (0730–1830 h), as a light rain fell, weak, scattered calls of easily disturbed *Gastrophryne olivacea* were heard in extensive grasslands where the toads were impossible to detect, hidden in the grass and not fully emerged from their burrows. A little later an exceptionally severe, protracted rainstorm rapidly filled low areas all around town, where water accumulated in many small pools as much as 25 cm deep where none existed before. During that process emerging individual *Gastrophryne* appeared in huge numbers on almost all of the pools, where they called loudly in a low buzz lasting as long as 6 sec (as opposed to 3 sec recorded for eastern populations). Females were seen approaching the much smaller males, but they seemed to be selective, turning away at times from one male to another. Amplexus was adhesive. Eggs were laid the same night by captive specimens. Most pools were shared with *Hyla wrightorum*; only two were occupied exclusively by *Gastrophryne*.

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HYLAACREANA (NCN). **LARVAL BEHAVIOR.** Carnivory in larval anurans is well documented, with the families Hylidae, Leptodactylidae, Myobatrachidae, Pelobatidae, Pipidae, Dendrobatidae, and Ranidae containing species known to have predaceous larvae (McDiarmid and Altig 1999. Tadpoles: The Biology of Anuran Larvae. University of Chicago Press, Chicago

and London. 444 pp.). The role of carnivorous species in tadpole assemblages, however, is poorly known.

During October 2002, I observed *Hyla acreana* tadpoles in the floodplain of the Madre de Dios River in southeastern Peru. *Hyla acreana* adults were most commonly found calling from secondary growth habitat bordering small pools and large puddles. These pools were common breeding habitat for upwards of thirty anuran species (McKeon and Baggallay, in prep.), though dominated by *Phrynohyas venulosus*, *Hamptophryne boliviana*, *Scinax rubra*, and *Hyla leucophyllata*. Tadpoles were captured and reared through metamorphosis for positive identification. Throughout the month, behavioral notes were taken on tadpoles *in situ*, using a mask and snorkel while lying on a balsa raft.

Four instances of depredation by tadpoles of *H. acreana* were recorded. Three prey individuals were larval *Hamptophryne boliviana*, the fourth was a tadpole of an unidentified *Scinax*. Tadpoles of *H. acreana* tended to hover near horizontal structures of submerged vegetation. Upon encountering another tadpole *H. acreana* would dart forward and seize the proximal portion of the prey in its mouthparts. Prey tadpoles were slowly consumed by tearing through the body wall.

Captive specimens of larval *H. acreana* (Gosner stages 28–36) were offered prey types belonging to the following species: *Hyla leucophyllata*, *Hamptophryne boliviana*, *Phyllomedusa camba*, *Phyllomedusa palliata*, *Scinax rubra*, *Allobates femoralis*, and *Phrynohyas venulosus*. All were smaller than, or equal in length to the *H. acreana*. All prey species were avidly consumed except for *P. venulosus*, the most common tadpole found in the pond assemblage.

I thank the Yine Project, Madre de Dios Explorations, and Pantiacolla Tours for their continuing support of herpetological research in the area.

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HYLA ALVARENGAI (NCN). **PREDATION.** Amphibians are common prey for a variety of predators (Castanho 1996. Herpetol. Rev. 27:141; Haddad and Bastos 1997. Amphibia-Reptilia. 18:295–298) *Hyla alvarengai* is endemic to the Serra do Espinhaço in the Brazilian states of Minas Gerais and Bahia (Frost 2004. Amphibian Species of the World: an Online Reference. Version 3.0. 22 Aug 2004. Electronic Database accessible at <http://research.amnh.org/herpetology/amphibia/index.html>). It is a saxicolous hylid, with a relatively large body size (Duellman 1993. Amphibians of the world: additions and corrections. Univ. Kansas Mus. Nat. Hist. Spec. Publ. 21:1–372) and little is known about its biology (see Sazima and Bokermann 1977. Rev. Bras. Biol. 37:413–417; Vrcibradic and Van Sluys 2000. Herpetol. Rev. 31:40–41; Carneiro et al. 2003. Anais de trabalhos completos. V Congresso de Ecologia do Brasil. pp. 563–564).

On 18 Sept 2003 at Serra do Cipó (19°20'S; 43°40'W), Minas Gerais, Brazil, ca. 1200 h, we observed an individual *H. alvarengai* being eaten by a Yellow-headed Caracara at the edge of the MG-010 road. We initially saw the hawk perched on a wall at the roadside while eating an individual *H. alvarengai*. The hawk flew away as we approached, leaving behind only the left tibia (25.9 mm) of

a young *H. alvarengai*. The young of *H. alvarengai* preferentially use stones as diurnal resting sites at Serra do Cipó (Carneiro 2003, *op. cit.*), a kind of substrate in which individuals of this species are cryptic (Sazima and Bokermann 1977, *op. cit.*). Nonetheless, the use of an uncovered microhabitat to rest might make young of this species potential prey for visually-oriented predators.

We are grateful to Tadeu J. Guerra for logistical support. This work was completed while CABG received a graduate fellowship from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

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HYLA ARILDAE (Teresópolis Treefrog). **DEATH FEIGNING.**

Death feigning behavior has been recorded in some neotropical hylid frogs (Azevedo-Ramos 1995. Rev. Brasil. Biol. 55:45–47; Napoli 2000. Herpetol. Rev. 32:36–37; Vrcibradic and Van Sluys 2000. Herpetol. Rev. 31:40–41). *Hyla arildae* is known to occur in forest fragments of the Serra do Mar and Serra da Mantiqueira in southeastern Brazil (Heyer et al. 1990. Arq. Zool., São Paulo, 31:255–256). During March 2004 at 1200 h, at the Parque Municipal das Mangabeiras (19°55'S; 43°56'W; 850 m elev.), Belo Horizonte, Minas Gerais State, we found an adult *Hyla arildae* (47 mm SVL) resting about 1 m above ground on a leaf of a shrub. When we touched the shrub, the treefrog jumped to the ground about 50 cm from its original position. One of us (PCFC) captured the frog by hand, and just after opening the hand we discovered the treefrog was feigning death. Immediately after being captured, the treefrog thrust its forelimbs upwards and remained motionless with eyelids half closed and its hindlimbs sheltered close to the body. We then turned the treefrog belly up, it remained in the same position for about 10 seconds. After that, we put the treefrog on the ground to take photos. It remained motionless for about five seconds then jumped into its surroundings. This is the first record of death feigning in *Hyla arildae*. We thank D. Vrcibradic and M. Van Sluys for suggested revisions to the text and FAPERJ for a grant to PCFC and CNPq for research grants to CFDR.

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HYLA CHRYSOSCELIS (Gray Treefrog). **DEPRIVATION**

TOLERANCE. On 23 July 2004, a healthy adult *Hyla chrysoscelis* was found inside a sealed 2-cubic-foot bag of red cedar bedding chips by Joann Listwak of North Branch, Lapeer County, Michigan, USA. The treefrog was donated to the Detroit Zoo (accession 11322). According to a representative of the manufacturer the logs for this batch of chips came from Kentucky and/or Alabama and

were shipped to a processing plant in Lebanon, Marion County, Kentucky. Because of the destructive nature of processing (chipping, kiln drying), the frog must have gotten in the bag late in the processing and more likely came from the region of the processing plant than the log source. Because *H. versicolor* is known from just a few counties around Ft. Knox in Kentucky and *H. chrysoscelis* occurs statewide (MacGregor et al. 2004. Frogs and Toads of Kentucky. Available online at www.bioweb.wku.edu/froglogger), I assume this animal is the latter species. The bag was purchased at the Tractor Supply Company store in Lapeer, Michigan between 7–16 July. According to the manufacturer, it takes about 1 month for the bag to go from the manufacturer to the distributor; summertime shipments to the distributor are monthly and all stock is sold within the month, so the bag was likely sealed at the processing plant 30–60 days prior to sale. With an additional 1–2 weeks at the home of the purchaser, this animal was apparently isolated for 5–10 weeks. Unlike in a similar event involving an *Eleutherodactylus planirostris* sealed in a bag of moist mulch for 8 months (Zippel et al. 2005. Herpetol. Rev. 36:299–300), cedar chips are kiln-dried and bagged shortly thereafter so the presence of food and water is unlikely.

Unintentional anthropogenic dispersal of amphibians and other wildlife has become increasingly common as various means of transportation become faster and wider reaching (e.g., Kaiser 1997. Biodiv. Conserv. 6:1391–1407). We regularly receive phone calls at the zoo to identify animals that emerge from plant and produce shipments. This example, in addition to one previously documented (Zippel et al., *op. cit.*), demonstrates how ectotherms are in some ways more likely to be inadvertently dispersed by human activities. Although ectotherms are affected by deprivation (e.g., Audo et al. 1995. Oecologia 103:518–522; Dunlap 1995. J. Herpetol. 29:345–351), their small size and low metabolic needs relative to endotherms (Pough 1980. Amer. Nat. 115:92–112) make them more likely to survive transportation under extreme conditions of deprivation.

Submitted by **KEVIN C. ZIPPEL**, National Amphibian Conservation Center, Detroit Zoo, Royal Oak, Michigan 48068, USA.

HYLA PULCHELLA CORDOBAE (Cordoba Treefrog). **PARASITISM.** Parasitism by copepods on anuran tadpoles is rarely documented. However, such parasitism has been reported on field caught (Baldauf 1961. J. Parasitol. 47[2]:195) and laboratory-reared (Martins and Souza 1996. Rev. Bras. Biol. 12[3]:619–625) *Rana catesbeiana*, and on field caught *R. chalconota* (Tzi Ming 2001. Froglog 46[3]:3).

During February 2002, one of us (LA) collected 46 *Hyla pulchella cordobae* tadpoles (Gosner stages 26–35), from a lotic environment (Arroyo Tanti, Tanti City, Córdoba province, Argentina). Tadpoles were preserved and transferred to the laboratory where we found 9 of them with a total of 12 parasitic copepods (Lernaeidae, *Lernaea* sp.). We observed a maximum of 4 copepods on any one tadpole, whereas the maximum number previously reported varied from 6 (Baldauf, *op. cit.*) to 15 (Tzi Ming, *op. cit.*). All copepods observed by us were anchored at the junction of the body and tail. The damage by parasitic copepods seems to be variable. Tzi Ming (*op. cit.*) observed a 5.5% incidence of external limb abnormalities, although no abnormalities were reported

by Baldauf (*op. cit.*), Martins and Souza (*op. cit.*) or us. Tzi Ming (*op. cit.*) found the copepod *L. cyprinacea* on *R. chalconota* tadpoles and fishes of the genus *Poecilia*. Similarly, we observed copepods (*Lernaea* sp.) on *Hyla pulchella cordobae* tadpoles and the fish *Astyanax* sp. and *Jenynsia* sp., which were collected sympatrically.

This information suggests that natural infestations of copepods on anuran tadpoles might occur at both lentic (Tzi Ming, *op. cit.*) and lotic environments. The material examined was deposited at the Invertebrates Collection of the Museo de La Plata (MLP COPEPOD 24). This is Scientific Contribution No. 763.

Submitted by **LEANDRO ALCALDE**, Área Sistemática, Sección Herpetología, Instituto de Limnología “Dr. Raúl A. Ringuelet,” CC 712, CP 1900, La Plata, Bs. As., Argentina (e-mail: alcalde@ilpla.edu.ar); and **PATRICIA BATISTONI**, División Zoología de Vertebrados, Sección Ictiología, Museo de La Plata, Paseo del Bosque s/n, 1900, La Plata, Bs. As., Argentina.

HYLA VERSICOLOR (Gray Treefrog). **RECORD SIZE.** Conant and Collins (1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. 3rd Ed. Expanded. Houghton Mifflin, Boston, Massachusetts. 616 pp.) reported maximum size for *Hyla versicolor* as 60 mm SVL. Herein I report a female *H. versicolor* 62.4 mm as determined by standard anuran SVL measurement techniques (Conant and Collins 1998, *op. cit.*) using a vernier caliper. This specimen was collected at the Thomas Baskett Wildlife Research Area 6.7 km E of Ashland, Boone County, Missouri, USA on 15 June 2004. Length and species identification (based on collection location) was confirmed by Richard Daniel. The specimen is deposited in the University of Missouri, Columbia Herpetological Collection (UMC 7709).

Submitted by **JARRETT R. JOHNSON**, 212 Tucker Hall, Division of Biological Sciences, University of Missouri, Columbia, Missouri 65211, USA.

LEPTODACTYLUS LABYRINTHICUS (South American Pepper Frog). **PREDATION.** *Leptodactylus labyrinthicus* lays its eggs in foam nests in basins at margins of water bodies and has aquatic tadpoles (Ceï 1980. Monit. Zool. Ital. [NS] Monogr. 2: XII. 609 pp; Silva et al. *in press*. J. Nat. Hist.). The morphology of these tadpoles has been described (Heyer 1979. Smithsonian. Contr. Zool. 301:1–43; Ceï 1980, *op. cit.*), although ecological data are scarce. Here we report field observations of predation upon tadpoles. We observed predatory events in a cement pool (3 m; 10 cm deep), in a garden at the Cerrado Reservation of Parque Estadual de Caldas Novas (17°43'S, 48°40'W), in the municipality of Caldas Novas, Goiás State, Brazil. Observations were made during the day and night in September 2003. During the day (0700–1800 h) we observed the Leaf-scrapper (*Turdus amaurochalinus*) disturbing the dead leaves on the bottom of the pool with its beak and capturing tadpoles. The bird had a nest with two nestlings about 20 m from the pool, and used the captured tadpoles to feed them. The tadpoles were swallowed or carried in the beak. At ca. 1830 h we also observed the snake *Liophis poecilogyrus* (voucher photo: AAG-

UFU 3227) preying on these tadpoles. This snake was captured (ca. 10 min after being found) and it regurgitated 11 tadpoles (38.5 ± 2.4 mm TL), five were still alive.

Predation has been considered the main cause of tadpole mortality (McDiarmid and Altig 1999. Tadpoles: The Biology of Anuran Larvae. University of Chicago Press, 444 pp.). The Leaf-scraper is an especially efficient diurnal predator because they can dislodge tadpoles from their retreats by removing leaves from the bottom of the pool.

We thank Celine de Melo for identification of the bird and A. A. Giaretta for critically reading the manuscript and identifying the snake.

Submitted by **KENI PAULA R. MUNIZ** (e-mail: keniribeiro@hotmail.com.br) and **WAGNER RODRIGUES SILVA** (e-mail: wagnerdrigues@yahoo.com.br), Laboratório de Ecologia e Sistemática de Anuros Neotropicais, Instituto de Biologia, Universidade Federal de Uberlândia, CEP 38400-902, Uberlândia, Minas Gerais, Brazil.

LEPTODACTYLUS LABYRINTHICUS (South American Pepper Frog). **NECROPHAGY.** On 26 Sept 2003 at a Cerrado reservation in Caldas Novas Municipality ($17^{\circ}43'S$, $48^{\circ}40'W$), Goiás State, Brazil, we observed tadpoles of *L. labyrinthicus* gathered around the carcass of a bird (*Turdus* sp.) in a cement pool (ca. 10 cm deep). Observations occurred from 0700–2000 h. We found about 30 tadpoles entering amidst the feathers and biting the carcass. Tadpoles of *L. labyrinthicus* have been reported to feed on tadpoles and frog eggs (Cardoso and Sazima 1977. *Ciência e Cultura* 29:1130–1132; Silva et al. *in press*. *J. Nat. Hist.*), but necrophagy was previously unknown. Eggs and carrion may represent a valuable protein source for these tadpoles, and compared to other frogs, animal matter may allow a faster development (McDiarmid and Altig 1999. Tadpoles: The Biology of Anuran Larvae. University of Chicago Press, 444 pp.).

We thank A. A. Giaretta for critically reading this manuscript.

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LEPTODACTYLUS OCELLATUS (Rã-Manteiga). **CANNIBALISM.** In some animals (Machado and Oliveira 1998. *J. Zool. London* 246:359–367), including frogs (Townsend et al. 1984. *Anim. Behav.* 32:421–431), cannibalism is a major factor of mortality of immature individuals. On 6 Aug 2003 in Unaí municipality, Minas Gerais state, Brazil, we collected an adult *Leptodactylus ocellatus* (62.4 mm SVL) and found a conspecific juvenile (30 mm SVL) in its stomach. *Leptodactylus ocellatus* has a broad diet, often feeding on other frogs (Gallardo 1964. *Physis* – Tomo XXIV N 68:373–384), including conspecifics (present note).

Specimens examined (AAG-UFU 2482, 2494) are housed in Museu de Biodiversidade do Cerrado, in the Universidade Federal de Uberlândia, Minas Gerais state, Brazil. We thank Ariovaldo

A. Giaretta for critically reading the manuscript and the owners of the Fazenda Sagres S. A. for logistic support.

Submitted by **MARCELO NOGUEIRA DE CARVALHO KOKUBUM** (e-mail: mnckokubum@hotmail.com), Laboratório de Ecologia e Sistemática de Anuros Neotropicais, Instituto de Biologia, Universidade Federal de Uberlândia, Minas Gerais, Brazil; and **ANDRÉ PEREIRA RODRIGUES**, Programa de Pós-graduação de Ecologia, Universidade de Brasília, Brazil.

MICROHYLA HEYMONSI (Dark-sided Chorus Frog). **ENDOPARASITES.** *Microhyla heymonsi* is known from south-east Asia (Ziegler 2002. *Die Amphibien und Reptilien eines Tieflandfeuchtwald-Schutzgebietes in Vietnam*. Natur und Tier - Verlag GmbH, Munster, Germany, 242 pp.). To our knowledge there are no reports of endoparasites from this species. The purpose of this note is to report the nematode *Cosmocercoides multipapillata* from *M. heymonsi*.

Two *M. heymonsi* (SVL 21 mm \pm 1 SD, range: 20–22 mm) were collected 21 April 1999 from Ha Tinh Province, Huong Son District, ($18^{\circ}20'N$, $105^{\circ}14'E$), Vietnam and deposited in the herpetology collection of the Natural History Museum of Los Angeles County, Los Angeles, California as LACM 14682, 14683. The esophagus, stomach, small intestine, large intestine, lungs, and urinary bladder were opened and examined separately for helminths using a dissecting microscope. The body cavity was also searched. One frog (LACM 14683) was found to harbor 5 (2 males, 3 females) nematodes in the large intestine. The nematodes were cleared in a drop of concentrated glycerol, identified as *Cosmocercoides multipapillata* and deposited in the United States National Parasite Collection, Beltsville, Maryland as USNPC 94915. Prevalence of infection (number infected frogs/number frogs examined) \times 100 was 50%.

Cosmocercoides multipapillata was described from *Bufo melanostictus* from India (Khera 1958. *Ind. J. Helminthol.* 10:6–12). It has also been reported in *Bufo gargarizans* from China (Wang 1980. *Acta Zootax. Sinica* 6:365–372). *Microhyla heymonsi* represents the third host for *Cosmocercoides multipapillata*. Vietnam is a new locality record.

We thank Amanda Woolsey (Whittier College) for assistance with dissections.

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PLEURODEMA BUFONINUM (NCN). **DIET.** *Pleurodema bufoninum* is a leptodactylid frog adapted to living under challenging climatic conditions of the Patagonian steppe, at the southern tip of South America (Ceï 1980. *Amphibians of Argentina*. *Monit. zool. ital.* [N.S.], Monogr. 2:1–609). The species is widely distributed in the Argentine Patagonia, but in Chile it is restricted to the few steppe areas that exist west of the Andes. Little is known about its biology, with the only reference to its diet from nine specimens collected in Chile, between Pino Hachado and Icalma. Both

areas are on the frontier with Argentina (38°40'–38°50'S; 71°W; 1200–1800 m elev.) (Pincheira-Donoso 2002. *Gayana* 66[1]:77–80). Nothing is known about the species' feeding ecology in the Argentine Patagonia. This note describes for the first time the diet of *P. bufoninum* collected east of the Andes.

On 9 March 2004 (late summer), during hot weather conditions (29°C), at 1530 h, we found *P. bufoninum* juveniles active, sheltering in the shade of a bridge on the shore of the Pichileufú River (Paso Flores, Río Negro Province, Argentina, 40°36'S, 70°39'W; 575 m elev), 3–5 m away from the water. The general surroundings are typical of the Patagonian steppe (semi-desert with xerophytic, stunted bushes less than 0.6 m tall alternating with grasses). On this occasion, the frogs were found at the highest, driest sites of the alluvial terrain, where there are only cobbles and boulders. Immediately after being captured, the frogs were killed and fixed in 10% formalin for later analysis. We examined 5 newly metamorphosed specimens (Gosner stages 45 and 46); measuring between 19.9 and 23.5 mm TL (mean 22.1 ± 1.57 mm). We identified stomach contents to family or order level. We recorded the number of items of each prey taxon and calculated its frequency of occurrence. We estimated the rate of feeding activity as the percentage of stomachs containing food with respect to the total number of stomachs examined (Sala and Ballesteros 1997. *Mar. Ecol. Prog. Ser.* 152:273–283). The percentage of stomachs containing food was 100%. We found 2–10 prey items per stomach. All prey were arthropods, and there was no plant material in the stomachs. Numerically, the diet was made up of hymenopterans (48%), coleopterans (44%), and Araneae (8%). In particular, ants (Formicidae) were the most abundant prey item (40%), followed by Hydrophilidae larvae (24%) and adult Carabidae and Curculionidae (20%). Non-Formicidae hymenopterans and Araneae were consumed in equal proportions (8%). The most frequently occurring items were Formicidae (100%), Hydrophilidae larvae (60%), and Araneae (40%).

Comparison of our results with Pincheira-Donoso (2002, *op. cit.*) shows that in both cases ants were the most abundant item in the diet of *P. bufoninum*. Coleopterans were more numerous and more frequent in our study, and they add two new families to known prey items (Curculionidae and Hydrophilidae). Hemiptera, Diptera, Homoptera, Acari, and Gastropoda, and seeds and plant remains were not present in our sample. Thus, based on our results, *P. bufoninum* feeds on a smaller number of prey taxa.

Our results complement the only previous data available on the diet of this species, and provide information on the trophic behavior of newly metamorphosed juveniles, at a lower altitude east of the Andes. Our results support the idea that the species is opportunistic, adapts to local conditions, and includes terrestrial walking and flying arthropods and aquatic coleopteran larvae in its diet.

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POLYPEDATES LEUCOMYSTAX (Java Whipping Frog). **ENDOPARASITES.** *Polypedates leucomystax* is known from India,

southeast Asia, and Japan (Ziegler 2002. *Die Amphibian und Reptilien eines Tieflandfeuchtwald-Schutzgebietes in Vietnam. Natur und Tier - Verlag GmbH, Munster, Germany*, 342 pp.). To our knowledge, there are no reports of helminths from *P. leucomystax* collected in Vietnam. The purpose of this note is to report the nematode *Cosmocercoides multipapillata* and the acanthocephalan *Acanthocephalus bufonis* in *P. leucomystax*.

Two *P. leucomystax* (SVL 57 mm \pm 4 SD, range = 54–59 mm) were collected 17 April 1999 from Ha Tinh Province, Huong Son District, (18°20'N, 105°14'E), Vietnam and deposited in the herpetology collection of the Natural History Museum of Los Angeles County, Los Angeles, California as 146820 and 146821. The esophagus, stomach, small intestine, large intestine, lungs, and urinary bladder were opened and examined separately for helminths using a dissecting microscope. The body cavity was also searched. Helminths were cleared in a drop of concentrated glycerol. One frog (LACM 146820) was found to harbor 6 (5 males, 1 female) *Cosmocercoides multipapillata* and 3 (2 males, 1 female) *Acanthocephalus bufonis*, both in the small intestines. Helminths were deposited in the United States National Parasite Collection (USNPC) as *Cosmocercoides multipapillata* (94916) and *Acanthocephalus bufonis* (94917). Prevalence of infection (number infected frogs/number frogs examined) \times 100 was 50% for each helminth.

Cosmocercoides multipapillata was originally described from *Bufo melanostictus* from India (Khera 1958. *Ind. J. Helminthol.* 10:6–12). It has also been reported in *Bufo gargarizans* from China (Wang 1980. *Acta Zootax. Sinica* 6:365–372). *Acanthocephalus bufonis* has an Oriental distribution where it is known from bufonids, ranids, and the lacertid lizard *Takydromus sexlineatus* (Kennedy 1982. *Can. J. Zool.* 60:356–360). It also occurs in *Bufo marinus* in Hawaii (Barton and Pichelin 1999. *Parasite* 6:269–272). *Cosmocercoides multipapillata* represents a new helminth species record for *P. leucomystax*. Vietnam is a new locality record for *C. multipapillata* and *A. bufonis*.

We thank Amanda Woolsey (Whittier College) for assistance with dissections.

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PSEUDACRIS CADAVERINA (California Treefrog). **PREDATION.** During an electro-shocking survey on 12 August 2004 (1145 h), a juvenile Largemouth Bass (*Micropterus salmoides*; 120 mm TL) was collected from a small pool (ca. 10 m \times 1.5 m, 40 cm) from San Mateo Creek, San Diego County, California, USA (T8S, R6W, Sec 24). Upon capture it was noticed that the rear legs of an adult *P. cadaverina* were protruding from the mouth of the *M. salmoides*. The frog had been partially digested when discovered and an examination of the legs of the *P. cadaverina* showed no abnormalities or decay leading us to conclude that the frog had been consumed live.

To our knowledge, this is the first documentation of predation of *P. cadaverina* by *M. salmoides*. Previously documented non-native fish predators on *P. cadaverina* include Rainbow Trout,

Oncorhynchus mykiss (hatchery raised-stock variety) and Green Sunfish, *Lepomis cyanellus* (Ervin 2005. In M. Lannoo [ed.], Amphibian Declines: The Conservation Status of United States Species, pp. 467–470. Univ. California Press, Berkeley and Los Angeles).

At the site of collection *M. salmoides* is an introduced invasive predatory fish. *Micropterus salmoides* has been widely introduced in North America (Courtenay and Stauffer 1984. Distribution, Biology, and Management of Exotic Fishes. John Hopkins University, Baltimore, Maryland) and has been implicated as a contributing factor in the declines of native amphibian populations (Hayes and Jennings 1986. J. Herpetol. 20:490–509; Fisher and Shaffer 1996. Cons. Biol. 10[5]:1387–1397).

The *M. salmoides* with the partially digested *P. cadaverina* remains, protruding from its mouth, were preserved in formalin and deposited, along with two digital prints of the specimen, in the Herpetological Collection at the California Academy of Sciences as vouchers (CAS 228883).

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PSEUDACRIS CRUCIFER (Spring Peeper). **PREDATION.** Because *Pseudacris crucifer* larvae are palatable (Kats et al. 1998. Ecology 69:1865–1870), they are typically excluded from wetlands containing predatory fishes (Hecnar and M'Closkey 1997. Biol. Cons. 79:123–131). Whether the allotopic distribution of *P. crucifer* and predatory fishes is the result of predation by fishes on *P. crucifer* eggs, larvae, or adults, or is the result of avoidance behavior by adult *P. crucifer* is unknown.

On 3 Feb 2004, I removed a Redfin Pickerel (*Esox americanus*; 13 cm TL) from a minnow trap set in a 0.2-ha isolated wetland on Moody Air Force Base, Lanier County, Georgia USA. A distended gut indicated that the fish had recently eaten. Upon dissection, I removed an adult male *P. crucifer* from the fish. Additional adult *P. crucifer* were captured in minnow traps and in funnel traps set at a drift fence adjacent to the wetland. The capture of amplexed pairs and spent females indicated breeding by *P. crucifer* despite the presence of a suite of predatory fishes (*Centrarchus macropterus*, *Elassoma evergladei*, and *Gambusia holbrooki*, in addition to *Esox*). Dipnetting and minnow trapping in March did not yield any *P. crucifer* larvae, suggesting complete reproductive failure.

The exclusion of certain species of amphibians from wetlands inhabited by predatory fishes has been explained as the result of predation (Knapp et al. 2001. Ecol. Monogr. 71:401–421) or adult avoidance (Hopey and Petranks 1994. Copeia 1994:1023–1025; Binckley and Reserants 2003. Oikos 102:623–629). My observation of *P. crucifer* breeding with, and being preyed upon by, *E. americanus* suggests *P. crucifer* is excluded from wetlands inhabited by predatory fishes by predation and not by adult avoidance behavior.

Surveys at Moody AFB are supported by the United States Air Force through a contract administered by the Center for Reptile and Amphibian Conservation and Management, Fort Wayne, In-

diana, and are authorized by Georgia scientific collection permit 29-WMB-04-147.

Submitted by **JOHN G. PALIS**, P.O. Box 387, Jonesboro, Illinois 62952, USA.

RANA CATESBEIANA (American Bullfrog). **CHYTRIDIOMYCOSIS.** Infection by the chytrid fungus *Batrachochytrium dendrobatidis* has been associated with mass mortality of anuran amphibians in Europe, Latin America, Australia, and North America (Berger et al. 1998. Proc. Nat. Acad. Sci. USA 95:9031–9036; Bosch et al. 2001. Biol. Cons. 97:331–337; Green et al. 2002. Ann. New York Acad. Sci. 969:323–339). As of May 2004, chytridiomycosis has been confirmed in at least 69 species of anurans worldwide (Berger et al. 1999. In Campbell [ed.], Declines and Disappearances of Australian Frogs, pp. 23–33. Environment Australia, Canberra; Green et al., *op. cit.*; Speare and Berger. Global distribution of chytridiomycosis in amphibians. <http://www.jcu.edu.au/school/phtm/PHTM/frogs/chyglob.htm>, 19 March 2004).

Chytridiomycosis has recently been found in native larval and post-metamorphic American Bullfrogs (*Rana catesbeiana*) in southeastern North America (Green et al., *op. cit.*), and in introduced larval bullfrogs in Uruguay, South America (Mazzoni et al. 2003. Emerging Infectious Diseases 9:995–998) and California, USA (G. Fellers and D. Green, unpubl. data). Here, we report chytridiomycosis in an adult bullfrog in western Oregon, USA. To our knowledge, this is the first reported case of chytridiomycosis in a free-living amphibian west of the Cascade Range in the Pacific Northwest.

On 08 Feb 2004, we captured an adult male bullfrog (99 mm SVL, 62 g), near Fern Ridge Reservoir in the southern Willamette Valley (UTM 0472617E, 4878466N; 117 m elev.). The bullfrog had atypical diffuse reddening of the ventral skin. The bullfrog was held alone in a laboratory aquarium for 8 days and was offered live crickets. The bullfrog became increasingly lethargic and was found dead on the ninth day of captivity. It was promptly frozen and mailed to the USGS National Wildlife Health Center for examination. Histological examinations of the ventral skin and toe webs showed mild to moderate numbers of chytrid thalli within keratinized epithelial cells only. Autolysis and freeze artifacts caused sloughing of much epidermis, hence the distribution and intensity of the host response may have been greater than what was detected histologically.

Our observation confirms the presence of *B. dendrobatidis* in the Willamette Valley, Oregon. Several factors suggest that bullfrogs could pose a threat to native amphibians by serving as disease reservoirs or vectors for *B. dendrobatidis* (see Daszak et al. 2003. Diversity and Distributions 9:141–150). Bullfrogs are introduced into at least four continents and are widespread in the lowlands of western North America (Bury and Whelan 1984. USDI Res. Publ. 155. Washington, DC. 23 pp.). Bullfrog farming operations are expanding in Latin America, and trade in bullfrogs is global (Mazzoni et al., *op. cit.*). Most bullfrog larvae overwinter in the Pacific Northwest (Bury and Whelan, *op. cit.*; Nussbaum et al. 1983. Amphibians and Reptiles of the Pacific Northwest. Univ. Idaho Press, Moscow. 332 pp.). Multiple species of overwintering ranid larvae (including *R. catesbeiana*) are known to develop oral

chytridiomycosis (Fellers et al. 2001. *Copeia* 2001:945–953; Mazzoni et al., *op. cit.*). A protracted larval stage may increase exposure to *B. dendrobatidis* and increase the likelihood of infection compared to single-season larvae (Fellers et al., *op. cit.*; Bosch et al., *op. cit.*). Mortalities among anuran larvae with oral chytridiomycosis have not been reported (Fellers et al., *op. cit.*). However, long-lived larval bullfrogs may serve as year-round reservoirs of *B. dendrobatidis*, and following completion of metamorphosis, may become vectors of the infection without demonstrating clinical signs or exceptional mortality rates (Daszak et al., *op. cit.*; Mazzoni et al., *op. cit.*). Moreover, laboratory experiments using fungal isolates suggest that transmission of *B. dendrobatidis* can occur between congeneric anurans, as well as between urodiles and anurans (Davidson et al. 2003. *Copeia* 2003:601–607; Nichols et al. 2001. *J. Wildl. Dis.* 37:1–11). Disease transmission is of particular concern in the Pacific Northwest, where bullfrogs occur sympatrically with native ranid species of concern (e.g., *Rana pretiosa*, *R. aurora*, *R. boylei*). We encourage further study of *Batrachochytrium* infection in Bullfrogs in western North America, and reiterate the need for researchers to wash and disinfect field gear between field sites.

The specimen is deposited in the National Wildlife Health Center Archives, #18972. This work was supported by the U.S. Department of Interior, Amphibian Research and Monitoring Initiative. We thank R. B. Bury and R. L. Hoffman for review and the U.S. Army Corps of Engineers for access to the study site. This animal was collected under a Scientific Collecting permit from the Oregon Department of Fish and Wildlife.

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RANA CATESBEIANA (American Bullfrog). **DIET.** Predation on vertebrates by adult American Bullfrogs is well documented (Bury and Whelan 1984. *US Fish and Wildlife Serv. Publ.* 155. USDI, Washington, DC). A recent literature review of prey items listed eight species of snakes taken as prey (Casper and Hendricks 2005. *In* Lannoo [ed.], *Amphibian Declines: The Conservation Status of United States Species*, pp. 540–546. Univ. California Press, Berkeley), including one species of rattlesnake, *Crotalus atrox* (Clarkson and DeVos 1986 *J. Herpetol.* 20:42–49) Herein I report another rattlesnake species (*C. oreganus*) previously undocumented as American Bullfrog prey.

On the evening of 17 May 2004, I collected a male (160 mm SVL, 384 g) and female (160 SVL, 503 g) *R. catesbeiana*, in amplexus, in End-of-the-Line Pond in Santa Clara County, California, USA (37°23'15.042"N, 121°44'51.413"W). The frogs were humanely killed and placed on ice overnight. They were subsequently dissected for stomach content analysis. The stomach of the gravid female contained a nearly intact *C. oreganus* (SVL not available; remaining carcass was 260 mm in length and weighed 12.5 g). This is the second documented case of *R. catesbeiana* eating rattlesnakes with no apparent ill effects.

I thank Mark R. Jennings for advice on processing specimens. Specimens were obtained under California fishing license number 044275-20. The frog and its stomach contents have been accessioned into the permanent collection at the Museum of Vertebrate Zoology, University of California, Berkeley (Accession No. MVZ 13907).

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RANA CHIRICAHUENSIS (Chiricahua Leopard Frog). **REPRODUCTION.** Northern populations of *Rana chiricahuensis* occur along the southern edge of the Colorado Plateau in central and eastern Arizona and western New Mexico in the USA, while southern populations are found in southeastern Arizona, southwestern New Mexico, and in northern Sonora, the Sierra Madre Occidental of Chihuahua, and northern Durango in Mexico (Platz and Mecham 1979. *Copeia* 1979:383–390). This species is federally listed as threatened in the USA (U.S. Fish and Wildlife Service 2002. *Fed. Regist.* 67:40790–40811, 13 June 2002), thus additional life history information is important to aid recovery efforts. Winter breeding of northern populations of *R. chiricahuensis* at high elevation sites in Arizona has not been reported previously. Populations of *R. chiricahuensis* inhabiting sites above 1800 m elev. in Arizona and New Mexico were thought to have a short breeding season that spanned June through August (Frost and Platz 1983. *Evolution* 37:66–78). Data from New Mexico, including observations of egg masses in December and March and young tadpoles in December, January, February, and March, indicate that winter breeding above 1800 m is possible in areas fed by warm springs of 21–28°C (Jennings 1988. *Ecological Studies of the Chiricahua Leopard Frog, Rana chiricahuensis*, in New Mexico. New Mexico Dept. Game and Fish, Santa Fe, New Mexico, 14 pp.; Scott and Jennings 1985. *Occas. Pap. Mus. Southwest. Biol.* 3:1–21). On 21 Feb 2002 at 1225 h, we discovered two egg masses in a 0.2 ha spring-fed pond at 2546 m elev. in the Three Forks area of Apache-Sitgreaves National Forest, Apache County, Arizona, USA. Snow still covered the surrounding hillsides and made many forest roads impassible. Thin ice was present along the grassy edges of the pond. The egg masses were 55 cm apart and located on the NE side of the pond. A spring vent, identifiable by a line of gravel and light upwelling of water, ran lengthwise between the two egg masses. The temperature of the water at each egg mass and at the spring vent was 18°C. Water temperature 6 m away from the eggs was 14°C. Air temperature was 15°C. The first egg mass was 8 × 6 × 4 cm and was located 24 cm from the shore in water 5.5 cm deep with the top of the egg mass 1 cm below the water's surface. The second egg mass was 10 × 5 × 4 cm and was 18 cm from the shore in water 6.5 cm deep with the top of the mass at the water's surface. Algae surrounded both egg masses. The embryos of the first and second masses were at Gosner stage 15 and 12. The next day at 1015 h embryos in the first egg mass had reached Gosner stages 16–17 and in the second mass stages 12–14.

On 25 February, we collected a small portion of each egg mass for our captive rearing and release program, which also allowed us to confirm the identity of the resulting metamorphs. The first egg mass had mostly hatched in captivity by 28 February and the

second by 2 March.

We continued to survey for eggs masses that season prior to our normal June start date. In the same area of the pool we found 5 egg masses 2–6 April and 2 masses on 15 May 2002.

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RANA PRETIOSA (Oregon Spotted Frog). **PREDATION.** North American river otters (*Lontra canadensis*) consume varying numbers of amphibians, but a high metabolic rate (Iversen 1972. J. Comp. Physiol. 81:341–344; Brown and Lasiewski 1972. Ecology 53:939–943) coupled with most dietary studies being biased toward gut contents and scats (versus direct observations) has often prevented identifying amphibian prey to species (e.g., Field 1970. Michigan Academician 3:49–58; Greer 1955. Amer. Midl. Nat. 54:299–313; Knudsen and Hale 1968. J. Wildl. Mgmt. 32:89–93; Wilson 1954. J. Wildl. Mgmt. 18:199–207). Even among studies in which prey identification was generally thorough, few amphibians were identified to genus or species (e.g., Lagler and Ostenson 1942. J. Wildl. Mgmt. 6:244–254; Ryder 1955. J. Wildl. Mgmt. 19:497–498; Toweill 1974. J. Wildl. Mgmt. 38:107–111). Scarcity of such data led us to report direct observations of *L. canadensis* predation on the Oregon Spotted Frog (*Rana pretiosa*), from south-central Washington, USA.

We made these observations at Conboy Lake National Wildlife Refuge (CLNWR), Klickitat County (45°55'–59°N, 121°15'–23°W; elev. 550 m) during the course of a study of *R. pretiosa* (1997–2004). The 1970-ha Conboy Lake wetland complex, 70% of which comprises CLNWR, is a seasonally fluctuating marsh fed by three largely channelized creeks and a series of springs. A mosaic of native sedges (*Carex*) and grasses (especially *Glyceria*), as well as introduced reed canarygrass (*Phalaris arundinacea*) dominate this marsh.

At 1306 h on 28 Feb 2000, CBH and MPH detected a group of five otters in Outlet Creek (the channel which drains the Conboy Lake wetland complex). Weather was sunny with a 7°C air temperature and a 4°C water temperature in the creek. When first observed, the otters were ca. 150 m east of the Glenwood-BZ Highway bridge. In the area of observation, Outlet Creek was diked, steep-banked, 6 m wide and 3 m deep. Concealing themselves behind the east bridge barrier, CBH and MPH watched through binoculars as the otters slowly swam toward them. The group would periodically stop and dive in what seemed to be a search of the submerged channel bank and bottom. As the otters approached within 10 m, one surfaced with a large (> 80 mm SVL) Oregon spotted frog in its mouth. Based on its large size and the broad extent (i.e., across the chest) of the orange wash, the frog was probably a female (MPH, unpubl. data). After briefly biting the frog's head, the otter swallowed it whole and dove, and the otter group continued its approach. When ca. 5 m from the bridge, one

otter saw CBH and MPH, and immediately gave a series of whistles and grunts. Following the vocalizations, the entire otter group reversed direction and rapidly swam away.

At 1205 h on 5 Sept 2000, CJR observed two *R. pretiosa* (ca. 50 and 65 mm SVL) sitting ca. 20 cm from each other in a large pondweed (*Potamogeton natans*) mat that covered much of the water surface of Bird Creek. At this site (200 m E of Glenwood-BZ Highway), Bird Creek was ca. 1.3 m deep with banks grown to reed canarygrass and scrubby willow (*Salix* sp.), and had a 7.7°C mid-channel (unvegetated) water temperature. At 1220 h, three adult river otters were observed to surface simultaneously < 3 m from the frogs. The otters submerged and surfaced several times over the next minute until one of them surfaced under the larger of the two spotted frogs, capturing it with a quick movement as the frog attempted to escape. The other frog dove beneath the mat. The otter that made the capture shook its head briefly, the anterior portion of the frog (all but the hind legs) protruding from the its mouth, then dove. The other two otters then noticed CJR, hissed, and also dove. All three resurfaced seconds later 20 m further downstream, the captured frog was no longer visible.

Rana pretiosa is only the fourth ranid frog species that has been unequivocally identified as North American river otter prey; the others are the American Bullfrog (*Rana catesbeiana*: Loranger 1981. Proc. Worldwide Furbearer Conf. 1[1]:599–605; Wilson, *op. cit.*), Green Frog (*Rana clamitans*; Ryder, *op. cit.*), and Northern Leopard Frog (*Rana pipiens*; Ryder, *op. cit.*). Oregon Spotted Frogs are highly aquatic (i.e., nearly all breeding, non-breeding active-season, and overwintering activities occur in aquatic habitat; Watson et al. 2003. J. Herpetol. 37:292–300; JDE, MPH, unpubl. data), so significant opportunities exist for the highly aquatic *L. canadensis* (Melquist and Hornocker 1983. Wildl. Monogr. 83:1–60) to prey on *R. pretiosa*. Moreover, drought or late summer conditions may increase vulnerability to otter predation at CLNWR as aquatic habitats largely recede to the channelized creeks and their diversion ditches. Some Oregon Spotted Frogs also overwinter in these structure-limited channels (JDE, MPH, unpubl. data), locations that may make them vulnerable to the river otter's aquatic-edge foraging mode (Melquist and Hornocker, *op. cit.*).

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RANA PRETIOSA (Oregon Spotted Frog). **AGGREGATION AND HABITAT USE.** Adult ranid frogs in western North America

generally disperse after spring breeding, and reports of aggregations after breeding season are limited (see Pope and Matthews 2001. *Copeia* 2001:787–793; Pilliod et al. 2002. *Can. J. Zool.* 80:1849–1862; Bulger et al. 2003. *Biol. Cons.* 110:85–95). As our literature search yielded no direct observations of aggregations of Oregon Spotted Frogs (*Rana pretiosa*), we report an early fall aggregation of adult *R. pretiosa* at Penn Lake (UTM 586800 E, 4866800 N; elev. 1445 m) in the Cascade Mountains, Oregon, USA.

At 1500 h on 20 Sept 2002 (air temp. ca. 20°C), we observed an adult *R. pretiosa* in shallow water dive beneath the edge of a large, flat boulder (2 m × 1 m × 0.4 m). We lifted the boulder to find 9 adult male *R. pretiosa* (mean SVL 67.8 mm; range 59–74 mm) between underlying cobbles in water 5–20 cm deep. The boulder was located in a ca. 25 m-wide bay that receives the 2 main inflows in Penn Lake. The boulder was located ca. 5 m from the larger of these two inflows; heavy discharges during late-spring snowmelt keep the substrate around this main inflow clear of sediment and vegetation. The cobble/boulder substrate at this inflow represents < 2% (< 900 m²) of the surface area of Penn Lake, and contrasts strongly with the organic sediments and heavy emergent vegetation in littoral zones around the rest of the 8.9-hectare lake. This is our first observation of aggregated *R. pretiosa* in >100 person-hours over 7 years of summer surveys at Penn Lake. During surveys at this and other *R. pretiosa* sites in the central Oregon Cascades, we typically find *R. pretiosa* adults occurring singly in or near warm, vegetated, shallows with flocculent substrate, which is used by frogs as escape cover (Licht 1986. *Amer. Midl. Nat.* 115:239–247).

The late-September timing of this observation, the atypical habitat, and the proximity of this aggregation to features sought by other ranids as overwintering sites (rock crevices, inflow streams, and associated springs) suggest that these Oregon Spotted Frogs were moving toward or were already in an overwintering location. Little is known of the overwintering habits of *R. pretiosa* (Watson et al. 2003. *J. Herpetol.* 37:292–300).

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SCINAX NASICUS (Lesser Snouted Treefrog). **PREDATION.** Birds are important predators on amphibians (Duellmann and Trueb 1994. *Biology of Amphibians*. Johns Hopkins, Baltimore. 670 pp.). *Scinax nasicus* is a small hyliid that occurs in Paraguay, northern Argentina (south to Buenos Aires province), Uruguay, eastern Bolivia, and southern Brazil along the drainages of the Paraná and Paraguai Rivers (Frost 2002. *Amphibian Species of the World: An online reference* V2.21). On 27 Sep 2003 at ca. 0850 h I found an

adult *Scinax nasicus* being preyed upon by a Great Kiskadee (*Pitangus sulphuratus*) along a fence in the Brazilian Pantanal, Nhimirim Ranch (18°59'S, 56°40'W), Mato Grosso do Sul State. The bird held the frog in its beak, and struck the frog on the fence until it was dead. The bird then swallowed the frog and flew away. *Scinax nasicus* sometimes vocalizes during the day, which might expose it to diurnal predators.

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SCINAX RUBER (Red Snouted Treefrog). **ARBOREALITY AND PARACHUTING.** Aerial descent in anurans occurs as both gliding and parachuting. Gliding is aerial descent at an angle <45° to the horizontal whereas parachuting is descent at >45° to the horizontal. Parachuting is known in several anurans including *Rhacophorus*, *Agalychnis*, and *Eleutherodactylus coqui* (Emerson and Koehl 1990. *Evolution* 44:1931–1946; Roberts 1994. *J. Herpetol.* 28:193–199; Stewart 1985. *J. Herpetol.* 19:391–401, and references therein), and it is suspected that many arboreal frogs may be capable of parachuting (Stewart 1985, *op. cit.*). Here we report on arboreal activity and parachuting in *Scinax ruber* from Gamboa, Panama.

Males of *S. ruber* call from the ground or low vegetation, and individuals and amplexant pairs can be found in shrubs and small trees. Arboreal activity at greater heights has not been reported although it is suspected (Ibañez et al. 1999. *The Amphibians of Barro Colorado Nature Monument, Soberania National Park and Adjacent Areas*. Editorial Mizrachi and Pujol, Panama. 192 pp.). Between 8–11 Aug 2004, we observed at least 20 *S. ruber*, including males and females, on the Gamboa Rainforest Resort Canopy Tower at heights up to 25 m, which is the top of the canopy. When approached or subsequent to a gentle touch, individuals jumped from the tower and descended to the ground, nearby vegetation, or to lower portions of the tower. Aerial descent was controlled and at angles >45°, which classifies it as parachuting.

On 8 Aug 2004 between 2200–2300 h, we observed eight *S. ruber* on the canopy tower. We returned the following night between 2325–0030 h (24.8°C at 25 m height) and observed 20 *S. ruber* of which 16 were captured and sexed. Aerial descents of these 16 individuals were observed, and we recorded the height at which each frog was found and the landing height to determine the vertical descent distance and also recorded the landing substrate (Table 1). Seven males, seven females, and two individuals of unknown sex were found. The average height at which individuals were found was 21.26 ± SE 1.01 m and the average vertical distance descended was 15.03 ± 1.63 m. Six of the females were gravid with eggs visible through the skin.

On 10 Aug between 2045–2115 h, ten *S. ruber* were observed on the canopy tower and another individual was observed in the top of a young palm 13.59 m from the ground. On 11 Aug between 1945–2030 h, 6 individuals were observed on the tower. These were weighed; two gravid females weighed 3.75 and 4.8 g while the four males weighed 2.5, 2.75, 3.35, and 4.15 g. Previous individuals observed appeared to be of similar sizes, and all ap-

peared to be adults. Only one non-gravid female was found on the tower throughout the four observations. Although males with vocal sacs were observed in the tower, we did not detect any calling activity. Among all descents observed between 8–11 Aug (N = 44), the maximum horizontal distance covered was ca. 7 m, but most descents resulted in less than 4 m of horizontal travel. Two individuals that originally descending with their heads away from the tower rotated 180° to land lower on the tower. One of these traveled ca. 1 m out from the tower before rotating and returning to the tower. Another frog turned ca. 130° and landed on a palm. Other individuals either turned smaller amounts or did not turn before landing on the ground, tower, or nearby vegetation.

While parachuting, individuals held their arms and legs lateral to the body, bent, and partially extended. Fingers and toes were spread. This is a common posture in frogs capable of aerial descent (Emerson and Koehl, *op. cit.*). Gliding frogs typically have enlarged hands and feet with extensive webbing between digits and accessory skin flaps on the limbs (Emerson and Koehl, *op. cit.*). *Scinax ruber* lack these characters and only have moderately webbed feet with reduced webbing between the first and second toes and only basal webbing on the hands (Ibañez et al. *op. cit.*). Unlike in the parachuting frogs examined by Emerson and Koehl (*op. cit.*), however, *S. ruber* is capable of turning during descent. These observations confirm the suspicions of arboreal activity in *S. ruber* and demonstrate their capabilities for aerial descent via parachuting.

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in the same area.

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SPEA HAMMONDII (Western Spadefoot). **REPRODUCTION.** *Spea hammondi* is restricted to semi-arid regions characterized by great variation in the amount, timing, and duration of rainfall, between and among years. Breeding activity of *S. hammondi* is closely associated with rainfall events and the availability of ephemeral pools (Jennings and Hayes 1994. Amphibian and Reptile Species of Special Concern in California. California Dept. Fish Game. Final Report Contract No. 8023. 94 pp.). Breeding has been reported to take place from January through May (Storer 1925. Univ. California Publ. Zool. 27:153–163; Brown 1976. Contrib. Sci. Los Angeles Co. Mus. Nat. Hist. 286:11; Stebbins 2003. Western Reptiles and Amphibians, 3rd. ed. Houghton Mifflin Co., Boston).

On 26 and 28 Dec 1996, SVC and ELE, observed *S. hammondi* larvae (ca. 4–10 mm TL) in an unshaded ephemeral pool that had formed in a road rut (3 m × 1 m, 15 cm deep) on a mesa dominated by a sage scrub/mixed grassland vegetation community at Mission Trails Regional Park, San Diego County, California, USA (32°50'86"N, 117°04'13"W, 248 m elev.).

On 30 Dec 1996, ELE observed *S. hammondi* larvae (ca. 13–15 mm TL) in an unshaded ephemeral pool that had formed in a road rut (5 m × 1 m, 20 cm deep) on a mesa dominated by chamise chaparral, University City, San Diego County (32°52'07"N, 117°11'43"W, 114 m elev.).

On 10 Nov 2002, ELE observed *S. hammondi* egg masses (N = 43) in an unshaded ephemeral pool that formed in a road rut (11 m × 2.5 m, 25 cm deep) surrounded by grassland at Mesa Del Arroz Preserve, Alpine, San Diego County (32°49'260"N, 116°45'076"W, 600 m elev.). An egg mass consisting of 22 egg capsules (Gosner stages 1–3) was collected and deposited in the herpetological collection of the California Academy of Science (CAS 226121).

On 9 Nov 2002, ELE observed *S. hammondi* egg masses (N = 26) in an unshaded vernal pool (3 m × 1 m, 15 cm deep) on the same mesa (as mentioned above) at Mission Trails Regional Park, San Diego County (32°50'159"N, 117°04'269"W, 255 m elev.). An egg mass consisting of 10 egg capsules (Gosner stages 8–9) was collected (CAS 226120). On 21 Nov. 2002, CDS and ELE salvaged 63 larvae from the same pool because the pool was in the final stages of drying (0.3 m diameter, 3 cm deep) as a result of evaporation and lack of additional precipitation (14–16 mm TL, Gosner stage 25) (CAS 226122–123). The pool had dried by 22 Nov. prior to any larvae successfully metamorphosing, resulting in 100% mortality. The pool refilled in late Nov due to rainshowers and on 8 Dec *S. hammondi* larvae (ca. 5–8 mm TL) were observed. During subsequent visits the pool was again drying prior to the metamorphosis of the larvae. On 24 Jan 2003, CDS and ELE found no surface water and clusters of dead *S. hammondi* larvae (~1800) in the wet mud of the pool basin. Approximately 200 of these slightly desiccated larvae were collected (19–33 mm TL, Gosner stages 25–30).

In the same vernal pool described above, CDS and ELE observed *S. hammondi* egg masses (N = 33) on 22 and 24 Oct 2004.

TABLE 1. Sex, height observed, descent distance, and landing substrate of 16 *Scinax ruber*. Asterisks denote gravid females. Individual 5 turned ca. 90° around a corner of the tower, landing among several tree branches before we could accurately observe the landing height.

	Sex	Height found (m)	Descent distance (m)	Landing substrate
1	M	24.90	24.9	ground
2	M	24.90	21.4	vegetation
3	F*	24.90	24.9	ground
4	U	24.90	9.15	vegetation
5	U	24.90	N/A	vegetation
6	F*	24.0	11.23	vegetation
7	F*	23.4	11.47	vegetation
8	M	22.43	12.03	vegetation
9	M	21.9	9.29	vegetation
10	F*	21.4	21.4	ground
11	F*	20.04	19.5	vegetation
12	M	20.04	11.3	vegetation
13	M	17.25	16.75	vegetation
14	M	16.25	16.25	ground
15	F	15.0	3.52	tower
16	F*	12.37	12.37	ground

On 24 Oct the embryos within the majority of egg clusters were motile indicating that they were in the final stages of development prior to emergence from their egg capsules. Using back calculation, the spawn was determined to be six days old, based on the stage of development and the rate of development, with the approximate daytime high for the last six days at ca. 24°C. It was determined that breeding occurred on 17–18 Oct, in response to the first measurable rainfall received in this region in 181 days (April–Oct 2004). This extended period of time without rain, tied the previous record set in 2003 for a rainless period for San Diego County since record keeping began in 1850 (National Weather Service).

We have documented *S. hammondi* breeding in Dec in 1996, Nov and Dec in 2002, and Oct in 2004. In an extended literature search, we determined that these observations reported herein appear to be the earliest breeding records reported for *S. hammondi*. Additional records for *S. hammondi* larvae (ca. 10–12 mm) occurring in January include observations made in vernal pools in Carmel Mountain Preserve in 2003 and 2004 (32°43'17"N, 116°56'56" W, 95 m elev.) and in a road rut in the San Diego National Wildlife Refuge in 2003 (32°43'17"N, 116°56'56"W, 95 m elev.), San Diego County, by Carlton Rochester and Pete Famolaro.

We thank Norm Scott and Kathie Meyer for providing comments and Jens Vindum of California Academy of Sciences for providing museum numbers. Thanks to Naomi Ervin and Tim Cass for their field assistance. *Spea hammondi* egg masses and larvae were collected under California Department of Fish and Game Permit 5399. Larvae were collected from Mission Trails Regional Park under the authority of Paul Kilburg, Senior Park Ranger.

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TESTUDINES

CHELYDRA SERPENTINA SERPENTINA (Common Snapping Turtle). **FLATULENCE.** On 19 June 2004 at ca. 1100 h, a female *Chelydra serpentina* (263 mm carapace length, 205 mm plastron length, 4082 g) was captured from an oxbow of Muddy Creek (0.30 ha mean surface area) at the Blue Grass Army Depot, Madison County, Kentucky (N37°42'15.5", W84°12'50.4"). As measurements were being taken of the animal, it released an audible gaseous discharge from its cloaca, accompanied by an unpleasant odor. No fluid was released during the discharge, but the sound it made was comparable to that of the characteristic hiss often given by this species when threatened. The odor was different from the typical musky odor released by this species, but was of equal severity. This behavior was accompanied by commonly-observed defensive behaviors in *C. serpentina*: snapping, gaping, hissing, and clawing (Ernst et al. 1994. *Turtles of the United States and Canada*. Smithsonian Inst. Press, Washington, D.C.). The turtle was marked and released, and was not recaptured during subsequent trapping.

Flatulence in this case may have resulted from one of several

factors. It may have been a displacement behavior, much like penis extrusion, which is often observed when male *C. serpentina* are handled (de Solla et al. 2001. *Chelon. Cons. Biol.* 4:187–189, pers. obs.). It may have been an intentional alternative to releasing musk, indicating a defensive behavior. Or the turtle may have had excess gas production due to something that it ingested. Such gas may have been released because of muscle contractions associated with the stress of handling, or because of a change in the pressure of internal organs on the intestines due to the position in which the turtle was held, or the gas release may have been coincidental with the time of capture. This apparently represents the first published account of flatulence in *C. serpentina*.

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CHRYSEMYS PICTA PICTA (Eastern Painted Turtle). **PREDATION.** On 22 January 2005, KED et al. found desiccated remains of a juvenile *Chrysemys picta picta* inside a Wood Duck nest box (Yates Millpond, ca. 6.8 km N of McCullers [35°43'07"N, 78°41'11"W], Wake County, North Carolina, USA) that was occupied by an adult Eastern Screech-owl (*Otus asio*). The turtle measured 51 mm in carapace length and 47 mm in carapace width. Scratches were present on the plastron and the left hind foot was missing, strongly suggesting predation by the owl. The head and remaining limbs were essentially intact.

Several raptor species have been reported as occasional predators of *C. picta* and other turtles (Ernst et al. 1994. *Turtles of the United States and Canada*. Smithsonian Institution Press, Washington, DC. 578 pp.). Browne (2002. *Herpetol. Rev.* 33:132) reported an attack on a juvenile *C. p. picta* by a northern harrier. Reports of owls taking turtles as prey are relatively few (Johnsgard 1988. *North American Owls*. Smithsonian Institution Press, Washington, DC. 295 pp.). To our knowledge, this represents the first report of predation on *C. picta* by a screech-owl.

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GLYPTEMYS (= CLEMMYS) MUHLENBERGII (Bog Turtle). **FECUNDITY.** On 12 June 2003, while surveying two populations of Bog Turtles, *Glyptemys (Clemmys) muhlenbergii*, with New York State Department of Environmental Conservation personnel, 21 turtles were located. Of these, 18 (85.7%) were of the 7–13 yr old cohort, which is much higher than what would have been expected. This age group cohort coincides with the rabies epidemic which reached this area of Dutchess County, New York in 1990 (www.dec.state.ny.us/website). On 6 May 2004, these two populations were again surveyed and two additional populations close by were also surveyed. Of the 20 located turtles, 12 were

new turtles (not recaptures); of these, 11 (91.7%) were of the 7–13 yr old cohort.

It is inviting to speculate that the higher than expected cohort density of *G. muhlenbergii* might reflect reduced predation of turtles and eggs by mammalian predators such as Raccoon (*Procyon lotor*), Striped Skunk (*Mephitis mephitis*), foxes (*Vulpes fulva* and *Urocyon cinereoargenteus*), and Coyote (*Canis latrans*), as the number of these predators has been reduced because of a reduction of numbers in their populations from the rabies virus. Hypothetically this would increase turtle recruitment and yield skewed population dynamics similar to our findings.

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GLYPTEMYS INSCULPTA (North American Wood Turtle). **TERRESTRIAL MOVEMENT.** Although long distance travel along waterways by *Glyptemys insculpta* has been reported (Quinn and Tate 1991. J. Herpetol. 25:220–222), published accounts indicate that terrestrial movement is conservative and within 150–300 m of the watercourse (Harding and Bloomer 1979. Bull. New York Herpetol. Soc. 15[1]:9–26; Arvisais et al. 2002. Can. J. Zool. 80:402–408; Tuttle and Carroll 2003. Chelonian Cons. Biol. 4:656–663). In 2000–2002, we radio-tracked *G. insculpta* in three Delaware River tributaries in Delaware Water Gap National Recreation Area. The longest axes of movements were observed to be 200–600 m and similar to those previously reported within the study region (Kaufmann 1995. Copeia 1995:22–27). In the populations studied, terrestrial movements were typically within the bounds of the aforementioned studies except for those of pre-nesting females which we observed to move randomly > 600 m an evening, while searching for nesting sites in agricultural fields.

The long-range terrestrial movement of one of our females is especially notable. This turtle (CL = 177 mm; 810 g; missing LF foot) was first captured and shell notched on 2 May 2000 in a stream (122 m elev.) ca. 400 m from its confluence with the Delaware River. Subsequently, this turtle was recaptured five times near the original capture site and then was radio-tagged in April 2002 and followed weekly. On 4 June 2002, the turtle was relocated 373 m from its previous streamside capture point in an upland meadow. Despite an exhaustive search, the signal was not heard again. On 8 June 2004, the female was recaptured at the edge of a marsh (213 m elev.) in the headwaters of a different stream system on private property 3.9 km SSE of the original capture site. Second growth woodlands, old fields, a highway, and pocket marshlands are found between the previous capture points and the 2004 recapture point. The female was palpated and determined to be gravid and assumed to be searching for a nesting site. This is a possible example of gene flow promotion between different populations (Kiester et al. 1982. Evolution 36:617–619).

We appreciate the assistance of radio-trackers Melissa Stepek and Stanley Boder. We too thank Tony Gonzalas for examining the turtle and the long-dead transmitter affixed to its shell, deciphering the information on its face, and contacting the investigators. The study was completed under National Park Service/Wildlife Conservation Society Cooperative Agreement with special assistance provided by Jeffrey Shreiner.

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GLYPTEMYS INSCULPTA (North American Wood Turtle). **NEST INVADING PLANTS.** The failure of *Malaclemys terrapin* nests as a consequence of beachgrass (*Ammophila breviligulata*) root encapsulation of eggs is well known (Lazell and Auger 1981. Copeia 1981:723–724; Stegmann et al. 1988. Can. J. Bot. 66: 714–718). Although plant species were not identified, root encapsulation was also reported to cause partial failure of *Emydoidea blandingii* nests (Congdon et al. 2000. Chel. Cons. Biol. 3[4]:569–579). And, sea oats (*Uniola paniculata*) has been implicated in the loss of 5.3% of the eggs of a Loggerhead Seaturtle (*Caretta caretta*) population (Caldwell 1959. In Caldwell and Carr. Bull. Florida State Mus., Biol. Sci. 4:319–348). In this last instance, the eggs were described as desiccated, with eroded shells, and invaded by roots in some cases. In 2001–2002, we studied the nesting habits of female *Glyptemys insculpta* in cornfields along the Delaware River in Warren County, New Jersey. Thirty-one nests were located and monitored. Of these, plants invaded two nests. In the first case, the roots of smooth crabgrass (*Digitaria ischaemum*) completely filled the nest chamber and enveloped all 7 eggs in the clutch. The roots of carpetweed (*Mollugo verticillata*) encapsulated 3 of 4 eggs in a second nest. One hatchling *G. insculpta* successfully emerged from the second nest. In both cases the encapsulated eggs were completely desiccated, badly eroded, and invaded by rootlets. It was not possible to determine if the eggs in these clutches were fertile, but 4% of the 228 eggs in the 31 nests were affected by root encapsulation. This observation represents another example of turtle nest invasion by plants. This mortality factor may be more significant than the current literature suggests.

We thank Daniel Atha of the New York Botanical Gardens for assistance in identifying the plant species. The study was completed under National Park Service/Wildlife Conservation Society Cooperative Agreement with special assistance provided by Jeffrey Shreiner and Larry Hilaire.

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GLYPTEMYS INSCULPTA (North American Wood Turtle). **ATYPICAL SCUTES AND ANOPHTHALMIA.** Atypical scute formation in chelonians is a commonly reported anomaly. Of 2,220 turtle specimens examined in the Chicago Field Museum, 43% had anomalous scute arrangements (Zangerl and Johnson 1957. Fieldiana: Geology 10:341–362). The majority of these arrangements had either more or fewer scutes than the standard number.

In a series of 243 *Malaclemys terrapin* specimens examined (Coker 1910. J. Morphol. 21:1–75), 24% had more or fewer scutes than normal. Aside from scute irregularities, abnormalities of the head, including anophthalmia (eyelessness), are the most numerous terata evident among advanced turtle embryos incubated under laboratory conditions (Ewert 1979. In Harless and Morlock [eds.], Turtles: Perspectives and Research, pp. 333–413. John Wiley and Sons, New York). Anophthalmia however does not seem to be a common phenomenon among wild turtles (Mausolf and Wunder 1974. Copeia 1974:548–550). Presumably this condition would negatively affect hatchling survival in the wild, whereas scute irregularities are not considered lethal. In 2001–2002, we studied nesting success of *Glyptemys insculpta* in cornfields along the Delaware River in Warren County, New Jersey. Ninety-two hatchlings from 20 nests, as well as 12 hatchlings found in the agricultural fields during the study, were examined for developmental abnormalities.

Irregularities in carapacial scute formation and arrangement were observed in seven individuals (6.7% of specimens). Of these, three exhibited a reduction in marginal scutes (11 right or left instead of 12) and one exhibited a supernumerary (13 right) marginal scute. Of the others, the fourth left costal scute extended between the fourth and fifth vertebrals in one individual, another exhibited “dovetail syndrome” (Ewert 1979, *op. cit.*) with eight vertebrals, and the last individual emerged with the fourth neural bone exposed. Additionally, an anophthalmic hatchling, of normal size and shell conformation, was found. Facial and maxillary bones were reduced and pinched. Eye-slits were not present, and the globes and bony elements that normally support them were missing. This individual displayed no visual ability. Although not previously reported in wild specimens, anophthalmia has been reported in *G. insculpta* that were hatched from eggs incubated under laboratory conditions (Ewert 1979, *op. cit.*).

It appears that the external abnormalities we observed are comparable to those reported elsewhere for turtle hatchlings associated with natural nests (Walde 1998. Unpubl. Ph.D. dissertation, McGill University, Quebec; Standing et al. 2000. Chelonian Cons. Biol. 3:661–664). Abnormalities in hatchling composition are most often attributed to thermal and hydric stressors present during incubation (Gutzke et al. 1987. Herpetologica 43:393–404). However, the hatchlings noted here emerged from nests located in agricultural fields that have been farmed for hundreds of years and exposed to various pesticides and fertilizers over the past century; thus a hypothetical relationship between external anomalies and chemical exposure would be a worthy topic for future research.

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KINOSTERNON SONORIENSE (Sonoran Mud Turtle). **DIET.** Hulse (1974. J. Herpetol. 8:195–199) concluded from an examination of stomach contents that *Kinosternon sonoriense* was an opportunistic carnivore that fed mainly on invertebrates, though plants, fish, and ranid frogs were occasionally eaten. Ligon and

Stone (2003. Herpetol. Rev. 34:241–242) reported two observations of *K. sonoriense* feeding on adult *Bufo punctatus*. Here, we add a reptile and a bird to the list of dietary items consumed by *K. sonoriense*. Both observations were made in small pools in the Peloncillo Mountains, Hidalgo Co., New Mexico (USA), in the same canyon as the observations reported by Ligon and Stone (*op. cit.*).

On 7 August 2004, at ca. 1000 h, we observed an adult female *K. sonoriense* (101.7 mm midline carapace length [MCL], 151 g) capture and kill a Black-necked Gartersnake (*Thamnophis cyrtopsis*, 348 mm SVL, 23.3 g). The observation began when we noticed splashing in a pool (ca. 12 m² area, ca. 10 cm deep) beside the trail. When first observed, the turtle’s jaws held the snake by the neck, ca. 10 cm behind the snake’s head. During the first 10 sec of the encounter, the snake attempted to bite the turtle on the carapace at least twice. Within two minutes, the snake was dead and the turtle was eating the snake. At this point the turtle appeared to notice us and released the snake, moving away from us toward the edge of the pool. We then captured and measured the turtle and collected the snake. The skin had been stripped off the dead snake from the point where the turtle had grasped the snake forward to the head, and there was a large piece of neck muscle missing. We released the turtle and deposited the snake in the University of Central Oklahoma Collection of Vertebrates (UCO 1001).

On 10 August 2004, at ca. 1800 h, we encountered an adult male *K. sonoriense* (114.5 mm MCL, 169 g) in a small pool (ca. 1 m² area, ca. 15 cm deep) with a dead Mockingbird (*Mimus polyglottos*). The intact, feathered head and wings of the bird were floating on the water surface. Below the water surface was the bird’s skeleton, which had been picked nearly clean of soft tissue. The turtle had bird flesh on its face and foreclaws. After we identified the turtle, we photographed the bird and observed the turtle feeding on scraps of the bird that had settled to the bottom of the pool. We do not know how the bird died and are uncertain as to whether our observation involved predation or scavenging.

Mud turtles are common in shallow pools in our study area (Stone 2001. Southwest. Nat. 46:41–53). The obvious benefits of inhabiting these pools include hydration and opportunities to eat invertebrates, which are common in pools. Our observations, coupled with those of Ligon and Stone (*op. cit.*), suggest that pools might provide opportunities for mud turtles to eat relatively large vertebrates, and that vertebrates might be more important to the diet of *K. sonoriense* than previously thought.

We thank J. Hellack and W. Radke for identifying the bird from photographs. We thank the College of Graduate Studies & Research at the University of Central Oklahoma for financial support. This study was conducted under permits issued by the New Mexico Department of Game and Fish (Permit #2905) and the U.S. Forest Service (Authorization ID: SUP0080).

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MACROCHELYS TEMMINCKII (Alligator Snapping Turtle). **DIET.** Feces from a male *M. temminckii* (52 cm carapace length

[CL]; 55.9 kg) captured by L. Allen and M. Lepori in the Trinity River off Collins Avenue (#157), 3.0 miles N of I-30, in Arlington, Tarrant Co., Texas (USA) on 28 September 1993, were collected over the week after capture, and the vertebrate components were sorted and identified. This sample included skeletal and scute elements from one juvenile Red-eared Slider (*Trachemys scripta*) (estimated carapace length = 145 mm), shell elements of a juvenile Spiny Softshell (*Apalone spinifera*) (estimated CL = 15 cm), and three unrelated items made of black rubber. A few additional bony elements of these turtle species may have represented additional individuals.

Although turtles (including *T. scripta*) have previously been reported in the diet of *M. temminckii* (Sloan et al. 1996. Chelon. Conserv. Biol. 2[1]:96–99, and references therein), this report represents the first record for a softshell turtle and documents the ingestion of inanimate objects. Furthermore, the presence of three different items made of rubber suggests that they were obtained by active foraging. This supports the hypothesis (e.g., Spindel et al. 1987. J. Morphol. 194:287–301) that large Alligator Snapping Turtles will seek food by active foraging in addition to lingual luring.

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PALEA STEINDACHNERI (Wattle-necked Softshell). **SIZE.** The published record straight line carapace length (SCL) for the Asian softshell turtle, *Palea steindachneri*, is 42.6 cm (Ernst and Barbour 1989. Turtles of the World. Smithsonian Institution Press, Washington, D.C., 313 pp.).

Two very large softshell turtles were found alive in an alley near the establishments of dealers in turtle and snake meat inside the city of Hong Kong, and brought to the junior author for identification. Each had the clusters of wattles at the base of the neck unique to *P. steindachneri* (Ernst and Barbour 1989, *op. cit.*). Both turtles weighed 25.4 kg when first received (one alive, one dead). The larger of the two exceeds the reported record length of the species with a SCL of 44.5 cm. Other measurements of this individual are: greatest carapace width, 40.8 cm; shell depth at the level of the forelimbs, 13.0 cm; total length (tip of snout to tip of tail), 86.0 cm; plastron length, 30.5 cm; plastron width at the bridge, 38.0 cm; bridge length, 7.0 cm; dorsal length of the stretched head and neck, 28.0 cm; greatest head width, 13.5 cm; mandibular length, 11.0 cm; neck length from occiput to anterior rim of carapace, 11.0 cm; total tail length, 7.6 cm; and basal tail width, 6.5 cm. Although not sexed, the size of the turtle probably indicates that it is a female. The specimens are in the collection of the junior author.

Palea steindachneri ranges naturally in China from Guandong and Guangxi provinces westward to Yunnan and Guizhou provinces, and also on Hong Kong and Hainan islands (Zhao and Adler 1993. Herpetology of China. SSAR Contributions to Herpetology 10). On Hong Kong Island, it occurs at the Byewash Reservoir of the Kowloon Reservoirs Group (Karsen et al. 1986. Hong Kong Amphibians and Reptiles. Urban Council Publications, Hong

Kong, 136 pp.), but these two turtles were probably brought to the city from the mainland of China to be sold in the markets, and then escaped. It is unfortunate that the origin of the two *P. steindachneri* is unknown.

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PSEUDEMYS GORZUGI (Rio Grande River Cooter). **RETICULATE MELANISM.** Increasing melanistic pigmentation with aging is well known in deirocheline turtles, particularly male *Trachemys scripta* and some *Pseudemys* (Ernst et al. 1994. Turtles of the United States and Canada, Smithsonian Inst.). However, reticulate melanism (RM), a netlike or vermiculate pattern of black markings that replaces the normal carapacial markings, has only been described in two subspecies of *Chrysemys* (Ernst et al., *op. cit.*; Smith et al. 1969. J. Herpetol. 3:173–176; Ultsch 1999. Herpetol. Rev. 30:225). Here, we report the occurrence of this pattern in *P. gorzugi*.

Though termed as a type of melanism, RM is not similar to the melanism reported in *Trachemys* (Tucker et al. 1995. J. Herpetol. 29:291–296). In *Trachemys*, melanism results in an almost completely black coloring of the carapace and significant darkening of the plastron. We completed extensive surveys of the turtle fauna in the Pecos and Devils River drainages of Texas from 2001–2005. During that study we documented RM in *P. gorzugi*, similar to the pattern reported in *Chrysemys*, with retention of the red carapacial coloration but with the pattern significantly broken by the invasion of black vermiculations. The marginal scutes of the plastron exhibit the same color change pattern but the central plastral scutes do not darken.

The pattern changes seen in *P. gorzugi* appear to be correlated with the age and sex of the specimen. Thus far, we have observed this pattern only in large adult males. In fact, this size-correlated color pattern change has only been observed in the largest 15% of the adult males encountered ($N = 124$, mean carapace length = 20.0 cm, $SD = 5.0$). Based on these values, males with carapace lengths at least one standard deviation greater than the mean, in this case, those males with carapace lengths ≥ 25.0 cm, display evidence of these changes in phenotype.

Reticulate melanism has not, to our knowledge, been reported in any other species of *Pseudemys*. In the hundreds of individuals of *P. texana* collected from Spring Lake (TSU Dept. of Biology survey data) and the San Marcos River (Caldwell and Hays counties, Texas; MRJF survey data), none of the specimens show evidence of this color pattern change. Thus, RM observed in large adult male *P. gorzugi* could indeed be a unique trait that further supports the monophyly of the species.

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STERNOTHERUS ODORATUS (Common Musk Turtle). **CLUTCH SIZE.** Typical clutch sizes in *Sternotherus odoratus* range from 1 to 9 eggs (Ernst et al. Turtles of the United States and Canada. Smithsonian Inst. Press, Washington and London. 578 pp.) and in the Jersey and Calhoun county populations in Illinois the clutch size averages 5.8 eggs (Tucker 1999. Bull. Maryland Herpetol. Soc. 35(3):61–75). On 11 May 2003, a gravid female *S. odoratus* (130 mm carapace length, 85 mm carapace width, 57 mm carapace height, 98 mm plastron length, and a gravid mass of 370 g) was collected crossing IL Rt 100 near Grafton, Illinois in Jersey County. Oviposition was induced via intramuscular oxytocin injection (Ewert and Legler 1978. Herpetologica 34:314–318). This female produced 13 eggs, exceeding all previous reports for this species from any population. The eggs averaged 4.06 g in mass, 26.1 mm in length, and 15.9 mm in width. These eggs were incubated in vermiculite at ambient environmental temperatures and hatched between 24–26 August 2003. *Sternotherus odoratus* is suspected of communal nesting with more than one turtle laying their eggs in the same place (Ernst et al. 1994, *op. cit.*) Intermingling of separate clutches from more than one individual is possible and might obscure field observations of clutch size. The laboratory induction of oviposition eliminates this bias.

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STERNOTHERUS ODORATUS (Common Musk Turtle) **SIZE and REPRODUCTION.** The seminal work of Tinkle (1961. Ecology 42:68–76) on clinal variation in turtle reproduction addressed *S. odoratus*, and subsequent study showed that local variation could distort putative geographic patterns (e.g., Gibbons. 1970. Can. J. Zool. 48:881–885). Local variation in the reproduction of *S. odoratus* occurred in Indiana (Clark 2000. Unpubl. Ph.D. Thesis, Indiana University, Bloomington). This note documents maximum sizes of three natural history parameters for *S. odoratus* from three geographically separated fish farms. These farms consisted of many adjacent shallow (~0.5–1 m deep) ponds that were drained and refilled asynchronously. Most data came through oxytocin-induced oviposition or dissection.

The largest turtle (CM 154456; measurements in mm: 150 Mx CL, 125 Mx PL, 103 CW, 66 SH; 626 g live mass, non-gravid female) came from a goldfish farm (Indiana, Morgan Co., Grassfork Hatchery, 39.47°N, 86.36°W, 27 May 1993, collected by J. M. Capler and M. A. Ewert). The mid-dorsum of the carapace was slightly depressed relative to its immediately lateral curvature. The head had bold, bright stripes typical of young adult *S. odoratus*. The carapace length of this

individual exceeded the published record of 137 mm (Conant and Collins 1991. A Field Guide to Reptiles and Amphibians: Eastern and Central North America [3rd ed.], Houghton-Mifflin, Boston).

Table 1 lists 11 clutches (from Indiana, *op. cit.*; another goldfish farm, Alabama, Marshall Co., Big Spring Farm, 34.22°N, 86.41°W; a natural lake, Wisconsin, Washington Co., 43.41°N, 88.22°W) that exceed the long standing record (nine eggs, Risley 1933. Pap. Michigan Acad. Arts, Sci. Lett. 17:685–711). The largest clutch (12 eggs), although partially destroyed during oviposition, was represented by 12 large (5–6 mm diam) ovarian corpora lutea. The same ovaries included nine small (2.5–3 mm diam) corpora lutea from a previous clutch and 11 enlarged (13–14 mm dia), pre-ovulatory follicles. The RCMs of these turtles (Table 1) were much larger than in other kinosternids (Iverson et al. 1991. J. Herpetol. 25:64–72). Ten additional turtles from the two goldfish farms yielded nine-egg clutches (7 from Indiana, 3 from Alabama).

The largest egg (7.63 g, 33.7 × 18.7 mm), from Indiana (*op. cit.*, 28 May 1994), from a female (116 mm CL, 279 g FSM), was normally elongate (l/w = 1.8, Clark et al. 2002. Funct. Ecol. 15:70–77), but did not develop. This egg was accompanied with four other eggs of normal size (4.5–4.6 g). The largest egg that has hatched (6.85 g, 30.3 × 19.0 mm) was part of a clutch of eight large eggs (5.5–6.9 g) from a female (128 mm CL, 315 g FSM) from Arkansas (Garland Co., Lake Hamilton State Fish Hatchery, 34.41°N, 93.06°W, 20 May 1989).

Which practices, if any, on fish farms enable female *S. odoratus* to become large and evidently uniquely prolific remain unevaluated. Nonetheless, these data suggest that geographical studies of reproductive data on turtles need cognizance of habitat type.

I thank J. Capler, P. Clark, and C. Etchberger for assistance with collecting these turtles, and the Carnegie Museum of Natural History (C. J. McCoy) for access to turtles in his possession.

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TABLE 1. Large clutch size and related attributes of *Sternotherus odoratus*. [CS = clutch size, FSM = female spent mass (g), Mx CL = maximum straight line carapace length (mm), Mx PL = maximum straight line plastron length (mm), RCM = relative clutch mass (clutch mass/FSM), (mm), corp. lut. = corpora lutea].

Locality	Obs. date	CS	Count	FSM	Mx CL	Mx PL	RCM
Alabama	20 May 1980	11	corp. lut.	297	129	97	0.137
Alabama	20 May 1980	10	eggs	270	124	94	0.140
Indiana	4 Jun 1988	12	corp. lut.	297	121	101	–
Indiana	24 Jun 1988	11	eggs	238	–	–	0.172
Indiana	7 Jun 1993	11	eggs	240	107	88	0.200
Indiana	6 Jul 1993	11	eggs	301	99	96	0.171
Indiana	4 Jun 1988	10	eggs	277	118	99	0.163
Indiana	21 Jun 1988	10	eggs	232	112	97	0.189
Indiana	15 Jun 1991	10	eggs	279	124	98	0.164
Indiana	13 Jun 1993	10	eggs	266	113	96	0.168
Wisconsin	16 Jun 1979	10	eggs	262	120	96	0.165

TERRAPENE CAROLINA CAROLINA (Eastern Box Turtle).

PREDATION. Eastern Box Turtles are omnivores that take a wide range of plant and animal matter (Dodd 2001. North American Box Turtles. A Natural History. Univ. Oklahoma Press). Every summer, from 1990 to 2004, I used a series of 17 mist nets to capture breeding songbirds. Box turtles are common in my study site, which is within the Jug Bay Wetlands Sanctuary (38°46'N; 76°42'W), on the east shore of the Patuxent River in Anne Arundel County, Maryland. Mist nets are 12 m long × 2 m high and are stretched between tall poles in forest, stream floodplain, and along the edge of a tidal wetland. The lowest tier of the net is normally about 30 cm above the ground, but when a bird is captured in this part of the net its weight causes the net to sag. As a result, a songbird can become entangled on the ground. On three occasions I have observed an Eastern Box Turtle eating a songbird that had been captured in a mist net.

On 29 June 1991, a turtle devoured an adult female Acadian Flycatcher (*Empidonax virens*; USFWS band No. 1830-75071). On 25 June 1996, I observed a turtle eating a Red-eyed Vireo (*Vireo olivaceus*; unbanded). The vireo was dead, partially eaten, and the turtle had blood and feathers on its face. On 1 July 2003, I observed a turtle eating an Ovenbird (*Serius aurocapillus*; unbanded). The left wing was missing all tertial and secondary flight feathers and most primary feathers. The wings and body were bloody and bird could not fly. The turtle's mouth was filled with feathers. At my approach the Ovenbird escaped but probably did not survive the attack.

In each incident, the songbird had been initially captured in the lowest part of the mist net and was unable to escape when the turtle attacked it. Box Turtles probably capture and eat small healthy vertebrate animals only under unusual circumstances. Legler (1960. Univ. Kansas Publ. Mus. Nat. Hist. 11:527–669) reports a *Terrapene* eating a bobwhite quail chick and Anton (1990. Bull. Chicago Herpetol. Soc. 25:143–144) reported one eating a house sparrow. Alsop and Wallace (1978. J. Tennessee Acad. Sci. 53:134) report box turtles eating songbirds that had been killed at a tall radio tower during migration. There are also reports of box turtles eating small mammals that had been captured in traps (Legler 1960, *op. cit.*; Metcalf and Metcalf 1970. Trans. Kansas Acad. Sci. 73:96–117). While predation on healthy adult songbirds is certainly rare, the nestlings of ground-nesting species could be vulnerable to opportunistic predation by these turtles.

Songbirds were captured for study under permit #09517-L issued by the U.S. Fish and Wildlife Service.

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TESTUDO GRAECA (Spur-thighed Tortoise). **SIZE.** The maximum straight carapace lengths (SCL) of *Testudo graeca* previously reported for Morocco come from Admine, in the Souss Valley (30°13'N, 9°31'W; 70 elev.). In this region, females reach 226.2 mm and males 184.4 mm (Carretero et al., *in press*. Anim. Biol.). Although Souss Valley specimens have been assigned to the subspecies *T. g. soussensis*, recent studies on mtDNA (Harris et al. 2003. Rev. Esp. Herpetol. 17:5–9) and morphometrics (Carretero et al., *in press*) do not support a distinction from the nominal sub-

species found elsewhere in Morocco. During a herpetological survey in several Moroccan localities, six extremely large specimens were found in Tagourast (Boulemane Province, 32°51'N, 3°52'W; 1130 m elev.) on 14 October 2003. Two females (236.4 mm and 248.6 mm) and one male (200.3 mm) exceeded the highest SCL values reported for Souss Valley specimens (Bayley and Highfield 1996. Chel. Cons. Biol. 2:36–42; Carretero et al., *in press*); another male measured 184.1 mm. To our knowledge the largest female represents the maximum size record of this species in nature for Morocco. Despite the low sample size, this population seems to be composed of adult individuals of large size (means: 181.8 mm males, 218.8 mm females, N = 3 in both cases). All tortoises were photographed and released after measuring. It is noteworthy that Admine and Tiguest are 750 km apart, occupy different climatic zones (littoral in Admine and continental with high thermal amplitude in Tagourast) at different altitudes and harbor different habitats (patchy open forest with irrigated cultures and dry steppe, respectively). Furthermore, the Tagourast population is the southeastern limit of the *T. graeca* range in Morocco (Bons and Geniez 1996. Amphibians and Reptiles of Morocco. AHE. Barcelona).

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LACERTILIA

ANOLIS SMARAGDINUS (Bahamian Green Anole). **DISPERSAL.** Several factors seem to influence lizard dispersal (Massot and Clobert 2000. J. Evol. Biol. 13:707–719), yet it remains the focus of relatively limited study. Notably, little attention has addressed how the patch size of unsuitable habitat might impede dispersal. Hence, we provide an observation of *Anolis smaragdinus* from the Bahamas showing how a patch of unsuitable habitat might have influenced dispersal.

In October 1993, as part of an experimental study of interspecific interactions (Losos and Spiller 1999. Ecology 80:252–258), five adult *A. smaragdinus* (2 males, 3 females) were introduced onto a tiny (801 m²) islet lacking lizards that was located SW of Georgetown, Great Exuma, Bahamas (23°25'N, 75°50'W). This islet is connected to another slightly larger one (943 m²) by an isthmus of bare rock that is land positive for only about one half of the tidal cycle; this latter islet also originally lacked lizards but none were introduced to it. The minimum distance between vegetation on the two islets is 17.7 m. However, the edge of both islets is vegetated with *Rhachicallis americana* (Rubiaceae), a small plant (mean height = 0.29 m; range = 0.05–0.58 m, N = 45) that *A. smaragdinus* rarely uses (JBL and DAS, unpubl. data). Moreover, *A. smaragdinus*, which is rarely seen on the ground, typically occupies shrubby vegetation > 1 m in height (Schoener 1968. Ecology 49:704–726). The minimum distance separating habitat typically occupied by *A. smaragdinus* (i.e., bushes > 1 m in height) on the two islets is 49.8 m. When we returned a year later (October 1994), we found one adult male and two smaller

individuals (sex undetermined) in a brief (ca. 15 min) survey of the larger islet (as well as an estimated 10 individuals on the smaller island to which they had been introduced).

This observation indicates that typically arboreal anoles may disperse some distance on the ground to colonize vegetation patches lacking canopy contact, a rarely reported phenomenon (Hicks and Trivers 1983. *In* Rhodin and Miyata [eds.], *Advances in Herpetology and Evolutionary Biology: Essays in Honor of Ernest E. Williams*, pp. 570–595. Museum of Comparative Zoology, Cambridge, Massachusetts). We consider the alternate possibility, that *A. smaragdinus* independently colonized the larger islet over water from another source island or was brought there by humans, to be highly unlikely. These islets are in a remote area ca. 5 km from Great Exuma. Natural colonization is unlikely because we have never observed this species on a tiny remote islet of this sort except for populations that we introduced in over two decades of studying the distribution of anoles on hundreds of islands in the Bahamas. Moreover, Hurricane Lili exterminated the populations on both islets in 1996. Since then we have visited these islets about four times a year and never found this species. In addition, these diminutive islets hold little interest for locals or tourists; we never saw evidence that humans other than ourselves visited them.

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ASPIDOSCELIS TIGRIS AETHIOPS (Sonora-Sinaloa Desert Whiptail). **HABITAT, BODY SIZE, and REPRODUCTION.** We present data on a population of *Aspidoscelis tigris aethiops* (= *Cnemidophorus tigris aethiops*; Reeder et al. 2002. *Am. Mus. Novitat.* 3365:1–61) sampled by JLE in 2004 at Estación Ortíz, Valle de Guaymas, municipality of Guaymas, Sonora, México (28°17'23.9"N, 110°43'0.8"W, elev. 103 m). Estación Ortíz, the most southerly continental locality and lowest elevation (see Vitt and Breitenbach 1993. *In* Wright and Vitt [eds.], *Biology of Whiptail Lizards (Genus Cnemidophorus)*, pp. 211–243. Oklahoma Mus. Nat. Hist., Norman, Oklahoma) at which habitat, body size, and reproductive characteristics for *A. tigris* (*sensu* Walker 1983. *Southwest. Nat.* 28:1–8) have been assessed, is situated ca. 40 km from the Gulf of California in a relatively flat Sonoran Desert basin surrounded by rocky hills. Most of the habitat utilized by *A. t. aethiops* (*sensu* Taylor and Walker 1991. *Copeia* 1991:800–809) in Valle de Guaymas is dominated by plant associations of mesquite (*Prosopis* sp.), large cholla and prickly pear cacti (*Opuntia* sp.), and scattered creosote bush (*Larrea* sp.). Some of these associations are impenetrable to humans; however, patches of open substrate among the plants are utilized by whiptail lizards and other reptiles. Most individuals of *A. t. aethiops* analyzed in this study were collected near the town, where they were easily stalked in severely altered habitats characterized by open areas, sandy soil, and degraded vegetation. This subspecies was also abundant, but difficult to collect, away from the town on gravelly soil in dense

vegetation at the base of the hills. No other species of *Aspidoscelis* was observed at Estación Ortíz.

Analyses of reproduction and body size in *A. t. aethiops* are based on dissections and measurements performed by JMW on 176 preserved specimens of this subspecies catalogued in the herpetological collection of Unidad de Biología, Tecnología y Prototipos (UBIPRO 12847–12859, 12865–12869 [22 July 2004]; 13155–13197, 13214–13328 [12–14 August 2004]). Data are presented by sex as ratios, ranges of variation, and/or means (to one decimal place) \pm 1SE.

Numbers of males and females, respectively (in parens), by size (as 10 mm increments in SVL) in the pooled UBIPRO sample are 35–39 (1:2), 40–49 (1:3), 50–59 (4:14), 60–69 (34:37), 70–79 (44:20), and 80–87 (13:3). Chi-Square tests revealed that the 22 July 2004 sample was significantly male-biased (16:2; $\chi^2 = 4.7$, $P = 0.03$); however, no significant gender bias existed in the 1214 August 2004 sample (81:77, $\chi^2 = 0.01$, $P = 0.91$). Collections of *A. tigris* are well known to often have unequal sex ratios that reflect behavioral differences correlated with the reproductive cycle (Pianka 1970. *Ecology* 51:703–720; Burkholder and Walker 1973. *Herpetologica* 29:76–83). Dearth of females in our July sample may reflect most females carrying oviductal eggs during which time their more retiring behavior made them less visible to humans (see Pianka 1970, *op. cit.*). Conversely, nearly equal sex ratio in the August collection may reflect most females ($N = 34$) carrying yolked ovarian follicles 3.0–8.0 mm in diameter, during which time they continue to actively forage to support clutch development (see Pianka 1970, *op. cit.*); at that time few females ($N = 7$) had oviductal eggs (mean dimensions 8.3×15.1 mm). In the pooled sample of *A. t. aethiops*, the 43 gravid females have a SVL range of 60–81 mm. Sexual dimorphism in the Estación Ortíz population of this subspecies is indicated by the significantly different SVL means ($P < 0.05$) for all adult females (68.5 ± 0.73 , range 60–81, $N = 60$) compared to all adult males (71.7 ± 0.71 , range 60–87, $N = 91$) in the pooled sample and the 13:3 ratio of males to females in the 80–87 mm SVL range. Numbers of undamaged gravid females (as 10 mm increments in SVL) are 60–69 (27), 70–79 (13), and 80–81 (3). Clutch size range in 43 females is 1–4, mean 2.2 ± 0.09 . The number of eggs per clutch in *A. t. aethiops* is positively correlated with SVL ($r = 0.66$, $P < 0.01$). In the SVL range of 60–73 mm, clutch size is 1 ($N = 1$), 2 ($N = 33$), and 3 ($N = 1$), and in the SVL range of 72–81 mm it is 2 ($N = 1$), 3 ($N = 5$), and 4 ($N = 2$).

The geographic distribution of no other species of whiptail lizard in North American deserts approximates the vast latitudinal range of *Aspidoscelis tigris*. Its range extends from Oregon and Idaho in the USA to Sinaloa State, México (Wright 1994. *In* Brown and Wright [eds.], *Herpetology of the North American Deserts: Proceedings of a Symposium*, pp. 255–271. Southwestern Herpetologists Soc. Special Publ. 5, Van Nuys, California.), which is roughly equivalent to the combined latitudinal limits of the Great Basin, Mohave, and Sonoran deserts. Ecological adjustments associated with the exceptionally high density for *A. t. aethiops* observed at Estación Ortíz by JLE ($N = 176$ collected in 4 days in 2004), based on a small clutch size, include a lengthy growing season (> 200 days), early reproductive maturity at a small body size in the second summer of life, and likely production of multiple clutches (see McCoy and Hoddenbach 1966. *Science*

154:1671–1672). In comparison, the much lower densities for *A. t. tigris* observed in the Snake River Valley in Canyon, Ada, Owyhee, and Elmore counties in southwestern Idaho (N = 243 specimens collected in > 20 days in 1967 and 1968; Burkholder and Walker 1973, *op. cit.*), the most northerly area (ca. 43°26'N) in which habitat, body size, and reproductive characteristics for this species have been assessed (Taylor et al. 1994. *Copeia* 1994:1047–1050), is based on a shorter growing season (ca. 150 days), maturation at a larger SVL in the third summer of life (SVL 69–75 mm), and annual production of single clutches of similar size.

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CTENOSAURA BAKERI (Utila Spiny-tailed Iguana). **PREDATION.** *Ctenosaura bakeri*, an endemic to the Isla de Utila (Islas de la Bahía, Honduras), dwells exclusively in mangrove swamp (Köhler 1995. *Salamandra* 31:93–106). Little information exists on its life history. Hence, here I present observations of predation on juvenile and adult *C. bakeri*.

At 1145 h on 3 September 1999, I observed a *Boa constrictor imperator* drop from a Black Mangrove tree, *Avicennia germinans*, on the inland mangrove edge near Iron Bound on the north coast of Utila (16°07'22"N, 86°54'16"W). The snake was in the process of constricting an adult female *C. bakeri* across its abdominal region. After the snake killed the lizard, prey and predator were collected to prevent ingestion. The iguana measured 192 mm SVL and 474 mm total length and had a mass of 235 g. The snake measured 1400 mm total length and was released at the site of capture after examination. Predation by the snake was photodocumented. A second case of predation was recorded at 1030 h on 6 June 2000 in the mangrove swamp at Big Bight Pond on the eastern part of Utila (16°06'20"N, 86°53'29"W). A Turkey Vulture (*Cathartes aura*) was observed grasping an adult male *C. bakeri* and flew away. The iguana, estimated at 700 mm total length, had been resting about 20 m from my point of observation on the exposed branch of a Black Mangrove tree.

At 0930 h on 22 June 2000, while checking the nesting sites at Iron Bound, a large (ca. 700 mm total length) male Basilisk (*Basiliscus vittatus*) was spotted among the beach vegetation. On approach, the basilisk started running over a distance of about 3 m and caught a freshly hatched *C. bakeri* (ca. 170 mm total length) that ran by and swallowed it head first.

At 1042 h on 31 July 2001, I observed a group of Great-tailed Grackles (*Quiscalus m. mexicanus*), consisting of the two adults and two immatures, enter the mangrove swamp at Iron Bound. During this summer dry season, water levels were low and no water was present in many places; at this time, juvenile *C. bakeri* usually remain among the mangrove roots. As I observed one of the adult grackles rummaging through the roots, I saw it hunt and kill 4 iguanas within 10 min. The prey items were fed to the immature birds, which swallowed the juvenile *C. bakeri* head first. Predation by the grackle was videotaped.

Published observations of predation on *C. hemilopha*, *C. pectinata*, and *C. similis* exist (e.g., Carothers 1981. *Behav. Ecol. Sociobiol.* 8:261–266; Mora 1987. *J. Herpetol.* 21:334–335; Ramírez-Bautista and Uribe 1992. *Herpetol. Rev.* 23:82), but these observations are the first records of predation on *C. bakeri*.

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CTENOSAURA HEMILOPHA (Cape Spiny-Tailed Iguana). **REPRODUCTION.** *Ctenosaura hemilopha* is known from Baja California south of Loreto to the Cape region and Cerralvo Island (Grismer 2002. *Amphibians and Reptiles of Baja California Including Its Pacific Islands and the Islands in the Sea of Cortés*, University of California Press, Berkeley, 399 pp.). The purpose of this note is to provide information on its reproductive cycle from histological examination of gonads from museum specimens.

A sample of 10 males (mean SVL = 177 mm ± 43 SD, range: 119–233 mm) and 11 females (SVL = 173 mm ± 25 SD, range: 153–237 mm) was examined from the Museum of Vertebrate Zoology (MVZ), Berkeley; and the Natural History Museum of Los Angeles County (LACM), Los Angeles. Histological procedures follow Goldberg and Beaman (2003. *Herpetol. Rev.* 34:143). Testes from 2 males (LACM 51838, 129 mm SVL; LACM 51840, 127 mm SVL) collected 4–6 March 1969 were in recrudescence just prior to the start of spermiogenesis (germinal epithelium dominated by primary spermatocytes and spermatids). A testis from 1 male (LACM 51839, 192 mm SVL), collected 4–6 March 1969 was undergoing early spermiogenesis (seminiferous tubules contained small amounts of sperm). Testes from 2 males (LACM 128245, 222 mm SVL; LACM 128246, 207 mm SVL) collected 30 April 1978, and 1 male (LACM 128248, 233 mm SVL) collected 7 May 1978, were undergoing spermiogenesis (lumina of seminiferous tubules lined by spermatozoa; rows of metamorphosing spermatids present). Testes from 1 male (LACM 19360, 209 mm SVL) collected 4 July 1959, 2 males (LACM 9850, 119 mm SVL; LACM 9852, 149 mm SVL) collected 17–18 July 1960, and 1 male collected on 19 July 1977 (LACM 126586, 183 mm SVL) were regressed (seminiferous tubules contained spermatogonia and Sertoli cells; germinal epithelium was exhausted). Presence of males undergoing spermiogenesis in April–May suggests that *C. hemilopha* breeds during spring, before late summer as suggested by Asplund (1967. *Amer. Midl. Nat.* 77:462–475).

The ovary from 1 female (LACM 51837, 157 mm SVL) col-

lected 4–6 March 1969, was undergoing early yolk deposition (follicles contained a ring of basophilic yolk granules). Yolk deposition was further advanced in a second female (LACM 51836, 153 mm SVL) collected 4–6 March 1969, with a total of 13 follicles ($5.8 \text{ mm} \pm 1.1 \text{ SD}$ diameter). However, whether all follicles would have completed development is unclear. No yolk deposition was underway in 9 females (SVL, collection date in parens): LACM 94820 (155 mm, 29 June 1967), LACM 126585 and 126587 (237 mm and 155 mm, respectively, both 16 July 1967), LACM 19361 (195 mm, 12 August 1964), MVZ 11489 (170 mm, 22 August 1929), LACM 19358 (163 mm, 28 August 1961), LACM 94821 (173 mm, 14 October 1968), MVZ 11476 (165 mm, 15 October 1928), and MVZ 11482 (178 mm, 30 October 1928). These data support that in *C. hemilopha*, yolk deposition is completed some time in spring. Asplund (*op. cit.*) observed hatchlings of *C. hemilopha* in late August, suggesting that eggs were deposited in spring.

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EUMECES FASCIATUS (Five-lined Skink). **HATCHLINGS.** Many aspects of the biology of *Eumeces fasciatus* are well known, but most data involve populations from the northern and eastern portions of its range. (e.g., McCauley 1939. Copeia 1939:93–95; Fitch 1954. Univ. Kansas Mus. Nat. Hist. Publ. 8:1–156). Further information regarding hatchling morphometrics is generally restricted to measurements of SVL and mass. For this reason, we report here on hatchlings from a nest found in southeast Texas.

On 4 July 2004, we discovered a nest of 11 intact eggs under an irregularly shaped porous limestone (28 cm wide \times 39 cm long \times 28 cm high) at the base of a pecan tree (*Carya illinoensis*) surrounded by mixed grasses and debris that nearly concealed the limestone. This site, in an abandoned pecan orchard, is now a wooded lawn near the town of Hull, Liberty County ($30^{\circ}11'24.3''\text{N}$, $94^{\circ}40'46.4''\text{W}$; elev. 24 m). The nest chamber was dome-shaped, measuring ca. 10 cm wide \times 15 cm deep \times 3 cm high. The entrance to the chamber was a natural crevice in the stone that opened toward the tree. The nest ceiling was a concavity beneath the stone, whereas the substrate beneath the eggs was bare soil excavated to a slight depression. An adult female *E. fasciatus* (ca. 60 mm SVL) accompanied the eggs. When the stone was lifted, she huddled on top of the eggs, but did not flee, even as the stone was carefully replaced. Examination of the nest at 1100 h the next day revealed that the adult had left and two of the eggs were slit and empty. No evidence of the hatchlings existed nearby. The remaining 9 eggs were collected and reared in a sealed container on moist potting soil. Hatchlings were each weighed and measured within 12 h of hatching. Method of taking measurements follows Smith (1946. Handbook of Lizards, Lizards of the United States and Canada. Comstock Publishing Associates. Ithaca, New York. 557 pp.)

All eggs hatched between 6 and 8 July 2004. Morphometric

TABLE 1. Morphometric data for 9 *Eumeces fasciatus* hatchlings from Liberty County, Texas. SVL = snout–vent length, TTL = total length, HL = head length, OHW = ocular head width, FLL = forelimb length, HLL = hindlimb length.

Hatchling (mm)	SVL (g)	Weight (mm)	TTL (mm)	HL (mm)	OHW (mm)	FLL (mm)	HLL (mm)
1	26	0.36	59	7.5	4.2	10.3	10.9
2	27	0.40	62	8.0	4.6	9.2	13.0
3	26	0.42	64	7.8	4.3	9.5	12.4
4	27	0.42	64	7.8	4.1	10.7	12.4
5	27	0.41	62	7.4	4.1	9.6	12.1
6	27	0.40	64	7.8	4.1	9.6	12.2
7	26	0.41	63	7.9	4.2	9.7	13.0
8	27	0.41	63	7.8	4.2	10.5	12.0
9	28	0.42	64	7.3	4.1	10.5	12.1

data were recorded for each hatchling (Table 1.) Mean values were as follows: 26.8 mm SVL (SD = 0.6), weight of 0.4 g (SD = 0.02), 62.8 mm total length (SD = 1.5), 7.7 mm head length (SD = 0.2), 4.2 mm ocular head width (SD = 0.2), 10.0 mm forelimb length (SD = 0.5), and 2.2 mm hind limb length (SD = 0.6).

The sizes (as SVL) and masses of these hatchlings are similar to those reported from Kansas (Fitch, *op. cit.*) and Maryland (McCauley, *op. cit.*). Data are lacking to compare remaining measurements. These data represent the first documentation of morphometric information for *E. fasciatus* hatchlings from the southwestern edge of its range.

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GAMBELIA WISLIZENII (Long-nosed Leopard Lizard). **PRE-DATION.** Despite a broad distribution, few reports of *Gambelia wislizenii* predators exist. Based on stomach contents, Ortenburger (1928. Mem. Univ. Michigan Mus. 1:1–243) identified *Masticophis flagellum* as a common predator of *G. wislizenii*. To my knowledge, the only other predators noted to date are larger conspecifics (McCoy 1967. Am. Midl. Nat. 77:138–146; Montanucci 1967. Herpetologica 5:119–126). Here I provide an observation of domestic cat (*Felis catus*) predation on *G. wislizenii* from southeastern Oregon.

Around 1000 h on 28 June 2003 on the west edge of the Alvord Desert in the hamlet of Fields, Harney Co. ($42^{\circ}15.8'\text{N}$, $118^{\circ}40.5'\text{W}$; elev. 1290 m), I saw an average-sized *F. catus* pounce from the edge of an unidentified shrub into a patch of grass. When it lifted its head, the cat was holding an adult *G. wislizenii*, ca. 90 mm in snout-to-vent length and with no visible nuptial coloration, by the lizard's neck. The lizard was immobile and appeared to be dead. The cat lowered the lizard back to the ground and although the cat's mouth was not visible through the grass, its head and shoulders made movements indicative of the tearing apart and ingestion of prey. I observed the cat for ca. 2 minutes, at which point it was apparently still ingesting the lizard. This entire observation

occurred in a small patch of unidentified mixed shrubs and grasses between the east side of State Route 205 and a grove of trees surrounding a small pond, < 100 m from the nearest house.

Cats prey on a wide variety of animals, including lizards (Fitzgerald and Turner 2000. *In* Turner and Bateson [eds.], *The Domestic Cat: The Biology of Its Behaviour*, 2nd ed., pp. 151–175. Cambridge University Press, Cambridge). For example, cats take an estimated 2.9–9.4 million lizards annually in Virginia (Mitchell and Beck 1992. *Virginia J. Sci.* 43:197–207). Cats are also thought to have driven some lizard species extinct (e.g., Iverson 1978. *Biol. Conserv.* 14:63–73). However, this is the first record of cat predation on *G. wislizenii*, or any *Gambelia* species (Fitzgerald and Turner, *op. cit.*). Knowledge of predators of *G. wislizenii* is important because their predators are likely to be similar to those of the closely related and federally Endangered *Gambelia sila* (Tollestrup 1982. *Am. Midl. Nat.* 108:1–20). The potential impact of feral and free-ranging domestic cats should be considered in the management of *Gambelia* lizards.

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HEMIDACTYLUS PLATYCEPHALUS (Flat-headed Tropical House Gecko). **REGIONAL INTEGUMENTARY LOSS.** Regional integumentary loss (RIL, *sensu* Bauer et al. 1989 *J. Exp. Biol.* 145:79–102), an anti-predator strategy complementary to tail autotomy, is reported for at least 10 genera of gekkonids (Bauer et al., *op. cit.*) and seems to evolve mainly in insular contexts (Bauer and Russell 1992. *Ethol. Ecol. Evol.* 4:343–358). Here, we add *Hemidactylus* to the list of genera that display this behavior and comment on the insular context.

During a field trip to the Comoro Islands (West Indian Ocean) in October–November 2003, MAC and DJH collected more than 50 *Hemidactylus* specimens by hand for genetic analysis from the four main islands (Mayotte, Grande Comore, Anjouan, and Moheli). More than the 90% of *H. platycephalus* spontaneously and systematically released part of the skin when handled (even if gently), without bleeding or any other apparent damage. In a second trip to Tanzania in October 2004, DJH and SR recorded similar observations for the same species in Zanzibar, Pemba, and the Tanzanian coast. Both insular and mainland populations of *H. platycephalus* showed RIL and genetic analysis did not reveal evidence for an insular origin of this species (Rocha et al. 2005. *Mol. Phyl. Evol.*, in press). Remarkably, other members of this genus collected in similar numbers at the same sites (*H. brooki*, *H. frenatus*, and *H. mercatorius* in the Comoros; *H. mercatorius* in Zanzibar, Pemba, and mainland Tanzania) did not display such strategy. Because the distinction was congruent with the estimates of relationships based on DNA sequence data (Rocha et al., *op. cit.*), RIL could be used as another character to identify *H. platycephalus*, at least in this area. To our knowledge, this is the first report of RIL in *Hemidactylus*, although the skin of *H. fasciatus* has been described as thin and weak similar to that of gekkonids for which RIL has been reported (Bauer et al., *op. cit.*).

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IGUANA IGUANA (Green Iguana). **NESTS and NESTING.** Widespread in tropical America, *Iguana iguana* occurs in a range of climates. Despite this broad-ranging condition, reproductive data are described for few populations (Alvarado et al. 1995. *Southwest. Nat.* 40:234–237; Bock and Rand 1989. *Copeia* 1989:978–986; Klein 1982. *Brenesia* 19–20:301–310; Rodda and Grajal 1990. *Amphibia-Reptilia* 11:31–39). *Iguana iguana* breeds seasonally throughout its range from Mexico to Brazil (Rand and Greene 1982. *Iguanas of the World: Their Behavior, Ecology, and Conservation*. Noyes Publ., Park Ridge, New Jersey), but reproductive data from Brazil are lacking. Here, we help fill this gap with preliminary data from northern Brazil.

During September–November 2001, we obtained data on some nests of *I. iguana* at Reserva Biológica do Rio Trombetas. The reserve, a 385,000-ha area located in the northwest part of state of Pará, municipality of Oriximiná, is on the northeast bank of Rio Trombetas (01°46'S, 55°52'W; elev. ca. 46 m). Nesting occurred in sand banks (tabuleiros) formed by dropping river water levels. Our data are based on five nests of *Iguana* discovered between 16 and 25 September at Tabuleiro do Farias and Tabuleiro do Jacaré. Based on regular surveys in the area, we estimated that nests were discovered ca. 10 days after egg laying. In order to limit predation on the nests following their disturbance, after recording the original position of each egg, we transferred the eggs to similar holes excavated in the same sand bank where they could be monitored continuously.

Nest dimensions (depth between the surface and incubation chamber, and the horizontal distance between the nest entrance and incubation chamber) were measured to the nearest centimeter. Egg data were obtained from two clutches measured immediately after their discovery using calipers to the nearest 0.05 mm and weighed to the nearest 1g with Pesola spring scales. We analyzed change in egg volume and mass in a 20-egg clutch between the day of initial measurements and the 70th day of incubation using a Wilcoxon signed rank test. Hatchlings were also measured (SVL) and weighed immediately after hatching.

Two nests were located in areas totally exposed to the sun; vegetation at least partially shaded the other three nests. Nest depth ranged from 30 to 120 cm (mean = 67.2 cm, *s* = 41.0) and distance between the nest entrance and incubation chamber from 100 to 463 cm (mean = 311 cm, *s* = 169). Clutch sizes were 20, 21, 22, 24, and 33. Mean egg length for the two clutches measured (33 and 20 eggs, data for each in this order hereafter) was 4.5 cm (*s* = 0.2, range: 4.2–5.0 cm) and 4.9 cm (*s* = 0.2, range: 4.7–5.3 cm), mean egg width was 3.4 cm (*s* = 0.1, range: 3.2–3.5 cm) and 2.9 cm (*s* = 0.1, range: 2.7–3.1 cm) and mean egg mass was 28.3 g (*s* = 0.9, range: 27.0–31.0 g) and 21.4 g (*s* = 0.9, range: 19.5–23.0 g). Increase in egg volume and weight during the incubation period was significant (*P* < 0.01 for both). Hatchlings (*N* = 6, all from first nest) averaged 7.2 cm SVL (*s* = 0.1, range: 7.1–7.3 cm), 19.9 cm tail length (*s* = 0.6, range: 19.0–20.5 cm), and 14.9 g in mass (*s* = 0.9, range: 14.0–16.0 g).

Rio Trombetas Green Iguanas laid larger clutches (mean = 24, range: 20–33, N = 5) than Green Iguanas from Curaçao, off the north coast of Venezuela (mean = 17 eggs, range: 10–31, N = 23; Fitch 1985. Misc. Publ. Mus. Nat. Hist. Univ. Kansas 76:1–76), but smaller clutches than those reported elsewhere in Mexico and Central America (means = 29.7–39.5, overall range: 13–60, N = 145; Alvarado et al., *op. cit.*; Fitch 1973. Univ. Kansas Sci. Bull. 50:39–126; Fitch 1985, *op. cit.*; Klein, *op. cit.*; Miller 1987. Zoo Biol. 6:225–236). Rand (1984. In Seigel et al. Vertebrate Ecology and Systematics: A Tribute to Henry S. Fitch. Mus. Nat. Hist., Univ. Kansas, Lawrence. 278 pp.) noted that clutch size increases with body size. Egg mass varied between our two monitored clutches but was greater than that reported for eggs from Mexico (mean = 15.2 g, range: 12.1–17.7 g; Alvarado et al., *op. cit.*). If a smaller clutch size as one nears the equator is a real trend, it may be related to an increase in mass of individual eggs. Size of Rio Trombetas hatchlings was also larger than that reported for Curaçao (mean = 6.6 cm, range: 6.2–6.8, N = 23; Bakhuis 1982. J. Herpetol. 16:322–325), similar to those reported for Michoacan (mean = 7.2 cm, range: 6.1–8.5, N = 327; Alvarado et al., *op. cit.*), but smaller than hatchlings from northern Colombia (range: 7.0–8.6; Rand and Greene, *op. cit.*). Variation we observed in size and weight of clutches and hatchlings may reflect variation in maternal size (Rand, *op. cit.*), but we lack data to test this hypothesis.

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IGUANA IGUANA (Green Iguana). **PREDATION.** *Iguana iguana* is exotic to Florida, but has been reported in the wild there since the 1960s, with breeding colonies reported since the 1980s (Meshaka et al. 2004. The exotic amphibians and reptiles of Florida, Krieger Publishing Company, Malabar, Florida, USA. 155 pp.). *Iguana iguana* is currently known to breed at diverse sites on the Florida mainland and in the Keys (Meshaka et al., *op. cit.*). As indigenous predators may represent one controlling influence on exotic Florida herpetofauna (Butterfield et al. 1997. In Simberloff et al. [eds.], Strangers in Paradise, pp. 123–138, Island Press, Washington, DC), we report here an observation of Yellow-crowned Night Heron (*Nyctanassa violacea*) preying on *I. iguana* from the Florida Keys.

At ca. 0800 h on 5 June 2004 (ca. 27°C air temperature), EMS observed a juvenile *N. violacea* that had just captured a hatchling (ca. 150 mm SVL) *I. iguana* by the old Bahia Honda Bridge in Bahia Honda State Park on Bahia Honda Key (24°39'17"N, 81°16'52"W; elev. ca 2 m). Based on size, the lizard had probably hatched the previous August (Meshaka et al., *op. cit.*).

The event was noteworthy not only because it involved another case of a juvenile wading bird foraging in a terrestrial situation and preying on an exotic species (Smith and Engeman 2004. Herpetol. Rev. 35:169–170), but because natural predators of *I. iguana* have not been recorded in Florida. Most foraging by *N. violacea* occurs in shallow water, with crustaceans the primary

prey (Bancroft and Strong 1996. In Rodgers, Jr. et al. [eds.], Rare and Endangered Biota of Florida, pp. 450–456, University Press of Florida, Gainesville). Herons and egrets have been known to capture and consume exotic lizards in terrestrial situations (Franz 2001. Herpetol. Rev. 32:253; Smith and Engeman, *op. cit.*), but prior to this observation only dogs had been reported as predators on *I. iguana* in Florida (Meshaka et al., *op. cit.*). This is also the first observation of a hatchling *I. iguana* on Bahia Honda Key, although ES has observed adult *I. iguana* here for at least 5 yrs.

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LEIOLOPISMA TELFAIRII (Telfair's Skink). **CAUDAL LURING.** Caudal luring is a technique employed by sit-and-wait foragers from a number of squamate lineages (e.g., Simon et al. 1999. Herpetol. Rev. 30:102–103), and typically involves the use of tail movement to attract potential prey within striking distance (Pough et al. 2004. Herpetology. Pearson Education Inc. New Jersey, 726 pp.). Among lizards, caudal luring has only ever been recorded in *Lialis burtonis* and was observed to occur only when the prey evaded an initial strike (Murray et al. 1991. Copeia 1991:509–516.). Here we report observations made during a field study that suggest that *Leiolopisma telfairii* might employ caudal luring as an opportunistic technique to enhance predation on other lizards.

Telfair's Skink, a historically common species throughout the island assemblage associated with Mauritius, has declined markedly because of ship-facilitated introduction of Black Rats (*Rattus rattus*), which has resulted in the species now being confined to Round Island, 22.5 km off the NE coast of Mauritius (Jones 1993. Proc. Roy. Soc. Art. Sci. Mauritius V:71–92). *Leiolopisma telfairii*, the largest living skink in Mauritius, attains a size over 160 mm SVL (Pernetta 2004. Microhabitat and Dietary Preferences of Telfair's Skinks (*Leiolopisma telfairii*): Implications for their Translocation. MSc thesis, University of East Anglia, Norwich, United Kingdom. 41 pp.). Fecal analysis of 59 individuals recorded 20 different food items and confirmed its omnivorous status (Pernetta, *op. cit.*). Evidence of saurophagy, in the form of scales and bones of Bojer's Skinks (*Gongylomorphus bojerii*), was recorded in three separate fecal samples and occurs from a young age (Fig. 1.).

While collecting data on *L. telfairii* ecology, we made observations of 3 adults (≥ 100 mm SVL) employing a novel behavior in attempting to capture Bojer's Skinks. On all three occasions (22 April, 15 May, and 1 June 2004), adult Telfair's Skinks had been observed making an initial unsuccessful attempt to capture adult (ca. 60 mm SVL) Bojer's Skinks. Despite the fact that an attempt at predation was made, the Bojer's Skinks remained within view of the pursuing *L. telfairii*. Each *L. telfairii* then stopped, curled their tail around until the tip was parallel to their head, and undulated the last ca. 5 cm of their tail several times while remaining



FIG. 1. A juvenile *Leiopisma telfairii* (56 mm SVL) with an adult? *Gongylomorphus bojerii bojerii* (35 mm SVL) regurgitated during handling on Round Island, Mauritius.

otherwise motionless. Each Bojer's Skink exhibited an obvious attraction to the tail undulation and moved to within 10–15 cm of the Telfair's Skinks. Once within this distance, all the Telfair's Skinks made a lunge at the Bojer's Skinks, but no episode resulted in the successful capture of the smaller skinks.

Our observations of this behavior suggest that Telfair's Skinks might be using an opportunistic form of caudal luring similar to that employed by *Lialis burtonis*. Notably, *L. telfairii* exhibits few characteristics common among species that frequently employ caudal luring. Caudal luring has generally been associated with sit-and-wait foragers with differently colored tail tips (Pough et al. 2004, *op. cit.*). *Leiopisma telfairii* is an omnivore that employs both sit-and-wait and active foraging modes (Pernetta, pers. observ.) and lacks variation in tail tip color. Saurophagy by *L. telfairii* is a deviation from the usual diet of arthropods observed among Scincidae (Greer 2001. J. Herpetol. 35:383–395), and might result from these island lizards broadening their diets to compensate for limited prey availability (Cooper and Vitt 2002. J. Zool. [London] 257:487–517). These observations constitute the second recorded use of caudal luring by a lizard and the first record of its use within Scincidae.

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TEIUS TEYOU (NCN). **BEHAVIOR.** Arm or hand waving is considered a pursuit-deterrent signaling evolved in many teiid lizards (Cooper et al. 2004. Behavior 141:297–311). This behavior is undescribed in the genus *Teius*. Hence, we provide observations of hand waving in *T. teyou* from western Brazil.

Observations were made in rocky areas near the municipality of Corumbá, state of Mato Grosso do Sul (19°10'49"S; 57°32'17.2"W; elev. 117 m). From May 2003 to April 2004, we observed *T. teyou* perform hand waving behavior on 34 different occasions (juveniles, N = 14; subadults N = 11; adults N = 9). Hand waving in *T. teyou* consists of lifting and waving the forelimbs, alternating the arms. In almost all cases, the initial wave was made with the arm closest to the observer. Each time the behavior was performed, the lizard-observer distance was ≥ 2 m. The waving lizard fled if the observer approached rapidly or made abrupt movements. Lizards continued to wave as they moved away from the observer until they were ca. 5 m away; at that distance, they resumed normal foraging behavior.

In contrast to hand waving behavior in *Cnemidophorus murinus*, which waves primarily while stationary and uses only the foreleg closest to the investigator (*fide* Cooper et al., *op. cit.*), *T. teyou* typically wave their arms as they are moving away, ceasing waving at a presumptively safe distance. *Cnemidophorus lemniscatus* also waves preferentially with one arm, although both arms are occasionally used (Magnusson 1996. Herpetol. Rev. 27:60). Similar to species of *Cnemidophorus*, *T. teyou* waves their arms looking directly at the predator (the observer), implying that this behavior functions to signal predators.

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SERPENTES

BOTHROPS ATROX (Common Lancehead). **MATING.** The mating season for *Bothrops atrox* in the Brazilian Amazon is poorly understood. Martins and Oliveira (1998. Herpetol. Nat. Hist. 6:78–150) reported two observations of mating in April for Adolph Ducke Reserve (40 km N of Manaus, Brazil) and Federsoni (1978/79. Mem. Inst. Butantan 42/43:159–169) reported a mating in captivity that lasted nearly 24 h. On 11 May 2004 (rainy season) at 0530 h we found a pair of *B. atrox* mating between the logs of a bridge over the stream Barro Branco at Adolph Ducke Reserve (02°55'S 59°59'W). The male was ca. 100 cm TL and the female was ca. 150 cm TL. We did not attempt capture them. A large lateral bulge just anterior of the female's cloaca evidenced intromission. When disturbed, the female moved into shallow water, dragging the male along. The pair was observed at one hour intervals for three hours, and were still mating when last observed at dusk (ca. 1800 h). On 31 January 2002 at ca. 1600 h local people found a second pair of *B. atrox* mating in a secondary forest bordering Lake Cururu near the Solimões River and town of Manacapuru (03°32'36.6"S 60°42'30.7"W), ca. 90 km SW of Manaus. The locals reported that a dog, which attacked the mating snakes, died from envenomation. After the attack the snakes continued to mate until the locals killed them. Both the male (84 cm SVL) and female (122 cm SVL) were deposited in the Instituto Nacional de Pesquisas da Amazônia Herpetological Collection (INPA-H 11674 and 11675).

In both of these observations, the female was dark brown and

larger, while the male was lighter (yellowish) brown and smaller. Although sexual dichromatism has not been reported in *B. atrox*, it has been reported for closely related species such as adult *Bothrops moojeni* (Leloup 1975. Acta Zool. Pathol. Antverp. 62:173–201), juvenile *B. asper* (Burger and Smith 1950. Science 112:431–433), and newborn *B. jararacussu* (Marques and Sazima 2003. Herpetol. Rev. 34:62).

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COLUBER CONSTRICTOR (Racer). **REPRODUCTION.** In many animal species a single mating is sufficient for reproductive success. Consequently, female reproductive success might not typically increase as a result of mating with multiple males (Barry et al. 1992. Behav. Ecol. Sociobiol. 30:193–199). Conversely, evidence from the European Adder (*Vipera berus*) suggests that multiple mating by females might benefit offspring viability (Madsen et al. 1992. Nature 355:440–441), and polyandry (and multiple paternity) have been reported from an increasing variety of snake taxa (Garner et al. 2002. Copeia 2002:15–23). Because it is generally thought that male snakes are unable to force copulations, behaviors such as multiple mating would be dictated by female choice (however see Shine et al. 2000. Behav. Ecol. Sociobiol. 48:392–401).

During the spring of 2004 in Rutherford County, Tennessee (USA), a radio tagged female *Coluber constrictor* was observed on four separate occasions either copulating with, or in close proximity to, three different males. On 28 April, she copulated with a telemetered male. The pair were joined for ca. two minutes before separating. On 4 May, the same female was observed copulating with a second male. The pair continued to copulate for ca. one minute before separating because of disturbance. On 8 May, the female was again located, and a third male *C. constrictor* was observed 3 m from the female's location. The male snake exhibited typical trailing behavior in the direction of the female. On 10 May, the female was located and found to be underground, and the telemetered male first observed mating with her on 28 April was within 10 cm of the opening of the hole she occupied. These observations demonstrate, for the first time, that the mating system of *C. constrictor* includes polyandry. These observations also suggest that males may court the same female multiple times.

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COLUBER CONSTRICTOR CONSTRICTOR (Northern Black Racer). **BEHAVIOR.** Entanglement of snakes, including *C. constrictor*, in plastic netting has been documented by Stuart et al.

(2001. Herpetol. Rev. 32:162–164) in terrestrial habitats. Robin Jung (pers. comm.) reported that in Shenandoah National Park, Virginia, 42 leaf litter bags in each of nine streams in a month-long sampling period yielded two dead Northern Watersnakes (*Nerodia sipedon*) and a dead Northern Green Frog (*Rana clamitans*). We used leaf litter bags (plastic netting; Pauley and Little 1998. Banisteria 12:32–36) to study streamside salamander communities in a small stream in Anderson County, Tennessee. We placed 18 litter bags in a first-order stream at the University of Tennessee Forestry Experiment Station and checked them twice a week from April through August for three seasons (2001–2003). During the second year of study, four adult *C. constrictor* were found on separate occasions (18 and 27 June, 18 and 23 July) entangled in separate leaf litter packs (963, 1045, and ca. 700 mm SVL; one unmeasured). Although each was unable to escape from the netting, only one was dead. One *Pseudotriton ruber* larva (35 mm total length) and one unidentified salamander larva (14 mm total length) were found alive in two of the litter bags after the snakes had been cut out of their bags.

These racers may have become entangled in the leaf litter bags while foraging for food. Ernst and Ernst (2003. Snakes of the United States and Canada. Smithsonian Inst. Press, Washington, DC, 668 pp.) describe *C. constrictor* habitat in the east as being dry with some water available nearby and noted that potential habitats are sometimes adjacent to swamps and marshes. Within the same study site described above, we have observed radio-tagged *C. constrictor* along stream margins, but have not found them foraging in streams. Mitchell (1994. The Reptiles of Virginia. Smithsonian Inst. Press, Washington, DC, 352 pp.) lists numerous prey of *C. constrictor*, including Northern Dusky Salamanders (*Desmognathus fuscus*), Northern Watersnakes (*N. sipedon*), and Common Gartersnakes (*Thamnophis sirtalis*). Besides this reference and Ernst and Ernst (2003, *op. cit.*), there are few records of racers preying on salamanders. Our single record of a live *N. sipedon* in a leaf litter bag on 7 June 2001 supplements Jung's observation (see above). Although stream foraging has not been described for *C. constrictor*, our capture records in stream litter bags, in conjunction with their catholic diet, suggest that racers may occasionally forage in water. Researchers using litter bags in streams to study salamanders should be aware of the potential danger to frogs and snakes.

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CROTALUS ATROX (Western Diamond-backed Rattlesnake). **DIET.** Although mammals constitute the majority of prey items taken by *Crotalus atrox*, several reports have documented that birds represent a small percentage of their diet (Spencer 2003. Geographic Variation in the Diet, Morphology, and Reproduction of a Widespread Pitviper, *Crotalus atrox*. Ph.D. dissertation. Univ. Texas, Arlington, Texas. 177 pp.; Werler and Dixon 2000. Texas Snakes: Identification, Distribution, and Natural History, Univ. of

Texas Press, Austin. 372 pp.). The majority of bird predations have been documented from stomach content analysis (Beavers 1976. Southwest. Nat. 20:503–515; Spencer, *op. cit.*). Herein we report a previously undocumented bird species as prey for *C. atrox*.

At 1520 h on 12 October 2002 a small adult *C. atrox* (ca. 800 mm SVL) was observed striking, killing, and consuming an adult Western Meadowlark (*Sturnella neglecta*) along the Colorado River Aqueduct in Pinto Gap (ca. 8 km NE of the Eagle Mountain Pumping Plant), San Bernardino County, California (USA). The bird landed on a concrete bank within 0.3 m of the rattlesnake, which lay coiled under an adjacent Brittlebush (*Encelia farinosa*). The snake struck ca. 5 sec after the bird landed and held onto it for ca. 6 minutes before it was immobilized and ingested.

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CROTALUS CATALINENSIS (Santa Catalina Island Rattlesnake). **DIET and MORTALITY.** On 19 April 2004 a thin, gray-phase male *Crotalus catalinensis* (580 mm SVL, 50 mm TL) was found dead under an Iron Tree (*Ebenopsis confinis*) on Isla Santa Catalina, México. An exceptionally large *Dipsosaurus catalinensis* (Cachorón Lizard; 130 mm SVL, 250 mm TL) was lodged in the snake's mouth and esophagus. Developmental stages of fly (*Sarcophaga* and *Cochliomyia*) larvae on the corpses suggest that death occurred approximately a week earlier. In addition, we have observed prey remains consistent with *D. catalinensis* in 13 of 83 (15.7%) scats obtained from *C. catalinensis* since 2003.

Examples of large snakes eating larger prey are common in the literature (e.g., Klauber 1982. Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind. Univ. of California Press, Berkeley, California. 350 pp.) and cost-benefit trade-offs associated with this behavior are addressed by Arnold (1993. In Seigel and Collins [eds.], Snakes: Ecology and Behavior, pp. 87–115. McGraw-Hill, New York.). This is the first published record of *D. catalinensis* in the diet of *C. catalinensis*, and the first observation of attempted ingestion of a seemingly fatal meal by *C. catalinensis*. Both predator and prey are endemic to Isla Santa Catalina (Grismer 2002. Amphibians and Reptiles of Baja California, Including its Pacific Islands and the Islands in the Sea of Cortés. University of California Press, Berkeley, California. 409 pp.).

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CROTALUS VIRIDIS VIRIDIS (Prairie Rattlesnake). **DIET.** Many diet studies implicitly assume that items found in gastrointestinal tracts were taken alive, and the importance of carrion in the diet of some snakes might be underestimated (DeVault and Krochmal 2002. Herpetologica 58:429–436). Evidence for scavenging by snakes continues to accumulate and scavenging appears to occur fairly frequently among pitvipers and aquatic snakes

(DeVault and Krochmal, *op. cit.*).

Just after noon on 24 June 2003 we found an adult *C. viridis* (ca. 900 mm TL) directly below an active Ferruginous Hawk (*Buteo regalis*) nest on the USDA-Forest Service Rita Blanca National Grasslands in Dallam County, Texas. The snake had ingested a large food item. Forced regurgitation revealed the freshly ingested cranial half of a *Cratogeomys castanops* (Yellow-faced Pocket Gopher) whose total length was estimated at 120 mm.

Buteo regalis frequently consume pocket gophers (Giovanni 2004. Prey Partitioning Between Sympatric Grassland Raptors. M.S. Thesis. Texas Tech University, Lubbock. 84 pp.) and prey remains often accumulate at the base of their nests (Marti 1987. In Giron Pendelton et al. [eds.] Raptor Management Techniques Manual. Raptor Food Habits Studies, pp. 67–80, National Wildlife Federation, Washington, D.C.). As there was no sign of the posterior half of the food item, it appears that the *C. castanops* was scavenged by the snake after falling from the nest. Raptor nest sites might provide convenient scavenging sites during the birds' breeding season months. DeVault and Krochmal (*op. cit.*) reviewed three prior cases of scavenging in this species, but this is the first incidence of finding scavenged food in the stomach of *Crotalus viridis*.

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DIADOPHIS PUNCTATUS STICTOGENYS (Mississippi Ring-necked Snake). **DIET.** *Diadophis punctatus* are known to feed on plethodontid salamanders (Ernst and Barbour 1989. Snakes of Eastern North America. George Mason Univ. Press, Fairfax, Virginia. 282 pp.) and *D. punctatus stictogenys* are commonly encountered on rocky hillsides in mountainous regions of Arkansas (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. Univ. of Arkansas Press, Fayetteville. 421 pp.).

On 10 September 2004 we found a *D. p. stictogenys* (ASUMZ 28733; 217 mm SVL, 44 mm tail length) in direct contact with an adult female *Plethodon albagula* (SVL 69 mm) in a crevice ca. 10 m from the entrance to Spillway Mine, Garland County, Arkansas. A single *P. albagula* egg was found on the floor of the mine below the snake and salamander. The snake was captured (1600 h) and put on ice (1700 h). Necropsy (2100 h) revealed eight eggs (ASUMZ 28734; six fully intact and two ruptured) in the snake's stomach. The six unruptured eggs averaged 5.59 mm in diameter. The snake weighed 4.93 g before necropsy and 3.68 g after the eight eggs (0.94 g total mass) were removed.

Konvalinka and Trauth (2003. Herpetol. Rev. 34:378) report a *Thamnophis sirtalis sirtalis* (Eastern Gartersnake) preying upon an adult *P. albagula* in this mine shaft. Furthermore, *D. p. stictogenys* has been seen in this same mine shaft during previous nesting seasons (three observations) and in one instance was observed preying upon an egg mass (R. R. Jordan, pers. observ.). Female *P. albagula* brood their clutches in crevices and on ledges on the mine shaft walls from August through December (Trauth et

al., *op.cit.*), and female *Plethodon cinereus* are known to abandon eggs when attacked by *D. punctatus* (Bachman 1984. *Herpetologica* 40:436–443). Thus, although the microclimate of the mine appears to be optimal for *P. albagula* nesting, we hypothesize that the openness of the brooding site increases the risk of predation.

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IMANTODES CENCHOA (Chunk-headed Snake, Bejuquilla). **DIET.** The diet of *Imantodes cenchoa* is comprised primarily of *Anolis* lizards and frogs (Henderson and Nickerson 1976. *J. Herpetol.* 10:205–210; Myers 1982. *Amer. Mus. Novitates* 2738:1–50; Scott 1983. In Janzen [ed.], *Costa Rican Natural History*, p. 402. The University of Chicago Press, Chicago), but also includes eggs of leaf-breeding anurans such as *Agalychnis* (Scott and Starrett 1974. *Bull. So. California Acad. Sci.* 73:86–94). On 21 May 2004 an adult female *I. cenchoa* (MHUA 14312, 759 mm SVL, 1093 mm TL, 35 ml volume) was collected from a disturbed primary forest at “El Chaquiral” farm (6°59'00"N, 75°08'05"W; ca. 1700 m elev.) in El Retiro, Anorí municipality, Antioquia Department, Colombia. A female *Anolis mariarum* (61.5 mm SVL, 4 ml volume) was in the snake's stomach and had been ingested head-first. This is the first report of *Anolis mariarum* in the diet of *I. cenchoa* throughout their distribution in Colombia.

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IMANTODES CENCHOA (Chunk-headed Snake). **MATING.** Records of mating in Neotropical snakes are scarce, especially for Amazon species (Feio et al. 1999. *Herpetol. Rev.* 30:99; Cechin and Hartmann 2001. *Herpetol. Rev.* 32:187). Here, we report mating and fighting by arboreal *Imantodes cenchoa* (Colubridae) in the field. At 1910 h on 8 October 2001 a female (MPEG 20023, 792 mm SVL, 23.2 g) and two males (MPEG 20025, 760 mm SVL, 13.9 g [male A]; MPEG 20024, 742 mm SVL 14 g [male B]) were observed at the top of a tree (3.5 m high) in primary forest at “Estación Científica Ferreira Penna” (1°42'30"S, 51°31'45"W), Pará, Brazil. The female and male A were entwined and obviously mating (Fig. 1A). Male B was 30 cm away on an adjacent branch at the same level. Male B displayed undulating parallel movements and tongue-flicked, but did not touch the mating pair (Fig. 1B). After 20 minutes of observation, the mating pair separated and male B remained distant. Male A approached

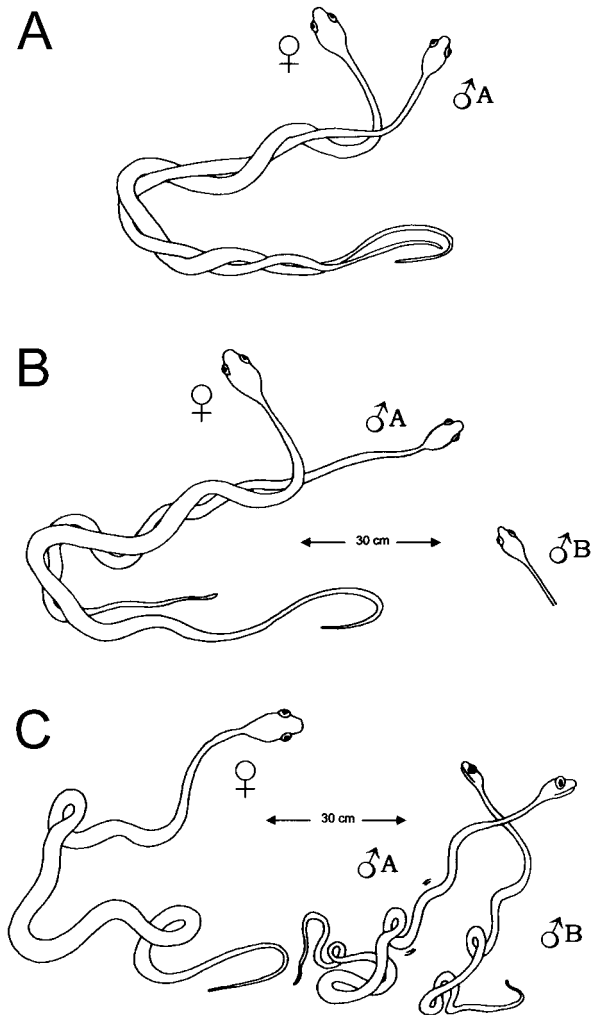


FIG. 1. Mating and fighting in *Imantodes cenchoa*.

male B and laterally undulated the anterior portion of his body (but stayed in the same place) for ca. one minute. At this point male A contacted male B, with the anterior portion of his body, forcing male B down and away (Fig. 1C). This sequence was repeated several times before male B retreated. The female remained immobile during the males' interactions. After the observations, the specimens were collected and dissected; all were sexually mature and devoid of prey remains.

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LAMPROPELTIS PYROMELANA (Sonoran Mountain Kingsnake). **MAXIMUM LENGTH.** The maximum length reported for *Lampropeltis pyromelana* is 1088 mm TL (Boundy 1995. *Bull. Chicago Herpetol. Soc.* 30[6]:109–122; Boundy and Balgooyen 1988. *Herpetol. Rev.* 19:26–27). On 7 July 1995 at

1248 h we captured a male *L. p. pyromelana* at 2037 m in Indian Creek Canyon, Animas Mountains (Hidalgo County, New Mexico, USA) that measured 1114 mm TL (945 mm SVL) and weighed 139 g. The snake was PIT tagged (7F7B0F4840) and released. Between 1994 and 2002 we captured (including recaptures) 55 *L. pyromelana* in the Animas Mountains. Males averaged 627 ± 23 (SD) mm SVL ($N = 45$, range 274–945) and 741 ± 30 mm TL ($N = 40$, range 331–1114). Females averaged 635 ± 43 mm SVL ($N = 10$, range 258–712) and 740 ± 49 mm TL ($N = 10$, range 313–839).

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LEPTOPHIS AHAETULLA MARGINATUS (Southern Green Parrot Snake). **DIET.** *Leptophis ahaetulla marginatus* is a diurnal, arboreal snake known to prey on lizards, birds and their eggs, and hylid frogs (Oliver 1948. Bull. Am. Mus. Nat. Hist. 92:280; Lopez et al. 2003. Herpetol. Rev. 34:68–69). We discovered a Veined Treefrog (*Phrynohyas venulosa*; SVL 66 mm) in the stomach of an adult female *L. a. marginatus* (SVL 875 mm) collected in Foz do Iguaçu (25°33'S, 4°34'W), Paraná, Brazil and deposited in the Instituto Butantan (IB 44678). *Phrynohyas venulosa* exude sticky, toxic secretions that deter predation by some colubrids (*Drymarchon corais*, Leary and Razafindratsita 1998. Amphibia-Reptilia, 19:442–446; *Leptodeira annulata*, Manzanilla et al. 1998. Herpetol. Rev. 29:39–40). However, *P. venulosa* have been recorded in the diet of other colubrids: *Liophis poecilogyrus* (Jorge-da-Silva et al. 2003. Herpetol. Rev. 34:69–70) and *Leptophis mexicanus* (Henderson and Nickerson 1977. J. Herpetol. 11:230–231). This is the first record of predation of *P. venulosa* by *Leptophis ahaetulla*.

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NAJA MELANOLEUCA (Forest Cobra). **LONGEVITY.** Some species of large snakes are known to be relatively long-lived. Bowler (1975. Longevity of Reptiles and Amphibians in North American Collections. SSAR Herpetol. Circ. 6. 32 pp.) reports over 14 years for *Dendroaspis angusticeps*, 17 years for *Naja naja*, and 29 years for *Naja melanoleuca*; all captive snakes maintained in zoos. In early July 1971, Melbourne Zoo, in Victoria, Australia, received a pair of Forest Cobras (*Naja melanoleuca*) from John Leakey in Kenya, as part of a larger shipment of reptiles. Both snakes were adults (ca. 160 cm TL) and were placed on public

exhibit in the Zoo's Reptile House. One of the snakes died 14 days after arrival. The remaining specimen, a female, was anaesthetized on 17 February 2004, for surgical examination of an abdominal mass. An abscess on her left ovary and compromised liver were discovered, and the snake failed to recover from surgery. At the time of her death, she weighed ca. 2200 g and measured 2035 mm SVL (2390 mm TL). She had been in the collection for 32 years, 7 months, and 4 days. Allowing an estimated age of at least two years at the time of her arrival, we conservatively estimate that she exceeded 34 years of age at the time of her death. As far as can be determined, this represents a longevity record for this species and perhaps for elapids overall.

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NERODIA SIPEDON (Northern Watersnake). **STOMACH CONTENTS.** The diet of *Nerodia sipedon* consists mainly of fishes and amphibians, with a small percentage of reptiles, mammals, birds, and invertebrates (Gibbons and Dorcas 2004. North American Watersnakes: A Natural History. University of Oklahoma Press. 438 pp.). On 2 June 2004 at Dow Lake in Athens, Ohio (USA), a single *N. sipedon* was captured and its stomach contents palpated. This adult female (690 mm SVL, 797 mm TL, 220 g) regurgitated an acorn from a White Oak (*Quercus alba*). No other items were regurgitated.

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OXYBELIS FULGIDUS (Green Vine Snake). **DIET.** *Oxybelis fulgidus* is diurnal and primarily arboreal when active (Martins and Oliveira 1998. Herpetol. Nat. Hist. 6:78–150) and preys primarily on small lizards (*Ameiva*, *Anolis*, and *Norops*) and birds (*Pipra*, *Traupis*, and *Volatinia*; Leenders and Colwell 2003. Herpetol. Rev. 34:152; Martins and Oliveira, *op. cit.*). Although *O. fulgidus* is primarily an ambush predator (Henderson and Binder 1980. Milwaukee Publ. Mus. Contrib. Biol. Geol. 37:1–38), it occasionally actively forages for prey (Martins and Oliveira, *op. cit.*; Leenders and Colwell, *op. cit.*). Here, we describe the behavior of an *O. fulgidus* preying upon a bird. At ca. 1445 h on 8 May 2004, at Parque da Araras (03°03'0.81"S; 60°17'0.93"W), Manaus, Amazonas, Brazil, we watched an adult *O. fulgidus* (ca. 1500 mm TL) capture and consume an *Elaenia* sp. (Tyrannidae: Passeriformes). The snake was ca. 7 m up in a tree when the bird perched near it. The snake seized the bird in the left scapular region and held it for ca. 8 minutes, at which point it had become immobilized by the snake's Duvernoy's gland secretions. Ingestion lasted ca. 20 minutes.

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PITUOPHIS CATENIFER SAYI (Bullsnake). **PREDATION.** Although Coyotes (*Canis latrans*) have been mentioned as a predator of broadly sympatric *Pituophis catenifer* (e.g., Ernst and Ernst. 2003. Snakes of the United States and Canada. Smithsonian Books, Washington. 668 pp.; Koch and Peterson. 1995. Amphibians and Reptiles of the Yellowstone and Grand Teton National Parks. University of Utah Press, Salt Lake City. 188 pp.), few definitive reports of such predation exist in the literature. Furthermore, these few reports are dated and concentrated in the western United States. Fitch (1949. Am. Midl. Nat. 41:513–579) published detailed data regarding coyotes preying upon *P. catenifer* in California. Johnson (1936. J. Mammal. 17:169–170) reported witnessing a coyote kill and consume what he believed was a *P. catenifer* in Arizona. However, according to his report, he was never closer than within 200 ft of the coyote or the snake, did not report a scientific name for the snake, and was never able to inspect the carcass of the snake for positive specific or subspecific identification. Here we report evidence of *C. latrans* predation on *P. catenifer* and provide information suggesting that predation might occur at relatively high frequency.

During the summer of 2004 we radio-tracked 23 *P. catenifer sayi* in the Lower Wisconsin River Valley, Sauk County, Wisconsin (USA). On 2 July 2004 we located a radio-tagged female *P. catenifer sayi* (1195 mm SVL, 1010 g) in a *C. latrans* den. After a week of no movement, we believed the snake might have been consumed by a *C. latrans*. On 15 July 2004 we searched the area surrounding the den entrance and found a pile of *C. latrans* scat that appeared to have been passed several days earlier. This scat contained many small rodent bones and a large number of snake ventral scales. The size and shape of these scales suggested they were those of *P. catenifer* and not one of the other three snakes known from this study site (*Coluber constrictor*, *Heterodon platirhinos*, *Lampropeltis triangulum*).

Furthermore, between 16 May and 18 August 2004, six additional radio-tracked adult (4M:2F) *P. catenifer* were killed and eaten by carnivorous mammals in lowland oak savannah habitat immediately adjacent to open sand prairie and bluffs. In two instances, the transmitters were found within a *C. latrans* den; in two other instances the chewed carcass of the snake (with transmitter) was discovered; and in the remaining two instances, the transmitter (with evidence of carnivorous mammal teeth marks) was found with no carcass. Although all six of these observations are consistent with predation by *C. latrans*, in only one case was scat containing snake scales found adjacent to the coyote den entrance. Although we also radio-tracked 21 *P. catenifer* during the spring and summer of the preceding year (2003), none was preyed upon.

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PROTOBOTHROPS JERDONII XANTHOMELAS (Chinese Mountain Pitviper). **REPRODUCTION.** Few data exist in herpetological literature on the reproductive biology of any of the three subspecies of *Protobothrops jerdonii*. Pope (1935. The Reptiles of China. Amer. Mus. Nat. Hist., New York. 604 pp.) summarized data on litter size from females originating from Szechwan Province, China. Smith (1981. The Fauna of British India, Ceylon, and Burma. Reptilia and Amphibia, Vol. III, Serpentes. Today and Tomorrow's Printers and Publishers, New Delhi. 583 pp.) noted that young from Burma are "7 to 8 inches" long. Here I report a litter born to an adult female *Protobothrops jerdonii xanthomelas* (710 mm SVL, 135 mm TL, and 98.8 g after parturition) collected from the wild in Szechwan Province, China on 16 June 2004. On 3 August 2004 she gave birth to six neonates in captivity. Neonates had a mean SVL of 209.5 mm \pm 5.4 SD (range = 199–219 mm), a mean TL of 42.3 mm \pm 4.3 SD (range = 37–49 mm), and a mean mass of 6.3 g \pm 0.45 SD (range = 5.85–6.98 g).

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PSEUDOERYX PLICATILIS PLICATILIS (Eel Snake). **REPRODUCTION.** Little is known about the reproductive biology of *Pseudoeuryx plicatilis*, and what few isolated anecdotal observations exist pertain to *P. plicatilis mimeticus* (Cunha and Nascimento 1981. Bol. Mus. Paraense Emílio Goeldi, nov. sér: Zool. 109:1–20). On 7 January 2002, D. Amaral collected an adult female *P. plicatilis plicatilis* (1370 mm SVL, 1577 mm TL) and her clutch of 49 eggs from Santarém (2°26'S, 54°42'W) on the right bank of the River Tapajós, Pará State, Brazil. The female and her freshly laid eggs (covered with viscous liquid when found) were found inside a drainage pipe and donated to our lab. The eggs contained fully developed juveniles. Forty-eight of 49 eggs hatched between 7 and 10 January 2002; the remaining egg contained a fully developed snake that failed to hatch. Female hatchlings (N = 26) averaged 186 mm SVL (171–200, SD = 8.8), 222 mm TL (202–236, SD = 7.7), and 8.0 g (5.6–9.3, 0.9). Male hatchlings (N = 22) averaged 180 mm SVL (168–187, SD = 4.8), 224 mm TL (207–234, SD = 6.3), and 7.8 g (5.5–10.4, SD = 0.9). The juveniles were kept in captivity until they had shed, which ranged from 11 to 18 days after hatching. The specimens are deposited in the scientific collection of the Laboratório de Pesquisas Zoológicas (LPZ) of the Faculdades Integradas do Tapajós (FIT).

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PSEUSTES POECILONOTUS and **PSEUSTES SHROPSHIREI** (Puffing Snakes). **DIET.** *Pseustes poecilonotus* is known to prey on birds (Falconidae, Emberizidae), bird eggs

(Cracidae), and occasionally on lizards and small mammals (Martins and Oliveira 1998. *Herpetol. Nat. Hist.* 6:78–150). There is no published information regarding *Pseustes shropshirei* diet. On 9 January 1991 a specimen of *P. poecilnotus* (Universidad San Francisco de Quito y Fundación Herpetológica Orcés; FHGO-USFQ 0192) was collected on the Río Payamino at Pozo Gacela, Province of Napo, Ecuador, that contained one adult beetle (Coleoptera: Scarabeidae), one moth (Lepidoptera), parts of a grasshopper (Orthoptera), parts of a bug (Hemiptera), and two legs of a woodpecker (Piciformes: Picidae). On 25 March 1994 a specimen of *P. shropshirei* (FHGO-USFQ 0892) collected at Piñas, Buenaventura, Province of El Oro, Ecuador, contained a capsule of seeds from an undetermined plant (ca. 2 cm in diameter) and two white brittle-shelled eggs (ca. 3 cm in diameter) with partially developed avian embryos.

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RAMPHOTYPHLOPS MULTILINEATUS (Striped Blind Snake). **BEHAVIOR.** Scolecophidians typically are regarded as fossorial. However, recent reviews (Das and Wallach 1998. *Herpetol. Rev.* 29:15–16; Gaulke 1995. *Asiatic Herpetol. Res.* 6:45–48) report both literature and novel records of arboreality in scolecophidians. Most of these records involve observations of snakes 0.5–5 m up the trunk of trees or climbing in limbs or palm fronds. However, Taylor (1922. *The Snakes of the Philippine Islands*. Bureau of Printing, Manila. 312 pp.) reported the occurrence of *Ramphotyphlops cumingii* (in his description of *Typhlops dendrophis*) in the root masses of aerial ferns (*Asplenium* sp.) from “high forest trees” where he suggested they feed on ant larvae and centipedes. We report here on climbing behavior in a specimen of *Ramphotyphlops multilineatus* (verified by V. Wallach) from the Crater Mountain Biological Research Station at Wara Sera, Chimbu Province, Papua New Guinea (6°43'S, 145°05'E). These snakes and their close relatives often prey upon ant pupae, larvae, and adults as well as termites (Shine and Webb 1990. *J. Herpetol.* 24:357–363; Webb and Shine 1993. *Copeia* 1993:762–770; Webb et al. 2001. *J. Zool. London* 250:321–327). This specimen (BSFS 11672, National Museum and Art Gallery of Papua New Guinea in Port Moresby) was collected at a height of 8 m from an interior chamber of a carpenter ant nest at the base of an epiphytic stag-horn fern growing on the side of a large tree.

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SALVADORA MEXICANA (Mexican Patch-nosed Snake). **REPRODUCTION.** *Salvadora mexicana* is known to be oviparous

(García and Ceballos 1994. *Field Guide to the Reptiles and Amphibians of the Jalisco Coast, México*. Fundación Ecológica de Cuixmala, A.C., Centro de Ecología, UNAM, México, D.F.), but to my knowledge there is no other published information on its reproduction. The purpose of this note is to provide additional information on the reproductive cycle of *S. mexicana* based on histological examination of gonads removed from museum specimens.

I examined three female (703 ± 109 mm SVL, range 596–813 mm) and four male (747 ± 44 mm SVL, range 710–805 mm) *S. mexicana* from the herpetology collections of the Natural History Museum of Los Angeles County (LACM) and the University of Arizona (UAZ). Histological procedures follow Goldberg (2004. *Herpetol. Rev.* 35:59). Spermiogenesis was in progress and the vas deferens contained sperm in all four males examined (LACM 136964, June, 716 mm SVL; LACM 25930, July, 756 mm SVL; LACM 75063, July, 805 mm SVL; LACM 58144, September, 710 mm SVL) indicating a prolonged period of sperm production. A female (LACM 2691; 700 mm SVL) collected in June from Jalisco contained 4 oviductal eggs. A female (LACM 74033; 813 mm SVL) collected in July from Guerrero contained three enlarged follicles (mean length = 27.4 mm ± 4.4 SD). Another female (UAZ 26331; 596 mm SVL) captured in August from Colima was undergoing yolk deposition (= secondary vitellogenesis *sensu* Aldridge 1979. *Herpetologica* 35:256–161), suggesting that some females might produce a second clutch of eggs the same year. These are the first clutches reported for *S. mexicana*.

I thank D. A. Kizirian (LACM) and G. L. Bradley (UAZ) for permission to examine specimens.

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SISTRURUS CATENATUS (Eastern Massasauga). **MATING ACTIVITY.** Narrative reports of reproductive behaviors by free-ranging snakes are infrequent, yet accretion of such observations is essential to characterizing mating systems and reproductive phenology. Here we describe reproductive behaviors observed during the course of a radio-telemetric study of adult *Sistrurus catenatus* conducted during summer and fall of 1993 in Will County, Illinois (Wilson and Mauger 1999. *In* B. Johnson and M. Wright [eds.], *Second International Symposium and Workshop on the Conservation of the Eastern Massasauga Rattlesnake, Sistrurus catenatus catenatus*, pp. 110–134, Toronto Zoo, Toronto, Ontario).

On 27 July at 2000 h we found an unmarked male coiled on top of a radio-tagged female (10L; 570 mm SVL), but the male escaped into tall dense vegetation. On 29 July at 2000 h we observed a male (possibly the same male) coiled on top of 10L. The male (8L9L; 665 mm SVL) was removed and surgically implanted with a radio-transmitter. On 2 August at 1900 h, another male (7L; 600 mm SVL) found on top of 10L was captured. On 07 August we released 7L next to 10L, although he moved away and subsequently was never found with 10L. During the time 7L was removed, no other males were found with 10L. Male 8L9L was released on 07 August at his last point of capture but did not immediately approach 10L, even though the snakes were close. On 12 August 8L9L was again coiled on top of 10L and for the next 19

days remained either coiled on top of, next to, or in close proximity (< 2m) to her. On 17 August 8L9L and 10L were coiled together with the posterior third of their bodies intertwined. We could not determine if the cloacae were in apposition, nor did we observe any other behaviors characteristic of courtship or copulation. By 31 August 8L9L was coiled alone 15 m from 10L and no subsequent interactions between the pair were observed. On 17 September male 8L9L was found coiled atop another female (8R; 550 mm SVL). After capturing and marking 8R, we released her at 8L9L's location on 18 September and she moved away and 8L9L did not follow. Subsequent observations were not possible due to failure of 8L9L's transmitter on 20 September.

After a prolonged period of accompaniment by 8L9L, 10L made frequent movements and on 9 September at 1350 h was found copulating with another male (3L, 590 mm SVL). At 1415 h they separated, possibly because of our presence. Although we tracked snakes on a daily basis as late as early November, no further reproductive behavior was observed by 10L after 9 September. Our third snake, male 6R (555 mm SVL), showed no reproductive behavior throughout the study.

Multiple observations of males coiling on top of females and the prolonged accompaniment exhibited by 8L9L are behaviors consistent with female defense polygyny. However, because we did not observe any male-male interactions, it is unclear if these behaviors constitute mate-guarding. Male *S. catenatus* have also been observed coiled on top of females during the mating season at Lake Carlyle, Illinois (M. J. Dreslik and B. C. Jellen, pers. comm.). A similar behavior (termed "stacking") has been observed in *Crotalus atrox* from central Arizona (J. O'Leile, pers. comm.). Although we only observed female 10L copulating with male 3L, her coiling with two other males, including the prolonged accompaniment by male 8L9L, suggests the potential for multiple mating by females.

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SPILOTES PULLATUS (Tiger Ratsnake). **REPRODUCTION.** *Spilotes pullatus* is a diurnal, semi-arboreal colubrine snake (Marques and Sazima 2004. In Marques and Duleba [eds.], *Estação Ecológica Juréia-Itatins: Ambiente Físico, Flora e Fauna*, pp. 254–274. Holos, Ribeirão Preto, S.P.), that is widely distributed in Brazil (Peters and Orejas-Miranda 1986. *Catalogue of Neotropical Squamata*. Smithsonian Institution Press, Washington, D.C. 284 pp.).

On 13 November 2003 a female *S. pullatus* (IB 69849: 1650 mm SVL, 210 mm tail length, 920 g after oviposition), collected in Pedro de Toledo (24°16'29"S, 47°13'58"W), São Paulo, south-eastern Brazil, was brought to Instituto Butantan (IB). On the same day it laid 12 eggs, averaging 48.2 mm in length (range = 39.8–62.0 mm) and 29.6 mm in width (range = 25.5–34.0 mm). Clutch size reported here exceeds that previously reported for *S. pullatus*

(5–10 eggs; Marques and Sazima, *op. cit.*). Relative clutch mass (RCM) was 0.36, which is similar to that reported for other oviparous snakes (Seigel and Fitch 1984. *Oecologia* 61:293–301). During incubation, ten eggs became infected by fungi and did not hatch. One newborn (male, 350 mm SVL, 115 mm tail length, 15 g) hatched on 8 March 2004. The other egg was dissected on 13 March 2004 and a dead but fully developed neonate was discovered inside (IB 71360; female, 364 mm SVL, 115 mm tail length, 19 g). Marques and Sazima (*op. cit.*) suggested that reproduction in *S. pullatus* is seasonal, although this inference was based on a limited number of preserved specimens (three vitellogenic individuals from July to October, and one with oviductal eggs in November), and one observation of oviposition in October and hatching in January. Our observation is consistent with the notion of seasonal reproduction, with oviposition early in the rainy season and hatching near the end of the rainy season.

We thank M. da Graça Salomão and O. A. V. Marques for assistance and suggestions. FUNDAP and FAPESP provided financial assistance.

Submitted by **EINAT HAUZMAN** (e-mail: einat@butantan.gov.br) and **ANTONIO CARLOS ORLANDO RIBEIRO DA COSTA**, Laboratório de Herpetologia, Instituto Butantan, Av. Vital Brazil, 1500, CEP 05503-900, São Paulo, SP, Brazil; and **RODRIGO ROVERI SCARTOZZONI**, Laboratório de Herpetologia, Instituto Butantan, and Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo, CP 11461, CEP 05422-970, São Paulo, SP, Brazil.

STORERIA STORERIOIDES (Mexican Brown Snake). **REPRODUCTION.** Relatively little has been published regarding reproduction in *Storeria storerioides*. Guillelte (1981. *Herpetologica* 37:11–15) reported that it is viviparous with mating in the fall. Ramírez-Bautista et al. (1995. *J. Herpetol.* 26:12–13) reported a mean litter size of 5.4 (range 3–10, N = 5) in *S. storerioides* from the state of México. On 27 April 2004 at 1300 h a female *S. storerioides* (Colección Herpetologica, Instituto de Investigaciones sobre los Recursos Naturales, Universidad Michoacana; INIRENA 483) measuring 244 mm SVL (52 mm TL) was found among pine-oak leaf litter 5 km W of Uruapán, Michoacán, México (19°22'4"N, 102°04'6"W, 1660 m elev.). On 23 June 2004 she gave birth in captivity to three neonates, after which she weighed 5 g. The neonates measured (mean \pm SD) 69.3 \pm 16.2 mm SVL (range: 59–88 mm SVL), 14.0 \pm 2.6 mm TL (12–17 mm TL), and 0.1 \pm 0.05 g (0.1–0.2 g).

I thank José Magaña for collecting the snake and Coordinación de Investigación Científica, Universidad Michoacana for assistance.

Submitted by **JAVIER ALVARADO-DIAZ**, Departamento de Zoología, Instituto de Investigaciones sobre los Recursos Naturales, UMSNH, Morelia, Michoacán, México (e-mail: jadianz@zeus.umich.mx).

THAMNOPHIS VALIDUS CELAENO (Baja California Gartersnake). **MORTALITY.** The most common macrobiological source of mortality for gartersnakes is predation by various verte-

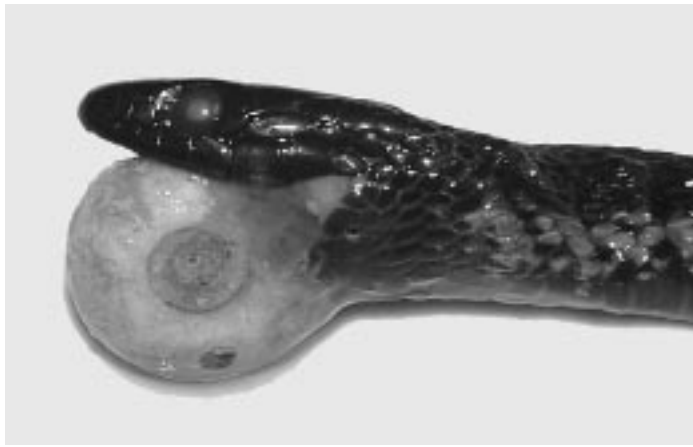


FIG. 1. Subadult *Thamnophis validus celaeno* (UABC 1016) with lower mandibles lodged in the aperture of a freshwater snail (Planorbidae: *Planorbella subcrenatum*).

brates (Rossman et al. 1996. The Garter Snakes: Evolution and Ecology. Univ. Oklahoma Press, Norman. 332 pp.). To our knowledge, mortality caused by invertebrates has not been reported (but see Schwendiman 2004. Herpetol. Rev. 35:73). Here we describe an apparent accidental case of subadult mortality caused by an aquatic gastropod.

On 02 April 2003 at ca. 1700 h we collected a subadult *Thamnophis validus celaeno* (UABC 1016; 303 mm SVL) from Arroyo Boca de la Sierra in the Sierra la Laguna, ca. 5 km NW of Miraflores (23°23.118'N, 109°49.022'W), Baja California Sur, México. The specimen was found dead on a sandy bank near a pool of water at the base of a concrete dam. The lower mandibles were firmly lodged within the aperture of an aquatic snail's (Planorbidae: *Planorbella subcrenatum*) shell; thus preventing the snake from closing its mouth (Fig. 1). These snails were abundant in the shallows of this and surrounding pools. The diet of *T. v. celaeno*, specifically for populations from the Sierra de la Laguna, is described as consisting entirely of larval and adult anurans and small fish (de Queiroz et al. 2001. Copeia 2001:1034–1042). However, given that snails/slugs have been reported in the diets of other *Thamnophis* species (e.g., *T. elegans*, *T. ordinoides*, *T. sirtalis*; Rossman et al. 1996, *op. cit.*), we examined the stomach contents of UABC 1016 along with two other specimens (UABC 1071, 1316) collected the same day. No prey items were discovered in all three specimens. Nonetheless, we presume that this event represents an accidental occurrence of mortality during a feeding attempt, yet it is possible that the snake did not target this specific prey item. It has been suggested that *T. validus* are less adapted to visual underwater feeding than are other strongly aquatic garter snakes and instead rely more on a tactile open-mouth foraging method (Conant 1969. Bull. Am. Mus. Nat. 142:1–140; de Queiroz 2003. Ethology 109:369–384). It is presumed that the individual died from starvation and/or exhaustion after trying to remove the snail from its mandibles.

We thank Kathryn Perez at the University of Alabama for helping identify the snail.

Submitted by **DUSTIN A. WOOD** and **BRADFORD D. HOLLINGSWORTH**, Department of Herpetology, San Diego Natural History Museum, P.O. Box 121390, San Diego, Califor-

nia 92101, USA; and **JORGE H. VALDEZ VILLAVICENCIO**, Universidad Autónoma de Baja California, Km. 103 Carretera Tijuana-Ensenada, A.P. 1653, C.P. 22800, Ensenada, B.C., México.

TRIMORPHODON BISCUTATUS (Lyre Snake). **DIET.** On 9 April 2003 at 1950 h we observed an adult *Trimorphodon biscutatus* hunting Gray Sac-winged Bats (*Balantiopteryx plicata*) as they exited a small cave known as the Coat of Tlálloc located in Area Natural Protegida Sierra Montenegro, Morelos, México (18°30'44.3"N, 99°00'39.8"W, 1104 m elev.). Our observation adds to a growing body of literature that suggests *T. biscutatus* feeds fairly frequently on colonial bats (Kruttsch 1944. J. Mammal. 25:410–411; Sánchez-Hernández and Ramírez-Bautista 1992. Herpetol. Rev. 23:121; Stager 1942. J. Mammal. 23:92).

We thank M. Barrios Damián for assistance.

Submitted by **ROSMANDI LARA LÓPEZ** (e-mail: rlara@cib.uaem.mx), **ALFREDO CHÁVEZ MARTÍNEZ**, **RUBÉN CASTRO FRANCO** (e-mail: castro@cib.uaem.mx), **ALEJANDRO GARCÍA FLORES**, and **SANDRA DENNISE BARRETO SÁNCHEZ**, Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Morelos. Av. Universidad 1001, Chamilpa 62210, Cuernavaca, Morelos, México.

TRIMORPHODON TAU (Mexican Lyre Snake). **REPRODUCTION.** Information on reproduction in *Trimorphodon tau* consists of one report of a clutch of seven eggs from a female collected 18 July (McDiarmid and Scott. 1970. Contrib. Sci. 179, Los Angeles County Mus. 43 pp.). Here I report additional information on *T. tau* reproduction. Fifteen males (mean SVL = 548 ± 48 mm SD, range = 477–650 mm) and eight females (705 ± 108 mm SVL, range = 545–870 mm) were examined from the herpetology collections of Arizona State University (ASU), the Field Museum of Natural History (FMNH), Natural History Museum of Los Angeles County (LACM) and the University of Arizona (UAZ). Snakes were collected 1953–1977. Histological procedures follow Goldberg (2004. Herpetol. Rev. 35:59). One August female (LACM 122906, 630 mm SVL) contained 8 enlarged follicles (> 8 mm length) that likely would have ovulated and represent the second published clutch for *T. tau*. One February female (FMNH 71531, 688 mm SVL), three July females (LACM 53024, 545 mm SVL; LACM 125589, 870 mm SVL; LACM 103390, 740 mm SVL), two August females (LACM 122904, 730 mm; UAZ 36377, 823 mm) and one December female (LACM 53206, 617 mm) were not undergoing yolk deposition (= secondary vitellogenesis, *sensu* Aldridge 1979. Herpetologica 35:256–261). All males were undergoing spermiogenesis (= sperm formation). This included one February male (FMNH 71532, 480 mm SVL), one April male (LACM 9157, 561 mm SVL), four July males (ASU 6377, 590 mm SVL; ASU 6684, 562 mm SVL; LACM 127811, 552 mm SVL; LACM 125587, 565 mm SVL), six August males (ASU 6651, 650 mm SVL; ASU 6663, 573 mm SVL; ASU 6712, 495 mm SVL; LACM 7109, 477 mm SVL; LACM 7110, 533 mm SVL; LACM 7111, 572 mm SVL), two September males (UAZ 27023, 480 mm SVL; UAZ 45492, 580 mm SVL) and one November male (LACM 9509, 562 mm SVL). The presence of males undergoing spermiogenesis in winter, spring, summer, and autumn

suggests *T. tau* has a prolonged testicular cycle similar to its congener *Trimorphodon biscutatus*. Males of *T. biscutatus* from Arizona were undergoing spermiogenesis in January and March–October (Goldberg 1995. Southwest. Nat. 40:334–335).

I thank G. Bradley (UAZ), A. Holycross (ASU), D. Kizirian (LACM), and A. Resetar (FMNH) for permission to examine specimens.

Submitted by **STEPHEN R. GOLDBERG**, Department of Biology, Whittier College, Whittier, California 90608, USA; e-mail: sgoldberg@whittier.edu.

TROPIDOPHIS PILSBRYI (NCN). **SIZE RECORD.** On 19 September 1980 Orlando H. Garrido and José F. Milera collected a female *Tropidophis pilsbryi* from the grounds of the Asunción Hotel, Maisí, Guantánamo Province, Cuba. This specimen (CZACC 4.12076; Colecciones Zoológicas del Instituto de Ecología y Sistemática, Havana City Province, Cuba) measures 371 mm snout–vent length and 47 mm tail length. A second female *T. pilsbryi* (CTR 27; “Charles T. Ramsden” Collection, deposited at the Instituto de Ecología y Sistemática) collected from Babiney, Hoyo del Río Guaso, Monte Líbano, Guantánamo Province, Cuba by Charles T. Ramsden on 17 February 1931, was erroneously identified as *Tropidophis maculatus* by the collector and later by Orlando H. Garrido and measures 307 mm snout–vent length and 41 mm tail length. The first specimen has 175 ventrals and 36 subcaudals, while the second specimen has 166 ventrals and 28 subcaudals. The previously reported maximum length for this species is 295 mm SVL (Hedges and Garrido 2002. J. Herpetol. 36:157–161). These specimens present external pelvic spurs and also extend the previously reported range of variation in both ventral and subcaudal counts from 160–169 to 160–175 ventrals and from 29–35 to 28–36 subcaudals (Hedges and Garrido 2002, *op. cit.*).

We thank Elier Fonseca and Lourdes Rodríguez Schettino for suggestions on the manuscript.

Submitted by **MICHEL DOMÍNGUEZ** (e-mail: micdom2002@yahoo.es) and **LUIS V. MORENO**, División de Colecciones Zoológicas, Instituto de Ecología y Sistemática, Carretera de Varona km 3, Capdevila, Boyeros, A.P. 8029, C.P. 10800, Ciudad de La Habana, Cuba.

TROPIDOPHIS WRIGHTI (NCN). **REPRODUCTION.** *Tropidophis wrighti* is endemic to Cuba and ranges from Northern Sancti Spiritus Province to Guantanamo Province (Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Florida Univ. Press, Gainesville. 720 pp.). On October 2001 a gravid female *Tropidophis wrighti* (335.5 mm total length) was discovered under a stone in an ecotone between pine forest and xeromorphic sub-thorny thicket on the Pinares de Mayari Plateau, in Sierra de Nipe (645 m elev.), Holguín, Cuba. This female contained a 154.0 mm (TL) neonate. Both specimens are deposited in the herpetological collection at the Institute of Ecology and Systematics (CZACC 4.9479–480). To the best of our knowledge, the only other record of clutch size or neonatal morphometrics in the genus

Tropidophis is Petzold’s (1969. Salamandra 5:124–140) report of a neonate *T. semicinctus* (160 mm and 1.5 g, respectively).

Submitted by **ALEJANDRO FERNÁNDEZ VELÁZQUEZ**, Centro de Investigaciones y Servicios Ambientales y Tecnológicos, Grupo de Recursos Naturales, Holguín, Cuba (e-mail: ale@cisat.holguin.inf.cu); and **ROBERTO ALONSO**, División de Zoología de Vertebrados, Instituto de Ecología y Sistemática, Carretera de Varona km 3, Capdevila, Boyeros, AP 8029, CP 10800, Ciudad de la Habana, Cuba (e-mail: zoologia.es@ama.cu).

GEOGRAPHIC DISTRIBUTION

Instructions for contributors to Geographic Distribution appear in Volume 36, Number 1 (March 2005). Please note that the responsibility for checking literature for previously documented range extensions lies with authors. Do not submit range extension reports unless a thorough literature review has been completed.

CAUDATA

AMBYSTOMA MACULATUM (Spotted Salamander). USA: NORTH CAROLINA: HENDERSON CO: 5.6 km SW Tuxedo. 28 March 1997. David A. Pike. Verified by Jeffrey C. Beane. North Carolina State Museum (NCSM slide DAP 97-385). First vouchered county specimen (NCSM files). Egg masses were also observed in a breeding pond at the same locality on 29 March 1997.

Submitted by **DAVID A. PIKE**, Glatting Jackson, Inc., Environmental Services Group, Orlando, Florida 32801, USA (e-mail: dapike22@hotmail.com); **DAVID G. COOPER**, North Carolina State Museum of Natural Sciences, 11 West Jones Street, Raleigh, North Carolina 27601, USA; and **DALE A. JACKAN**, 311 Merrick Road, Tryon, North Carolina 28782, USA.

ENSATINA ESCHSCHOLTZII KLAUBERI (Large-blotched Ensatina). MEXICO: BAJA CALIFORNIA: Sierra de Juárez, ca. 19 km airline S of Laguna Hanson. Two specimens were recorded. The first specimen was seen at Rancho Las Cuevitas, 0.7 km E of, 31°53.021'N, 115°55.780'W, 1540 m elev., in pine-oak forest. 8 May 2005. C. D. Heim, B. Alexander. Museum of Vertebrate Zoology (MVZ 249145, photo voucher). The second specimen was located at Rancho Baja Largo del Sur, 2.0 km NW of, 31°52.304'N, 115°55.850'W, 1602 m elev., in pine-oak forest, on NE-facing slope, during a rainy day. 29 July 2005. J. H. Valdez-Villavicencio, B. D. Hollingsworth, T. J. Devitt, C. R. Mahrtdt, J. A. Soto-Centeno. Universidad Autónoma de Baja California (UABC 1433). Verified by D. B. Wake. First records from the Sierra de Juárez and represents an isolated population that fills a 240 km distributional gap between the Sierra San Pedro Mártir, B.C. (Mahrtdt et al. 1998. Herpetol. Nat. Hist. 6[1]:73–76; MVZ 229220–1) and Alpine, San Diego Co., California (Stebbins 1949. Univ. California Publ. Zool. 48[6]:377–526; SDSNH 32525–7). The two Sierra de Juárez localities are 1.5 km from each other in a north–south direction. Unconfirmed reports also exist from the vicinity of Laguna Hanson in the Sierra de Juárez (see overview in Grismer 2002. Amphib-

ians and Reptiles of Baja California Including its Pacific Islands and the Islands in the Sea of Cortés. Univ. California Press, Berkeley and Los Angeles, California. p. 61).

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ANURA

ANDINOPHRYNE OLALLAI (Tandayapa Andes Toad). COLOMBIA: NARIÑO: Municipio de Barbacoas: Corregimiento Ortiz y Zamora: Vereda El Barro. Reserva Natural Río Ñambi (1°18'N, 78°05'W), 1500 m elev. Highway Pasto-Tumaco Km 130. 13 October 2001 and 29 March 2002. Colección Zoológica. Universidad de Nariño. Pasto. (PSO 0055–57) and Instituto Ciencias Naturales. Universidad Nacional de Colombia. Bogota (ICN 47711). Verified by J. Lynch. Species previously known only from the type locality, Tandayapa, Pichincha Province, NW Ecuador (0°1'S, 78°46'W) (Hoogmoed 1985. Zool. Med. 59: 251–273). First country record, extends known distribution 160 km NW from the type locality.

Submitted by **JOHANNA MURILLO PACHECO** Corporación Llanera de Ornitología KOTSALA, Calle 8 # 41-125, Villavicencio, Colombia (e-mail: avejohis@yahoo.com); **BELISARIO CEPEDA QUILINDO**, Universidad de Nariño, Facultad de Ciencias Naturales y Matemáticas, Departamento de Biología. Sede Torobajo. Calle 16 # 30-07 Apart. 202, Pasto, Colombia (e-mail: becequi2000@yahoo.com.mx); and **CRISTIAN FLOREZ PAI**, Fundación Ecológica Los Colibríes de Altaquere-FELCA. A.A 384 Pasto, Colombia (e-mail: ffelcacolombia@yahoo.com).

BARYCHOLOS PULCHER (NCN). ECUADOR: PROVINCIA DE AZUAY: Tamarindo (79°33'W, 02°47'S, 400 m). 04 August 1996. J.-M. Touzet et al. Universidad San Francisco de Quito & Fund. Herpetológica Orcés, Quito (FHGO-USFQ 623, 748, collected in the leaf litter). Verified by W. Ron Heyer. This endemic frog is known from western lowlands of Ecuador along the transition zone between rainforest and dry seasonal forest from 30 to 600 m; with previous records in the provinces of Esmeraldas, Manabí, Guayas, Los Ríos, and Pichincha (Heyer 1969. Contrib. Sci. Los Angeles Co. Mus. Nat. Hist. 155:1–14). First province record, extends its range ca. 70 km NE from the nearest known locality (7 km SE Buenavista, province of Oro; Heyer, *op. cit.*).

Submitted by **DIEGO F. CISNEROS-HEREDIA**, College of

Biological and Environmental Sciences, Universidad San Francisco de Quito, Ave. Interoceánica y calle Diego de Robles, Campus Cumbayá, Edif. Maxwell. Casilla Postal 17-12-841, Quito, Ecuador; e-mail: diegofrancisco_cisneros@yahoo.com.

BUFO GUTTATUS (Spotted Toad, Smooth-sided Toad): ECUADOR: PROVINCIA SUCUMBIÓ, Reserva de Producción Faunística Cuyabeno: Puerto Bolívar, (00°05'19"S, 76°08'31"W, 240 m elev.) 05, 07 and 14 August 2003. M. Guerrero, P.A. Menéndez and M.R. Bustamante. Museo de Zoología, Pontificia Universidad Católica del Ecuador, Quito, Ecuador (QCAZ 26013–4, 26414). 4 km N of Tarapoa (00°07'24"S, 76°20'24"W, 230 m elev.). 20 July 2000. D. F. Cisneros Heredia, M. Brandt, A. León, and C. Ponce. Laboratorio de Anfibios y Reptiles FHGO-USFQ Universidad San Francisco de Quito (DFCH-USFQ 0715). PROVINCIA ORELLANA: Parque Nacional Yasuní: Tiputini Biodiversity Station (00°37'05"S, 76°10'19"W, 215 m). 23 November 1996. D. Romo. (QCAZ 10211). 11 August and 23 November 1999. D. F. Cisneros Heredia and K. Swing. (DFCH-USFQ 0270, DFCH-USFQ 0710). Estación Científica Yasuní (00°40'16.7"S, 77°24'01.8"W, 250 m). 20 February 2002. I. Tapia and G. Carotti. (QCAZ 19247). All verified by L. A. Coloma. Frost (1985. Amphibian Species of the World. A Taxonomic and Geographical Reference. Allen Press and the Association of Systematics Collections, Lawrence, Kansas; and 2002. Amphibian Species of the World. [on line]. V2.21 [15 July 2002]). Museum of Natural History. New York, <http://research.amnh.org/herpetology/amphibia/index.html> reports this species from Colombia, Guyanas, Venezuela, Amazonian and central Brazil and Ecuador, although no published records with associated voucher specimens were available for Ecuador. Because no vouchers existed, Coloma and Quiguango-Ubillús (2000–2004. Anfibios de Ecuador: Lista de Especies y Distribución Altitudinal [online]. Ver. 1.3 [2 April 2001]). Museo de Zoología, Pontificia Universidad Católica del Ecuador. Quito, Ecuador. « <http://www.puce.edu.ec/zoologia/vertebrados/amphibiawebec/index.html> did not include *B. guttatus* in the list of Ecuadorian amphibians. These specimens represent the first vouchered records from Ecuador. Estación Científica Yasuní extends the range of the species ca. 990 km to the west from the nearest known locality “east of Departamento de Vichada” in Colombian Amazonia (Ruíz-Carranza et al. 1996. Rev. Acad. Colomb. Cienc. 20[77]:366–415).

Submitted by **MARTÍN R. BUSTAMANTE** and **PABLO A. MENÉNDEZ**, Museo de Zoología, Centro de Biodiversidad y Ambiente, Escuela de Biología, Pontificia Universidad Católica del Ecuador, Av. 12 de Octubre y Roca, Aptdo. 17-01-2184, Quito, Ecuador (e-mail: mrbustamante@puce.edu.ec); and **DIEGO F. CISNEROS-HEREDIA**, Laboratorio de Anfibios y Reptiles FHGO-USFQ, Universidad San Francisco de Quito, Av. Interoceánica y calle Diego de Robles, edif. Newton Plaza, of. NP004, Casilla Postal 17-12-841, Quito, Ecuador (e-mail: diegofrancisco_cisneros@yahoo.com).

BUFO MARINUS (Cane Toad). LESSER ANTILLES: ST. VINCENT: THE GRENADINES: Mustique Island, northern part of island by pond at Buttercup House on eastern side of the north end of airstrip, at about sea level. 9 February 2004. M. R. Paice. MPM - P718 (photograph). Verified by Robert W. Henderson. First record

for Mustique Island, although it has been recorded from St. Vincent in general (Schwartz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Univ. Florida Press, Gainesville, Florida, xvi + 720 pp). This exotic species, first noticed by islanders in early 2003, was likely an accidental introduction with building material. At least four other individuals were observed near the airstrip, so a breeding colony has probably been established on the island.

Submitted by **MICHAEL R. PAICE**, 8D Rochdale Way, London SE8 4LY, UK; e-mail: mrpaice@yahoo.co.uk.

ELACHISTOCLEIS PIAUIENSIS (Piaui Oval Frog): BRAZIL: CEARÁ: MUNICIPALITY OF MOMBACA: Fazenda Minador (05°40'08.25"S, 39°38'20.43"W, elev. 401 m). 15 July 2004. E. Maranhão dos Santos, P. Thieres Pinto de Brito, F. Oliveira Amorim, and I. Joventino Roberto. Verified by M. Trefault Rodrigues and E. M. Xavier Freire. Coleção Herpetologica do Departamento de Botânica, Ecologia e Zoologia, Instituto de Biociência, Universidade Federal do Rio Grande do Norte (CHBEZ 1028). Adult specimen (SVL 21.4 mm). Previously known only from the type locality: Picos, State of Piauí, in northeastern Brazil (Caramaschi and Jim 1983. Herpetologica 39[4]:390–394). First state record, extends the known distribution 258 km SW.

Submitted by **EDNILZA MARANHÃO DOS SANTOS**, Pós-graduação em Psicobiologia, Universidade Federal do Rio Grande do Norte, 59078-970, Natal, RN, Brazil; **FABIANA OLIVEIRA AMORIM**, Laboratório de Ecofisiologia Comportamental, Departamento de Morfologia e Fisiologia Animal, Universidade Federal de Pernambuco, 52171-900, Recife, PE, Brazil; **PAULO THIERES PINTO DE BRITO** and **IGOR JOVENTINO ROBERTO**, Associação de Pesquisa e Preservação de Ecossistemas Aquáticos – AQUASIS. Rua Praia de Iparana, SESC Iparana, Iparana, 61600-000, Caucaia, Ceará, Brazil.

ELEUTHERODACTYLUS CYSTIGNATHOIDES (Rio Grande Chirping Frog). USA: TEXAS: BRAZORIA CO.: City of Alvin, 2216 FM 517. 18 March 2004. Michael James McCoid. Texas Natural History Collection 63681. Verified by Travis LaDuc. First record for this county (Frost 2004. Amphibian Species of the World: an Online Reference. Version 3.0 (22 August, 2004). <http://research.amnh.org/herpetology/amphibia/index.php>. American Museum of Natural History, New York, USA. The specimen was collected at 0645 h from beneath discarded cardboard. There had been rain the previous evening. Many additional animals were heard calling suggesting the population has been established for some time.

Submitted by **MICHAEL JAMES MCCOID**, Department of Pathology, University of Texas Medical Branch, 301 University Blvd., Galveston, Texas 77555-0609, USA; e-mail: mjmccoid@utmb.edu.

GASTROPHYRNE CAROLINENSIS (Eastern Narrow-mouthed Toad). USA: ARKANSAS: JOHNSON Co.: Clarksville city limits. 12 May 2005. Joe Kremers. Arkansas State University Museum of Zoology, Herpetological Collection (ASUMZ 29326). Verified by Stanley E. Trauth. New county record and fills a gap along Arkansas River Valley (Trauth et al. 2004. Amphibians and Reptiles of Arkansas, Univ. of Arkansas Press, Fayetteville).

Submitted by **HENRY W. ROBISON**, Department of Biological Sciences, Southern Arkansas University, Magnolia, Arkansas 71754-9354, USA (e-mail: hwrobison@saumag.edu); and **JOE KREMERS**, 2019 Clark Road, Clarksville, Arkansas 72830, USA.

HUIAABSITA (NCN). VIETNAM: QUANG NAM PROVINCE: Ngoc Linh Mountain Range: Tra My District: 15°11'41"N, 108°02'25"E, 930 m asl. 10 March 1999. 15°09'37"N, 108°02'26"E, 920–1060 m asl. 26–28 March 1999. Nguyen Quang Truong. American Museum of Natural History (AMNH A-163698 and AMNH A-163729, respectively). Verified by Bryan L. Stuart. First country record for Vietnam (Stuart and T. Chan-ard 2005. Copeia 2005:279–289).

Submitted by **RAOUL H. BAIN**, Center for Biodiversity and Conservation, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024, USA (e-mail: bain@amnh.org); and **NGUYEN QUANG TRUONG**, Department of Zoology, Institute of Ecology and Biological Resources, Vietnamese Academy of Science and Technology, 18 Hoang Quoc Viet St., Cau Giay, Hanoi, Vietnam (e-mail: truongnq@iebr.vast.ac.vn).

HYLA POLYTAENIA (Striped Treefrog). BRAZIL: ESPÍRITO SANTO: MARECHAL FLORIANO: Alto Nova Almeida (20°24'S, 40°49'W). 17 October 2004. R. B. Ferreira. Museu Nacional, Rio de Janeiro (MNRJ 38954). Verified by C. A. G. Cruz and U. Caramaschi. Previously recorded only from the states of Minas Gerais and Rio de Janeiro (Cruz and Caramaschi 1998. Bol. Mus. Nac., Rio de Janeiro, Zool. 392:1–19). First state record extends known distribution ca. 350 km eastwards from Caraça Natural Park, in Minas Gerais, and ca. 300 km to the northeast of Santa Maria Madalena, in Rio de Janeiro (Cruz and Caramaschi, *op. cit.*).

Submitted by **RODRIGO BARBOSA FERREIRA**, Departamento de Biologia, Universidade Federal do Espírito Santo, 29075-910, Vitória, ES, Brazil (e-mail: rodrigoecologia@yahoo.com.br); and **DAVOR VRCIBRADIC**, Departamento de Ecologia, Instituto de Biologia, Universidade do Estado do Rio de Janeiro, 20550-011, Rio de Janeiro, RJ, Brazil (e-mail: davor@centroin.com.br).

HYLA WEYGOLDTI (Weygoldt's Tree Frog). BRAZIL: MINAS GERAIS: MUNICIPALITY OF ALMENARA: Fazenda Limoeiro, (16°01'77"S, 40°49'96"W). February 2003 and January 2004. P. L. Ferreira, R. N. Feio, and D. L. Pantoja. Museu de Zoologia João Moojen de Oliveira, Universidade Federal de Viçosa (MZUFV 4883–5373). Verified by C. A. G. Cruz. Previously known only from the type locality, in the Municipality of Santa Tereza, Espírito Santo, eastern Brazil (Cruz and Peixoto 1985. Arq. Univ. Fed. Rural Rio de Janeiro 8:63). First state record, extends northern range ca. 450 km airline from type locality.

Submitted by **PAULA LEÃO FERREIRA**, **DAVI LIMA PANTOJA**, and **RENATO NEVES FEIO**, Museu de Zoologia João Moojen de Oliveira, Universidade Federal de Viçosa, 36571-000, Viçosa, Minas Gerais, Brazil.

LEPTODACTYLUS MYSTACINUS. ARGENTINA: SAN JUAN: DEPARTAMENTO VALLE FÉRTIL: 250 km San Juan city on Las Tumanas river, Ruta Provincial N° 510 (30°52'S, 67°20'W), Janu-

ary 2004. E. Sanabria, L. Quiroga, and F. Cano. Herpetological Collection, Instituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan, Argentina (IMCN-UNSJ 5011). Verified by G. Blanco. Previously known from Argentina in Misiones, Corrientes, Formosa, Chaco, southward to Rio Negro and Chubut, westward to La Pampa and San Luis (Ceí 1980, Mon. II Mus. Reg. Sci. Nat. Torino, 609 pp.). First province record, extends the known range ca. 110 km NW of the nearest locality (San Luis Province).

Submitted by **EDUARDO A. SANABRIA, LORENA B. QUIROGA**, and **JUAN C. ACOSTA**, Departamento de Biología e Instituto y Museo de Ciencias Naturales, F.C.E.F. y N., Universidad Nacional de San Juan, Avenida España 400 (N) C.P. 5400, San Juan, Argentina.

OSTEOPILUS SEPTENTRIONALIS (Cuban Treefrog). UNITED STATES VIRGIN ISLANDS: St. John: Virgin Islands National Park, Lameshur Bay Trail, 130 m from end of State Hwy. 107 (18°19'20.3"N, 64°43'44.6"W). 22 June 2001. J. Hardin Waddle. Virgin Islands National Park Collection (VIIS0001563–1567). Verified by Kenneth L. Krysko. First record for St. John and fills the gap between St. Thomas and St. Croix, U.S. Virgin Islands and Tortola and Necker Islands, British Virgin Islands (Schwarz and Henderson 1991. Amphibians and Reptiles of the West Indies: Descriptions, Distribution, and Natural History. Univ. Florida Press, Gainesville, Florida, 720 pp.; Meshaka 2001. The Cuban Treefrog in Florida: Life History of a Successful Colonizing Species. Univ. Press of Florida, Gainesville, Florida, 208 pp.; Owen et al. 2005. Herpetol. Rev. 36:76). Specimens were collected from trees along a hiking trail and from abandoned buildings near Lameshur Bay along southern shore of the Island.

Submitted by **J. HARDIN WADDLE**, Florida Cooperative Fish and Wildlife Research Unit, U.S. Geological Survey, Big Cypress National Preserve, 33100 Tamiami Trail, Ochopee, Florida 34141, USA (e-mail hardin_waddle@usgs.gov); **MARQUETTE E. CROCKETT**, Florida Cooperative Fish and Wildlife Research Unit, Box 110485, University of Florida, Gainesville, Florida 32611-0485, USA; and **KENNETH G. RICE**, U.S. Geological Survey, Florida Integrated Science Center, 3205 College Avenue, Ft. Lauderdale, Florida 33314, USA.

PHYLLOMEDUSA SAUVAGII. ARGENTINA: SAN JUAN: DEPARTAMENTO VALLE FÉRTIL: 250 km San Juan city on Astica, Ruta Provincial N° 510 (30°59'S, 67°22'W), January 2004. M. Jordan and E. Herrera. Herpetological Collection, Instituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan, Argentina (IMCN-UNSJ 5010). Verified by G. Blanco. Previously known from Jujuy, Formosa, Chaco, Corrientes, Cordoba, Salta, Santiago del Estero, Santa Fe, La Rioja flats westward and San Luis provinces in Argentina (Ceí 1980. Mon. II Mus. Reg. Sci. Nat. Torino, 609 pp.; Lavilla et al. 2000. Categorización de los Anfibios y Reptiles de la República Argentina. Asociación Herpetológica Argentina, 97 pp; Lavilla and Ceí 2001. Mon. XXVIII Mus. Reg. Sci. Nat. Torino, 179 pp.). First province record, extends the known range ca. 150 km W of the nearest locality (Potrero de los Funes, San Luis Province) (Avila and Carrizo 2003. Acta Zool. Lilloana 47[1–2]:93–115; Lavilla and Ceí 2001, *op. cit.*).

Submitted by **EDUARDO A. SANABRIA, LORENA B.**

QUIROGA, and **JUAN C. ACOSTA**, Departamento de Biología e Instituto y Museo de Ciencias Naturales, F.C.E.F. y N., Universidad Nacional de San Juan, Avenida España 400 (N) C.P. 5400, San Juan, Argentina.

PLEURODEMA NEBULOSUM (Mendoza Four-eyed Frog). ARGENTINA: NEUQUÉN: DEPARTAMENTO AÑELO (38°21'S, 68°47'W): Arroyo Ojos de Agua. 14 November 1976. O. de Ferrariis. Museo Argentino de Ciencias Naturales “Bernardino Rivadavia,” Buenos Aires, Argentina (MACN 36078); Auca Mahuida (37°53'S, 68°31'W). April 1945. O. Adams (MACN 7980). DEPARTAMENTO CATAN-LIL (39°33'S, 70°35'W): Charahuilla. 04 February 1973. O. de Ferrariis. Colección del Centro Nacional de Investigaciones Iológicas, housed at MACN (CENAI 7081). First province records, extends known distribution 275 km W from previous closest record (General Roca, La Pampa Province; Gallardo 1965. Rev. Mus. Arg. Cs. Nat. B. Rivadavia [Zool.], 1 [2]:57–77). SALTA: DEPARTAMENTO CAFAYATE (26°06'S, 65°57'W): Cafayate. 11 January 1991. J. McGuire. Fundación Miguel Lillo, Tucumán, Argentina (FML 5245); Cafayate, on Ruta Nacional N° 68, between 8 and 12 km N of its intersection with Ruta Provincial N° 40. 11 January 1991. R. Etheridge (FML 5246, three specimens); Cafayate, Los Médanos. 02 January 1993. N. Abdala (FML 5232, three specimens). DEPARTAMENTO SAN CARLOS (25°53'S, 65°56'W): San Carlos, ca. 10 km E from Animaná. 04 January 1993. E. O. Lavilla (FML 5234, two specimens). First vouchered specimens reported, attributed to Salta Province by Lavilla (1999. Anfibios. In E. O. Lavilla and J. A. González [eds.], Biodiversity of Agua Rica, Catamarca, Argentina. Fund. M. Lillo - BHP Copper). DEPARTAMENTO ANTA (24°55'S, 64°28'W): Finca Los Colorados. 13 January 2000. E. O. Lavilla and R. Heyer (FML 9094–96). First department record. Salta Province reports extends known distribution 350 km NE from previous closest record (Andalgalá, Catamarca Province; Lavilla 1999, *op. cit.*). TUCUMÁN: DEPARTAMENTO TAFÍ DEL VALLE: Quilmes (26°30'S, 66°00'W). 18 January 1975. R. Laurent and C. Halloy (FML 2427, 43 specimens). New province record, referred to by Laurent as Tucumán Province (1969. Acta Zool. Lilloana 25[7]:81–96). This report extends known distribution 102 km NE from previous closest record (Andalgalá, Catamarca Province; Lavilla 1999, *op. cit.*). Boundary between CATAMARCA and TUCUMÁN Provinces: Arroyo los Médanos, between Santa María and Amaicha del Valle. 20 January 1975. R. Laurent and C. Halloy (FML 2425, 3 specimens); ca. 10 km from bridge of Santa María River. 25 January 1975. R. Laurent and C. Halloy (FML 2429, 2 specimens). New record for this area, extends known distribution ca. 111 km N from previous closest record (Andalgalá, Catamarca Province; Lavilla 1999, *op. cit.*). All specimens verified by Esteban O. Lavilla. The previous geographical range of this species includes the western Argentine provinces from Catamarca to Río Negro (Aun and Martori 1999. Herpetol. Rev. 30[4]:231; Ceí 1980. Amphibians of Argentina. Monit. Zool. Ital. [N.S.] Monogr. 2: [i–xii] + 1–609) and Tucumán Province (Laurent 1969, *op. cit.*).

Submitted by **DAIANA PAOLA FERRARO**, Sección Herpetología, División Zoología Vertebrados, Museo de La Plata, Paseo del Bosque S/N° (1900) La Plata, Buenos Aires, Argentina; e-mail: dferraro@fcnym.unlp.edu.ar.

PSEUDACRIS FERIARUM FERIARUM (Upland Chorus Frog). USA: TEXAS: LA SALLE CO.: Approximately 12 km E of Cotulla on Hwy 97, ca. 30 m S of the highway. 13 March 2004. Joshua R. Engelbert and Robert C. Jadin. Verified by Jonathan A. Campbell. UTA – Collection of Vertebrates (UTA Slide No. 31331–32). Caught in small flooded area about an hour before sunset, during intermittent rain. Photographed and released. New county record (Dixon 2000. *Amphibians and Reptiles of Texas*. 2nd Ed. Univ. of Texas A&M Press, viii + 421 pp.).

Submitted by **ROBERT C. JADIN** (e-mail: snakeman1982@hotmail.com) and **JOSHUA R. ENGELBERT**, Northeastern State University, Tahlequah, Oklahoma 74464, USA (e-mail: okieherper@yahoo.com).

PSEUDIS PARADOXA (NCN). VENEZUELA: FALCÓN: MUNICIPIO MAUROA: embalse de Matícora (10°40'N, 70°55'W). 28 January 2000. T. Barros. Museo de Biología de La Universidad del Zulia, Maracaibo (MBLUZ-A-0102). Verified by G. Rivas Fuenmayor. The species occurs east of the Andes from Colombia, Venezuela and the Guianas to northern Argentina. (La Marca 1992, *Catálogo Taxonómico, Biogeográfico y Bibliográfico de las Ranas de Venezuela*, Cuadernos Geográficos, No. 9, Universidad de Los Andes, Mérida, 197 pp.). In Venezuela it has a wide distribution in the lowland savannas below 300 m (Barrio 1998. *Acta. Biol. Venez.* 18[2]:1–93; Gorzula and Señaris 1998. Contribution to the Herpetofauna of the Venezuelan Guayana I. A Data Base, *Scientia Guaianae*, No. 8, Caracas, 269 pp.; Pefaur and Rivero 2000. *Amph. Rept. Cons.* 2[2]:42–70; Rivero 1964. *Carib. J. Sci.* 4[1]:307–319). First state record and northernmost locality for the country, extends known range ca. 130 km N from La Ceiba in Trujillo state (Barrio, *op. cit.*).

Submitted by **FERNANDO ROJAS RUNJAIC** (e-mail: rojas_fernando@hotmail.com), **TITO BARROS BLANCO** (e-mail: trbarros@cantv.net), and **EDWIN INFANTE RIVERO** (e-mail: edwininfantembluz@hotmail.com), La Universidad del Zulia, Facultad Experimental de Ciencias, Museo de Biología de La Universidad del Zulia, Sección de Herpetología, Apartado Postal 526, Maracaibo 4011, Venezuela.

PSEUDIS TOCANTINS (NCN). BRAZIL: MARANHÃO: MUNICIPALITY OF PORTO FRANCO: 'Fazenda Maravilha' (06°00'38.2"S, 47°25'43.9"W), 162 m elev. 07 January 2005. E. M. Lucas. Célio F. B. Haddad collection, Departamento de Zoologia, Universidade Estadual Paulista, Rio Claro, São Paulo (CFBH 8132). Verified by C. F. B. Haddad. Species previously known from type locality, Municipality Porto Nacional, state of Tocantins, Brazil (10°42'S, 48°25'W, 212 m elev., Caramaschi and Cruz 1998. *Rvta. Brasil. Zool.* 15:929–944); Bananal Island National Park region (10°28'12"S, 50°28'48"W), Municipality of Santa Terezinha, State of Mato Grosso, and Municipality of Britania (15°14'34"S; 51°10'44"W), state of Goiás, Brazil (Brandão et al. 2003. *Phyllomedusa* 2:69–70). First state record, extends the distribution ca. 595 km N from type locality in Tocantins State.

Submitted by **ELAINE M. LUCAS**, Departamento de Ecologia, Universidade de São Paulo, CP 11461, CEP 05508-900, São Paulo, Brazil; and **CINTHIA A. BRASILEIRO**, Museu de História Natural, Instituto de Biologia, Universidade Estadual de Campinas, CP 6109, 13083-970 Campinas SP, Brazil (e-mail: elainelg@ib.usp.br).

RANA PALMIPES (Amazon River Frog). BRAZIL: ALAGOAS: Passo de Camarajibe (09°15'S, 35°26'W). 13–17 January 1988. H. R. Silva, L. C. Carcerelli, C. C. Geovannini, and D. Teixeira. Museu Nacional - Universidade Federal do Rio de Janeiro. Rio de Janeiro, Brazil (MNRJ 9903). 26–30 June 1988. D. Teixeira. (MNRJ 9797). Murici (09°19'S, 35°56'W). 8 January 1988. D. Teixeira, H. R. Silva, L. C. Carcerelli, C. A. Caetano, L. Geovannini, and L. A. Caetano. (MNRJ 9725). BAHIA: Caravelas (17°45'S, 39°15'W). 1876. Rathbun (Comm. Geol. do Brasil). (MNRJ 494). MATO GROSSO: Matupá (10°03'S, 54°58'W). 6 March 1990. C. Yamashita. (MNRJ 35796–97). PARÁ: Cachimbo (08°57'S, 54°54'W). 25 September – 9 October 1956. L. Travassos, Oliveira, and Adão col. (MNRJ 3319, 13764–71). Jacareacanga (06°16'S, 57°39'W). July 1951. H. Sick. (MNRJ 35795). All verified by José P. Pombal, Jr. The species has a broad distribution in northern South America (Miranda-Ribeiro 1923. *Rev. Mus. Paulista* 13:801–809), but published data are lacking for most of Brazilian Amazon according to Bernardi et al. 1999. *Herpetol. Rev.* 30:176–177. The species occurs in Bolivia, Brazil, Colombia, Ecuador, Guyana, French Guyana, Peru, Trinidad, and Venezuela. In Brazil, the published distribution is limited to states of Amazonas, Mato Grosso, Pará, Paraíba, Pernambuco, and Rio Grande do Norte (Bernardi et al. 1999, *op. cit.*; Hillis and de Sá 1988. *Herpetol. Monogr.* 2:1–26; Strussmann and Carvalho 1998. *Herpetol. Rev.* 29:183–185). Herein, we present the first state records for Alagoas and Bahia, northeastern Brazil. These new records extend by ca. 1170 km the southern range limits for this species in northeastern Brazil. The other records corroborate occurrence of the species in the Brazilian Amazon.

Submitted by **CLARISSA CANEDO** and **MARCOS BILATE**, Departamento de Vertebrados, Museu Nacional/UFRJ, Quinta da Boa Vista s/n, São Cristovão, Rio de Janeiro, RJ, Brazil, 20940–040; e-mail: canedo@mn.ufrj.br.

RANA SPHENOCEPHALA (Southern Leopard Frog). USA: ARKANSAS: CLEVELAND CO: Roadside ditch 5.1 km SW of Rison, AR (Sec. 27, T9S, R11W). 20 May 2005. H. W. Robison. Arkansas State University Museum of Zoology, Herpetological Collection (ASUMZ 29327). Verified by Stanley E. Trauth. New county record in southern Arkansas (Trauth et al. 2004. *Amphibians and Reptiles of Arkansas*, Univ. of Arkansas Press, Fayetteville).

Submitted by **HENRY W. ROBISON** and **JANET RADER**, Department of Biological Sciences, Southern Arkansas University, Magnolia, Arkansas 71754-9354, USA; e-mail: hwrobison@saumag.edu.

RHACOPHORUS ORLOVI (Orlov's Tree Frog). VIETNAM: GIA LAI PROVINCE: AN KHE DISTRICT: Buon Luoi Village, 20 km NW of Kannack Town (14°20'N, 108°36'E), on leaf of an Araceae plant near a stream, 700–750 m elev., 1700–1900 h, 06 April 1995. Nikolai L. Orlov and Ilya Darevsky. FMNH 253156. Verified by Robert F. Inger. First record for southern Vietnam. Known previously from Ninh Binh, Nghe An, Ha Tinh (type locality), and Quang Binh Provinces in northern and central Vietnam (Ziegler and Köhler 2001. *Sauria* 23:37–46; Orlov et al. 2002. *Russ. J. Herpetol.* 9:81–104; Ziegler et al. 2002. *Herpetol. Rev.* 33:146). This record extends the known range of the species at least 350 km southward. This specimen was reported as

Rhacophorus bimaculatus (type locality Mindanao, Philippines) by Inger et al. 1999 (Fieldiana, Zool., N.S. 92:1–46) and Orlov and Ho (2000. Herpetofauna 22:5–15), and is illustrated in life in the latter reference. Ziegler and Köhler (2001. Sauria 23:37–46) did not examine this specimen, but suggested that it might be referable to *R. cyanopunctatus* (type locality Surat Thani Province, southern Thailand) based on its locality. Other records of *R. bimaculatus* from Vietnam (Gia Lai and Kon Tum Provinces in Orlov et al. 2002. Russ. J. Herpetol. 9:81–104) might also refer to *R. orlovi*. Orlov et al. 2002 (Russ. J. Herpetol. 9:81–104) remarked that *R. bimaculatus*, *R. cyanopunctatus*, *R. hoanglienensis* (type locality Lao Cai Province, northern Vietnam), and *R. orlovi* form a complex of closely-related species, and this might account for misidentifications.

Submitted by **BRYAN L. STUART**, The Field Museum, Department of Zoology, 1400 S. Lake Shore Drive, Chicago, Illinois 60605-2497, USA; e-mail: bstuart@fieldmuseum.org.

SPEA INTERMONTANA (Great Basin Spadefoot) USA: OREGON: UNION CO.: (45°15'885"N, 117°57'574"W, 845.5 m elev.). 13 May 2005. Laura A. Mahrt. Verified by Burr Betts. Eastern Oregon University Vertebrate Museum (A05-1). New county record (Leonard et al. 1993. Amphibians of Washington and Oregon, Seattle Audubon Society, Seattle. 168 pp.).

Submitted by **LAURA A. MAHRT**, Science Office, One University Blvd., Eastern Oregon University, La Grande, Oregon 97850, USA (e-mail: lmahrt@eou.edu); and **M. CATHY NOWAK** Ladd Marsh Wildlife Area, 59116 Pierce Road, La Grande, Oregon 97850, USA (e-mail: mcnowak@eoni.com).

SCINAX FUSCOVARIUS (Snouted Treefrog). ARGENTINA: CATAMARCA: EL ALTO DEPARTAMENT: Rosario de Abajo (ca. 28°37'S, 65°25'W), 500–750 m elev. 5 February 2004. D. Baldo and S. D. Rosset. Verified by G. R. Carrizo. Herpetological collection Museo de La Plata, La Plata, Buenos Aires, Argentina (MLP-DB 2666–2667). Male and female in amplexus, found on the bank of a small stream in the Sierra de Ancasti. Species previously known from Corrientes, Chaco, Entre Ríos, Formosa, Jujuy, Misiones, Salta, Santiago del Estero, Santa Fe, and Tucumán (Lavilla et al. 2000. In Lavilla et al. [eds.], Categorización de los Anfibios y Reptiles de la República Argentina, pp. 11–34, Edición Especial Asociación Herpetológica Argentina, Tucumán, Argentina). First province record, extends the species range ca. 80 km S from Tucumán (Lavilla et al., *op. cit.*).

Submitted by **DIEGO BALDO**, Laboratorio de Genética Evolutiva y Molecular, Departamento de Genética, Facultad de Ciencias Exactas, Químicas y Naturales, Universidad Nacional de Misiones, Félix de Azara 1552, 3300 Posadas, Misiones, Argentina, and **SERGIO D. ROSSET**, Instituto de Limnología “Dr. Raúl A. Ringuelet” cc 712, 1900 La Plata, Buenos Aires, Argentina.

TESTUDINES

ACANTHOCELYS MACROCEPHALA (Pantanal Swamp Turtle). BRAZIL: MATO GROSSO DO SUL: Corumbá (Nhumirim Farm: 18°57'S, 56°37'W) and Aquidauana (Rio Negro Farm: 19°34'S, 56°14'W). 1–15 October 2002. M. A. Kinas and F. L. Souza. Verified by A. S. Abe. Zoological Collection of Department Biology, Universidade Federal de Mato Grosso do

Sul, Brasil (ZUFMS-CHEL: 0001–0007). Intact carapace, plastron and bones found around bays and salt lagoons. These are the first species records for Mato Grosso do Sul State, better defining the Paraguay River basin as the core geographical distribution area for this species. These records are ca. 260 km straightline south from Mato Grosso State and 290 km N of Puerto Casado, Paraguay, the closest locality records (Rhodin et al. 1984. Herpetologica 40:38–46).

Submitted by **MARCO AURÉLIO KINAS**, Universidade Federal de Mato Grosso do Sul, Centro de Ciências Biológicas e da Saúde, Departamento de Biologia, 79070-900, Campo Grande, Mato Grosso do Sul, Brazil; **RODINEY DE ARRUDA MAURO**, Empresa Brasileira de Pesquisa Agropecuária, Caixa Postal 154, 79002-970, Campo Grande, Mato Grosso do Sul, Brazil; and **FRANCO LEANDRO SOUZA**, Universidade Federal de Mato Grosso do Sul, Centro de Ciências Biológicas e da Saúde, Departamento de Biologia, 79070-900, Campo Grande, Mato Grosso do Sul, Brazil (e-mail: flsouza@nin.ufms.br).

CUORA GALBINIFRONS (Indochinese Box Turtle). VIETNAM: LAO CAI PROVINCE: VAN BAN DISTRICT: Hoang Lien Mountain Range: Nam Tha forest, 21°55'23"N, 104°22'43"E, ca. 640 m elev. 01 September 2004. Raoul H. Bain, Nguyen Quang Truong, and Doan Van Kien. Institute of Ecology and Biological Resources (IEBR 1497, with field tag AMNH FS-16418). Verified by Bryan L. Stuart. In Vietnam, this species has been reported only from some central and northeastern provinces. This is the first record for northwestern Vietnam including Lao Cai Province (Nguyen et al. 1996. A Checklist of Amphibians and Reptiles of Vietnam. Agricultural Publishing House of Vietnam, Hanoi, pp. 115–116).

Submitted by **NGUYEN QUANG TRUONG** and **DOAN VAN KIEN**, Department of Vertebrate Zoology, Institute of Ecology and Biological Resources, 18 Hoang Quoc Viet, Hanoi, Vietnam; and **RAOUL BAIN**, Center for Biodiversity and Conservation, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024, USA.

AMPHISBAENIA

AMPHISBAENA DUBIA (Uncertain Worm Lizard): BRAZIL: MINAS GERAIS: Ritópolis (20°59'47"S, 44°16'20.5"W). 07 December 2002, collector unknown. Coleção Herpetológica, Universidade Federal de Juiz de Fora, Juiz de Fora, Minas Gerais (CH-UFJF 209). Verified by S. Potsch de Carvalho e Silva. Previously known from Santa Catarina, Paraná, and São Paulo States, Brazil, and Formosa, Argentina (Gans 1964. Breviora 205:1–11; Montero 1996. Cuad. Herpetol. 10[1–2]:25–45; Vanzolini 2002. Papéis Avulsos Zool. S. Paulo 42[15]:351–362). First state record, extends known distribution ca. 230 km NE from Campos do Jordão, São Paulo State, the nearest previously known locality (Gans 1964, *op. cit.*)

Submitted by **JOSÉ DUARTE DE BARROS FILHO**, Laboratório de Anfíbios e Répteis, Universidade Federal do Rio de Janeiro, Rio de Janeiro-RJ, Cx.P. 68044, CEP 21944-970, Brazil (e-mail: jduartef@biologia.ufjf.br); **BERNADETE MARIA DE SOUSA** (e-mail: bernadete.sousa@ufjf.edu.br) and **ROSE MARIE HOFFMANN DE CARVALHO** (e-mail: rosemarie@acessa.com), Laboratório de Herpetologia, Universidade Federal de Juiz de Fora, Minas Gerais, Brazil.

LACERTILIA

ANOLIS CAROLINENSIS CAROLINENSIS (Northern Green Anole). USA: ARKANSAS: CHICOT Co.: Lake Village city limits (Sec. 3, T16N, R2W). 30 May 2005. H. W. Robison. Arkansas State University Museum of Zoology, Herpetological Collection (ASUMZ 29328). Verified by Stanley E. Trauth. New county record in extreme southeastern Arkansas (Trauth et al. 2004. *Amphibians and Reptiles of Arkansas*, Univ. of Arkansas Press, Fayetteville).

Submitted by **HENRY W. ROBISON** and **JANET RADER**, Department of Biological Sciences, Southern Arkansas University, Magnolia, Arkansas 71754-9354, USA; e-mail: hwrobison@saumag.edu.

ANOLIS PENTAPRION (Lichen Anole). MÉXICO: VERACRUZ: MUNICIPALITY OF LAS CHOAPAS: Batería Los Soldados (17°57'49.4"N; 94°06'52.2"W), 7 m elev. 5 July 2003. José Luis Aguilar López. Museo de Zoología, Facultad de Ciencias, Universidad Nacional Autónoma de México (MZFC 16574). Verified by Edmundo Pérez Ramos. Second record for Veracruz and bridges the distributional gap between recorded localities in the Los Tuxtlas region, ca. 132 km to the NE, and records ca. 225 km ESE from near Palenque, Chiapas (Lieb 2001. *In* Johnson et al. [eds.], *Mesoamerican Herpetology: Systematics, Zoogeography, and Conservation*, pp. 53–64. Centennial Mus. Spec. Publ. No. 1, University of Texas at El Paso). The specimen was found on a tree branch in a tropical semideciduous forest.

Submitted by **JOSE LUIS AGUILAR LÓPEZ**, Laboratorio de Herpetología, Escuela de Biología, Benemérita Universidad Autónoma de Puebla, C.P. 72570, Puebla, México (e-mail: bothrops_asper@hotmail.com); **LUIS CANSECO MÁRQUEZ** (e-mail: lcm@correo.unam.mx) and **URI OMAR GARCÍA VÁZQUEZ**, Museo de Zoología, Facultad de Ciencias, Universidad Nacional Autónoma de México, A.P. 70-399, México, D.F. 04510, México.

ANOLIS SAGREI (Brown Anole). USA: FLORIDA: OKALOOSA Co: Fort Walton Beach, Uptown Station shopping center, 99 Eglin Parkway (FL Hwy 85), 30°25'9"N, 86°36'22"W. 16 July 2002. David C. Bishop. Verified by Kenneth Krysko. University of Florida (UF 133632, 133633). New county record (Campbell 1996. *Herpetol. Rev.* 27:155–157). Male and female captured in copulation. Another female and four juveniles observed.

Submitted by **DAVID C. BISHOP**, Department of Fisheries and Wildlife Sciences, Virginia Tech University, Blacksburg, Virginia 24061-0321, USA; e-mail: dabishop@vt.edu.

BACHIA HETEROPA LINEATA (NCN). VENEZUELA: TRUJILLO: MUNICIPIO PAMPANITO: Urbanización “El Prado” (9°25'N, 70°27'W), 480 m. 20 November 2002. C. Cuevas. Museo de Biología de La Universidad del Zulia, Maracaibo (MBLUZ-R-0763). Specimen found on sandy ground in residential garden. ZULIA: MUNICIPIO JESÚS MARÍA SEMPRÚN: Casigua-El Cubo (8°45'N, 72°30'W). 12 August 1965. R. Hernández. Museo de Historia Natural La Salle, Caracas (MHNS 2497). Both verified by G. Rivas. The distribution of this subspecies is restricted to Venezuela (Dixon 1973. *Univ. Kansas, Mus. Nat. Hist., Misc. Publ.* [57]:47 pp.). The previously known range included the Capital District and Falcón, Yaracuy, and Portuguesa states (Dixon, *op.*

cit.; Donoso-Barros 1968. *Carib. J. Sci.* 8[3–4]:105–122; Esqueda et al. 2001. *Herpetol. Rev.* 32[3]:198–200; Markezich 2002. *Herpetol. Rev.* 33[1]:69–74; Mijares and Arends 1999. *Herpetol. Rev.* 30[2]:115). First records for these two states of the Maracaibo Lake Basin, and the westernmost localities for the subspecies. MHNS 2497 extends the distribution ca. 210 km W (airline) from the nearest known locality (Markezich, *op. cit.*).

Submitted by **FERNANDO ROJAS** (e-mail: rojas_fernando@hotmail.com) and **EDWIN INFANTE** (e-mail: edwininfantemluz@hotmail.com), La Universidad del Zulia, Facultad Experimental de Ciencias, Museo de Biología de La Universidad del Zulia, Sección de Herpetología, Apartado Postal 526, Maracaibo 4011, Venezuela.

CHALCIDES OCELLATUS OCELLATUS (Ocellated Skink). LIBYA: NAULT PROVINCE (Sha'abeyyat Nalut): Ain Al-Khenjari (31°59'33"N, 11°36'12"E). Collected from an oasis ca. 190 km SW of Tripoli. 21 March 2004. Asmaa Mohammad Ali. Muséum National d'Histoire Naturelle, Paris (MNHN 2004.0084). SVL = 97 mm. Verified by Ivan Ineich. Several other individuals were also collected from the same locality during spring and summer. First provincial record (Schleich et al. 1996. *Amphibians and Reptiles of North Africa*. Koeltz Scientific Publishers, Koenigstein; Frynta et al. 2000. *Acta. Soc. Zool. Bohem.* 64:17–26).

Submitted by **ADEL A. IBRAHIM**, Faculty of Education at Al-Arish, Suez Canal University, North Sinai, Egypt; e-mail: Laudakia@hotmail.com.

CNEMIDOPHORUS LONGICAUDA (Long-tailed Whiptail). ARGENTINA: CHUBUT: TELSEN: Sand flats along Telsen stream, on the edges of Ruta Provincial 61, 40.3 km S junction Ruta Provincial 1 (42°44'48.8"S, 66°59'54.8"W, 117 m elev.). 02 February 2005. N. Frutos and L. Camporro. Herpetological Collection Museo de La Plata, La Plata, Buenos Aires (MLP.S 2584). Verified by N. Basso. First province record (Ceí 1986. *Mon. IV. Mus. Reg. Sc. Nat. Torino*: 1–427), and southernmost record for the species, extending known range 238 km S (airline) from Valcheta, Rio Negro province (Cabrera 2004. *Amphibia-Reptilia* 25:265–275).

Submitted by **NICOLAS FRUTOS** (e-mail: frutos@cenpat.edu.ar), **LEONARDO CAMPORRO** (e-mail: leocamporro@hotmail.com), and **LUCIANO JAVIER AVILA** (e-mail: avila@cenpat.edu.ar), CENPAT-CONICET, Boulevard Almirante Brown s/n, U9120ACV, Puerto Madryn, Chubut, Argentina.

EUTROPIS LONGICAUDATA (Long-tailed Sun Skink). MYANMAR: MANDALAY DIVISION: PYIN-Oo-LWIN DISTRICT: Tha Baik Kyin Town, Shwe-U-Daung Wildlife Sanctuary (headquarters) (22°53'29.3"N, 95°59'27.7"E, WGS84). 28 September 2000. Htun Win and San Lwin Oo. California Academy of Sciences (CAS) 216129. SHAN STATE: YWANGAN TOWNSHIP: Panlaung-Pyadalin Cave Wildlife Sanctuary, entrance to Pyadalin Cave (21°07'58.4"N, 96°20'25.0"E, WGS84). 14 July 2002. Rhonda S. Lucas, Guin O.U. Wogan, Jens V. Vindum, Htun Win, Thin Thin, Kye Soe Lwin, Awan Khwi Shein, and Hla Tun. CAS 230469. SHAN STATE: YWANGAN TOWNSHIP: Panlaung-Pyadalin Cave Wildlife Sanctuary (21°07'17.3"N, 96°21'19.1"E, WGS84).

Rhonda S. Lucas, Guin O.U. Wogan, Jens V. Vindum, Htun Win, Thin Thin, Awan Khwi Shein, and Hla Tun. CAS 230538. All identifications verified by George R. Zug. New country record. Given that *E. longicaudata* (formerly known as *Mabuya longicaudata*: see Mausfeld et al. 2002. Zool. Anz. 241:281–293) occurs in a broad area of southeastern Eurasia and adjacent islands, including Taiwan, Hong Kong, Hainan, southern continental China, and parts of Southeast Asia (Manthey and Grossmann 1997. Amphibien und Reptilien Südasiens. Natur und Tier-Verlag, Münster, 512 pp.; Taylor 1963. Univ. Kansas Sci. Bull. 44:687–1077), the species might actually represent a complex of more than one morphologically similar species. Further detailed studies examining both morphological and genetic variation among samples from throughout the entire range of *E. longicaudata* are needed.

Submitted by **MARLENE GONZALEZ**, University of San Francisco, College of Arts and Sciences, 2130 Fulton Street, San Francisco, California 94117, USA; and **JENS V. VINDUM**, Department of Herpetology, California Academy of Sciences, 875 Howard Street, San Francisco, California 94103, USA.

LIOLAEMUS OLONGASTA (NCN). ARGENTINA: MENDOZA: DEPARTAMENTO LAS HERAS: 60 km Mendoza city on Puesto Sta. Clara de Abajo, Ruta Provincial N° 319 (32°40'S, 69°10'W), January 2004. L. Quiroga and E. Sanabria, Herpetological Collection, Instituto y Museo de Ciencias Naturales, Universidad Nacional de San Juan, Argentina (IMCN-UNSJ 5009). Verified by G. Blanco. This species is distributed in two localities in extreme western La Rioja Province at elevations between 900 and 1600 m and west of San Juan Province to the Cerrillo Barboza (Etheridge 1993. Boll. Mus. Reg. Sci. Nat. Torino 11[1]:137–199; Avila et al. 1998. Cuad. Herpetol. 12[1]:11–29). First province record. Extends known range (Avila et al. 1998, *op cit.*) ca. 75 km SW of the nearest locality (Cerrillo Barboza, Departamento Rawson, San Juan Province).

Submitted by **EDUARDO A. SANABRIA**, **LORENA B. QUIROGA**, and **JUAN C. ACOSTA**, Departamento de Biología e Instituto y Museo de Ciencias Naturales, F.C.E.F. y N., Universidad Nacional de San Juan, Avenida España 400 (N) C.P. 5400, San Juan, Argentina.

MESOSCINCUS ALTAMIRANI (Tepalcatepec Skink). MÉXICO: MICHOACÁN: MUNICIPALITY OF HUETAMO: Rancho El Zipiate, 8 km from the west bank of the Río Balsas (18°37'03"N, 100°54'54"W), 330 m elev. 04 November 2003. D. Suazo and J. Alvarado. Colección Herpetologica, Instituto de Investigaciones sobre los Recursos Naturales, Universidad Michoacana (HINIRENA 452). GUERRERO: Municipality of Zirandaro: Rancho El Tecolote, 500 m from the east bank of the Río Balsas (18°30'48"N, 101°00'37"W), 215 m elev. 27 March 2004. D. Suazo and I. Suazo. HINIRENA 481. Both specimens verified by Alfredo Estrada-Virgen.

Each specimen was found in the southern part of the Río Balsas Basin and both represent substantial range extensions for the species. HINIRENA 481 is the first record from Guerrero and is a ca. 180 km range extension NW from nearest known record at the type locality, Apatzingán, Michoacán. The location of HINIRENA 452 is ca. 155 km SE of the type locality. Both skinks were located in areas containing tropical dry forest.

Submitted by **JAVIER ALVARADO-DIAZ** (e-mail: jadiaz@zeus.umich.mx) and **IRERI SUAZO-ORTUÑO**, under CIC, Universidad Michoacana Project 5.5, Laboratorio de Herpetología, Instituto de Investigaciones sobre los Recursos Naturales, Universidad Michoacana, Av. San Juanito Itzicuaró s/n, Col San Juanito Itzicuaró, Morelia, Michoacán 58330, México.

SCINCELLA SILVICOLA CAUDAEQUINAE (Horsetail Falls Ground Skink). MÉXICO: COAHUILA: MUNICIPALITY OF ARTEAGA: Los Lirios, ca. 8 km E of Arteaga (25°24'00"N, 100°28'18"W). 30 May 1998. David Lazcano Villarreal. Colección Herpetología de la Universidad Autónoma de Nuevo León (UANL 5255). Verified by Andrés Alberto Mendoza-Hernández. First record for Coahuila, extending its known range ca. 42.5 km (air-line) NW of Laguna Santiago, Nuevo León (Smith 1951. Univ. Kansas Sci. Bull. 34:195–200). The specimen was found in pine forest.

Submitted by **URI OMAR GARCÍA-VÁZQUEZ**, Museo de Zoología, Facultad de Ciencias, UNAM, A.P. 70-399, México D.F. 04510, México (e-mail: urigarcia@gmail.com); **DAVID LAZCANO-VILLARREAL** (e-mail: dvlazcano@hotmail.com), **MARIA CRISTINA GARCIA-DE LA PEÑA**, and **GAMALIEL CASTAÑEDA**, Laboratorio de Herpetología, Universidad Autónoma de Nuevo León. A.P. 513, San Nicolás de los Garza, Nuevo León, 66450, México.

SCINCOPUS FASCIATUS FASCIATUS (Banded Skink). LIBYA: NAULT PROVINCE (Sha'abeyyat Nalut): Badr Village (32°02'27"N, 11°32'38"E). Collected from a farm ca. 200 km SW of Tripoli. 2 March 2004. Amna Al-Bahi. Muséum National d'Histoire Naturelle, Paris (MNHN 2004.0081). SVL = 149 mm. Verified by Ivan Ineich. First provincial record (Frynta et al. 2000. Acta. Soc. Zool. Bohem. 64:17–26) and second country record (Sindaco 1995. Bull. Mus. Reg. Sci. nat. Torino, pp. 117–122; Schleich et al. 1996. Amphibians and Reptiles of North Africa. Koeltz Scientific Publishers, Koenigstein). The known range of this species extends from south Mauritania to Sudan (Schleich et al. 1996, *op. cit.*). This is the only specimen of the species collected during a survey from November 2003 to July 2004.

Submitted by **ADELA. IBRAHIM** Faculty of Education at Al-Arish, Suez Canal University, North Sinai, Egypt; e-mail: Laudakia@hotmail.com.

SPHENOMORPHUS INCERTUS (Stuart's Forest Skink). HONDURAS: CORTÉS: Sierra de Omoa, Parque Nacional El Cusuco, near Centro de Visitantes (15°30'N, 88°13'W), 1570 m elev. 2 March 2005. Josiah H. Townsend. Florida Museum of Natural History (UF 144061). Verified by Kenneth L. Krysko. First record for Cortés, Parque Nacional El Cusuco, and the Cordillera de Merendón (Wilson and McCranie 2004. Herpetol. Bull. 87:13–24), and bridges a distributional gap between localities located 100 km E in Refugio de Vida Silvestre Cerro Texiguat, Yoro, Honduras (Wilson and McCranie 1994. Amphibia-Reptilia 15:416–421) and 185 km W near Purulha, Baja Verapaz, Guatemala (KU 187230–32). The skink was found on a trail going through mixed pine-broadleaf forest.

Submitted by **JOSIAH H. TOWNSEND**, Tropical Conservation and Development Program, Center for Latin American Stud-

ies and Division of Herpetology, Florida Museum of Natural History, University of Florida, Gainesville, Florida, 32611-7800, USA; e-mail: jtownsend@flmnh.ufl.edu.

UROSAURUS ORNATUS LATERALIS (Coastal Tree Lizard). MEXICO: CHIHUAHUA: MUNICIPIO MORIS: Santa María (28°12'20.9"N, 108°31'36.7"W), 794 m elev. 23 September 2003. Julio A. Lemos-Espinal. Herpetological collection of Unidad de Biología, Tecnología y Prototipas (UBIPRO 11638, 11711–2). Verified by Richard L. Holland. First record for Chihuahua, extending its known range ca. 75 km from nearby San Miguel, Sinaloa (Hardy and McDiarmid 1969. Univ. Kansas Publ. Mus. Nat. Hist. 18[3]:39–252) and Guirocoba, Sonora (Bogert and Oliver 1945. Bull. Am. Mus. Nat. Hist. 83:297–426).

Submitted by **HOBART M. SMITH**, Department of EE Biology, University of Colorado, Boulder, Colorado 80309-0334, USA (e-mail: hsmith@colorado.edu); **JULIO A. LEMOS-ESPINAL** (under DGAPA-PASPA and CONABIO projects BE002, CE001 and CE002), Laboratorio de Ecología, UBIPRO, Facultad de Estudios Superiores Iztacala, UNAM, Apartado Postal 314, Avenida de los Barrios 1, Los Reyes Iztacala, Tlalnepantla, edo. de México, 54000 México (e-mail: lemos@servidor.unam.mx); and **DAVID CHISZAR**, Department of Psychology, University of Colorado, Boulder, Colorado 80309-0345, USA; e-mail: chiszar@clipr.colorado.edu.

SERPENTES

AGKISTRODON PISCIVORUS LEUCOSTOMA (Western Cottonmouth). USA: TEXAS: CALDWELL CO.: 0.9 mi. W of Martindale on Hwy 1979 (N29°50.009', W97°50.529'), 520 ft elev. 5 May 2005. James R. Dixon. Verified by Kathryn Vaughan, Texas A&M University Texas Cooperative Wildlife Collection (TCWC 89762). New county record (Dixon 2000. Amphibians and Reptiles of Texas. Second Edition. Texas A&M University Press, College Station, Texas, 421 pp.). The female specimen was found DOR just east of the Blanco River bridge, and measured 65 cm SVL, tail 10.2 cm.

Submitted by **SHAWN F. MCCracken**, Texas State University, Department of Biological Sciences, 601 University Drive, San Marcos, Texas 78666-4615, USA (e-mail: smccracken@txstate.edu); **JAMES R. DIXON**, Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, Texas 77843-2258, USA; and **MICHAEL R. J. FORSTNER**, Texas State University, Department of Biological Sciences, 601 University Drive, San Marcos, Texas 78666-4615, USA.

BOTHROPS PUNCTATUS (Chocoan Forest Pitviper). COLOMBIA: DEPARTAMENTO DE ANTIOQUIA: MUNICIPALITY OF YOLOBÓ: Quebrada La Cancana (6°48'N, 75°06'W) ca. 1000 m. elev. 09 May 1997. J. Aubad. Museo de Herpetología Universidad de Antioquia, Medellín, Colombia (MHUA 10041, adult male). MUNICIPALITY OF AMALFI: 6°53'N, 75°09'W. 04 Oct 1990. J. Asprilla. Serpentario Universidad de Antioquia, Medellín, Colombia (SUA 552). Municipality of San Luis (6°02'N, 74°59'W). 13 Jul 1990. (SUA 483). 22 Apr 1997. J. Asprilla (SUA 2220). Verified by W. W. Lamar. This species has been considered endemic from Chocoan lowland rainforest from eastern Panama to northwestern Ecuador

(Campbell and Lamar 2004. The Venomous Reptiles of the Western Hemisphere. Cornell University Press). The easternmost record in Colombia is Municipality of Urrao (Antioquia) on the Cordillera Occidental. First record for Cordillera Central, it documents the occurrence of the species in the Río Cauca and Río Magdalena Basins to eastern Chocó, and extends the distribution almost 125 km northeast and 130 km east from Urrao, a previously known locality in Antioquia (Campbell and Lamar, *op. cit.*).

Submitted by **JUAN MANUEL DAZA-R.**, Grupo Herpetológico de Antioquia, Instituto de Biología, Universidad de Antioquia, oficina 7-121. A.A. 1226, Medellín, Colombia (e-mail: juandaza35@hotmail.com); **JUAN CARLOS QUINTANA**, and **RAFAEL OTERO**, Serpentario Universidad de Antioquia. A.A. 1226, Medellín, Colombia (e-mail: jquintana@epm.net.co).

CLELIA HUSSAMI (Mussurana). BRAZIL: RIO GRANDE DO SUL: São Francisco de Paula (29°02'S, 50°23'W), Floresta Nacional de São Francisco de Paula. 18 January 2004. R. Fleck. Coleção de Répteis, Museu de Ciências Naturais da Fundação Zoobotânica do Rio Grande do Sul (MCN.15175, female, 606 mm SVL + 80 mm tail). Verified by F. L. Franco. Previously reported only from Santa Catarina and Paraná states (Morato et al. 2003. Phyllomedusa 2:93–100). This record corroborates the suggested association of *C. hussami* to the Araucaria forest biome (Morato et al., *op. cit.*). First state record and southernmost record for the species, extends known distribution ca. 230 km airline S from Fraiburgo, Santa Catarina (Morato et al., *op. cit.*).

Submitted by **MÁRCIO BORGES-MARTINS** (e-mail: marciobmartins@fzb.rs.gov.br), **JONATAS GONÇALVES ROSSETTI**, and **ANA CAROLINA ANÉS**, Núcleo Regional de Ofiologia de Porto Alegre, Museu de Ciências Naturais da Fundação Zoobotânica do Rio Grande do Sul, Rua Dr. Salvador França, 1427, CEP 90690-000, Porto Alegre, Rio Grande do Sul, Brazil.

CONIOPHANES MERIDANUS (Peninsular Stripeless Snake). MEXICO: QUINTANA ROO: MUNICIPALITY OF OTHÓN P. BLANCO: Chetumal (18°30'22"N, 88°17'05"W). 01 February 2005. Magdalena Hernández and Pierre Charruau. Herpetological Collection, Museum of Zoology, El Colegio de la Frontera Sur, Chetumal, Quintana Roo (ECO-CH-H 2716). Verified by Gunther Köhler. Southernmost record for the species on the Yucatán Peninsula, extending the range ca. 80 km SW of the closest known locality in central Quintana Roo on road to Noh Bec, 15.6 km N of jct. with Hwy. 307 (Lee 1996. The Amphibians and Reptiles of the Yucatán Peninsula. Cornell University Press, Ithaca, New York. 500 pp.).

Submitted by **PIERRE CHARRUAU** (e-mail: rcedev@ecosur-groo.mx) and **J. ROGELIO CEDEÑO-VÁZQUEZ** (e-mail: rogeliocv@mexico.com), El Colegio de la Frontera Sur, Unidad Chetumal, Av. Centenario km 5.5, 77900 Chetumal, Quintana Roo, México.

CORALLUS CANINUS (Emerald Tree Boa). COLOMBIA: ANTIOQUIA: MUNICIPIO DE CÁCERES: 7°35'N, 75°20'W, 500 m elev. 21 March 1994. A. Ramírez. Verified by R. Powell. Museo de Ciencias Naturales Universidad de Antioquia, Medellín, Colombia (MUAREP 001). The species has a wide distribution in the Guianas and Amazonia, but records from north or west of the

Andes have, until recently, lacked voucher specimens. First record from Depto. Antioquia, and second verified record from north of the Colombian Cordillera Central and Cordillera Occidental. This record and that of Renjifo and Lundberg (1999. *Anfibios y Reptiles de Urrá*. Ed. Colina, Medellín, Colombia) from Depto. Córdoba are the only documented records for the species north of the Colombian Andes. Present record extends the known distribution ca. 110 km SW of the Depto. Córdoba locality, and ca. 240 km NW of Muzo (Depto. Boyacá) on the western slope of the Cordillera Oriental.

Submitted by **JUAN MANUEL DAZA-R.**, Grupo Herpetológico de Antioquia, Instituto de Biología, Bloque 7-121, Universidad de Antioquia, A.A. 1226, Medellín, Colombia (e-mail: juandaza35@hotmail.com); and **ROBERT W. HENDERSON**, Section of Vertebrate Zoology, Milwaukee Public Museum, Milwaukee, Wisconsin 53233-1478, USA (e-mail: rh@mpm.edu).

DRYMOLUBER BRAZILI (Brazilian Woodland Racer). PARAGUAY: CANINDEYU DEPARTMENT: Mbaracayu Forest Natural Reserve: Horqueta mí (24°08'09.2"S, 55°19'21.3"W). 2004. S. Fernández and F. Ramírez. Museo Nacional de Historia Natural del Paraguay, Asunción, Paraguay (MNHP 11025, female, SVL 291.5 mm, TL 120.5 mm). Verified by N. Scott. Previously known only from Brazil (Amaral 1977. *Serpentes do Brasil*. Iconografía colorida. Ed. Melhoramentos & Inst. Nac. Livro, Edit. Univ. São Paulo, 248 pp.; Nogueira 2001. *Herpetol. Rev.* 32[4]:286; Argôlo 2004. *Herpetol. Rev.* 35[2]:191; Lehr et al. 2004. *Copeia* 2004[1]:46–52). First country record, extends range ca. 167 km S of Ponta Porã, Mato Grosso do Sul, Brazil, the southernmost locality known for the species (Lehr et al., *op.cit.*).

Submitted by **PIER CACCIALI**, Museo Nacional de Historia Natural, Sucursal 1, Ciudad Universitaria, San Lorenzo, Paraguay (e-mail: pier_cacciali@yahoo.com); **SIXTO FERNÁNDEZ** and **FREDDY RAMÍREZ**, Fundación Moisés Bertoni, Prócer Carlos Argüello 208, CC 714, Asunción, Paraguay (e-mail mbertoni@mbertoni.org.py).

ENULIUS FLAVITORQUES (Pacific Long-tailed Snake). MÉXICO: PUEBLA: MUNICIPALITY OF IZUCAR DE MATAMOROS: ca. 1 km SE Tepenene (18°28.91'N, 98°23.80'W), 1237 m elev. 08 August 2002. J. Wiens, T. Reeder, and A. Nieto-Montes de Oca. MZFC 15973. Verified by Edmundo Pérez Ramos. First record for Puebla, extending its known range 54 km SE from 3 km E “El Limón” Tepalcingo, Morelos (Castro-Franco and Aranda-Escobar 1984. *Estudio Preliminar Sobre la Ecología de los Reptiles del Estado de Morelos*. Unpublished bachelor’s thesis. Universidad Autónoma del Estado de Morelos. 124 pp.). The snake was found active at night on a rock in tropical semideciduous forest.

Submitted by **LUIS CANSECO-MÁRQUEZ** (e-mail: lcm@correo.unam.mx), **ANDRÉS ALBERTO MENDOZA-HERNÁNDEZ**, and **ADRIÁN NIETO-MONTES DE OCA**, Museo de Zoología, Facultad de Ciencias, Universidad Nacional Autónoma de México, Apartado Postal 70-399, México, Distrito Federal 04510, México.

LEPTOPHIS DEPRESSIROSTRIS (Satiny Parrotsnake). PERÚ: LAMBAYEQUE: FERREÑAFE: LAQUIPAMPA: Quebrada Negrahuasi (6°20'58"S, 79°28'32"W, 600 m elev.). 25 August 2001. P. J. Venegas. Museo de Historia Natural Universidad Mayor de

San Marcos, Lima, Perú. (MHNSM 21536 adult male, 21537 adult female). Verified by W. W. Lamar. Previously known from Atlantic slopes of Nicaragua, Costa Rica, and Panama, and Pacific Slope of Colombia and Ecuador, and a questionable record from Peru (Peters and Orejas-Miranda 1970. *Bull. U.S. Nat. Mus.* 297:164). Recorded for Peru only from Depto. Loreto (Carrillo de Espinoza e Icochea 1995. *Publ. Mus. Hist. Nat. UNMSM[A]* 49:1–27). First department record, first record from the Pacific slope of the Cordillera Occidental in northwestern Peru, and southernmost distribution of the species on the Pacific slope of South America.

Submitted by **PABLO J. VENEGAS**, Facultad de Medicina Veterinaria de la Universidad Nacional Pedro Ruiz Gallo, Alfonso Ugarte 93, Pimentel, Chiclayo, Perú; e-mail: sancarranca@yahoo.es.

LEPTOTYPHLOPS SALGUEIROI (Espírito Santo Blindsnake). BRAZIL: RIO DE JANEIRO: MUNICIPALITY OF NITERÓI: Itaipú (22°58'S, 43°03'W). 29 May 2005. C. C. Ratto. Museu Nacional – Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (MNRJ 13124, adult male 211mm TL). Verified by P. Passos. The species occurs in southeastern Atlantic Rain Forest, in southern Bahia, Espírito Santo, and eastern Minas Gerais, Brazil (Passos et al. 2005. *Bol. Mus. Nac., N. S., Zool.*, Rio de Janeiro 520:1–10). First state record. Extends range ca. 170 km S from Minas Gerais, municipality of Recreio (Passos et al. 2005, *op. cit.*), formerly the southernmost locality.

Submitted by **MARCOS BILATE** (e-mail: marcosbilate@ig.com.br) and **ELIZA RIBEIRO COSTA**, Museu Nacional, Universidade Federal do Rio de Janeiro, Departamento de Vertebrados. Quinta da Boa Vista, São Cristóvão, Rio de Janeiro, RJ, 20940-040, Brazil.

OPHEODRYS AESTIVUS (Rough Greensnake). USA: ARKANSAS: LONOKE Co.: 1 km E Cabot, Hwy. 38 (T4N, R9W, S8). 22 May 2005. Nick Goodwin and Jeff Shaver. Verified by Stanley E. Trauth. Arkansas State University Museum of Zoology Herpetological Collection (ASUMZ 29317). New county record (Trauth et al. 2004. *The Amphibians and Reptiles of Arkansas*. Univ. of Arkansas Press, Fayetteville. 421 pp.).

Submitted by **MICHAEL V. PLUMMER**, Department of Biology, Box 12251, Harding University, Searcy, Arkansas 72149, USA (e-mail: plummer@harding.edu); and **JEFF SHAVER**, Cabot High School, 401 North Lincoln, Cabot, Arkansas 72023, USA (e-mail: Jeff.Shaver@cps.k12.ar.us).

OPHEODRYS VERNALIS (Smooth Greensnake). USA: IOWA: WOODBURY Co.: Owego Wetland Complex (42°16'72.3"N, 96°9'26.8"W). 24 June 2003. Christian Cox, Matthew Morrill, Aubrey Heupel, and Eugenia Farrar. Verified by Fredric Janzen. Iowa State University Research Collection ISUA-E-200520. New county record (Christiansen and Bailey 1994. *Snakes of Iowa*. Iowa Department of Natural Resources. Nongame Tech. Ser. No. 1, 16 pp.).

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PAREAS MARGARITOPHORUS (White-spotted Slug Snake). SINGAPORE: Khatib Bongsu (01°25.993'N, 103°51.207'E, ca. 7 m elev.). 26 December 2004. Benjamin Lee and Puay Koon Koh. Verified by Kelvin K. P. Lim. Raffles Museum of Biodiversity Research Zoological Reference Collection, The National University of Singapore (ZRC.2.6115). Adult, 350 mm in total length. Found crushed, probably by a motor vehicle, in a rural coastal area of degraded secondary forest and back mangrove. First specimen-based record from Singapore, also representing the southernmost extent of the species' range. In 2003 an individual snake, most likely belonging to this species, was found along Mandai Road and photographed, but was not collected (K. K. P. Lim, pers. comm.). Another individual of this species was found dead at Sungei Buloh Wetland Reserve on 15 April 2005. This individual, though measured (300 mm in total length) and photographed, was not collected (James W. M. Gan and K. K. P. Lim, pers. comm.). *Pareas margaritophorus* is distributed over continental Southeast Asia from southern China to northern Peninsular Malaysia (Cox et al. 1998. A Photographic Guide to Snakes and other Reptiles of Peninsular Malaysia, Singapore and Thailand. Asia Books, Bangkok, 144 pp.) as far south as Kedah and Kelantan (based on material at the Raffles Museum of Biodiversity Research: K. K. P. Lim, pers. comm.). The present record is unusual because this species has yet to be reported from southern Peninsular Malaysia. However, artificial introduction of the present specimen or other recent specimens (see above) is unlikely, because this species is apparently not traded commercially.

Submitted by **BENJAMIN LEE**, Central Nature Reserve, Conservation Division, National Parks Board, 601 Island Club Road, Singapore 578775 (e-mail: canopyben@gmail.com); and **PUAY KOON KOH**, National Parks Board HQ, 1 Cluny Rd, Singapore 259569.

REGINA GRAHAMI (Graham's Crayfish Snake). USA: IOWA: WOODBURY Co.: Owego Wetland Complex (42°16'74.6"N, 96°8'10.2"W). 24 June 2003. Christian Cox, Aubrey Heupel, and Eugenia Farrar. Verified by Fredric Janzen. Iowa State University Research Collection ISUA-E-200521. New county record (Christiansen and Bailey 1994. Snakes of Iowa. Iowa Department of Natural Resources. Nongame Tech. Ser. No. 1, 16 pp.).

Submitted by **CHRISTIAN L. COX** (e-mail: nazg@iastate.edu), **EUGENIA S. FARRAR** (e-mail: esf@iastate.edu), Department of Ecology, Evolution and Organismal Biology, Iowa State University, Ames, Iowa 50011-3223, USA; and **JANE D. HEY** (Department of Biology, Morningside College, Sioux City, Iowa 51106, USA (e-mail: hey@morningside.edu)).

SISTRURUS CATENATUS TERGEMINUS (Western Massasauga). USA: TEXAS. ERATH Co.: 19 May 2001 at 1240 h an adult female was found DOR on county road 149 ca. 5.6 miles N of Hwy 377. 32°25.83'N and 98°02.05'W, 1053 ft elev. First county record (Dixon 2000. Amphibians and Reptiles of Texas, A&M University Press. 421 pp.). Verified by Eric N. Smith. University of Texas at Arlington Collection of Vertebrates (UTACV R 52937).

Submitted by **CARL J. FRANKLIN**. Amphibian and Reptile Diversity Research Center, The University of Texas at Arlington Department of Biology. Arlington, Texas 76019, USA (e-mail:

Franklin@uta.edu); and **MICHAEL SMITH**, Dallas Fort Worth Herpetological Society, 7111 Layla Road, Arlington, Texas 76016, USA (e-mail: Masmith51@yahoo.com).

SONORA SEMIANNULATA (Groundsnake). USA: ARKANSAS: MARION Co.: ca. 3.6 km S AR Hwy 202, off County Road 113 (T20N, R15W, S01, SE1/4, NE1/4); (NAD 27 Conus) N36.44178, W92.53421. 15 April 2005. Joseph R. Milanovich. Verified by Chris T. McAllister. Arkansas State University Museum of Zoology, Herpetological Collection (ASUMZ 29257). New county record (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, 421 pp.) and the first verified Arkansas specimen collected since 1958 (Dowling 1958. Southwest. Nat. 27:228–230). This represents ca. 170 km eastern range extension within Arkansas and extends the range southward from Missouri (Johnson 2000. The Amphibians and Reptiles of Missouri. Missouri Dept. Conserv., Jefferson City. 400 pp.).

Submitted by **JOSEPH R. MILANOVICH**, **JANE ANFINSON**, **TROY J. BADER**, **RICHARD J. BAXTER**, **STEVE C. BRANDEBURA**, **SARAH A. DEVINEY**, **WAYLON R. HILER**, **JILL LEARNED**, **MICKEY W. MATTHEWS**, **CHARLES R. MCDOWELL**, **ROBERT G. NEAL**, **NATHAN T. STEPHENS**, **JOHN P. STEWART**, **BENJAMIN A. WHEELER**, and **STANLEY E. TRAUTH**, Department of Biological Sciences, Arkansas State University, P.O. Box 599, State University, Arkansas 72467-0599, USA; e-mail: strauth@astate.edu.

TRETANORHINUS MOCQUARDI (Swamp Snake). ECUADOR: PROVINCE OF ESMERALDAS: Atacames (00°52'12"N, 79°50'32"W, 8 m elev.), 13 and 25 February 1990, V. Cevallos and E. Kramer. Universidad San Francisco de Quito & Fundación Herpetológica G. Orcés, Quito, Ecuador (FHGO-USFQ 121–5, 187; collected at night in water, at a shrimp pond near coastline). Verified by J.-M. Touzet. The species was known from Panama, with no records from Colombia (Dunn 1939. Copeia [4]:212–217; Peters and Orejas-Miranda 1970. USNM Bull. 297). Uetz (1995–2005. The EMBL Reptile Database. Online. EMBL Heidelberg. <http://www.reptile-database.org>) mentioned the species from Ecuador, citing Almendáriz (1992 [1991]) *In* Barriga et al. [eds.], Lista de Vertebrados de Ecuador. Revista Politécnica, Quito XVI [3]:89–162; however, the author does not mention the species in that paper, nor subsequent lists (Coloma et al. 2000–2004. Reptiles de Ecuador. Online. Museo de Zoología, PUCE Quito, Ecuador <http://www.puce.edu.ec/zoologia/>). First vouchered country record. Extends known distribution ca. 900 km S from nearest localities in Panama (Dunn, *op. cit.*).

Submitted by **DIEGO F. CISNEROS-HEREDIA**, Colegio de Ciencias Biológicas & Ambientales, Universidad San Francisco de Quito, Ave. Interocéánica y calle Diego de Robles, Campus Cumbayá, Edif. Maxwell. Casilla Postal 17-12-841, Quito, Ecuador; e-mail: diegofrancisco_cisneros@yahoo.com.

BOOK REVIEWS

Herpetological Review, 2005, 36(3), 341–343.
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Checklist of Amphibians and Reptiles in Thailand, by Jarujin Nabhitabhata, Tanya Chan-ard, and Yodchaiy Chuaynkern. “2000” [2004]. Office of Environmental Policy and Planning (OEPP), Bangkok, Biodiversity Series, Volume 9. 152 pp., color plates, map. Softcover. Free. ISBN 974-87704-3-5.

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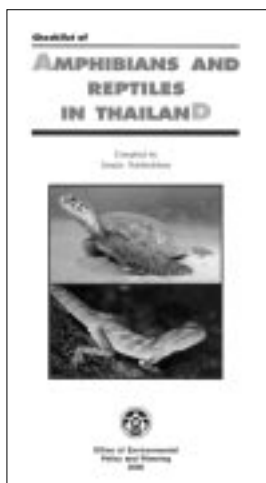
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This new publication, co-authored by three experienced herpetologists from the Thai National Science Museum (Pathum Thani) is the first comprehensive list of Thai reptiles and amphibians giving details on their distribution within the country and aiming to list all provinces from which each taxon has been recorded so far. Before describing the contents of this new and welcome addition to the herpetological bibliography on Thailand, a remark should be made about its publication date. Although “September, 2000” is indicated in the book, it was actually not printed before 2004 (T. Chan-ard and Y. Chuaynkern, pers. comm.).

The practically-conceived, pocket-sized book includes a) an administrative map of Thailand (p. 3), with different colors grouping the provinces in five divisions, corresponding to north, west, center, east, southeast and south regions; b) a foreword by the Secretary General of the Thai Office of Environmental Policy and Planning (p. 4); c) a “compilers’ note” (pp. 5–6); d) a table of contents, showing the orders and families of the taxa treated (pp. 7–8); e) two colour plates of amphibians (19 species) and four of reptiles (34 species), showing, among others, some rarely illustrated taxa like *Caluella guttulata* and *Glyphoglossus molossus* (Microhylidae), *Gehyra lacerata* (Gekkonidae) and *Tropidophorus microlepis* (Scincidae) (pp. 9–14), although with photographs of small size and average quality; f) a table of amphibian species (pp. 15–48); g) a table of reptile species (pp. 49–143); h) a short bibliography with 126 references (pp. 144–151). The tables are divided into four columns: 1) taxon/species; 2) common names (in English, and in Thai with transliteration into English); 3) “locality”, giving the Thai regions and provinces of occurrence, often with indication of the district or locality – distribution outside Thailand is not given; 4) “reference”, detailing the sources for the



species records.

In the locality column, the provinces of occurrence are grouped in geographical areas: north, northeast, east, southeast, central, southwest, and south, i.e. more divisions than the six appearing on the map. Moreover, the grouping of provinces in the two tables does not correspond to that in the map (see for example the distribution of *Leptobrachium smithi* on pp. 16–17, where the provinces of Kanchanaburi, Phetchaburi, Prachuap Khiri Khan and Uthai Thani are referred to a “southwest” area). Another example, among many, is the placement of Hua Hin (Prachuap Khiri Khan Province) in southwestern Thailand on p. 104 and in southern Thailand on p. 105.

The amphibian table lists 132 species, which is lower than the number of species actually recorded in 2004. Chan-ard (2003), in his excellent photographic field guide on Thai amphibians, indeed included 141 species. Although the compilers’ note indicates a total of 325 reptile species, the table actually includes 326. The most recent herpetological works included in the bibliography date back from 2001, so all recent major works and additions to the amphibian and reptile faunas were not included. Since 2000, many gecko species have been added to the fauna of Thailand: *Cnemaspis phuketensis* Das & Leong, 2004, *Cyrtodactylus chanhomeae* Bauer, Sumontha & Pauwels, 2003, *C. sumonthai* Bauer, Pauwels & Chanhom, 2002, *C. thirakhupti* Pauwels, Bauer, Sumontha & Chanhom, 2004 and *C. tigroides* Bauer, Sumontha & Pauwels, 2003, and *Dixonius hangseesom* Bauer, Sumontha, Grossmann, Pauwels & Vogel, 2004, as well as two skinks, *Tropidophorus latiscutatus* Hikida, Orlov, Nabhitabhata & Ota, 2002 and *T. matsuii* Hikida, Orlov, Nabhitabhata & Ota, 2002. Asian skinks long placed in the genus *Mabuya* are now referred to the genus *Eutropis* Fitzinger, 1843 following Mausfeld et al. (2002) and Mausfeld and Schmitz (2003). The snake list includes 177 species, while 181 species (and in total 185 species and subspecies) were listed by David et al. (2004). Three additional species and one genus have been added since: *Lycodon cardamomensis* (Pauwels et al. 2005), *Macrocalamus lateralis* (Chan-ard et al. 2002; David and Pauwels 2004) (Colubridae) and *Trimeresurus fucatus* (Vogel et al. 2004; all peninsular localities of *T. popeiorum* seem in fact referable to *T. fucatus*) (Crotalidae). It should also be noted that the binomen *Boiga ocellata* Kroon, 1973 is a junior subjective synonym of *Boiga siamensis* Nootpand, 1971 (Pauwels et al. 2005), that Thai *Trimeresurus “stejnegeri”* were shown to be in fact *T. gumprechtii* and *T. vogeli* (David et al. 2001, 2002), and that *Trimeresurus venustus* was clearly shown to be specifically distinct from *T. kanburiensis* (David et al. 2004). Thai populations of *Psammophis condanarus* (sic) (Merrem, 1820) should be better regarded as *Psammophis indochinensis* Smith, 1943 (Pauwels et al. 2003).

The subspecific level is not considered in the tables. However, it would have stressed the existence of some endemic subspecies (endemic species are marked with an asterisk and, according to the foreword, this list is aimed to contribute to biodiversity conservation), notably *Draco maculatus divergens* Taylor, 1934 (known only from Chiang Mai Province), *Eutropis macularia malcolmi* (Taylor & Elbel, 1958), *E. m. postnasalis* (Taylor & Elbel, 1958) and *E. m. quadrifasciata* (Taylor & Elbel, 1958) (all three of doubtful but unresolved taxonomic status; still to be conservatively considered endemic to Loei Province), *Elaphe porphyracea*

coxi Schulz & Helfenberger, 1998 (Chaiyaphum and Loei provinces), and *Gongylosoma baliodeirum cochranae* (Taylor, 1962) (Chanthaburi Province).

The main weakness of this opus is the lack of documentation for the species records. For 75 of the 132 amphibian species, one finds “per. com.” sources, by the three authors (!) and six other persons. The records of 28 amphibian species (21% of all 132 species) are even exclusively based on “personal communications”, thus without any reference to a published work or museum collection material. In addition, the source for *Leptolalax gracilis* is a reference that is not listed in the bibliography. For some of these 28 species, Thai material was however published, and all 28 except *Rana andersonii* were treated and illustrated by Chan-ard (2003). The only source indicated for *Chaperina fusca* is “Taksinham (per. com.)”; the species was mentioned as *Chaperina* cf. *fusca* by Chan-ard (2003), thus expressing some doubt as to its identity. The source for *Kaloula baleata* is indicated as “Chan-ard (per. com.); Nabhitabhata (per. com.)” and the species is said to occur in the provinces of Krabi, Phuket, Ratchaburi, Surat Thani, Trang and Yala. One of the authors however co-authored a paper studying specimens from the provinces of Phang-Nga, Phuket and Trang (Pauwels et al. 1999). The records of *Rana milleti* from Chanthaburi, Chachoengsao, Nakhon Nayok and Nakhon Ratchasima provinces are indicated as originating from “per. com.” by the three authors, without any other reference, but Chan-ard (2003) and Chuaynkern et al. (2004) reported specimens from the provinces of Chachoengsao, Nakhon Ratchasima and Ubon Ratchathani. What is called *Huia nasica* from Kanchanaburi Province was recently shown to be a distinct species, *Huia melasma* Stuart & Chan-ard, 2005. The problem of undocumented records is slightly less dramatic in reptile species. There are 271 species at least in part recorded on the basis of “per. com.”; this is in fact the only source for 18 reptile species (by the authors or by a certain Damman), which represents 6 % of the total of 326 reptiles. Again, if literature had been better exploited, some published references could have been mentioned to justify many records. For instance, *Dogania subplana* is said to be based on a “per. com.”, but among other references, Chan-ard et al. (1999) illustrated specimens from Surat Thani and Satun provinces. *Cyclemys tcheponensis*, listed on the basis of “Nabhitabhata (per. com.)”, was however listed from Thailand, including Chiang Mai Province, on the basis of several specimens studied by Fritz and Ziegler (1999). The agamid *Pseudocalotes microlepis* is mentioned from three provinces, based on “per. com.” but was already recorded from Thailand by Hallermann and Böhme (2000) (see also Pauwels et al. 2003). The record of *Fordonia leucobalia* is based only on “per. com.”, but the species was already mentioned from Thailand by Frith and MacIver (1978). Idem for *Ahaetulla mycterizans*, listed, among others, by Chan-ard et al. (1999). The source for the record of *Lycodon butleri* is indicated as “Nabhitabhata (per. com.)”; however the species was mentioned twice by Cox (1991a-b), who indicated that the identification had been verified by J. Nabhitabhata. The record of *Ptyas fusca* is presented as known from “South (from animal dealer); Chan-ard (per. com.)”, although the species was recorded from a precise locality by Pauwels et al. (2000). The records of the agamid *Bronchocela smaragdina*, the geckos *Cnemaspis flavolineata* and *Cyrtodactylus feae*, the skinks *Lipinia surda* and *Lygosoma corpulentum*, the colubrids *Oligodon*

catenatus and *O. theobaldi*, *Stegonotus borneensis*, and of the sea snakes *Disteira nigrocinctus* and *D. obscurus*, and *Hydrophis inornatus*, based only on personal communications, definitely require confirmation through voucher material. *Hemidactylus b. brookii*, listed without any source from Thailand by Chan-ard et al. (1999) but confirmed from the country by Bauer et al. (2002), is not listed. Many of the records from Kaeng Krachan and Pala-U, in Phetchaburi and Prachuap Khiri Khan provinces, are based on material and observations gathered during field surveys in December 2002 and July 2004 and published by Pauwels and Chan-ard (2005).

Although we did not check each locality record, we noted some errors. *Cantoria violacea* is cited from Sai Yok, in Kanchanaburi, on the basis of “Gairder and Smith (1915)”. These authors did not list *Cantoria violacea*, but *Simotes violaceus* Cantor, a synonym of *Oligodon cyclurus* Cantor, but long used for Thai and Indochinese populations in place of *Oligodon cinereus* (Günther, 1864) (see Smith 1943), which is the valid name for these populations. Many important distributional data on endangered species, such as *Chitra chitra* (Kitimasak and Thirakhupt 2002), *Pelochelys cantorii* (Pauwels et al. 2003), or *Crocodylus siamensis* (Platt et al. 2002), were published between 2000 and 2004.

Some references listed in the text are missing in the bibliography: Bohme (sic) (1982); Chuaynkern (2001) (pp. 45, 93); Cochran (1922) (p. 77); Colwell et al. (1977) (p. 105); Fritz and Bbst (sic) (1999) (p. 53); Grossmann (1992) (p. 235); Grossmann and Tillack (2001) (pp. 98, 111); Lauhajinda et al. (1999) (p. 17); Lauprasert and Thirakhupt (2001) (p. 93); Nutaphand (1990) (p. 50); Schaffer (sic) (1991) (pp. 60-61); Steiof et al. (1991) (p. 69); Welch (1980) (p. 116); Welch et al. (1990) (p. 151); and Wuster (sic) et al. (1997) (p. 132). Listing the works done by Thai authors is of special importance, since these references, often in Thai language, are regularly overlooked by Occidental researchers. Some references are wrongly indicated in the main text: “Günther (sic) (1961)” on p. 91; “Inger and Elbel (1977)” on p. 92 (Inger and Colwell, 1977); Manthey and Grossmann “(1977)” on p. 55 (1997); Taylor and Elbel “(1950)” on p. 25 (1958). The literature section is largely incomplete. One would have hoped to find a complete list of the numerous herpetological publications of the three authors, but, as two examples among many others, the intensive surveys of the second and third authors (Chan-ard 1996; Chan-ard et al. 2002) in Hala-Bala Wildlife Sanctuary, an area of great zoogeographical importance, or the first record of the Anguidae from Thailand (Nabhitabhata 1987) are absent.

Many of the undocumented species records concern species of difficult identification, or outside of their previously known range, thus with a special zoogeographical or conservation importance. In some cases new taxa could be involved, and the availability of internationally available voucher specimens is crucial. The high proportion of species partly or entirely recorded on the basis of observations made by the authors of the checklist gives, on the one hand, an idea of the huge field experience of the three authors, and on the other hand it stresses the importance of publishing detailed accounts of herpetological collections, in order to firmly document the listing of taxa. Also, it gives an idea of the richness of the mostly unpublished collections of the Thai National Science Museum, on which many records are based, as stressed by the authors in the compilers’ note. This museum houses the most

important collection of reptiles in Thailand, more significant than those of Chulalongkorn University and the Queen Saovabab Memorial Institute of the Thai Red Cross in Bangkok.

The present checklist, in spite of the shortcomings listed above, is a very useful work that serves as a perfect companion to the field guide on frogs by Chan-ard (2003) and to the book on amphibians and reptiles of Thailand and Peninsular Malaysia by Chan-ard et al. (1999). Moreover, This checklist, available at the Thai National Science Museum in Pathum Thani and at the OEPP in Bangkok, has an unequaled advantage over all other herpetological books on Thailand: it is free. Although this checklist is a welcome addition to published material on the herpetofauna of Thailand, an updated second edition with more emphasis on voucher specimens and on the source literature would be desirable. Thai amphibian and reptile faunas are far from being adequately known, in spite of the extensive series of investigations made by both Western and Thai herpetologists. A work like this distributional checklist is the right way to present an overview of the Thai fauna, from which taxonomic and biogeographical data can be easily derived. Pending the eventual availability of a more carefully prepared, updated second edition, we highly recommend the prompt acquisition of the present list by all herpetologists and biologists working on the fauna of southeast Asia.

LITERATURE CITED

- BAUER, A. M., O. S. G. PAUWELS, AND M. SUMONTHA. 2002. *Hemidactylus brookii brookii* (Brook's Gecko). *Herpetol. Rev.* 33:322.
- BÖHME, W. 1982. Über Schmetterlingsagamen, *Leiolepis b. belliana* (Gray, 1827) der Malaiischen Halbinsel und ihre parthenogenetischen Linien (Sauria: Uromastycidae). *Zool. Jb. Syst.* 109:157–169.
- CHAN-ARD, T. 1996. Preliminary survey of herpetofauna of Bala Forest, Narathiwat, southern Thailand [in Thai]. *Wildl. J. Thailand* 5(2):1–11.
- . 2003. A photographic guide to amphibians in Thailand [in Thai]. Darnsutha Press, Bangkok. 176 pp.
- , W. GROSSMANN, A. GUMPRECHT, AND K.-D. SCHULZ. 1999. Amphibians and Reptiles of Peninsular Malaysia and Thailand. An illustrated checklist. *Amphibien und Reptilien der Halbinsel Malaysia und Thailands. Eine illustrierte Checkliste.* Bushmaster Publ., Würselen, Germany. 240 pp.
- , S. THONG-AREE, AND Y. CHUAYNKERN. 2002. Diversity study on Amphibians and Reptiles in Hala-Bala Wildlife Sanctuary, Yala and Narathiwat Provinces [in Thai]. Unpublished report to BRT. National Science Museum, Pathum Thani, and Royal Forest Department, Bangkok. 118 pp.
- CHUAYNKERN, Y., A. ÖHLER, C. INTHARA, P. KUMTONG, AND A. DUBOIS. 2004. The recent distribution of *Rana milleti* Smith, 1921 in mainland south-east Asia with the first record of Cambodia. *Nat. Hist. J. Chulalongkorn Univ.* 4:1–13.
- COX, M. J. 1991a. *Lycodon butleri* (Butler's Wolf Snake). *Herpetol. Rev.* 22:26.
- . 1991b. *Lycodon butleri* (Butler's Wolf Snake). *Herpetol. Rev.* 22:103.
- DAVID, P., M. J. COX, O. S. G. PAUWELS, L. CHANHOME, AND K. THIRAKHUP. 2004. When a bookreview is not sufficient to say all: an in-depth analysis of a recent book on the snakes of Thailand, with an updated checklist of the snakes of the Kingdom. *Nat. Hist. J. Chulalongkorn Univ.* 4:47–80.
- DAVID, P., AND O. S. G. PAUWELS. 2004. A re-evaluation of the taxonomy of *Macrocaltamus lateralis* Günther, 1864 (Serpentes, Colubridae), with the descriptions of two new species. *Raffles Bull. Zool.* 52:635–645.
- , N. VIDAL, AND O. S. G. PAUWELS. 2001. A morphological study of Stejneger's pitviper *Trimeresurus stejnegeri* (Serpentes, Viperidae, Crotalinae), with the description of a new species from Thailand. *Russian J. Herpetol.* 8:205–222.
- , G. VOGEL, O. S. G. PAUWELS, AND N. VIDAL. 2002. Description of a new species of the genus *Trimeresurus* from Thailand, related to *Trimeresurus stejnegeri* Schmidt, 1925 (Serpentes, Crotalidae). *Nat. Hist. J. Chulalongkorn Univ.* 2:5–19.
- , M. SUMONTHA, O. S. G. PAUWELS, AND L. CHANHOME. 2004. Confirmation of the validity of *Trimeresurus venustus* Vogel, 1991, with an expanded description of *Trimeresurus kanburiensis* Smith, 1943 (Reptilia: Serpentes: Crotalidae). *Russian J. Herpetol.* 10:81–90.
- FRITH, C. B., AND D. MACIVER. 1978. The crab-eating water snake, *Fordonia leucobalia* (Schleg.); another snake new to Thailand. *Nat. Hist. Bull. Siam Soc.* 27:189–191.
- FRITZ, U., AND T. ZIEGLER. 1999. Contribution to the knowledge of *Cyclemys tcheponenensis* (Bourret, 1939) and the distribution of *Cyclemys* in the Indochinese region (Reptilia: Testudines: Bataguridae). *Revue française Aquariologie*, Nancy 26:71–78.
- HALLERMANN, J., AND W. BÖHME. 2000. A review of the genus *Pseudocalotes* (Squamata: Agamidae), with description of a new species from West Malaysia. *Amphibia-Reptilia* 21:193–210.
- KITIMASAK, W., AND K. THIRAKHUP. 2002. New record of *Chitra chitra* Nutphand, 1986 in Mae Ping River, Thailand. *Nat. Hist. J. Chulalongkorn Univ.* 2:62–63.
- MAUSFELD, P., AND A. SCHMITZ. 2003. Molecular phylogeography, intraspecific variation and speciation of the Asian scincid lizard genus *Eutropis* Fitzinger, 1843 (Squamata: Reptilia: Scincidae): taxonomic and biogeographic implications. *Organisms Diver. Evol.* 3:161–171.
- , W. BÖHME, B. MISOF, D. VRCIBRADIC, AND C. F. D. ROCHA. 2002. Phylogenetic affinities of *Mabuya atlantica* Schmidt, 1945, endemic to the Atlantic Ocean archipelago of Fernando de Noronha (Brazil): necessity of partitioning the genus *Mabuya* Fitzinger, 1826 (Scincidae: Lygosominae). *Zool. Anz.* 241:281–293.
- NABHITABHATA, J. 1987. Anguidae, a new family of lizard for Thailand. *Nat. Hist. Bull. Siam Soc.* 35:59–62.
- PAUWELS, O. S. G., AND T. CHAN-ARD. 2005. Reptiles of Kaeng Krachan National Park, Western Thailand. *Nat. Hist. Bull. Siam Soc.* (in press).
- , P. DAVID, L. CHANHOME, G. VOGEL, T. CHAN-ARD, AND N. L. ORLOV. 2005. On the status of *Boiga ocellata* Kroon, 1973, with designation of a neotype for *Boiga siamensis* Nootpand, 1971 (Serpentes, Colubridae). *Russian J. Herpetol.* 12 (in press).
- , C. CHIMSUNCHART, AND K. THIRAKHUP. 2003. Reptiles of Phetchaburi Province, western Thailand: a list of species, with natural history notes, and a discussion on the biogeography at the Isthmus of Kra. *Nat. Hist. J. Chulalongkorn Univ.* 3:23–53.
- , O.-A. LAOHAWAT, P. DAVID, R. BOUR, P. DANGSEE, C. PUANGJIT, AND C. CHIMSUNCHART. 2000. Herpetological investigations in Phang-Nga Province, southern peninsular Thailand, with a list of reptile species and notes on their biology. *Dumerilia* 4(2):123–154.
- , A. ÖHLER, A. DUBOIS, J. NABHITABHATA, O.-A. LAOHAWAT, AND C. CHIMSUNCHART. 1999. *Kaloula baleata* (Müller, 1836) (Anura: Microhylidae), an addition to the batrachofauna of Thailand. *Nat. Hist. Bull. Siam Soc.* 47:261–264.
- , M. SUMONTHA, P. DAVID, T. CHAN-ARD, AND G. VOGEL. 2005. First record of *Lycodon cardamomensis* from Thailand, with a key to Thai *Lycodon* (Serpentes: Colubridae). *Nat. Hist. Bull. Siam Soc.* (in press).
- PLATT, S. G., A. J. LYNAM, Y. TEMSIRIPONG, AND M. KAMPANAKGARN. 2002. Occurrence of the Siamese crocodile (*Crocodylus siamensis*) in Kaeng Krachan National Park, Thailand. *Nat. Hist. Bull. Siam Soc.* 50:7–14.
- SMITH, M. A. 1943. The Fauna of British India, Ceylon and Burma, including the whole of the Indo-chinese subregion. Reptilia and Amphibia. Vol. III, Serpentes. Taylor & Francis, London. xii + 583 pp.
- VOGEL, G., P. DAVID, AND O. S. G. PAUWELS. 2004. A review of morphological variation in *Trimeresurus popeiorum* (Serpentes: Viperidae: Crotalinae), with the description of two new species. *Zootaxa* 727:1–63.

Cusco Amazónico: The Lives of Amphibians and Reptiles in an Amazonian Rainforest, by W. E. Duellman. 2005. Cornell University Press, Ithaca, New York (www.cornellpress.cornell.edu). xv + 433 pp. Hardcover. US \$74.95. ISBN 0-8014-3997-3.

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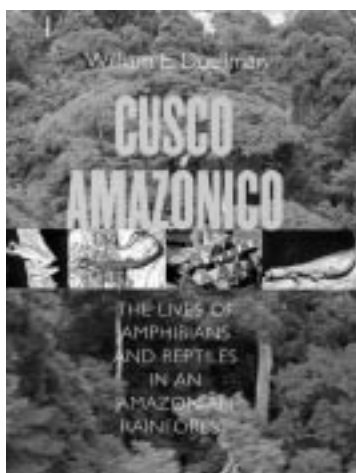
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Neotropical rainforests are home to an incredible diversity of amphibians and reptiles, and the taxonomy and systematics of tropical species is becoming clearer, especially with the advent of molecular techniques. However, basic natural history data are still lacking for most Neotropical species, even relatively common ones, due to their generally low abundance and the difficulties associated with studying vertebrates in the tropics. In the field of herpetology, William E. Duellman has devoted a large portion of his career to studying the diversity and natural history of the Neotropical herpetofauna. His latest book, *Cusco Amazónico: The Lives of Amphibians and Reptiles in an Amazonian Rainforest*, is the culmination of decades of work, both in the field and laboratory, on an assemblage of Peruvian herpetofauna. His study site, Cusco Amazónico (now Reserva Amazónica), is located in southeastern Peru along the Madre de Dios River near the Peruvian-Bolivian border. Reserva Amazónica has been highlighted for its high herpetofaunal diversity (e.g., Doan and Arizábal 2002), and Duellman's recent work describes in wonderful detail the natural history of this area, including the geography, topography, weather patterns, vegetation, and of course, the amphibians and reptiles.

Cusco Amazónico is divided into five distinct sections that together encompass the abiotic factors affecting the herpetofauna, community aspects of the herpetofauna, and descriptions with ecological data for each species occurring at the site. The first section includes the introduction, which provides background on the study area and describes the methodology used in data collection. The next section describes the vegetation and physical characteristics of the environment in a very readable (even for a herpetologist) and comprehensive manner. The work of other researchers on the abiotic characteristics of the site complements the amphibian and reptile data, resulting in a comprehensive description of the Reserva Amazónica site rarely seen in the herpetological literature. The



third section presents a site-specific summary of the general natural history, species diversity, abundance, and biomass of the herpetofauna. These summaries are incredibly interesting, and give an accurate picture of the overall dynamics of the site. Finally, the last two sections, one for amphibians and one for reptiles, provide thorough dichotomous keys and detailed data for all species recorded from the site or expected to occur at the site based on nearby collection records. Each species account includes nomenclature, morphological characteristics, occurrence, reproduction, and diet information recorded primarily from Reserva Amazónica and supplemented by other literature, which helps to yield a very detailed literature cited section that highlights the herpetology of the Amazon basin as a whole. Helpful attributes of the amphibian section include descriptions of most tadpoles and sonograms of the advertisement calls of many frog species, most of which were previously undescribed.

Two sets of color plates are provided for visual reference, one for amphibians and the other for reptiles. In general, the photography is of good to excellent quality; however, some pictures are dark or out-of-focus, especially those of the rarer species. In many cases where great variation in morphology exists, several photos are included, making the plates more useful for identification purposes. However, in the case of *Oxyrhopus melanogenys*, Duellman notes that this snake has a unique color morph at Cusco Amazónico (page 379); a photograph of a more typical color morph would be helpful for comparative purposes, but noting this in the text provides the reader with a citation to investigate this further.

One obvious benefit of the dichotomous keys is that they are printed in both English and Spanish. This greatly increases the usefulness of the keys and ensures that Peruvians and other Latin American researchers can also take advantage of this work. We visited Reserva Amazónica in late 2004 through early 2005, and had the opportunity to use the keys in a field setting. There are a paucity of works dealing with both reptiles and amphibians from this region, and Duellman's keys are the most comprehensive published to date. In general, the keys were as descriptive and comprehensive as available data allow, although we found a few mistakes, particularly in the reptile key. For example, *Oxyrhopus melanogenys* was identified as *Clelia clelia* using the dichotomous key. Although the two species have similar dorsal scalation and juvenile patterns, after consulting Dixon and Soini (1977), we determined that this was in error. When working with such diversity, and sometimes with very few specimens, mistakes are to be expected and otherwise seemed minimal throughout the book. In fact, just having this material on reptiles and amphibians available in one edition is a huge benefit to neotropical ecologists working in the field.

In particular, we wish to highlight the Epilogue, which relates the field experiences of a biologist at Reserva Amazónica. The interesting twist is that the setting is in a futuristic time period when technology and rainforest knowledge are more advanced. This portion of the book adds a touch of mystery and fantasy to what neotropical fieldwork may be in the future, but we will stop our summary here to prevent spoiling the ending...

For those seriously interested in tropical areas, or areas with high herpetofaunal diversity, this book is a must-have for your collection. *Cusco Amazónico* is the most comprehensive book published on South American herpetofauna to date, displacing

Duellman's (1978) sought-after classic *The Biology of an Equatorial Herpetofauna in Amazonian Ecuador* for this honor. Indeed, this book is rivaled among other volumes on Neotropical amphibians and reptiles only by Jay Savage's *The Amphibians and Reptiles of Costa Rica: A Herpetofauna between Two Continents, Between Two Seas*. Duellman has set the standard for tropical works extremely high, and those looking to publish a work encompassing amphibians and reptiles residing in the tropics will have a difficult time matching the quality of this book.

LITERATURE CITED

- DIXON, J. R., AND P. SOINI. 1977. The Reptiles of the Upper Amazon Basin, Iquitos Region, Peru II. Crocodilians, Turtles, and Snakes. Milwaukee Public Museum Press. 91 pp.
- DOAN, T. M., AND W. ARIZÁBAL A. 2002. Microgeographic variation in species composition of the herpetofaunal communities of Tambopata region, Peru. *Biotropica* 34:101–117.
- DUELLMAN, W. E. 1978. The Biology of an Equatorial Herpetofauna in Amazonian Ecuador. The University of Kansas Museum of Natural History Misc. Publication No. 65. 352 pp.
- SAVAGE, J. M. 2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna between Two Continents, Between Two Seas. University of Chicago Press. 954 pp.

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Varanoid Lizards of the World, edited by Eric R. Pianka and Dennis King with Ruth Allen King. 2004. Indiana University Press, 601 North Morton Street, Bloomington, Indiana 47404-3797, USA (iupress@indiana.edu). 602 pp. Hardcover. US \$89.95. ISBN 0-253-34366-6.

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Monitor lizards and their close relatives have always been a source of interest and fascination among herpetologists and laymen alike. Despite this, until the 1980s general works on varanids were largely limited to those by Mertens (1942a; 1942b; 1942c) for the living species and Fejérváry (1918; 1935) for the extinct taxa. Recently, interest in these lizards has undergone a renaissance with the publication of important volumes devoted to individual taxa, for example: Auffenberg (1981; 1988; 1994), Lenz (1995), and Murphy et al. (2002), as well as general works and symposia, such as: Böhme and Horn (1991), Bennett (1998), Horn and Böhme (1999), and Green and King (1999), and books on varanid paleontology (Molnar 2004). This brief listing does not even begin to account for the enormous wealth of current pub-

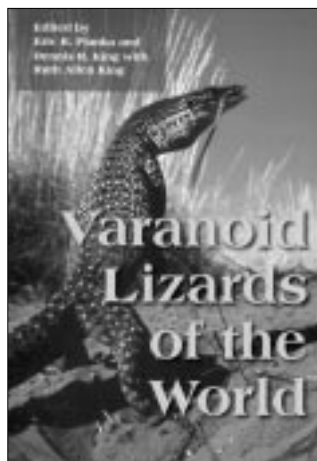
lications focused on the husbandry of these forms. This new book, edited by Pianka, King, and King, which purports to be a "comprehensive account of virtually everything important that is known about monitor lizards and their allies," is divided into three major sections. The first is focused largely on phylogeny and biogeography, the second and longest is committed to species by species descriptions, and the third discusses the evolution of body size and its importance to reproduction and also examines captive care.

In their introduction Eric Pianka and Dennis King briefly explain that their goal was to compile a single volume reference work about monitor lizards and their allies that touches not only on the systematics of individual species, but also examines their collective biogeography, paleontology, and other important features of their biology. A significant discussion of the paleontology of varanoids by Australian paleoherpetologist Ralph Molnar follows the introductory chapter and occupies 58 pages of this 602-page book. It is the most detailed and up-to-date paleontological review of the group and it also contains a very useful annotated inventory of terrestrial fossil varanoids, updating that of Estes (1983).

There are occasional confusing or erroneous statements in Molnar's review. For example, he notes that the oldest "necrosaur" traces back to the Albian of Utah (Early Cretaceous, about 112–99 million years mya). This can only be the fossil originally described by Cifelli and Nydam in 1995. However, this fossil was later shown by Nydam (2000) to be that of *Primaderma*, which is a monstersaurian not a "necrosaur." Molnar at first refers to *Primaderma* as the oldest land-dwelling platynotan. Later when he discusses monstersaurs in detail, Molnar claims that members of this taxon date back to at least the Late Cretaceous, and that the oldest forms were found in Asia. However, a mere paragraph afterward, Molnar states: "*Primaderma nessovi* is the oldest known monstersaur...its remains were found in the [Early Cretaceous] Cedar Mountain Formation of Central Utah" (page 28). Unfortunate oversights such as this should not have escaped the editors.

The first section of the book concludes with two relatively brief chapters. One, by Pianka and Molnar, is concerned with the biogeography and phylogeny of varanoids generally, although its focus is on the genus *Varanus*. The final chapter in the first section, contributed by Jennings and Pianka, summarizes hypotheses about the tempo and timing for the radiation of Australian monitor species. Their analysis suggests that Australian goannas have undergone repeated and episodic speciation, that the increasing aridity of Australia during the later Tertiary apparently helped drive this diversification and radiation, and that the Australian varanid radiations appear to parallel those of pygopods.

In Part II, the individual species accounts are broken up into four sub-groupings: African varanid species, Asian varanid species, Australian varanid species, and other varanoids. Each subsection contains its own bibliography, and virtually all species descriptions contain all or most of the following subdivisions: nomenclature, geographic distribution, fossil record, diagnostic characteristics, description, size, habitat and natural history, reproduction, movement, population genetics, physiology, fat bodies, testicular cycles, and parasites. Range maps varying in their level of detail are also usually included. Some species accounts are supplemented by tables summarizing morphometric, physiological, or breeding data, or graphs, such as that showing the relation-



ship between body mass and snout-vent length in *Varanus gouldii*. Nearly all species accounts provide a black and white photo above the text for each description, along with duplicate, but separately organized color print, showing a typical representative, usually an adult. These photographs vary in quality, size, and detail.

The African varanid section had a wide range of authors and, as with all the other sections, the amount of detail varied from species to species. All known African species (*Varanus albigularis*, *V. exanthematicus*, *V. griseus*, *V. niloticus*, *V. ornatus*) and the relatively recently described Middle Eastern *V. yemenensis* (Böhme et al. 1987, 1989 [note: these two citations are incorrectly listed in the book's bibliography and are corrected here]) are discussed. The account by Michael Stanner describing the desert monitor, *Varanus griseus*, consumes the greatest percentage of this section, about 45%, but fails to resolve whether or not this species is actually venomous as some earlier reports claimed (Ballard and Antonio 2001; Sopieiev et al. 1987).

The Asian monitor section describes 23 species, with that for *Varanus salvator* split into two separate segments: one devoted to the nominate form and the other to the various subspecies. It is heavily dominated by German authors and, therefore, many of the species descriptions include diagnostic characters containing references to hemipeneal (and sometimes hemiclitoral) characters that are derived from Böhme (1988). Unfortunately, no general discussion of the specialized terms regarding these important genital characters is provided in this volume and the book's glossary also lacks any definitions to assist unfamiliar readers. Considering that these and many other authors place great significance on these morphological characters to differentiate many varanid species, this deficiency must be corrected in any future editions to ensure comprehensiveness.

In the Asian monitor section several individual species members of the so-called "*Varanus indicus* group" are described separately from the nominate taxon and similar partitioning was also made for members of the "*V. prasinus* group" (which in this volume includes: *V. kordensis*, and *V. macraei*; but not *V. beccari*, and *V. bogerti*). None of the Asian monitor chapters are as detailed as that for *V. griseus*, however, the two segments concerned with *V. salvator* and its subspecies, when combined, come close. The others, all succinct reviews, average about four or five pages each.

The section on Australian monitors has the greatest number of authors and, not surprisingly, the majority are Australians (the one dealing with *V. keithhornei* was even contributed by "Croc Hunter" Steve Irwin). One significant difference between this section and those for the African and Asian monitors is that each Australian species contains a list of specimens in the major Australian museum collections. Many of these specimen lists appear quite exhaustive and all are potentially very useful to any varanid researcher doing work on these species. Unlike for the previous two sections, I could not detect any missing or incorrectly cited references, but similar to these earlier sections, the amount of detail provided for any given Australian species varies. Generally, these descriptions were all concise and averaged somewhere between six and ten pages.

The "Other Varanoids" section contains accounts for *Lanthanotus*, both living species of *Heloderma*, and the Late Cretaceous monstersaur, *Estesia mongoliensis*. *Estesia*, which did not merit a color photo, although a black and white print of the skull

leads the chapter, is the only fossil taxon treated in its own individual segment (about two pages) despite the fact it was discussed earlier in Molnar's chapter. Not even the gigantic Australian varanid, *Varanus priscus* [*Megalania prisca*] warranted its own chapter, although this latter species went extinct much more recently in the Pleistocene. All subspecies for *Heloderma* are discussed within the chapters about the two species and their range maps also include subspecies information (both chapters are by *Heloderma* expert, Daniel Beck). Eric Pianka's short chapter on *Lanthanotus* is notable for demonstrating how little is known about this important taxon, particularly concerning its diet and times of activity, as well as reproductive, thermoregulatory, and foraging behaviors.

The book concludes with a two-chapter section. The first, by Pianka, draws an important relationship between body size and reproductive tactics, and basically argues that body size influences reproduction more strongly than phylogeny, particularly: egg mass, clutch size, clutch mass, neonate snout-vent length, and neonate body mass. Pianka also notes that clutch sizes for larger species are normally smaller than those produced by the smaller species and that maternal snout-vent length is a more potent influence on clutch size within a given species than between any two species. The final chapter, by Hans-Georg Horn, examines the captive care of monitors with an eye toward biological, technical, and legal difficulties, and he discusses many relevant issues including: difficulties providing the proper diets, distinguishing males from females, the problems involved with distinguishing between two species showing very similar appearance, problems involving the proper lighting and construction of enclosures, and the effects of various laws, including CITES legislation, on the captive conservation of monitors.

This book will likely be an important single-volume source about varanoid lizards for some time to come. Despite some mostly minor editorial oversights, including those mentioned above, some of which may have resulted from the sudden and unfortunate death of Dennis King during the production of this volume, I believe this book to be a welcome and important addition to the library of any herpetologist. Its importance lies not only in what information it manages to include within its covers, but also in its indication of the significant work still remaining for the more complete understanding and conservation of these important reptiles.

LITERATURE CITED

- AUFFENBERG, W. 1981. The Behavioral Ecology of the Komodo Monitor. University of Florida Press, Gainesville. 406 pp.
- . 1988. Gray's Monitor Lizard. University of Florida Press, Gainesville. 419 pp.
- . 1994. The Bengal Monitor. University of Florida Press, Gainesville. 560 pp.
- BALLARD, V., and F. B. ANTONIO. 2001. *Varanus griseus* (desert monitor): toxicity. Herpetol. Rev. 32:261.
- BENNETT, D. 1998. Monitor Lizards: Natural History, Biology and Husbandry. Edition Chimaira, Frankfurt am Main. 352 pp.
- BÖHME, W. 1988. Zur Genitalmorphologie der Sauria: Funktionelle und stammesgeschichtliche Aspekte. Bonn. Zool. Monogr. 27:1–176.
- , J. P. FRITZ, and F. SCHÜTTE. 1987. Neuentdeckung einer Großechse (Sauria: *Varanus*) aus der Arabischen Republik Jemen. Herpetofauna. 46:13–20.

- , and H.-G. HORN (eds.). 1991. Advances in Monitor Research, *Mertensiella* 2:1–266.
- , U. JOGER, and B. SCHÄTTI. 1989. A new monitor lizard (Reptilia: Varanidae) from Yemen, with notes on ecology, phylogeny and zoogeography. *Fauna of Saudi Arabia* 10:433–448.
- CIFELLI, R. L., and R. L. NYDAM. 1995. Primitive helodermatid-like platynotan from the early Cretaceous of Utah. *Herpetologica*. 51:286–291.
- ESTES, R. 1983. *Sauria terrestria*, *Amphisbaenia*. Gustav Fischer Verlag, Stuttgart, Germany. 249 pp.
- FEJÉRVÁRY, G. J. 1918. Contributions to a monograph on fossil Varanidae and on Megalanidae. *Ann. Mus. Natl. Hung.* 16:341–467.
- . 1935. Further contributions to a monograph of the Megalanidae and fossil Varanidae—with notes on recent varanians. *Ann. Hist.-Nat. Mus. Natl. Hung.* 29:1–130.
- GREEN, B., and D. KING. 1999. *Monitors: The Biology of Varanid Lizards*, 2nd Edition. Krieger Publishing Co., Malabar, Florida. 116 pp.
- HORN, H.-G., and W. BÖHME (eds.). 1999. Advances in Monitor Research II. *Mertensiella* 11:1–366.
- LENZ, S. 1995. Zur Biologie und Ökologie des Nilwarans, *Varanus niloticus* (Linnaeus 1766) in Gambia, Westafrika. *Mertensiella* 5:1–256.
- MERTENS, R. 1942a. Die Familie der Warane (Varanidae) Erster Teil: Allgemeines. *Abh. Senckenberg. Naturforsch. Ges.* 462:1–116.
- . 1942b. Die Familie der Warane (Varanidae) Zweiter Teil: Der Schädel. *Abh. Senckenberg. Naturforsch. Ges.* 465:117–234.
- . 1942c. Die Familie der Warane (Varanidae) Dritter Teil: Taxonomie. *Abh. Senckenberg. Naturforsch. Ges.* 466:235–391.
- MOLNAR, R. E. 2004. *Dragons in the Dust: The Paleobiology of the Giant Monitor Lizard Megalania*. Indiana University Press, Bloomington, Indiana. 210 pp.
- MURPHY, J. B., C. CIOFI, C. DE LA PANOUSE, and T. WALSH. 2002. *Komodo Dragons: Biology and Conservation*. Smithsonian Institution Press, Washington, D.C. 267 pp.
- NYDAM, R. L. 2000. A new taxon of helodermatid-like lizard from the Albian-Cenomanian of Utah. *J. Vert. Paleontol.* 20:285–294.
- SOPIEV, O., V. M. MAKEYEV, S. V. KRUDRISTEV, and A. N. MAKAROV. 1987. A case of intoxicification from the bite of *Varanus griseus* [in Russian]. *Izv. Akad. Nauk Turmen. SSR, Ser. Biol. Nauk.* 87:78.

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Die Mimikry zwischen Eidechsen und Laufkafern (Mimicry Between Lizards and Ground Beetles), by Almuth D. Schmidt. 2004. Edition Chimaira, Frankfurt am Main, Germany (www.chimaira.de). 374 pp. Hardcover. ♂ 58.00 (approximately US \$75.00). ISBN 3-930612-69-0.

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For more than a century, warning coloration and mimicry have fascinated evolutionary biologists and natural historians. In fact, these phenomena helped convince late 19th Century biologists of the power of natural selection.

During the 20th Century, studies of mimicry were common; but

reptiles and amphibians were bit players in these studies. A few species were notable exceptions, of course (e.g., coral snakes, egg-eating snakes; reviewed in Pough 1994); but these involved one herp mimicking another. Cases of a herp mimicking an invertebrate are rare (Autumn and Han 1989; Gans 1987; Parker and Pianka 1974; Vitt 1992) and often anecdotal.

In 1977 we proposed that a ground-dwelling lizard in the Kalahari Desert mimicked a beetle (Huey and Pianka 1977). The possibility that a lizard could mimic a beetle must have seemed ludicrous to many, and no doubt some of our colleagues wondered whether we'd spent too much time out in the Kalahari sun. Our evidence was circumstantial; but we were convinced that this was mimicry, and that it involved both color and locomotor behavior.

The model is the juvenile lacertid lizard, *Heliobolus lugubris*, and the mimic is a carabid beetle, *Anthia* spp. Adult *H. lugubris* are sand colored and reasonably cryptic, but juveniles are decidedly conspicuous against the red Kalahari sand. Juveniles have jet-black bodies, with broken white stripes—only their tails are sand colored (Fig. 1). No other lacertid in the Kalahari changes color so dramatically during ontogeny. Nor does any other lacertid of which we are aware.

Both juvenile and adult *H. lugubris* are wide foragers (Huey and Pianka 1981), but they differ strikingly in the way they move. Adults move like normal lacertids (with lateral undulations), but juveniles often move stiff legged, with their backs arched and their tails pressed to the ground (Fig. 1). When the juveniles 'metamorphose' to the adult coloration, they switch from arch-walking to a normal walking style. Juvenile *H. lugubris* are the only lizards known to use arch-walking.

We didn't do a formal phylogenetic analysis, but we realized that two unique features of the juveniles (coloration, arch walking) must be evolutionarily derived and thus called for explanation. When we looked around the Kalahari, we soon noticed carabid beetles (*Anthia*). These beetles are black-and-white, a classic aposematic pattern, and often abundant. Locals refer to them as "oogpisters" (which translates euphemistically as "eye squirter"), because these beetles squirt from their abdomen a noxious mixture of formic acid, tiglic acid, and other compounds (Scott et al. 1975). As far as we were aware, no vertebrate predator ate these noxious beetles.

To us the observed patterns strongly suggested that the beetles were noxious models and that juvenile *H. lugubris* (approximately the same size as the beetles) were Batesian mimics, involving both color and movement. We noted that juveniles of this species had a



FIG. 1. An arch-walking juvenile *Heliobolus lugubris* (photograph courtesy of A. Schmidt).

low tail-break frequency relative to other juvenile lacertids in the Kalahari, and we interpreted this as evidence of the efficacy of the mimetic resemblance (but see Schoener 1979).

In the late 1990s we began to hear rumors that a German graduate student (Almuth Schmidt) was studying this mimicry complex for her thesis. She has published a few papers on this over the years, but has now synthesized her work in a well-illustrated book. Naturally, we were excited to see her book, to find out how well our ideas stood up, and to learn what new evidence she had uncovered.

Her book is largely in German (a language that has sadly decayed from our brains during ontogeny). Fortunately, all of the table and figure legends are in both English and in German; and the book has a 3-1/2 page summary in English. So the essence of her study is accessible even to an English-restricted audience.

Schmidt worked mainly in two nature reserves in the Limpopo Province of South Africa, rather than in the Kalahari. She presents a diverse set of studies involving careful observations as well as clever experiments. Her studies solidly reinforce the idea of mimicry. Here is a small sample of the kinds of evidence she has garnered:

1) The geographic range of the lizards overlaps with that of abundant carabid beetles (a dozen species of *Thermophilum* and three species of *Anthia*), which serve as models.

2) As juvenile lizards grow, their color and patterns shifts progressively, matching the color of size-matched species of beetles!

3) In staged encounters with beetles, most predators (birds, mammals, monitor lizards) consistently avoided the beetle after being sprayed only once. Thus beetles are indeed strongly noxious, and seemingly unforgettable.

4) Arch-walking juveniles were avoided 100% of the time by visually hunting snakes, but were invariably attacked by the same snakes if they moved normally. Thus arch walking is highly effective against visual predators. (Note: it was against us, too! More than once we briefly confused juvenile lizards for beetles.)

5) Most remarkably, juveniles change their behavior when encountering different snakes. When they encounter a visual hunter, they either remain immobile or use arch-walking. But, when they encounter a snake that hunts using olfaction, they run away at high speed!

Schmidt's studies are inventive and comprehensive, and she has put together one of the most impressive studies of models and mimics we've seen. Her findings will be of considerable interest not only to herpetologists, but also to any behavioral and evolutionary ecologists interested in predation, aposematic coloration, and mimicry. In particular, her discovery that juveniles modify their evasive behavior in response to different kinds of predators is remarkable and deserves to be widely highlighted.

Acknowledgments.—We thank Almuth Schmidt for permission to publish her photograph of an arch-walking *H. lugubris* and for discussion.

LITERATURE CITED

- AUTUMN, K., AND B. HAN. 1989. Mimicry of scorpions by juvenile lizards, *Teratoscincus roborowskii* (Gekkonidae). *Chin. Herpetol. Res.* 2:60–64.
- GANS, C. 1987. Automimicry and Batesian mimicry in uropeltid snakes: Pigment, proportions, pattern, and behavior. *J. Bombay Nat. Hist. Soc.*

83 (Suppl.):153–158.

- HUEY, R. B., AND E. R. PIANKA. 1977. Natural selection for juvenile lizards mimicking noxious beetles. *Science* 195:201–203.
- , AND ———. 1981. Ecological consequences of foraging mode. *Ecology* 62:991–999.
- PARKER, W. S., AND E. R. PIANKA. 1974. Further ecological observations on the western banded gecko, *Coleonyx variegatus*. *Copeia* 1974:528–531.
- POUGH, F. H. 1994. Mimicry and related phenomena, p. 153–234. In C. Gans and R. B. Huey (eds.), *Biology of the Reptilia*, vol. 16, *Ecology B: Defense and Life History*, pp. 153–234. Branta Books, Ann Arbor, Michigan.
- SCHOENER, T. W. 1979. Inferring the properties of predation and other injury-producing agents from injury frequencies. *Ecology* 60:1110–1115.
- SCOTT P. D., H. R. HEPBURN, AND R. M. CREWE. 1975. Pygidial defensive secretions of some carabid beetles. *Insect Biochem.* 5:805–811.
- VITT, L. J. 1992. Mimicry of millipedes and centipedes by elongate terrestrial vertebrates. *Natl. Geogr. Res. Expl.* 8:76–95.

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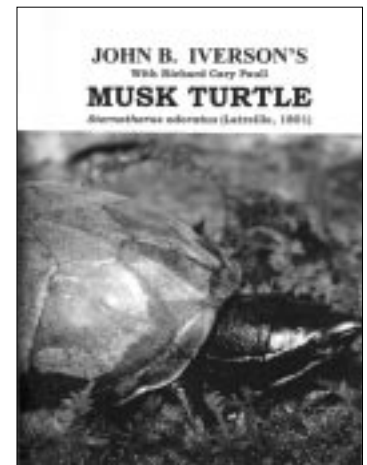
The Musk Turtle Book, by John B. Iverson, with a **Section on Husbandry**, by Richard Cary Paull. 2003. Green Nature Books, P.O. Box 105, Sumterville, Florida 33585, USA. 78 pp. Soft cover. US \$29.95 + \$3.95 postage. ISBN 1-888089-58-X.

C. KENNETH DODD, JR.

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Musk turtles are ubiquitous denizens of many types of fresh waters in North America. Populations can be very large, and as such these little turtles are likely important components of aquatic ecosystems as both predators and prey. Anyone who has kept Stinkpots in an aquarium knows that they are quite entertaining and easy to maintain, and it is fortunate that commercial collecting has been restricted in many states because they undoubtedly would be popular in national and international trade. There are a number of musk turtles other than Stinkpots (*S. carinatus*, *S. depressus*, *S. minor*), however, and despite this little book's title, these are not covered except exceedingly cursorily in Paull's 5 page section on "Other Musk Turtles."

The book (really a booklet) consists of 40 pages of large bold text by Iverson on the natural history of Stinkpots, 9 pages on husbandry and other musk turtles by Paull, 4 pages of biography (including pictures of the Iverson family and Paull with his granddaughter), and 19 pages of literature cited (with references to early 2003). Only a bare minimum of information on Stinkpot morphology, physiology, or factors other than those relating to natural his-



tory, are included. The book appears to be printed on high quality vellum without using any special publishing program, which in turn makes photographs reproduce very poorly (almost black in some cases) and allows text to be seen through the page. The booklet is paper bound, with a clear front page protector over a color photograph of *Sternotherus odoratus*. The cover provides one version of the title, whereas page 3 has a completely different version (I have shortened both to avoid excessive and confusing verbiage). Maps are identical to those in Iverson (1992), except for a very poor map on page 12 depicting localities for *S. odoratus*. Photos include pictures of turtles and habitats, with some photos taking entire pages.

I almost don't know where to begin, for I consider John Iverson to be one of the most respected turtle scientists active today. There is probably no one who knows more about "little brown turtles" than he does, so my impressions of the booklet become all the more difficult to convey. Iverson reviews the literature on the life history and ecology of Stinkpots quite thoroughly and in great detail, although he adds no new insights or data. I could not find any missing studies of note; if a reader wants facts on natural history, they are here. However, the sheer volume of the literature makes the litany of facts difficult to assimilate, as the reader is embalmed in statement after statement, for example, of "(so and so) reported (x to y) eggs in (wherever)." Simply putting more of this repetitive information (e.g. growth increments, nesting dates, incubation duration) in tables would have helped. Iverson also makes little attempt to put studies of Stinkpots in context with other chelonians, except when they are included with his meta-studies, such as on biomass or survivorship. This is not a book to read, but one that could be consulted for raw information.

A few things need clarification. I presume Iverson means latitudinally rather than altitudinally when discussing reproductive cycles (page 24); if *S. odoratus* is diurnal, as suggested, why does mating and nesting often occur at night (pages 27 and 28); variable sex ratios may not need a complex explanation (pages 36–37) since stochastic variation may occur for a variety of reasons in any one year (in other words, turtle biologists focus too much weight on results from short-term studies of sex ratios, rather than on the long-term population structure); turtles do not hibernate (a physiological ecology term involving endotherms), but become dormant.

I don't have any idea of whom the intended audience of the book might be. All the Stinkpot facts are beyond the interests of most herpetoculturists and amateur naturalists, and the fairly uninformative section on husbandry would insult most turtle aquarists (Paull takes much space talking about tortoises, for some reason). One cannot read this booklet because of its non-literary style, and the price is completely outrageous; I can't imagine herpetologists paying > \$30 for this booklet rather than consulting Ernst et al. (1994) and the recent published literature. The poor quality of reproduction, the frequent editorial mistakes (scientific names not italicized, occasional use of English metrics, the heading 'Activity Patern' misspelled), the out-of-place folksy comments by Paull (page 32: "the musk turtle enjoys diving almost as much as boys do on a hot day"), the lack of attention to nomenclature (Stinkpot versus the all-inclusive 'musk turtle'), and the gushy biographies are overwhelming.

The authors could have collaborated to produce a valuable ref-

erence, even if privately published (Green Nature Books is Paull's personal publishing outlet), by using a good publishing program, by taking the time to edit the text for style, by opting for consistency in style between authors, and by using paper compatible with photographs. What were the authors thinking?

LITERATURE CITED

- ERNST, C. H., J. E. LOVICH, AND R. W. BARBOUR. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington, D.C. xxxviii + 571 pp.
- IVERSON, J. B. 1992. A Revised Checklist with Distribution Maps of the Turtles of the World. Privately published, Richmond, Indiana. xiii + 363 pp.

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Verzeichniss der Reptilien, welche auf einer Reise im nördlichen America beobachtet wurden, by Maximilian, Prince of Wied. 1865 (reprint 2004). Bibliomania!, Salt Lake City, Utah (www.herplit.com). 152 pp., 7 handcolored plates. Leatherbound edition US \$875. ISBN 1–932871–04–7; unbound edition US \$675. ISBN 1–932871–03–9.

KRAIG ADLER

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In 1832, Prince Alexander Philipp Maximilian of the German principality of Wied-Neuwied – former major general in the Prussian army during the Napoleonic wars and veteran explorer of Brazil – embarked on his second and last great expedition, at the age of 50. Together with his Swiss artist, Karl Bodmer, and a team of five assistants, Maximilian traveled by



means of small boats over nearly 2700 miles from Saint Louis, Missouri, to Fort McKenzie (near present-day Great Falls, Montana), along the then-treacherous Missouri River. Besides his other credentials, Maximilian was a naturalist and ethnologist, trained by Johann Blumenbach, and he sought to explore what was then "Indian country" beyond the border states of Missouri and Illinois. He was the first trained scientist to do so and his book, "Reise in das innere Nord-Amerika . . . in den Jahren 1832 bis 1834" (published 1839–1841), records his ethnological observations with notes on natural history including herpetology.

Maximilian's definitive scientific report on the amphibians and reptiles – the book reviewed here – was published much later, in

1865, only two years before his death. At that time it was the only extensive account covering the herpetofauna of central North America, thus filling the enormous gap between the region east of the Mississippi River that had been monographed by Holbrook in his two editions of "North American Herpetology" and the various reports on the herpetology of the Pacific Coast based primarily on foreign naval explorations (Russian, French, and British). Maximilian's book is comprehensive, covering 48 species (16 amphibians, 32 reptiles) with detailed descriptions of adults and (where available) juveniles, their colors in life, dimensions, and including extensive natural history notes. It is the fundamental first summary of the herpetology of the Great Plains and also includes Maximilian's observations made along the Ohio River (especially in Pennsylvania and southern Indiana) before he began his ascent of the Missouri.

As such, this book is a classic work that richly deserved reprinting, especially since original copies nowadays fetch prices of US\$2000 and more. A reprint of this book is thus welcome, but this is no ordinary reprint. To the contrary, the seven beautifully drafted and accurate plates (five of them depict turtles, the other two the large aquatic salamanders *Cryptobranchus* and *Necturus* plus details of some snake heads; five plates are foldouts) were all originally drawn by Bodmer and are handcolored, both in the original and in this reprint. The latter is a remarkable achievement, given the difficulty to match the originals, and this represents the only herpetological work on North American herpetology with handcolored plates that has been issued in more than a century! These were faithfully colored by Lara Carroll. Copies of the book are available in two states: (1) exquisitely bound with leather spine, raised bands, and marbled paper covers, and (2) unbound, so that the purchaser can have the volume bound to a particular style. The volume is quarto in format, measuring 9 3/4 x 12 1/4 inches (25 x 31 cm).

As with the plates, the text is an exact facsimile of the original in every detail. The rear side of the title page, which is blank in the original, has the only new text added to the reprint. Here, the publisher gives details of the reproduction; it notes the copy number in the limited edition of only 100, and is individually signed by the publisher and colorist. The text and plates are printed on 100% cotton, mould-made, acid-free paper, a distinct improvement over the original in which the paper is routinely browned with age and often foxed due to its poor quality. The only other change from the original is that the final two pages (the errata and an explanation of the plates) are combined on a single leaf in the reprint.

Compared to reprints of classical herpetological works issued by various commercial firms in Europe, South Africa, Japan, and Australia, and including those by the SSAR over the past 45 years, this reprint surpasses them all in the standard of production. It meets the highest criteria and is of a quality of materials and appearance that Prince Maximilian's classic work deserved to have had in 1865!

Amphibians and Reptiles of Montana, by J. Kirwin Werner, Bryce A. Maxell, Paul Hendricks, and Dennis L. Flath. 2004. Mountain Press Publishing Company, P.O. Box 239, Missoula, Montana, USA. xii + 262 pp. Softcover. US \$20.00. ISBN 0-87842-500-4.

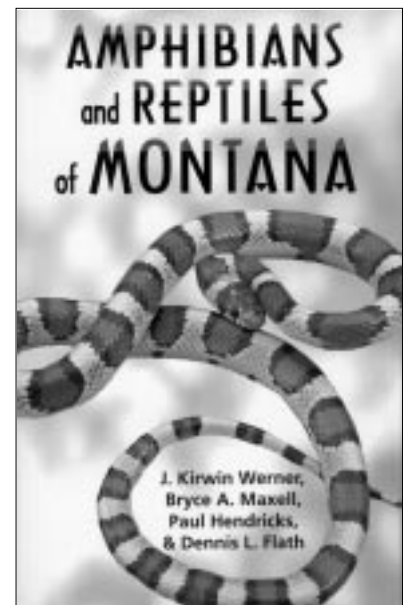
NOAH J. ANDERSON

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Two-hundred years have elapsed since the first formal scientific survey of Montana's biota; since that time, 31 species of amphibians and reptiles have been documented from the state. *Amphibians and Reptiles of Montana* summarizes the state of knowledge on the distribution, natural history and conservation status of Montana's herpetofauna. As a state field guide, this book has a large niche to fill; only a handful of recent, comprehensive summaries on amphibians and reptiles exist for the upper Great Plains (Hammerson 1999; Jundt 2000; Russell and Bauer 2000) and surrounding areas (Koch and Peterson 1995; Oldfield and Moriarty 1994; St. John 2002).

The introduction starts with "A Brief History of Herpetology in Montana." This section begins with a short discussion on the role of herpetofauna in the culture of Native Americans of Montana. From there the authors overview a rough chronology of the various and often famous naturalists who studied in Montana, starting with Meriwether Lewis and William Clark's explorations of 1804–1806 to Edward Drinker Cope in the 1860's to present day efforts of herpetologists. Overall, this section is lucid and interesting, but very brief at slightly over eight pages long.

In the "Biology of Amphibians and Reptiles" the authors discuss biological phenomena such as ectothermy, diversity, metamorphosis, food sources, predator relationships, diseases and deformities. The review is accurate and accessible to laypeople. "The Montana Landscape: Habitats for Herpetofauna" covers Montana's spectacular landscape features, from the alpine tundra and boreal forest of the Rocky Mountains, to the five major river systems, and the moonscapes of southeastern Montana's badlands. "Observing Amphibians and Reptiles in the Field" covers the basic steps in observing, capturing and handling reptiles and amphibians. The authors emphasize a conservation ethic in observing and collecting while recognizing the potential role of public reporting



of reptile and amphibian observations. In the "Conservation and Management" section the authors detail conservation concerns, both abroad and within the state.

The majority of the book is composed of species accounts for the 31 amphibians and reptiles found within the state and the six amphibians and reptiles that are of questionable occurrence. Each account includes sections on distribution, notes on identification, taxonomy, habitat/behavior, reproduction/development, remarks and scientific name etymology. The taxonomy is up-to-date and follows SSAR approved lists (Crother 2000). The distribution maps include a full range map and statewide dot locality map (which combines observations and museum vouchers). The species accounts are generously illustrated (most have at least four color photographs), which document color variants, various life stages and natural behaviors. The information in the accounts is accurate but little of it appears to be derived from data on Montana's amphibians and reptiles.

An "Identification Guide" overviews the diagnostic characteristics of adult, larval stages and eggs of all amphibians and reptiles (reptile eggs are not included) in Montana. The guide is well illustrated with color photographs and black and white drawings for each species/stage. This helpful feature ensures that readers will not have to flip back and forth from the species accounts to the keys while attempting to identify an animal. While not a formal dichotomous key, the identification guide should prove useful for anyone to make a solid identification of a reptile or amphibian in hand. I worked through the keys for several species and did not find any mistakes.

The book finishes with several appendices, which include a table of species by eco-region, reproductive characteristics of amphibians and reptiles, contact information for various agencies, an observation report form and a snakebite action sheet. In the tables of the reproductive characteristics, the authors give an impressive summary on the reproductive biology of reptiles and amphibians found in Montana. However, the tables suffer significantly by the complete lack of citations. The book wraps up with a glossary of terms used in the book, an index and a state checklist. The bibliography deserves special mention because it is a "selected bibliography"; this is particularly frustrating, as this belies the fact that the book is well researched at over 500 references consulted.

The front cover includes a county map of Montana and the back cover has a printed ruler. The book is fairly sturdy and appears to be up to the rigors of fieldwork. Finally, a state field guide that was meant to be brought into the field!

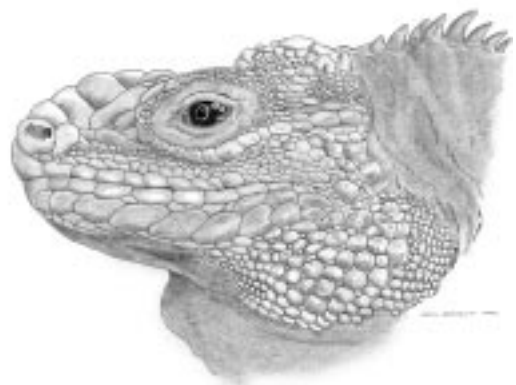
I noted very few errors in the text itself; more significant were the photographs that were out of context (e.g., dead animals posed as live and aquatic larvae on land; pgs. 9, 59, 64, 107, 175). For example, the description of handling a snapping turtle (p. 106) states not to handle large animals by the tail, whereas the picture on the opposing page shows someone carrying an adult snapping turtle by the tail. More importantly, I found the nearly complete lack of citations to be the most significant omission of the book. Presumably, the authors did this to keep the text readable for lay-people, however a compromise could have been reached if they simply included significant references at the end of each species account (e.g., Russell and Bauer 2000). Fortunately, all the references are included in a separate publication (Maxell et al. 2003), but will only be accessible those willing to track down that publi-

cation.

Overall, Werner et al. have done a fine job on Montana's state field guide. *Amphibians and Reptiles of Montana* should be a handy reference for lay-people, educators, students, state and federal wildlife biologists, and anyone with an interest in the natural history of Montana's biota. Herpetologists will also want to pick up the companion publication (Maxell, et al. 2003) which more formally summarizes the distribution, history, museum records, dichotomous keys and complete bibliography. Between these two books (Maxell et al. 2003, Werner et al. 2004), the authors have created an excellent reference set on Montana's amphibians and reptiles that compares favorably with many state herpetological guides in print. Anyone interested in reptiles and amphibians of the west and great plains regions should have this book on their shelf.

LITERATURE CITED

- CROTHER, B. I. (chair). 2000. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, with Comments Regarding Confidence in Our Understanding. *SSAR Herpetol. Circ.* 29:1–82.
- HAMMERSON, G. A. 1999. *Amphibians and Reptiles in Colorado*. University Press of Colorado, Niwot, Colorado. 484 pp.
- JUNDT, J. A. 2000. *Distributions of Amphibians and Reptiles in North Dakota*. Unpublished Master's Thesis, Dept. of Zoology. North Dakota State University, Fargo, North Dakota. 159 pp.
- KOCH, E. D., AND C. R. PETERSON. 1995. *Amphibians and Reptiles of Yellowstone and Grand Teton National Parks*. University of Utah Press, Salt Lake City, Utah. 188 pp.
- MAXELL, B. A., J. K. WERNER, P. HENDRICKS, AND D. L. FLATH. 2003. *Herpetology in Montana: A history, status summary, checklists, dichotomous keys, accounts for native, potentially native and exotic species, and indexed bibliography*. Society for Northwestern Vertebrate Biology, Olympia, Washington. 138 pp.
- OLDFIELD, B., AND J. J. MORIARTY. 1994. *Amphibians and Reptiles Native to Minnesota*. University of Minnesota Press, Minneapolis, Minnesota. 237 pp.
- RUSSELL, A. P., AND A. M. BAUER. 2000. *The Amphibians and Reptiles of Alberta: A Field Guide and Primer of Boreal Herpetology*, revised second edition. University of Alberta Press, Calgary, Alberta, Canada. 269 pp.
- ST. JOHN, A. 2002. *Reptiles of the Northwest*. Lone Pine Publishing, Renton, Washington. 272 pp.



Cyclura cychlura cychlura (Andros Island Iguana). Illustration by John Bendon (Lizardwizard@btinternet.com).

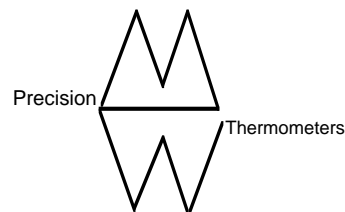
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