9-2007

Eleutherodactylus ridens (Pygmy Rainfrog) Predation

Tobias Eisenberg

Twan Leenders
Sacred Heart University

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SOCIETY FOR THE STUDY OF AMPHIBIANS AND REPTILES

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

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

ANNUAL DUES AND SUBSCRIPTIONS: Annual membership dues for the year 2007 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*.

To join SSAR or to renew your membership, please visit the secure online Allen Press website:

http://timssnet.allenpress.com/ECOMSSAR/timssnet/common/tnt_frontpage.cfm

Future Annual Meetings

2008 — Montreal, Canada, 23–28 July (with ASIH, HL)
2009 — Portland, Oregon (with ASIH, HL)

About Our Cover: *Adenorhinos barbouri*

The Udzungwa Short-Headed Viper, *Adenorhinos barbouri*, is among the rarest and least known vipers in Africa. Known from only a few localities in the Udzungwa and Ukinga Mountains of southwestern Tanzania, *A. barbouri* was described in 1930 by Arthur Loveridge (Proc. New England Zoöl. Club 11:107–108), who placed it within the genus *Atheris*. It has been seen few times since, and until the discovery of this specimen, had yet to be photographed alive. The snake remains enigmatic—museum specimens number fewer than 25 and several of these were obtained as dead specimens from local farmers or tea estate workers.

After Loveridge formally described the species from localities in the Udzungwas, he reported on a collection of additional material in 1933 (Bull. Mus. Comp. Zoöl., Harvard College 74[7]:195–416), extending the range south to the Ukinga Mountains, which have volcanic origins in the East African Rift rather than the more ancient Eastern Arc orogeny. Remarkably, no specimens of *Adenorhinos* were reported for nearly 50 years following this publication. A few individuals were sporadically collected during the 1980s and 1990s, in large part because of focused efforts to locate the species. Instrumental in these efforts was Jens Rasmussen, the late curator of herpetology at the University of Copenhagen who, along with Kim Howell (University of Dar es Salaam, Tanzania), summarized all known information on *Adenorhinos* in a 1998 paper (Rasmussen and Howell 1998. Afr. J. Herpetol. 47[2]:69–75).

The taxonomy of *Adenorhinos* has fluctuated somewhat over the last 77 years. In his original description, Loveridge placed this snake within *Atheris*, the genus containing the African bush vipers. However, in light of several morphological apomorphies, in particular a unique subcutaneous compound mucus secreting gland, Marx and Rabb (1965. Field. Zool. 44[21]:161–206) elevated the species to its own genus, *Adenorhinos* (adeno = gland, rhinos = nose). *Adenorhinos* is unique in many additional respects as well, and several features led Marx and Rabb to place *Adenorhinos* near the base of the viperine radiation, a hypothesis that was supported by later morphological phylogenies (Groombridge 1986. *In* Z. Rocek [ed.], Studies in Herpetology, pp. 219–222. Proceedings of the Third Ordinary General Meeting of the Societas Europaea Herpetologica, Prague; Ashe and Marx 1988. Field. Zool. [N.S.] 52:1–23). It exhibits a foreshortened snout, a squat, seemingly terrestrial habitus, brown checkered coloration, and an extremely short tail. Hardly resembling the bush vipers at first glance, *Adenorhinos* has several hallmarks of a terrestrial lifestyle.

Nonetheless, affinities with the atherine bush vipers have been strongly supported by a recent molecular study (Lenk et al. 2001. Mol. Phylogen. Evol. 19[1]:94–104). Surprisingly, despite its disparate morphology, analysis of mitochondrial DNA places *Adenorhinos* well within the *Atheris* clade where it is sister to *Atheris ceratophora*, a horned bush viper and another endemic of Tanzania's ancient highland rainforests. If this result is supported by further molecular studies, *Adenorhinos* will represent the evolution of a truly different morphology from within a somewhat more conservative clade of relatives.


PHOTO BY MIKE HETTWER

Luke Mahler is a PhD candidate in the Department of Organismic and Evolutionary Biology at Harvard University. His thesis research investigates the role of ecological factors on rates and patterns of evolution in several families of lizards. Luke encountered this female *Adenorhinos* fortuitously in the Udzungwa Mountains of Tanzania in March 2007. The snake was photographed using a Canon 20D digital camera with a 100mm macro lens (f2.8) and an MT-24EX Twin Lite flash.

NEWSNOTES

USNM Collections Moving

The collections of the Division of Amphibians and Reptiles, National Museum of Natural History (Smithsonian Institution) are scheduled to be moved from the Natural History Building on the National Mall to a new storage wing at the Museum Support Center in Suitland, Maryland beginning about 1 October 2007 and continuing through the first week of April 2008.

It is anticipated that the collection management staff will be devoting significant amounts of time to preparing the collection for the move as well as moving the collection. It is realistic to assume that there will be significant periods of time between now and when the collection move is complete when there will be delays in processing loan requests and times when parts of the collection will not be available for examination by visitors. Visitors in particular should contact us well ahead of their projected visits to assure that collections will be available for their use. The collection will be moved by major taxonomic units. Each unit will be unavailable for study during the time that unit is being moved to the new facility.

Once the move has been completed, we will send out an announcement, including new contact information for the collection management staff as well as appropriate addresses to use for loan returns.

The Use of Amphibians in the Research, Laboratory, or Classroom Setting

The Institute for Laboratory Animal Research announced the publication of *ILAR Journal*'s most recent issue, "Use of Amphibians in the Research, Laboratory, or Classroom Setting" (vol. 48, no. 3). This important issue covers a broad range of topics relevant to research and related work with amphibians, as indicated in the table of contents: Introduction: The Art of Amphibian Science (Stephen A. Smith and Michael K. Stoskopf); Amphibians Used in Research and Teaching (Dorcas P. O'Rourke); Facility Design and Associated Services for the Study of Amphibians (Robert K. Browne, R. Andrew Odum, Timothy Herman, and Kevin Zippel); Amphibian Biology and Husbandry (F. Harvey Pough); Reproduction and Larval Rearing of Amphibians (Robert K. Browne and Kevin Zippel); Diseases of Amphibians (Christine L. Densmore and D. Earl Green); Medicine and Surgery of Amphibians (Edward J. Gentz); Amphibians as Animal Models for Laboratory Research in Physiology (Warren W. Burggren and Stephen Warburton); Amphibians as Models for Studying Environmental Change (William A. Hopkins); IACUC Issues Associated with Amphibian Research (Leanne C. Alworth and Stephen B. Harvey); Amphibian Resources on the Internet (Michael W. Nolan and Stephen A. Smith); Compendium of Drugs and Compounds Used in Amphibians (Stephen A. Smith). To purchase copies of this issue or for more information about the *ILAR Journal*, please visit our website: http://dels.nas.edu/ilar_n/ilarjournal/journal.shtml. In

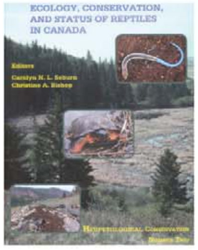
Society for the Study of Amphibians and Reptiles
New Releases for 2007

Contributions in Herpetology

CONTRIBUTIONS TO THE HISTORY OF HERPETOLOGY VOLUME 2 by Adler, Applegarth, and Altig

The books consists of three sections, each worldwide in coverage. The first and longest section is a series of 285 completely new biographies. The coverage of herpetologists is global and taxonomically diverse. The second section in an index of 3,603 authors in taxonomic herpetology. The third section is a listing of PhD herpetologists and their academic lineages. 400 pp., clothbound. July 2007, in conjunction with 50th Anniversary meeting. ISBN 978–0–916984–71–7 $65.00 (member price until Nov. 2007 $50.00) plus shipping.

Herpetological Conservation



ECOLOGY, CONSERVATION, AND STATUS OF REPTILES IN CANADA by Seburn and Bishop (eds.)

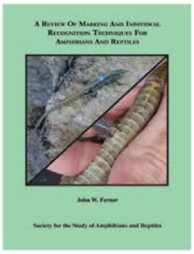
This volume covers the current view of the status of all 46 species Canadian reptiles and the difficult issues faced in their conservation. Overviews of the ecology and conservation of the major groups (turtles, sea turtles, snakes, and lizards). Published in association with the Canadian Amphibian and Reptile Conservation Network. x + 246 pp., clothbound with a dust-jacket. June 2007. ISBN 978-0-916984-70-0. $40.00 (member price until Nov. 2007 $32.00) plus shipping.

Facsimile Reprints in Herpetology

THE LIFE AND HERPETOLOGICAL CONTRIBUTIONS OF MARIO GIACINTO PERACCA (1861-1923)

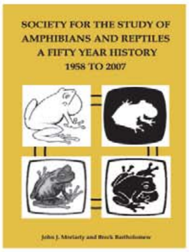
Mario Peracca was one of the foremost Italian herpetologists of the late 19th and early 20th centuries. He published numerous faunal works and described 72 species in 64 papers–all of which are reproduced in this facsimile. He was a pioneer of reptile husbandry, keeping a great diversity of species. The book includes an extensive biography, bibliography and synopsis of taxa by Franco Andreone and Elena Gavetti. Published in cooperation with Societas Herpetologica Italica. 570 pp., clothbound. February 2007. ISBN 978-0-916984-69-4. $55.00 plus shipping.

Herpetological Circulars



A REVIEW OF MARKING AND INDIVIDUAL RECOGNITION TECHNIQUES FOR AMPHIBIANS AND REPTILES by Ferner

This circular is a complete revision of Ferner's 1979 Marking Techniques Circular. Techniques covered range from toe clipping, shell notching and paint marking to PIT tagging and radio telemetry. This is the only up-to-date marking manual currently available. A must for any herpetologist or field biologist. iii + 72 pp., February 2007, ISBN 0-916984-68-0 $11.00 plus shipping.



SOCIETY FOR THE STUDY OF AMPHIBIANS AND REPTILES: A FIFTY YEAR HISTORY: 1958 TO 2007 by Moriarty and Bartholomew

The SSAR History provides highlights of the first 50 years of the Society's existence. This publication includes complete listing of 50–yr, 40+–yr, and 25+–yr members, Society Officers, Publications, Editors, Annual Meetings, and Committee Chairs. The history is illustrated in color with meeting photos and publication covers. A must have for anyone interested in SSAR. iv + 60 pp., July 2007, in conjunction with 50th Anniversary meeting. ISBN 978–0–916984–72–4 $10.00 (member price until Dec. 2007 $7.00) plus shipping.

Send orders to: Breck Bartholomew, SSAR Publications Secretary, P.O. Box 58517, Salt Lake City, UT 84158-0517, USA. **Telephone / fax** 801-562-2660; *email*: ssar@herplit.com. Make checks payable to "SSAR." Overseas orders must be paid in USA funds using a draft drawn on American banks or by International Money Order. Orders may be charged to VISA or MasterCard (Account number and expiration date must be provided). SSAR membership details and a complete list of Society publications can be obtained on request from the Publications Secretary.

addition to the purchase prices for single and multiple issues, the site has a link to sign up to receive the *Journal* regularly. We hope you find this issue useful, interesting, and informative. We welcome your ideas of topics for future issues, as well as submissions for discrete publication in our web-based e-Journal. (Ms.) Cameron H. Fletcher, Managing Editor, *ILAR Journal*, Institute for Laboratory Animal Research (ILAR), The National Academies, 500 Fifth Street NW, Keck 681,Washington, DC 20001, USA. Tel: 202/ 334-2592; Fax: 202/334-1687; e-mail: cfletcher@nas.edu.

MEETINGS

Meetings Calendar

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

11–14 October 2007—29th Annual Meeting of the Gopher Tortoise Council, Milton, Florida, USA. Information: http://www.gophertortoisecouncil.org/.

2–4 November 2007—34th Annual Meeting, Kansas Herpetological Society, Topeka Zoo, Topeka, Kansas, USA. Information: http://www.cnah.org/khsAnnualMeetingInfo.html.

23–27 June 2008—6th Symposium on Lacertids of the Mediterranean Basin, Lesvos Island, Greece. Information: http://www.gli.cas.cz/seh/news/6th%20Lacertids%20Symposium%20-%20First%20Circular.pdf.

17–22 August 2008—6th World Congress of Herpetology, Manaus, Brazil. Information: www.worldcongressofherpetology.org.

CURRENT RESEARCH

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

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

Influence of Altitude and Topography on Population Structure in Salamanders

Understanding the influence of abiotic factors on the spatial distribution of genetic variation is one of the primary goals of molecular ecology. The authors investigated the effects of altitude and topography on genetic variation in *Ambystoma macrodactylum*, the long-toed salamander, in northwestern Montana. They sampled individuals (N = 549) from 10 low altitude (< 1200 m) and 11 high altitude (> 1200 m) populations and used seven microsatellite loci to genotype each individual. Genetic structure was analyzed using pairwise F_{ST} estimates, population graphing methods and Bayesian analyses of population structure. The authors found that gene flow was limited between high and low altitude populations and among high altitude sites. Results also showed that gene flow was relatively higher among low altitude populations. The authors propose that wide-scale spring flooding may account for the high genetic diversity of low altitude populations by facilitating gene flow among these populations, while harsh habitat and climatic conditions may explain the limited gene flow between high altitude populations. The authors also suggest that different life history characteristics of high and low altitude populations (e.g., clutch size, egg size, time to metamorphosis) may result from divergent selection pressures and could further contribute to the limited gene flow observed between high and low altitude populations.

Giordano, A. R., B. J. Riddenhour, and A. Storfer. 2007. The influence of altitude and topography on genetic structure in the long-toed salamander (*Ambystoma macrodactulym*). Molecular Ecology 16:1625–1637.

Correspondence to: Andrew Storfer, School of Biological Sciences, Washington State University, Pullman, Washington 99164-4236, USA; e-mail astorfer@wsu.edu.

Effect of Leaf-Litter Depth on Rainforest Frog Distribution

Anurans are recognized as an important component of leaf-litter communities in tropical forests; however, studies of microhabitat characteristics and their effect on these anurans are limited. To address this, the authors investigated the abundance, distribution and microhabitat of leaf-litter anurans in the Atlantic Rainforest at Ilha Grande, south-eastern Brazil. They conducted nocturnal and diurnal surveys, counting all frogs within 234 2m × 1m plots on the forest floor, and determined the depth, weight and composition of the leaf-litter from each plot. The authors found 185 frogs of eight species, each of which was endemic to the Brazilian Atlantic Rainforest: *Brachycephalus didactylus*, *Dendrophryniscus brevipollicatus*, *Adenomera marmorata*, *Eleutherodactylus binotatus*, *Eleutherodactylus guentheri, Eleutherodactylus parvus, Zachaenus parvulus,* and *Chiasmocleis* sp. Results indicated that the depth and proportion of leaves in the leaf-litter was positively related to frog abundance and species richness. The authors propose that species richness and abundance are higher in environments with deep leaf-litter because these environments provide a wider range of microhabitats—especially for egg laying, a greater number of refuges against predators, and a higher density of arthropod prey. They also found that while leaf litter depth and leaf composition correspond to higher anuran community diversity, individual species had different responses to local leaf litter conditions.

Van Sluys, M., D. Vrcibradic, M. A. S. Alves, H. G. Bergallo, and C. F. D. Rocha. 2007. Ecological parameters of the leaf-litter frog community of an Atlantic Rainforest area at Ilha Grande, Rio de Janeiro state, Brazil. Austral Ecology 32:254–260.

Correspondence to: M. Van Sluys, Departmento de Ecologia, Instituto de Biologia Roberto Alcantara Gomes, Universidade de Estado do Rio de Janeiro, Rua São Francisco Xavier 524, CEP 20550-013, Rio de Janeiro, RJ, Brazil; e-mail vansluys@uerj.br.

Delaying Parturition in a Viviparous Lizard

The delaying of parturition (i.e., birth) following the completion of embryonic development can be important for maximizing offspring fitness in challenging environmental conditions. This is especially true in ectothermic viviparous species, where the environment experienced by the female during pregnancy can profoundly influence both gestation length and offspring phenotype and fitness. The authors studied populations of the viviparous Snow Skink, *Niveoscincus ocellatus*, at the extremes of their altitudinal range in Tasmania, Australia, by investigating their ability to delay parturition in cold conditions and the fitness consequences for the offspring. Late-term pregnant females from both high (1200 m) and low (50–75 m) elevation sites were maintained in one of four treatments: control conditions in which they could effectively thermoregulate in a thermal gradient ranging 12–35°C (N = 60), or treatments at 10°C with no chance of thermoregulation for one (N = 60), two (N = 40), or three weeks (N = 40). The authors found that females from both the high and low altitude sites were able to delay parturition in cold conditions with no effect on offspring weight at birth, dispersal distance or survivorship after birth, with one exception: females from the high altitude site maintained at 10°C for three weeks were less able to delay parturition and suffered a decrease in offspring viability. The authors propose that while delaying parturition can act to maximize fitness in some conditions, in severe environments, such as those experienced by the high altitude population, the benefits of delayed parturition in response to environmental cues are reduced by the constraints of their short breeding season.

Atkins, N., R. Swain, E. Wapstra, and S. M. Jones. 2007. Late stage deferral of parturition in the viviparous lizard *Niveoscincus ocellatus* (Gray 1845): implications for offspring quality and survival. Biological Journal of the Linnean Society 90:735–746.

Correspondence to: Susan M. Jones, School of Zoology, University of Tasmania, Private Bag 5, Hobart, Tasmania 7001, Australia; e-mail: s.m.jones@utas.edu.au.

Marine Resources Subsidize Diet Of Desert Geckos

The movement of nutrients from aquatic ecosystems to coastal habitats via biotic and abiotic vectors can have a profound influence on terrestrial ecosystems. This is especially true in the Atacama desert in Peru, an arid area of extremely low productivity that faces the Peru-Chile cold current, one of the world's most productive marine ecosystems. To investigate the relationship between marine and terrestrial food webs in the Atacama desert, the authors surveyed populations of terrestrial consumers (i.e., desert invertebrates and geckos) and analyzed stomach contents and stable isotope ratios of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) from several desert predators, one of which was the Paracas Gecko, *Phyllodactylus angustidigitus* (N = 105). The average number of geckos in near-shore plots was significantly higher than in desert plots situated inland, and the majority of gecko prey items were intertidal invertebrates, although the proportion of intertidal prey items covaried with the geckos' distance to the shore. The $\delta^{13}C$ isotope signatures of geckos was more similar to *Ulva*, a marine algae, than to terrestrial plants, and the $\delta^{15}N$ values suggested that geckos occupy a high trophic level in both the intertidal and desert nocturnal food webs. The authors compare these results to those from other desert predator species, and suggest that a lack of rainfall in the Atacama desert promotes a reliance on marine resources in these geckos and other desert species, which as a consequence, are more affected by variability in marine productivity than patterns of terrestrial plant growth.

Catenazzi, A., and M. A. Donnelly. 2007. The *Ulva* connection: marine algae subsidize terrestrial predators in coastal Peru. Oikos 116:75–86.

Correspondence to: Alessandro Catenazzi, Department of Biological Sciences, Florida International University, Miami, Florida 33199, USA; e-mail: acaten01@fiu.edu.

Potential Impacts of Climate Change on Marine Turtles

Climate change has the potential to affect the ecology, phenology and survival of many species, particularly thermally sensitive species. In the Loggerhead Seaturtle, *Caretta caretta*, sex is determined by temperature in the middle third of incubation. Female offspring result from high, and male offspring from relatively low, temperatures. To investigate potential affects of climate change on this species, the authors compiled 26 years of nesting site data from North Carolina, the northernmost nesting site for this species in the United States, with local climate data. They used these data to predict current sex ratios and to model possible changes under different climate change scenarios. Currently, North Carolina nesting sites produce proportionally more males than nests further south in Florida, which has the majority of nesting sites in the United States but produces less than 10% males. The results of their model show that a 2°C increase in air temperature would likely lead to the complete feminization of the primary sex ratios in Florida, and with a 3°C increase, incubation temperature would be above lethal. In contrast, the model shows that on North Carolina beaches, turtles need only shift temporal distribution of nesting by one week to adapt to a 3°C increase in air temperature. The authors highlight the importance of preserving the disproportionately significant male-producing beaches, especially those beaches that may be shielded from future climate change.

Hawkes, L. A., A. C. Broderick, M. H. Godfrey, and B. J. Godley. 2007. Investigating the potential impacts of climate change on a marine turtle population. Global Change Biology 13:923–932.

Correspondence to: Brendan J. Godley, Centre for Ecology and Conservation, School of Biosciences, University of Exeter, Cornwall Campus, Penryn TR10 9EZ, UK; e-mail: bgodley@seaturtle.org.

Geckos in Termitaria

Gymnodactylus carvalhoi, a gecko species found in the Brazilian Cerrado, appears to be entirely restricted to termitaria (i.e., termite nests), but reasons for this habitat specialization remain unknown. The authors tested three, non-exclusive hypotheses to explain this specialization, including: to avoid thermal extremes, to avoid predators, or to take advantage of abundant food. First, the authors used drift nets and pit traps to confirm that these geckos are restricted to termitaria, most likely only leaving to find new nests. The authors used data loggers to monitor temperature within and on the surface of four termitaria every 10 mins for 13 days. To assess the effect of predators on this population, and to determine diet, geckos were collected and examined for tail loss (N = 69), and stomach contents were analyzed (N = 60). Results showed that temperature remained relatively constant within the temitaria, buffering these geckos against external temperature extremes. Stomach content analysis revealed that termites are abundant and comprise the vast majority of the geckos' diet (92% of prey by number, 77% by volume). The authors suggest that the high frequency of tail loss indicates that predator avoidance is not an important factor. The authors concluded that a combination of thermal constraints, a paucity of other suitable refuges, and diet preferences explain the restriction of these geckos to termitaria in the Brazilian Cerrado.

Vitt, L. J., D. B. Shephard, J. P. Caldwell, G. H. C. Viera, F. G. R. França, and G. R. Colli. 2007. Living with your food: geckos in termitaria of Cantão. Journal of Zoology, Online Early; doi: 10.1111/j.1469-7998.2006.00273.x.

Correspondence to: Laurie J. Vitt, Sam Noble Oklahoma Museum of Natural History, 2401 Chautauqua Avenue, Norman, Oklahoma 73072, USA; e-mail: vitt@ou.edu.

Chemicals Signal Status in Male Iberian Rock Lizards

Conspicuous badges of status play an important role in male competition in many species, preventing potentially costly fights by signaling fighting ability or dominance. Most previous studies have concentrated on visual or acoustic signals; however, it is increasingly being recognized that chemical signals can also indicate male status. To examine this, the authors determined whether chemicals in femoral gland excretions signaled dominance status in male Iberian rock lizards, *Lacerta monticola monticola*. The authors staged encounters between pairs of males (N = 30 males) to establish which individuals were dominant, while controlling for body size. Femoral secretions were collected from each male and analyzed with a gas chromatograph-mass spectrometer. A phytohaemagglutinin injection test was used to assess immune response from each lizard. Finally, behavioral responses to different components of the femoral gland secretions were also measured. Results were analyzed using both Principal Component Analysis and ANOVA. Dominant males had high levels of hexadecanol in their femoral gland secretions, a substance which was also shown to elicit aggressive behavior in males. Further, male immune response was correlated with the abundance of hexadecanol in the femoral gland secretions. The authors suggested that, because of its correlation with immune responses and the aggressive behavior it elicits in conspecifics, the hexadeconol content of femoral gland secretions may provide a reliable signal of male dominance and status in the Iberian Rock Lizard.

Martín, J., P. L. Moreira, and P. López. 2007. Status-signalling chemical badges in male Iberian rock lizards. Functional Ecology 21:568–576.

Correspondence to: J. Martin, Departamento de Ecología Evolutiva, Museo Nacional de Ciencas Naturales (MNCN), CSIC, José Gutiérrez Abascal 2, 28006, Madrid, Spain; e-mail: Jose.Martin@mncn.csic.es.

Timberland Rattlesnakes Use Public Information to Assess Foraging Locations

Animals generally make foraging decisions based on an integration of information from their own experience and from monitoring other foraging animals. The use of public information to make decisions about resource quality has been well studied in animals that live in groups, however, its importance for solitary animals is unknown. To address this, the author conducted choice experiments to determine whether public information, in this case chemical cues, inform foraging decisions in the timber rattlesnake, *Crotalus horridus*. All experiments were performed using 16 captive-born snakes. In the first experiment, snakes were given the choice between an arm of a T-maze containing chemical cues from a conspecific, and another arm with no cues. In the second, one arm of the T-maze contained the chemical cue of a fed, and the other of an unfed, conspecific. Finally, a third experiment, an arena trial, was designed to measure the amount of time spent in an ambush coil in areas previously occupied by fed or unfed conspecifics. Results revealed that snakes were more likely to choose the arm of the T-maze that contained the chemical cue of a conspecific over an untouched arm, but they did not distinguish between fed and unfed conspecifics. However, the results of the third choice trial showed that snakes spent more time in an ambush coil in areas previously occupied by fed than unfed individuals. The author concludes that public information may be a more important factor informing foraging decisions in solitary animals than previously thought.

Clark, R. W. 2007. Public Information for solitary foragers: timber rattlesnakes use conspecific chemical cues to select ambush sites. Behavioral Ecology 18:487–490.

Correspondence to: Rulon W. Clarke, Department of Neurobiology and Behavior, Seeley G. Mudd Hall, Cornell University, Ithaca, NY 14853, USA; email: rwc13@cornell.edu.

Multiple Stressors and Frog Declines

Worldwide, more than 40% of the 6000+ described amphibian species have undergone alarming declines, with a number of studies having examined potential causing factors. However, the majority of these studies have concentrated on single stressors, which may mistakenly inflate the importance of a particular stressor in the decline. To address these concerns, the authors investigated the effect of two stressors, pesticides and introduced fish, on the

Mountain Yellow-legged Frog, *Rana muscosa*. Each lake, pond, and marsh encountered in the central southern Sierra Nevada of California (N = 6831 waterbodies) was categorized for frog and fish presence, and the surrounding habitat was surveyed and upwind pesticide use estimated. Results from multivariate generalized additive models suggested that while frog presence was influenced by multiple stressors, pesticide use contributed substantially more to frog presence or absence than introduced fish. Further, the topography of the waterbodies themselves was important, with sheltered waterbodies far more likely to have frogs, despite the presence of pesticide use. The authors suggest that windborne pesticides may be a crucial factor in amphibian declines, even in pristine locations, especially as pesticide exposure weakens immune responses in amphibians and increases susceptibility to disease. Finally, the authors emphasize the importance of investigating multi-factor causes in amphibian decline research.

Davidson, C. and R. A. Knapp. 2007. Multiple stressors and amphibian declines: dual impacts of pesticides and fish on yellow-legged frogs. Ecological Applications 17:587–597.

Correspondence to: Carlos Davison, Environmental Studies Program, San Francisco State University, 1600 Holloway Avenue, San Francisco, California, 94132, USA; e-mail: carlosd@sfsu.edu.

Lizard Pollinator Mediates Positive Interactions Between Plant Species

Previous studies of indirect relationships between species have focused primarily on predator-prey and competitive interactions. However, indirect interactions can also be an important factor in mutualistic relationships. In this study, the authors tested whether the declining, endemic *Trochetia blackburniana* plant benefits from proximity to the endemic *Pandanus* plant in Le Pétrin, Mauritius. This positive interaction is thought to be mediated by the blue-tailed day gecko, *Phelsuma cepediana*, which moves between *Pandanus* thickets, the gecko's preferred microhabitat, and *T. blackburniana*, where it feeds on nectar and pollinates the plants. By comparing *T. blackburniana* plants growing close to (< 10 m) with those growing away from *Pandanus* (> 20 m), the authors confirmed that gecko visitation to *T. blackburniana* was related to its proximity to *Pandamus* plants. Also, by fitting a generalized linear mixed-model, the authors demonstrated that the number of fertilized fruits on the *T. blackburniana* plants was also positively related to proximity to *Pandamus* thickets, but results from a previous study show that these differences are unrelated to variation in soil quality. Finally, an experiment was conducted in which geckos were excluded from some *T. blackburniana* branches. This resulted in fewer fertilized fruits relative to branches on the same plant from which geckos were not excluded. The authors highlight the importance of considering these types of indirect, positive interactions in both plant and lizard conservation.

Hansen, D. M., H. C. Kiesbüy, C.G. Jones, and C. B. Müller. 2007. Positive indirect interactions between neighboring plant species via a lizard pollinator. American Naturalist 169:534–542.

Correspondence to: Dennis M. Hansen, Institute of Environmental Sciences, University of Zurich, Winterhurerstrasse 190, CH-8057 Zurich, Switzerland; e-mail: dhansen@uwinst.unish.ch.

ZOO VIEW

Herpetological Review, 2007, 38(3), 262–273.

Seventy-Five Years of Herpetology at the Smithsonian's National Zoological Park: The Facilities, Collection, People, and Programs

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A major challenge presented itself to zoo herpetologists since World War II: how could they become important players in a world of shrinking biodiversity and maximize the use of their collections? It is beyond the scope of this paper to provide specific details but what happened at the Smithsonian's National Zoological Park (NZP) over 75 years may mirror, in part, what happened at other zoo herp departments and at other zoos throughout the world and provide clues as to the substantial change during this period.

FACILITIES

> *"This building promises to be one of the finest of its kind in the world."*
>
> —William M. Mann in *1930 Smithsonian Annual Report, 100*

> *"The content of the art fulfills two roles; identifying the building as a reptile house, and artistically displaying the evolutionary history of reptiles. The large mosaic stegosaurus over the entrance connects present day reptiles to their larger ancestors. Pterodactyls clutching the corners of the portico ready to spring off into flight hint at the ancestral connection between birds and reptiles. The ten panels on the doors alternately display a lumbering stegosaurus and battling yin-yang lizards. Much like religious stained glass, the art is used in the traditional role as a means to communicate. A simple message is conveyed: 'these animals are all related, and here are some of their ancestors.'. . . The art enriches the experience of the building: yielding pleasure and education, two of the founding directives of the zoo."*
>
> —Gavin Farrell in *Smithsonian Institution National Zoological Park: A Historic Research Analysis* in 2004.

William M. Mann, Director of the National Zoological Park (NZP), and municipal architect Albert L. Harris traveled to Europe in the spring of 1929 to evaluate zoo reptile buildings to use as models for the new one being planned at NZP. Mann's vision was to construct a facility second to none by using artwork and architectural ornamentation prominently to place the visitor in a beautiful setting immersed in animal imagery. Only two years later, the National Zoo's Reptile House was opened to the public and

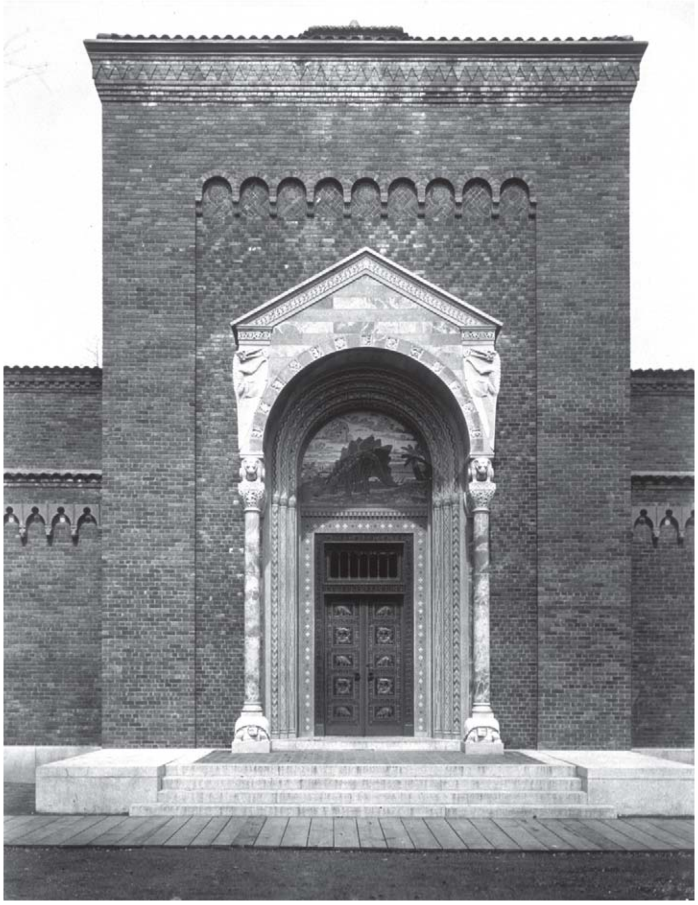

FIG. 1. Photograph of Reptile Building at National Zoological Park shortly after completion in 1931. Credit: National Zoological Park Photo Archives.

this impressive building remains one of the most beautiful reptile facilities in the world (Figs. 1–4). Ewing (1990) published a report called "An Architectural History of the National Zoological Park." According to Ewing, the architecture exemplifies the Italian Byzanto-Romanesque ecclesiastical style and the main cathedrals in Ancona and Verona, built in Romanesque style in Northern Italy, provided the idea for Harris' design. ". . . The brick structure was assembled in a building-block fashion, accumulating to form several ranges. Rising from a low asymmetrical level, the tower culminated in an octagonal drum and lantern . . . articulated with round windows encircled by alternating red and white marble blocks . . . the arch of the pedimented porch displayed small alternating curved blocks of little creatures: toads, turtles, lizards, etc. Under the cornice along the entire facade the arched corbels culminated in roughly-hewn abstracted reptiles. These terracotta figures served as subtle gargoyles, continuing the correlations with the cathedral model." Unfortunately, the original elevated porch leading to the entrance has been removed but the porch columns supported by turtles remain. The massive wooden entrance doors with essonite/gold leaf panels depicting many extinct and extant

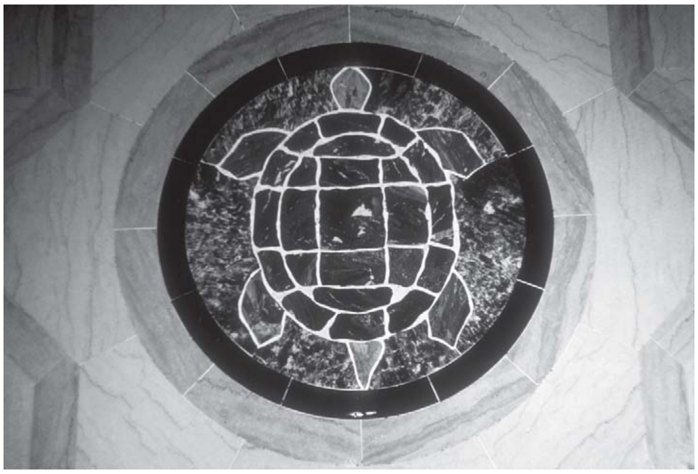

FIG. 2. Inlaid marble turtle mosaic medallion on floor by John Joseph Earley. Credit: National Zoological Park Photo Archives.

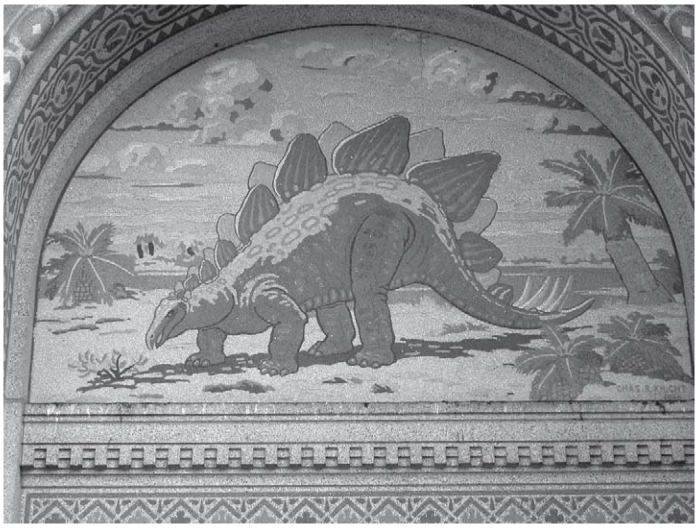

FIG. 3. Mosaic of *Stegosaurus* above doorway of visitor entrance to reptile building at Smithsonian Institution's National Zoological Park. Credit: photograph by Dennis Desmond in 2004.

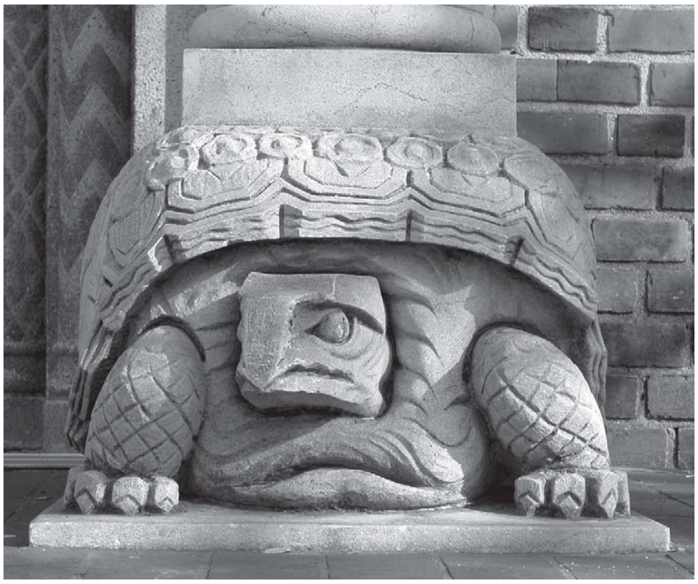

FIG. 4. Carved rock tortoise supporting column at entrance to reptile building at Smithsonian Institution's National Zoological Park. Credit: photograph by Dennis Desmond in 2004.

reptiles have been moved to an interior space; the original bronze door pulls with two entwined serpents have been replaced. A secondary entrance shows two dragon-like reptiles facing each other under a rounded arch of molded bricks.

The renowned artist and sculptor John Joseph Earley[1], known for his remarkable creations of concrete mosaics and figures, in part fashioned the façade which abounds with stylized reptiles and amphibians—*Stegosaurus* over the entrance and crocodiles as decorative figures (Fig. 3), turtles supporting columns (Fig. 4), toady creatures peering down from the top of the archway, and an array of turtles, toads, and lizards scattered near the roof and around the building. The colored concrete door molding was fashioned by Earley, and the dinosaur mosaic in the transom was by artist Charles R. Knight. All of the larger exhibits within the building had background murals painted by Knight. These were detailed paintings of ancient ruins, such as Egyptian temples, as well as natural habitat scenes. Unfortunately, all of these murals were either painted over or the exhibits were totally destroyed and rebuilt during the middle 1950s and into the early 1960s. Even with these changes, this wonderful building is a spectacular edifice which probably could not be duplicated today because of cost and lack of skilled artisans. It must be said, however, that many modern reptile buildings are impressive structures with splendid exhibits[2].

The basement served as a commissary and butcher shop for animal feed (pictured in Conant 1980). In the early 1980s, the interior of the building was remodeled, exhibits were improved, and an acoustical ceiling was added to reduce noise in the visitor area. Added outside the building in 1980–1981 was a series of three small exhibits constructed of concrete masonry (and a wooden walkway) and four outdoor displays containing pools which now hold crocodilians and Komodo Dragons. The central basement interior area was re-worked into an invertebrate exhibit in 1986, and a walk-through greenhouse with butterflies and hummingbirds was added five years later. During the past few years, the exterior of the building has been cleaned, the roof has been repaired, the original skylights replaced, and the interior walls re-plastered and re-painted.

In 1984, a family learning center called HERPlab was installed in the building. There, docents and zoo staff interact with zoo visitors by describing amphibian and reptile biology, answering questions and leading tours. Curator Dale Marcellini and herpetologist Thomas Jenssen observed visitor behavior in the National Zoo's Reptile House and discovered that zoo visitors spend an astonishingly brief time viewing exhibits, averaging only ca. 8 sec per stop (Marcellini and Jenssen 1988). Based on this disturbing finding, a stronger emphasis on interactive education was developed by opening the Reptile Discovery Center, supported by a grant from the National Science Foundation. This unique exhibit approach incorporated some of the aspects of HERPlab but added a series of interesting modules and displays throughout the building addressing other features of amphibians and reptiles. One important element of the approach was the use of polling/survey data derived from visitors to quantitatively assess the effectiveness of this exhibit. Doering (1994:viii) stated that the modules had significant effects on visitors: "*Behaviorally*, the interactive stations slowed persons down, made them more attentive, and lengthened their time in the exhibit. *Emotionally*, the modules improved visitors' feelings about reptiles. *Intellectually*, they communicated new ideas, especially about internal anatomy, communication, and feeding."

During the past seventy-five years, reptile buildings and accompanying exhibits throughout the world were often designed by architects and zoo administrators who had little experience with living herps, public education, or who paid scant attention to the concept of exciting and aesthetically-pleasing presentations. Educational and interactive exhibits were an afterthought; visitors were subjected to row after row of uninspiring and unimaginative displays, hardly an enriching experience. One problem was the lack of input from the biological staff. Until the 1960s, amphibians and reptiles were rarely kept in appropriate social situations and little attention was paid to behavioral or environmental cues; social stressors among conspecifics such as competition or aggression were barely considered. Fortunately, zoo biologists have now become aware of these deficiencies and have worked to remedy them.

History of the Collection

In the late 1920s and early 1930s, a number of interesting herps were represented in the NZP collection: Komodo Dragons[3], Sumatran Cobras, King Cobras, Boa Constrictors, Gila Monsters and Beaded Lizards, Zaire Toads, many rattlesnakes, Radiated Tortoises, Gould's Monitor, and other lizards. In the Annual Reports of NZP beginning in 1931, one can see the enormous variety of specimens in the collection, such as tuataras.

The Zoo collection was utilized in 1932 for a classic scientific study on brooding behavior in pythons by Frances G. Benedict, Director of the Nutrition Laboratory at the Carnegie Institution of Washington. He observed an incubating female African Rock Python (*Python sebae*) on exhibit and made detailed environmental and body temperature readings during one entire day.

Captive crocodilians can be exceedingly dangerous, especially if their exhibits are poorly designed without shift cages[4]. In the late 1950s, the solarium housed a Nile Crocodile (*Crocodylus niloticus*) and an American Crocodile (*Crocodylus acutus*) in the same enclosure. The middle enclosure housed an aggressive and agile[5] Saltwater Crocodile (*Crocodylus porosus*) called "Biggie" by the staff, and the end enclosure featured a group of 5–7 foot long American Alligators (*Alligator mississippiensis*). Because there were no shift cages, keepers had to work around the crocodilians. The Nile and American crocodiles were extremely aggressive, attacking the keepers constantly. Two keepers were always in attendance, one to clean and the other to fend off the reptiles. Holding them off with a broom and shovel worked for the most part but cleaning these enclosures was a constant strain on the staff.

"Biggie" was acquired in the 1930s and lived over 40 years at the zoo where it attained a length of over 14 feet. When the crocodilian was weighed and measured in 1932, its size was modest: 150 lbs and six feet total length. One of us (WAX) was responsible for cleaning its enclosure during the late 1950s and early 1960s, a very dangerous task indeed, for the procedure was to actually enter its domain. On one occasion, "Biggie" was lying in the emptied pool and WAX was on the surrounding land, picking up some leaves. "Biggie" spun around and charged with mouth agape and WAX had to leap over the recurved bars. Unfortunately,

FIG. 5. Adult male Cayman Island blue iguana (*Cyclura nubila lewisi*) on exhibit at Smithsonian National Zoological Park in 2003. Described in 1940, the lizard was widely distributed in dry habitats over most of the island but is now restricted to a few remnant populations, due to human influences. In 2005, the population crashed precipitously; now only 15–25 lizards are left. Credit: photograph by Jessie Cohen, Smithsonian National Zoological Park.

the cuff on his pants was caught on one of the pointed tips. As WAX tried to free his cuff while balanced on the top of the bars, his hand fell off to one side. The reptile redirected the attack toward the dangling hand rather than the foot and just missed a tasty snack when WAX was able to pull his hand away, extricate his leg from the bars, and fall into the next enclosure.

At NZP, live food was used until the 1960s[6]. When one of the keepers was seen by a mother and child carrying a rabbit in a wicker basket, the child recognized his pet "Fluffy," donated just minutes before to the zoo. When the child asked where the keeper was taking his rabbit, the latter said, "I am going to feed him to the python" and continued on to finish his task. His horrified parents wrote a seething letter to Director Theodore H. Reed, who immediately banned the use of live food during public hours. Although offering dead prey is now common in zoos, some reptile buildings remain closed during feeding, due to concern about public sensitivities. NZP feeds only dead vertebrate prey and stays open.

Many years ago, NZP herp keepers also fed dead animals from the collection to reptiles. Head keeper Lee Schmeltz acquired a carcass of a muntjac that recently died in the collection and fed it to the Komodo Dragon. The dragon seized the muntjac by the belly and tossed its head in a violent slashing motion which eviscerated the deer, and splashed the glass front of the enclosure. Someone reported the incident to higher authorities and Schmeltz was warned never to let it happen again (C. Wemmer, pers. comm.).

NZP is the national zoo of the United States, so governmental employees, Smithsonian scientists, and military personnel, particularly the Naval Medical Research Unit-S.E. Asia (NAMRU) and the Army Medical Research Unit-North Africa (AMRU), often sent amphibians and reptiles to the Zoo. During the 1960s, unannounced large shipments regularly arrived at the local airport, such as one sent by Wesley Dickinson from India (see Murphy and Jacques 2006). The animals in these shipments were mostly unidentified, some venomous, often loose in the box or with their cloth bags unmarked; unpacking these shipments, although exciting, could also be hazardous. Many of the venomous species, such as sea snakes (*Laticauda*), King Cobras (*Ophiophagus*), Indian Cobras (*Naja naja*), kraits (*Bungarus*), Asian coralsnakes (*Calliophis*, *Maticora*), bamboo vipers (*Trimeresurus*), Hundred-Pace Vipers (*Deinagkistrodon acutus*), and saw-scaled vipers (*Echis*) were new to the collection.

On Easter Sunday in 1983, a teenaged boy who liked snakes waited until the building closed, broke the glass of the Gaboon Viper (*Bitis gabonica*) exhibit, put two adult snakes into a plastic garbage bag, flung the bag over his shoulder and caught a bus to take them home. He was bitten through the bag on the shoulder while departing the bus and rushed to the hospital. He survived the ordeal after antivenin therapy was undertaken but recovery was protracted. Later, some well-meaning citizens, including Smithsonian Secretary S. Dillon Ripley's wife, suggested that he be hired at the Zoo since he liked snakes but this recommendation was not adopted. Several others sent get-well cards to Mr. and Mrs. Gaboon Viper.

Play behavior in reptiles is rarely reported. At NZP, an adult Nile Softshell Turtle (*Trionyx triunguis*) collected by William Mann in Liberia, played with a variety of objects: pushing a basketball with its snout, swimming through a hoop, and biting and pulling a hose (Burghardt et al. 1996). One of the captive-hatched Komodo Dragons (*Varanus komodoensis*) named Kraken interacted in the most unexpected way with humans and objects (see Burghardt et al. 2002; Murphy and Walsh 2006 for details).

When we entered the zoo profession (WAX in the late-1950s, JBM in the mid-1960s), there was little discussion in zoos about wildlife conservation. Most efforts centered on keeping amphibians and reptiles alive and plans to accumulate breeding groups were rarely considered. We could not sex our animals accurately and if successful reproduction occurred, it was a major event. Virtually all zoo collections at that time were composed of herps from the wild; captive-bred amphibians and reptiles were mostly unavailable. Now that captive breeding has been relatively successful (although long-term breeding programs producing multiple generations are still somewhat rare), zoos tend to get their new ani-

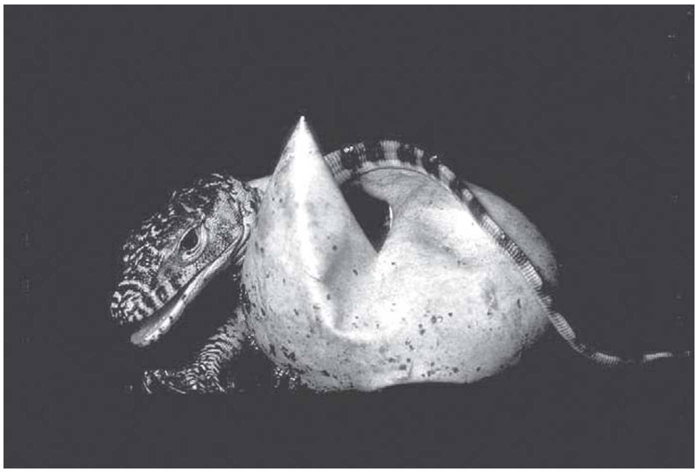

FIG. 6. Komodo dragon (*Varanus komodoensis*) female named "Kraken," hatched in 1992 at Smithsonian National Zoological Park. Credit:
photograph by Jessie Cohen, Smithsonian National Zoological Park.

mals from other zoos rather than the wild. Today there are many cooperative breeding programs in zoos. The downside of these collaborative programs is that we now rarely see something new in zoos; there is not room or resources for a diverse collection with many new species.

Today, the NZP collection is stable, many of the specimens bred in captivity, with ca. 63 species of reptiles totaling nearly 350 specimens and 15 species of amphibians numbering nearly 140 animals. The collection includes Cuban Crocodiles, Gharials, highly-endangered Cayman Island Iguanas (Fig. 5), Aldabran and Radiated Tortoises, an adult Japanese Giant Salamander, large constrictors and a variety of amphibians such as breeding colonies of a number of poison dart frogs (*Dendrobates*) and Panamanian Golden Frogs (*Atelopus zeteki*). Komodo Dragons reproduced at NZP in 1992 for the first time in any zoo in the Western Hemisphere (Fig. 6). Reproduction over multiple generations has been accomplished in several taxa: Emerald Tree Boas (*Corallus canina*), Green Tree Pythons (*Morelia viridis*), Brazilian Rainbow Boas (*Epicrates cenchria*), African Rufous-beaked Snake (*Rhamphiophis oxyrhynchus rostratus*), Chinese Water Dragons (*Physignathus cocincinus*), and Madagascan Giant Day Geckos (*Phelsuma madagascariensis*).

PEOPLE

Like a notorious keeper at London a century earlier[7], WAX and a fellow keeper at NZP held contests to see who could handle pitvipers (rattlesnakes, copperheads, moccasins, bamboo vipers) without getting bitten. Their reasoning, hardly justifiable and certainly illogical, was this practice was acceptable as a displacement activity to relieve the stress of battling crocodilians. The snakes chosen to be handled all resided on the same row of exhibit cages. Each day before the building opened, these foolhardy caretakers would take turns, starting at the first exhibit cage and working their way down the line. The process was simple: when the serpent was in a resting coil, the contestants would slide hands beneath the coils, lift gently from the substrate for a few seconds, then replace the reptile in its original resting place. The contest ended after the entire group of exhibits holding venomous snakes was sampled or one of the participants lost courage. Miraculously, no one was bitten so none of the snakebite recommendations in Footnote #7 could be tried but had this practice been discovered by their bosses, repercussions would have probably been more unpleasant than a bite.

Over the years, Roy Jennier, Charlie Braxton, Jack Armstrong, Lester Ratliff, Lee Schmeltz, Cecelia Chang, Russell Morrison, Mike Johnson, William Xanten, Sam Davis, Bob Davis, Tom Keefer, Roger Rosscoe, Charles Coutris, Rob Lewis, and David Kessler worked as keepers in the department. The first woman keeper ever hired at NZP was Brenda Hall in the early 1970s, who wrote a paper on tegu lizards (*Tupinambis teguixin*). Today, women outnumber men in the Animal Department. Before curatorial positions were established at NZP, Mario (Jack) DePrato was the Head Keeper. Now retired, the first herpetological curator was Jaren Horsley, who was elevated to General Curator (Fig. 7). His replacement was Dale Marcellini, whose research interests were primarily directed toward public education and visitor behavior, as well as gekkonid and iguanid ethology (Fig. 8). Louis (Trooper) Walsh retired from the zoo as Biologist/Museum Specialist and is best known for his work with Komodo Dragons and boid snakes. Biologist Béla Demeter published a number of papers on Malagasy geckos. Michael Davenport is the current curator who focuses on the captive breeding of crocodilians. In addition to Davenport and Demeter, the current staff is Janis Gerrits, Sean Henderson, and Robin Saunders. After retiring from the Dallas Zoo, one of us (JBM) is now a research associate at the Zoo.


FIG. 7. Retirement photograph of Jaren Horsley in 1996. Credit: photograph by Jessie Cohen, Smithsonian National Zoological Park.

Jonathan Ballou is the Population Manager at NZP's Department of Conservation Biology; he has published many papers and several books on the proper management of captive populations.

Long-term investigation of essential dietary ingredients for captive and wild reptiles by Mary Allen and Olav Oftedal includes evaluating the diets of desert tortoises. The evolution, expansion and sophistication of herpetological medicine and the understanding of emergent diseases has contributed to significant advances. Recently, the pathogenic chytrid fungus attacking captive and wild amphibians was isolated and described by former NZP pathologist Donald Nichols.

John (Jack) Frazier has studied chelonians since 1979 as a Smithsonian research associate. His major focus centers on the conservation of marine turtles and he has published widely in this area. In addition, his earlier studies have included behavioral and ecological aspects of the Aldabran Tortoise and the Star Tortoise, and recently a sortie into nomenclatural never-never land (see Frazier 2006).

The Smithsonian Institution offers stipends for limited periods to outside investigators, mostly from the academic community, to do research at the Zoo. Using this program, Marcellini brought in an impressive series of herpetologists. Eliezer Frankenberg (The Hebrew University of Jerusalem) focused on animal communication, lizard ecology, and reproductive biology. Thomas Jenssen (Virginia Polytechnic Institute and State University) studied lizard ethology and visitor behavior, beginning in the 1980s. Paul Weldon (Texas A & M University) was a research associate at the Zoo from January 1991 to January 1993, working closely with zoo personnel on a variety of studies, such as collecting and analyzing glandular materials from reptiles in zoos. Now living in Baltimore, he currently

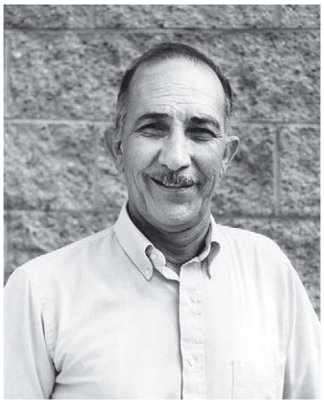
FIG. 8. Retirement photograph of Dale Marcellini in 1996. Credit: photograph by Jessie Cohen, Smithsonian National Zoological Park.

holds the same appointment at the Zoo's Conservation and Research Center in Front Royal, Virginia. Eric Wikramanayake from Sri Lanka was a research associate at the Zoo, specializing in field studies on varanid lizards. He is now a senior conservation biologist for World Wildlife Fund-US in Southeast Asia.

PROGRAMS

Christen Wemmer, retired Director of the NZP Conservation and Research Center (CRC) in Front Royal, Virginia, and his associates were instrumental in creating Zoo Biology Training Courses held in many developing countries throughout the world (see Wemmer et al. 1990 for description). The program and all written materials were developed by the staff at the Zoo, beginning in 1987. These courses included a herpetological component and focused on captive management. Zoo herpetologists, including JBM, were participants in these various training courses. In 1997, Wemmer, George Zug from the US National Museum of Natural History, and JBM traveled to Myanmar (Burma) to teach a workshop on herpetology to local wildlife biologists. The course provided an introductory treatment of amphibian and reptile biology, including a field component for sampling populations. This herpetofaunal survey continues to this day.

The American Association of Zoos and Aquariums hosted a Wildlife Conservation and Management Committee (WCMC) workshop on the conservation and captive management of Komodo Dragons, held at Tamin Safari in Bogor, Indonesia in 1995, which included a presentation by Trooper Walsh on the husbandry of these lizards. Three years later, the Thoiry Komodo Dragon Symposium was held at the Thoiry Zoological Park in France. The program was created by Walsh and Colomba de La Panouse, who invited the world's leading experts involved with field research and conservation, laboratory studies, and zoo conservation/education initiatives, to present their findings and write chapters for a comprehensive book on dragons. The research presented by several of the attendees was supported financially by grants from NZP's "Komodo Dragon Conservation Fund." Four years later, the book entitled *Komodo Dragons: Biology and Conservation* appeared.

There have been several herp initiatives at CRC: metapopulation analysis of the Eastern Newt (*Notophthalmus viridescens*) in northern Virginia, including sampling the CRC population; drift fence survey of indigenous species; Box Turtle (*Terrapene carolina*) study; and northern Virginia frog study guide written by Joseph Mitchell for the education program at CRC.

In the reptile building, several dozen volunteers serve as instructors, teaching zoo visitors about amphibians and reptiles. As an example, these interpreters explained the research that was being done on play behavior in Komodo Dragons.

SUMMARY

Retired curator Dale Marcellini (1994) summarized the challenges that zoo herpetologists face when managing zoo collections, "Conservation is one of the main goals of zoo reptile houses, and yet curators act in ways which may be harmful to the conservation of species in the wild. Collections are composed largely of exotic, rare, and wild-caught species. Only rarely are breeding programs done on a long-term basis. When breeding is successful, reintroduction into the wild is almost never done. Zoo herpetologists must begin to act more responsibly in the way collections are managed, and more emphasis needs to be placed on conservation education."

In the same volume, Robert J. Wiese and Michael Hutchins (1994) enumerate additional responsibilities, "There is much work to be done if we are to assist even a fraction of the species currently at risk. Through the successful use of captive-breeding and reintroduction programs in conjunction with strategic collection planning, scientific research, in situ conservation efforts, and public education, professionally managed zoos and aquariums can play a significant role in amphibian and reptilian conservation."

In our view, the results have been mixed! On the plus side, the dramatic improvements of husbandry protocols have led to better lives for captive herps—no longer are "snake dens" ordered every year from suppliers to replace losses as was the case occasionally in the past. Zoos and aquariums are involved in many *in situ* and *ex situ* conservation projects. We are concerned, however, that herpetological collections and buildings are viewed as a relict from the past[8]; as a result, there has been a significant decline in new facilities, emphasis, and financial support. Instead, many zoo administrators build elaborate and costly zoogeographic mixed exhibits housing mostly mammals and birds.

One can track the paradigm shift over seventy-five years at NZP in the literature citations below as the staff gradually became more aware of the enormity of the threat to a diverse and interesting natural world, and began taking steps to intervene by adjusting their programs and research focus.

Acknowledgments.—We dedicate this contribution to veterinarian and retired NZP director Theodore H. Reed, who was at the helm from 1956 until 1983. Reed inherited a facility where major building construction and preventive maintenance had been halted for over twenty years due to inadequate funding. Under his leadership, NZP was reborn with increased appropriations, construction of a number of new buildings and revitalized exhibits. He established the first education department in a zoo in the United States and created the first research positions (Department of Zoological Research) with the hiring of the late John Eisenberg. The acquisition of the Conservation and Research Center (CRC) in Front Royal, Virginia, comprising more than 1200 hectares, was the culmination of a dream and years of intense work by Dr. Reed and Assistant Director John Perry.

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Footnotes

[1] "John Earley was the last of the concrete pioneers. Others before him had discovered how to produce the 'magic powder' — portland cement — how to mix it with stone and sand to make concrete, and how to use concrete as a structural material. But Earley was the first to control the exterior appearance of concrete in an important way and to impart brilliant permanent color to the surface. His contribution was unique: he was the man who made concrete beautiful."
Frederick W. Cron in *The man who made concrete beautiful: A biography of John Joseph Earley* in 1977

[2] "One of the most interesting and one of the most fascinating additions of recent years to zoological exhibits is the modern reptile house. Both the animal and the vegetable world are represented in it. It is a whole world of forests, dusky swamps, barren deserts, and tangled jungles brought from North and South and East and West and crowded under one roof. And under the roof, caged among giant palms, hanging bushrope, and drooping resurrection ferns, there squirm and coil the most mysterious and uncanny and merciless of all of God's creatures, housed according to the most advanced ideas of animal science, with all the surroundings peculiar to the wild and natural state of each. This novelty of showing the animals, and the modern facilities for feeding them as once they fed themselves, for studying reptile diseases, and even for operating with the surgeon's knife, have practically revolutionized the snake house of old into the marvelous reptile house of to-day."
—A. W. Rolker in *Treasury of Snake Lore* (1956)

[3] In the paper files on Komodo Dragons in the Reptile House there is an interesting entry attributed to Raymond L. Ditmars. Back in ~1934 when the first dragon arrived at NZP Ditmars was contacted and asked what he thought the lizards would eat and how often they should be fed. He replied, "Offer lobster, fish, octopus, horse meat, cattle organs, fresh killed rats and mice, deer meat, and pig . . . offered three times a day." It is fascinating that the then "world authority" on reptiles would provide such guess work about how much food was appropriate, showing how little was really known about the biology of these animals at the time.

[4] Raymond L. Ditmars (1933) described crocodilians in this way: "Such is the average crocodile—an active, vicious and, above all, treacherous brute. When the keepers of the reptile house in the New York Zoological Park clean out the big pool for crocodilians, they actually walk over the backs of some of the big 'gators, so tame are these. They never become unduly familiar with the crocodiles, finding it necessary to pen the latter behind heavy barred gates—and in the process the men are often chased from the enclosure."

[5] Saltwater Crocodiles have acute vision. At Zoo Atlanta, a large individual located and consumed mealworms tossed into its pool. At NZP, a mixed exhibit of birds and crocodilians was attempted. A large Asian jay was released into the solarium where it flew several times from one end to the other. When it passed overhead on its final journey, "Biggie" exploded from the water and caught the bird in mid-air—over a meter above the surface.

[6] The feeding of live food to snakes has always been controversial among some sectors of the public. It was an issue so inflammatory in London over a century ago that it was discussed in Parliament. For many years, live mice, rabbits, birds, frogs and other prey had been fed to snakes at the London Zoo but little public outcry ensued; in fact, the feeding demonstrations were enthusiastically viewed by the visitors. In 1869, however, the climate began to change, fueled in part by newspaper campaigns in London to elicit reader responses as to whether the practice should continue. A few selected sentences quoted in Blunt (1976) should put the controversy in proper perspective:". . . that a rabbit should be shut up in a cage with a snake without any chance of his life, deprived of the means of escape allotted to him by nature, and subject to the exquisite torture of terror prolonged by factitious circumstances and enhanced by despair" or ". . . trembling rabbits devoured by a serpent?-a monster reptile maintained and thus feasted for the pleasure of the English—for their children . . ." To deal with continuing public pressure, P. Chalmers Mitchell, Secretary of the Society from 1902 to 1935, and curator of mammals Reginald I. Pocock presented dead prey to snakes at the Zoo to determine whether this practice was a viable alternative. They documented (Proc. Zool. Soc. London 1907:785–794) that dead prey would be taken by many different species and would often be ingested at night. A subsequent study on the acceptance of dead prey by

snakes was undertaken by curator Edward George Boulenger in 1915 (Proc. Zool. Soc. London 1915:583–587). The situation at the London Zoo becomes clear when one refers to a quote by Mitchell in 1929: “My rule about no living prey being given except with special and direct authority is faithfully kept, and permission has to be given in only the rarest cases, these generally of very delicate or new-born snakes which are given new-born mice, creatures still blind and entirely unconscious of their surroundings.”

[7] Edward Horatio Girling, head keeper of the snake room in 1852 at the London Zoo, may have been the first zoo snakebite victim. After consuming alcohol in prodigious quantities in the early morning with fellow workers at the Albert Public House on 29 October, he staggered back to the Zoo and announced that he was inspired to grab an Indian cobra a foot behind its head. It bit him on the nose. Girling was taken to a nearby hospital where current remedies available at the time were tried: artificial respiration and galvanism; he died an hour later. Many respondents to *The Times* newspaper articles suggested liberal quantities of gin and rum for treatment of snakebite but this had already been accomplished in Girling’s case. Other recommendations were a bit unnerving: 1) being buried in manure to the neck; 2) application of a white-hot iron or other fiery instrument for at least an hour; 3) solicit a bite from a second snake to neutralize the effects of the first one; and 4) since sleep was always fatal, taking desperate measures to keep the injured party awake. For example, two Indians in the British army had dragged a screaming victim around a verandah for 3$^{1}/_{2}$ hrs; death was prevented.

[8] Two of the three most popular exhibits were the aquarium and reptile house at the London Zoo (Balmford 2000).

POINTS OF VIEW

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The Destabilization of North American Colubroid Snake Taxonomy

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The classification of taxa has always been an area of debate among systematists—empirically, methodologically, and philosophically. Arguably, the single most important change over the past forty years is the widespread recognition that a classification system is only useful when it functions as a storage and retrieval system of phylogenetic information. Although the type of information to be stored has largely been agreed upon (i.e., propinquity of descent and monophyly), debate continues on the method of this system (e.g., PhyloCode: Cantino and de Queiroz 2003; contra Keller et al. 2003; Nixon et al. 2003). Regardless, the role of classification as a subdiscipline of the science of systematics is clear, and it is separate from that of nomenclature, although both are subdisciplines of taxonomy (de Queiroz 2006). Taxonomy is informed by phylogenetics, and this information is used in the naming of biodiversity (nomenclature) and in the organization of the named groups (classification). All systems of classification and nomenclature that are based on evolutionary hypotheses (phylogeny) provide ranks and names for only monophyletic groups. It is from this framework that we address recently proposed changes to the taxonomy of the Colubroidea in North America (NA; Table 1).

One of the largest groups of squamates, the Colubroidea, was recently found to contain a number of families and subfamilies that were determined to be para- or polyphyletic (Kelly et al. 2003; Lawson et al. 2005). The ‘traditional’ classification, with four families and 15 subfamilies, has remained in this state at least since Dowling and Duellman (1978; although five subfamilies were used as tribes in that work). All of the subfamily names (except Pseudoxyrhophiinae), even those used as tribes in Dowling and Duellman (1978), long predate that publication (Table 2). To rectify this disconnection between phylogeny and taxonomy, establish consistency with phylogenetic hypotheses generated from a large number of morphological and molecular studies (see references in Lawson et al. 2005), and make only modest corrections

TABLE 1. A comparison of recent classifications of North American colubroid snake genera.

Zaher (1999) and Zug et al. (2001)			Lawson et al. (2005)			Collins (2006)		
Family	Subfamily	Genus	Family	Subfamily	Genus	Family	Subfamily	Genus
Colubridae			Colubridae			Colubridae		
	Colubrinae			Colubrinae			N/A	
		Arizona			*Arizona*			*Arizona*
		Bogertophis			*Bogertophis*			*Bogertophis*
		Cemophora			*Cemophora*			*Cemophora*
		Chilomeniscus			*Chilomeniscus*			*Chilomeniscus*
		Chionactis			*Chionactis*			*Chionactis*
		Coluber			*Coluber*			*Coluber*
		Drymarchon			*Drymarchon*			*Drymarchon*
		Drymobius			*Drymobius*			*Drymobius*
		Ficimia			*Ficimia*			*Ficimia*
		Gyalopion			*Gyalopion*			*Gyalopion*
		Lampropeltis			*Lampropeltis*			*Lampropeltis*
		Masticophis			*Masticophis*			*Masticophis*
		Opheodrys			*Opheodrys*			*Opheodrys*
		Oxybelis			*Oxybelis*			*Oxybelis*
		Pantherophis [*Elaphe*]			*Pantherophis*			*Pantherophis*
		Phyllorhynchus			*Phyllorhynchus*			*Phyllorhynchus*
		Pituophis			*Pituophis*			*Pituophis*
		Rhinocheilus			*Rhinocheilus*			*Rhinocheilus*
		Salvadora			*Salvadora*			*Salvadora*
		Senticolis			*Senticolis*			*Senticolis*
		Sonora			*Sonora*			*Sonora*
		Stilosoma			*Stilosoma*			*Stilosoma*
		Tantilla			*Tantilla*			*Tantilla*
		Trimorphodon			*Trimorphodon*			*Trimorphodon*
	Natricinae			Natricinae		Natricidae		
		Clonophis			*Clonophis*			*Clonophis*
		Nerodia			*Nerodia*			*Nerodia*
		Regina			*Regina*			*Regina*
		Seminatrix			*Seminatrix*			*Seminatrix*
		Storeria			*Storeria*			*Storeria*
		Thamnophis			*Thamnophis*			*Thamnophis*
		Tropidoclonion			*Tropidoclonion*			*Tropidoclonion*
		Virginia			*Virginia*			*Virginia*

TABLE 1. Continued.

Zaher (1999) and Zug et al. (2001)			Lawson et al. (2005)			Collins (2006)		
Family	Subfamily	Genus	Family	Subfamily	Genus	Family	Subfamily	Genus
Colubridae			Colubridae					
	Dipsadinae (Xenodontinae)			Xenodontinae		Dipsadidae		
		Carphophis (*incertae sedis*)			*Carphophis*			*Carphophis* (*incertae sedis*)
		Contia (*incertae sedis*)			*Contia*			*Contia (incertae sedis)*
		Coniophanes			*Coniophanes*			*Coniophanes*
		Diadophis (*incertae sedis*)			*Diadophis*			*Diadophis* (*incertae sedis*)
		Hypsiglena			*Farancia*			*Hypsiglena*
		Leptodeira			*Heterodon*			*Leptodeira*
		Rhadinea			*Hypsiglena*			*Rhadinea*
	Xenodontinae (Xenodontinae)				*Leptodeira*			
		Farancia			*Rhadinea*			
		Heterodon	Elapidae			Xenodontidae		
Elapidae				Elapinae				*Farancia*
	Elapinae				*Micrurus*			*Heterodon*
		Micrurus			*Micruroides*	Elapidae		
		Micruroides		Hydrophiinae				*Micruroides*
	Hydrophiinae				*Pelamis*			*Micrurus*
		Pelamis	Viperidae			Hydrophiidae		
Viperidae				Crotalinae				*Pelamis*
	Crotalinae				*Agkistrodon*	Crotalidae		
		Agkistrodon			*Crotalus*			*Agkistrodon*
		Crotalus			*Sistrurus*			*Crotalus*
		Sistrurus						*Sistrurus*

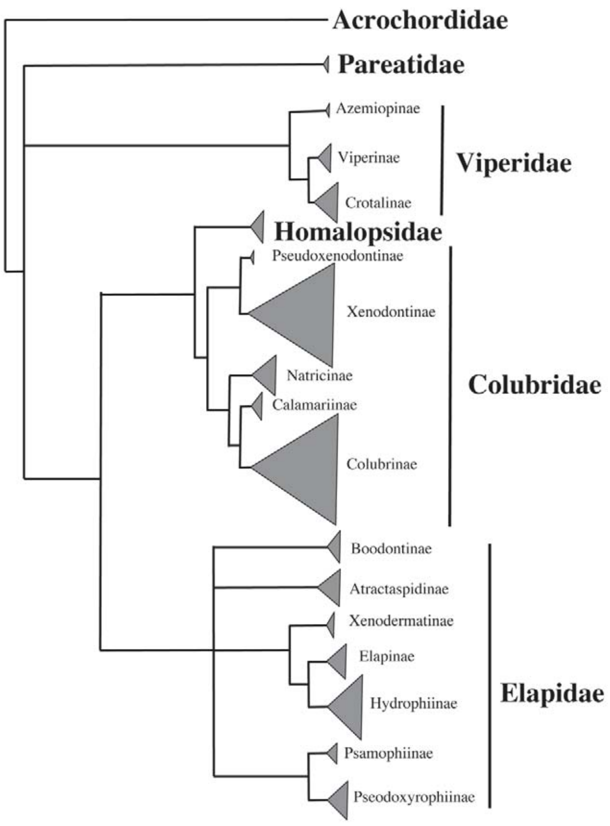

FIG. 1. Phylogenetic relationships of the Colubroidea (including the outgroup Acrochordidae) based on Lawson et al. (2005). The widths of the triangles for families and subfamilies indicate relative numbers of genera.

to the currently used taxonomy, while providing enough information to reflect taxonomic changes, Lawson et al. (2005) proposed a new classification (Table 1; Fig. 1). This classification included the following five families and 15 subfamilies (in parentheses): Colubridae (Calamariinae, Colubrinae, Natricinae, Pseudoxenodontinae, and Xenodontinae), Elapidae (Atractaspidinae, Boodontinae, Elapinae, Hydrophiinae, Psammophiinae, Pseudoxyrophiinae, and Xenodermatinae), Homalopsidae, Pareatidae, and Viperidae (Azemiopinae, Crotalinae, and Viperinae). The only radical change here concerned the inclusion of "nonvenomous" snakes (in the traditional sense) in the Elapidae. However, both venomous subfamilies of the former Elapidae, Elapinae and Hydrophiinae, were retained. This taxonomic decision was based on strong evidence and an application of the oldest family name, Elapidae, to the most recent common ancestor of the node including all aforementioned taxa (Fig. 1).

Collins (2006) suggested that placing the NA colubroid snake genera into the seven basic Linnean categories (Kingdom, Phylum, Class, Order, Family, Genus, and Species) would be more useful because the "layperson" would have difficulty memorizing one extra category, the subfamily. Aside from an unqualified assessment concerning the intelligence of the public on taxonomic matters, the system unilaterally proposed by Collins (2006) destabilizes colubroid classification to an extent possibly worse than the para- or polyphyletic classification in existence prior to Lawson et al. (2005). Here we address several major concerns that the proposal of Collins (2006) would have on colubroid classification. We also present a classification of the NA colubroid snakes that reflects Lawson et al. (2005), which provides the maximum phylogenetic information in this nomenclatural system (Table 1). Finally, we discuss three main areas where the classification of Collins (2006) is detrimental to information storage, communication, and phylogenetic representation.

THE LOSS OF PHYLOGENETIC INFORMATION

By eliminating subfamily from the classification hierarchy, Collins (2006) has effectively reduced the phylogenetic information inherent in the taxonomy proposed by Lawson et al. (2005). The arrangement of the NA Colubroidea in Collins (2006) simply elevates seven subfamilies to familial level while discarding interfamilial relationship. Retaining these as subfamilies nested within families, as suggested by Lawson et al. (2005), reveals information concerning relationships among these subfamilies (Table 1; Fig. 1). For example, it is not clear in Collins (2006) that the Elapidae and Hydrophiidae share a more recent common ancestor with each other than any of the other NA families of the Colubroidea (i.e., Colubridae, Natricidae, etc.).

In classification B of Collins (2006), he misrepresents Lawson et al. (2005) by suggesting this system contains less taxonomic information than his preferred system (classification A; Table 1) because it only reveals three taxonomic groupings for the Colubroidea of NA: Colubridae, Elapidae, and Viperidae. If he were to use the classification system in Table 5 of Lawson et al. (2005) for NA snakes, then it should have been clear that various monophyletic groups within NA are represented by subfamilies nested within families. This not only yields more taxonomic information than Collins (2006), but is more consistent with the historical use of these names and modern phylogenetic hypotheses.

The claim that Collins (2006) represents a standard classification because it refers only to the seven primary Linnaean groupings is also misleading. For example, Collins (2006) only includes two of the Linnaean ranks (family and genus)—a practice that is not commonplace in herpetology. In fact, the oldest use of subfamilies for the Colubroidea dates back to 1768 (Viperinae; Laurenti) and the majority of the others date to the 1800s (Table 2). All the names applied in Lawson et al. (2005) were used in Dowling and Duellman (1978) and are still used by two of the standard college texts on Herpetology (Pough et al. 2004; Zug et al. 2001).

DISRUPTION OF INTERNATIONAL SCIENTIFIC COMMUNICATION

The primary goal of the Linnaean hierarchy is to facilitate accurate scientific communication among researchers living throughout the world and speaking different languages. Elevating the subfamily names for colubroid snakes only occurring north of the Mexican border ignores the higher-level taxonomy of snakes occurring outside of the U.S. and Canada. It does not facilitate scientific communication between researchers speaking different languages when the same taxa found in two different countries are represented by two different classification systems. For instance, 92% of the snake genera in the U.S. and Canada are also found in Mexico (Conant and Collins 1991; Stebbins 2003), but the pro-

TABLE 2. Earliest usage of colubroid subfamily and tribe names adopted by Lawson et al. (2005).

Taxon Name	Author(s)	Dowling & Duellman (1978)
Atractaspidinae	Guenther (1858)	Subfamily
Azemiopinae	Liem et al. (1971)	Subfamily
Boodontinae	Cope (1893)	Tribe
Calamariinae	Bonaparte (1838)	Tribe
Colubrinae	Oppel (1811)	Subfamily
Crotalinae	Oppel (1811)	Subfamily
Elapinae	Boie (1827)	Subfamily
Homalopsinae	Jan (1863)	Tribe
Hydrophiinae	Boie (1827)	Subfamily
Natricinae	Bonaparte (1838)	Subfamily
Pareatinae	Romer (1956)	Tribe
Psammophiinae	Bonaparte (1845)	Tribe
Pseudoxenodontinae	McDowell (1987)	Not used
Pseudoxyrhophiinae	Dowling (1978)	Tribe
Xenodermatinae	Smith (1939)	Tribe
Xenodontinae	Bonaparte (1845)	Subfamily
Viperinae	Laurenti (1768)	Subfamily

posal of Collins (2006) only grants the same hierarchical classification for species in the two countries north of Mexico. Moreover, this taxonomic change does not consider how to place the nearly 90% of other snake genera not found within the U.S. and Canada. For instance, the family Colubridae of Lawson et al. (2005) contains 244 genera in five subfamilies and occurs on all continents except Antarctica. In comparison, the family Colubridae of Collins (2006) addresses only 25 genera, no subfamilies, and only applies to the U.S. and Canada. It is not a grand revelation to understand that species distributions do not coincide with political boundaries. Likewise, classification systems should not be bounded by political borders.

PHYLOGENETIC INACCURACIES

In two cases, the elevation of subfamily to family by Collins (2006) requires a taxonomic decision not in keeping with the phylogenetic hypothesis presented by Lawson et al (2005). The Xenodontinae have typically been divided into two groups: the Xenodontinae representing South American genera and the Dipsadinae representing Central American genera (Cadle 1984; 1985; Crother 1999). For the nine genera of NA xenodontines, Zaher (1999) tentatively placed *Farancia* and *Heterodon* in the Xenodontinae and the remaining genera in the Dipsadinae. Lawson et al. (2005) found a sister relationship between *Farancia* (Xenodontinae) and *Carphophis* (Dipsadinae), which suggests that either the taxonomic contents of the subfamilies are incorrect, or that these groups are artificial. Lawson et al. (2005) contended that their sampling was not adequate to address this issue, so they placed both the Xenodontinae and Dipsadinae under the heading of Xenodontinae in their taxonomic list in Table 5. This classification placed all of the monophyletic Xenodontinae and Dipsadinae under one subfamily, but still made note of the traditional groupings of Xenodontinae and Dipsadinae of Zaher (1999). Collins (2006), without conducting any original phylogenetic research or reanalysis of available data, indicated that the uncertainty in the classification of the Xenodontinae had been solved when he placed *Farancia* and *Heterodon* in the family Xenodontidae and the other NA xenodontines in Dipsadidae. To aid with the description of this putatively paraphyletic classification, he also invented new common names for these subfamilies that do not accurately define either group: slender rear-fanged snakes (Dipsadidae) and robust rear-fanged snakes (Xenodontidae). Again, this classification does not reflect the phylogeny presented in Lawson et al. (2005), creates two paraphyletic groups, and should not be supported.

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Notes on the Ecology of the Colubrid Snake *Leptodeira annulata* in the Pantanal, Brazil

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The ecology of many Neotropical snakes, especially Brazilian species, is poorly known (Cadle and Greene 1993; Vitt 1996). Moreover, published studies are often based on examination of preserved specimens (Marques 1996) and therefore deal mainly with diet and reproduction of particular species (e.g., Bizerra et al. 2005), whereas activity patterns, habitat use and thermal ecology are infrequently reported (e.g., Oliveira and Martins 2001).

The Brazilian Pantanal is a low-lying floodplain covering an area of some 140,000 km^2, consisting of a mosaic of lakes, permanent swamps and seasonally inundated grassy fields with elevated patches bearing forest or cerrado vegetation (Ratter et al. 1988). The Pantanal is located in the Western region of Brazil and eastern Bolivia and is characterized by mean annual temperature of 25°C, and annual precipitation of 1100–1200 mm (Brasil 1997). The Pantanal has low species richness relative to the Cerrado and Amazon, but has some locally abundant snake species, thus facilitating studies of snake ecology (Strüssmann and Sazima 1993).

In spite of being one of the most abundant species in the Pantanal, little is known about the biology of the cat-eyed snake *Leptodeira annulata* in Brazil (Brasil 1997). Moreover, available data on *L. annulata* are largely from the Amazon (Vitt 1996) and Chaco (Lavilla and Scrocchi 1996) biomes. Here we present data on the activity, thermal ecology and habitat use of *Leptodeira annulata* in the Nhecolândia region, Pantanal, collected over five months.

MATERIALS AND METHODS

Study Site.—The study was conducted from February–May and July 2005 in the vicinity of human habitation at the Nhumirim Ranch (18°98'814"S; 56°61'900"W), Corumbá municipality, Mato Grosso do Sul state, western Brazil. The region has an elevation of around 100 m and consists of a mosaic of lakes, grassland, savanna ("cerrado" vegetation) and semideciduous forest (Ratter et al. 1988).

One-hour searches were conducted on seven days each month, between 1800 h and 2400 h, with two observers searching for snakes in all accessible microhabitats. Each observed snake was considered an activity record; thus, each individual could have been observed more than once during the study. However, no snake was counted more than one time in a day.

We marked all trees (N = 32) at the 4 ha study site and recorded tree height (m) and diameter at breast height (mm). For each snake observed we recorded the microhabitat (tree, ground, building). When possible we caught the snake by hand and took the body, substrate, and air temperature with a cloacal thermometer (Miller and Weber Inc.). We considered snakes as active if they were moving or otherwise observed outside of tree holes.

In the laboratory, we measured snout–vent length (SVL) to the nearest cm using a measuring tape, tail length (TL) and head length (HL) to the nearest mm with a digital caliper (Mitutoyo Corp.), and mass to the nearest g using a Pesola scale. The snakes were sexed by probing. We then marked the individuals with ventral scale clips and released them at the site of capture.

To evaluate sexual size dimorphism we used analysis of covariance (ANCOVA) on tail length, head length, head width, and body mass with SVL as covariate and sex as a factor. Differences in SVL between sexes were tested by *t*-test. We also performed a Pearson's correlation between body vs. air and substrate temperature.

RESULTS

We marked 19 (10F: 9M) *Leptodeira annulata*. Female SVL (481.60 ± 54.41 mm) was not significantly different from male SVL (528.44 ± 99 mm; $t = 1.277$, P = 0.218). Females also had significantly wider heads and were heavier than males (ANCOVA $F = 7.097$, P = 0.017, $r^2 = 0.358$; $F = 12.434$, P = 0.003, $r^2 = 0.470$; Table 1).

Observed activity of *L. annulata* (N = 81) occurred mainly between 1830 h and 2330 h, with a peak from 1930 h to 2230 h (Fig. 1). Around 1830 h snakes were observed emerging from tree holes. We found snakes in Acuri palms (*Attalea phalerata*) most often

TABLE 1. Summary of statistics on sexual size dimorphism of *Leptodeira annulata* in the Pantanal, Brazil. Test statistics for head length (HL), head width (HW), tail length (TL) and body mass (MASS) are from ANCOVAs adjusting for SVL, and thus refer to intersexual differences in size.

	Males (N = 9)	Females (N = 10)	Statistical Results
SVL	528.44 ± 99.00	481.60 ± 54.41	*t* = 1.277, df = 1, P = 0.218
HL	14.12 ± 1.27	14.64 ± 1.69	*F* = 4.434, P = 0.054
HW	10.15 ± 1.77	11.15 ± 1.93	*F* = 7.097, P = 0.017
TL	140.11 ± 17.14	139.20 ± 18.56	*F* = 0.869, P = 0.365
MASS	29.91 ± 7.13	33.70 ± 8.11	*F* = 12.434, P = 0.003

(63%), followed by fig trees (*Ficus calyptroceras*; 23%) and an unidentified tree species of Leguminosae (6%; Fig. 2). Only 3% of detections were of snakes on the ground. Trees where snakes were located averaged 0.80 ± 0.83 m diameter and snake height on the tree averaged 1.65 ± 0.65 m.

Body temperature averaged 26.8 ± 2.9°C (range 22.5–31.4°C, N = 20 including one recapture) and was positively correlated with substrate (r = 0.92, P < 0.001) and air temperature (r = 0.88, P < 0.001). There was no difference in body temperature between sexes (t = 0.46, P = 0.81).

DISCUSSION

Although we conducted our investigation in close proximity to human habitations, we did observe several *L. annulata* in more pristine environments, indicating that this species occurs in a variety of habitats.

The observed activity of *L. annulata*, a primarily anuran-eating snake (Lavilla and Scrocchi 1986) seems to coincide with amphibian activity, as suggested by Vitt (1996). At our study sites, we observed *Scinax acuminatus* and *Scinax nasicus* during observations, including in the same tree with *L. annulata*. The activity of these amphibians is, in general, restricted to 4–6 h after dark (Cardoso and Martins 1987), which may explain the reduced activity of *L. annulata* after 2230 h. Our sampling efforts however ceased at 2400 h so we cannot say anything about snake activity after midnight.

Although snakes may regulate their body temperature both behaviorally and physiologically (Peterson et al. 1993), the thermal environment (e.g., air and substrate temperature) can influence activity patterns, even in tropical nocturnal snakes (Shine and Madsen 1996). Thus, the observed low snake activity in late evening could conceivably be due to the drop in ambient temperature (Shine and Madsen 1996), rather than due to reduced prey availability as discussed above.

In the Pantanal, *L. annulata* largely used arboreal habitats, in contrast to previous findings (Vitt 1996; Martins and Oliveira 1998). It is notable that the Pantanal has more open habitats (even in forests) than the Amazon, but even so, fewer snakes were found on the ground in the Pantanal. Habitat openness or vegetation cover may affect vulnerability of reptiles to visual predators (Stuart-Fox and Ord 2004). Thus, predation pressure may cause greater use of vegetation and reduced use of open habitats (Watts 1991). Alternatively, taxonomic differences may account for the observed differences, since Vitt (1996) studied the biology of *L. a. annulata*, while we studied the subspecies *L. a. pulchriceps*. It is also possible that our detection probability for terrestrial snakes was lower than for arboreal snakes.

The use of Acuri palms by *L. annulata* may be due to either the ready availability of crevices and holes in the trunk (provided also by *F. calyptroceras* in the study area) or the abundance of this tree, which represents 44% of individual trees on the study site. In pristine areas of the Pantanal at Nhumirim Ranch, Acuri palms are the most common tree species in forests (Ratter et al. 1988).

Due to the short duration of our study, further work is needed to understand seasonal variation in body temperatures, activity and habitat use. The Pantanal has a highly seasonal climate with rainfall restricted to November–March and a flood season from April-August (Junk and Cunha 2005) and these cycles may affect snake biology.

Although apparently abundant, *Leptodeira annulata* is vulnerable to reductions in population size, due to indiscriminate killing of individuals. During our study, two individuals were known to have been killed by local inhabitants. Humans may have a natural

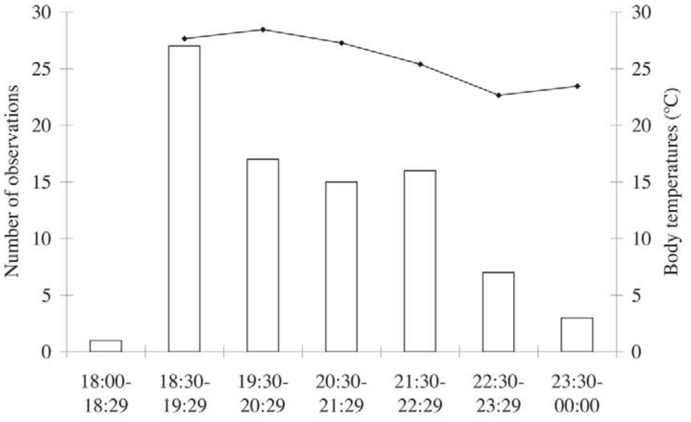

FIG. 1. Observed activity patterns (bars) and body temperatures (line) of *Leptodeira annulata* in the Pantanal, Brazil.

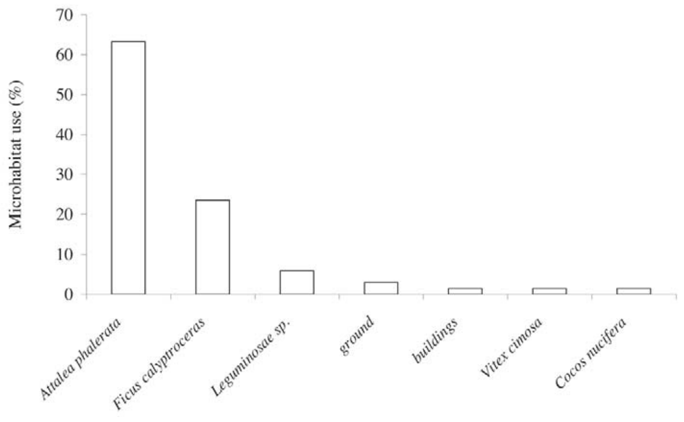

FIG. 2. Observed habitat use of *Leptodeira annulata* in the Pantanal, Brazil, based on 81 observations of active snakes.

fear of snakes (Greene 1997) and this species in particular is often confused with a venomous snake (the pitviper *Bothrops mattogrossensis*; Lavilla and Sccrochi 1986; pers. obs). Educational programs, especially for children, are necessary in the region to prevent indiscriminate killing of snakes.

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A Previously Undescribed Bone in the Snout of the Brown Watersnake, *Nerodia taxispilota*

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While examining more than 400 skulls of thamnophiine snakes currently assigned to the genera *Nerodia* and *Thamnophis*, we encountered a bone in the snout region of most of the specimens of the Brown Watersnake, *Nerodia taxispilota*, that was not present in any other species we examined—nor are we aware of a comparable osseous element being described in any other snake species. Here we describe and illustrate this neomorph and speculate about its possible function.

The neomorph, which we propose to call the **postnasal strut,** is present in ten of the 16 skulls (62.5%) of *Nerodia taxispilota* we examined (LSUMZ 10569, 16849, 20555, 21062, 24363, 28213–214, 34183, 43155, 43455). The skulls range in length from 22.5–33.1 mm, and represent both sexes (5 females, 4 males, 1 undetermined). Six specimens are from Florida, two from North Carolina, and two from undetermined localities. The six skulls that lack the postnasal strut (LSUMZ 12876, 16851, 16935, 39194, 43159, 43454) range in length from 19.3–35.5 mm, and also represent both sexes (4 females, 2 males). Four are from Florida, two from North Carolina.

The following description is based on the skull of LSUMZ 34183, a large (1029 mm snout–vent length, 33.1 mm skull length) female from Lake Newnan, Alachua Co., Florida. The faintly grooved dorsal surface of the narrow postnasal strut lies essentially in the same horizontal plane as the dorsal laminae of the nasal bones and the dorsal surface of the frontals, hence the strut is readily apparent when the dorsal aspect of the snout region is viewed (Fig. 1, upper). The strut is relatively long, its dorsal surface being nearly 70% as long as the dorsal laminae of the nasals (nearly 60% in LSUMZ 20555; 29.5 mm skull length). The anterodorsal tip of the strut is inserted between the posteromedial ends of the nasals. The posterodorsal tip of the strut is inserted between the anteromedial ends of the frontals, which are deflected laterally to accommodate it, but they are not deflected in snakes lacking the strut (Fig. 1, lower).

In order to better determine the relationship of the strut to the bones around it, we soaked the skull in water for several hours to loosen the dried soft tissue that remained after the initial cleaning by dermestid beetles. Further cleaning was then accomplished by hand-picking tissue with a small needle-nosed forceps. Finally, the entire nasal component was removed when it was discovered that this could be accomplished without damaging or altering the position of the strut, which apparently has only loose connections to the nasal and septomaxillary bones.

The postnasal strut was thus revealed to be shaped somewhat like an I-beam in cross-section, with the dorsal "crosspiece" being narrower than the ventral one (which expands toward its posterior articulation; Fig. 2). Anteriorly, where the dorsal "crosspiece" extends forward between the posterior ends of the nasal laminae, the ventral "crosspiece" appears to rest on the posterior processes of the septomaxillae—which themselves articulate with the articular facets on the anterior frontals to form the nasofrontal joint.

Posteriorly, the dorsal "crosspiece" sits between the anteromedial ends of the frontals, which it appears to contact only by way of connective tissue (Fig. 1, upper). The ventral "crosspiece," on the other hand, appears to form a three-way articulation with the dorsal tip of the parasphenoid process of the sphenoid medially, and with the descending anteromedial laminae of the frontals laterally. Although the postnasal strut is immobile when the skull is dry, when moistened it is capable of a limited amount of dorsoventral flexure against the fulcrum provided by the dorsal tip of the parasphenoid process.

Discussion.—The presence or absence of the postnasal strut in *Nerodia taxispilota* clearly does not reflect sex, size, or geography, so the genetic potential for its development appears to exist throughout the genome. Failure to find any trace of the strut in 55 skulls of *N. rhombifer*, the sister taxon of *N. taxispilota*—or in any of the smaller series of other *Nerodia* species available to us—strongly suggests that the presence of the strut in *N. taxispilota* is an autapomorphic feature of the species.

In the absence of studies of its functional morphology, we can

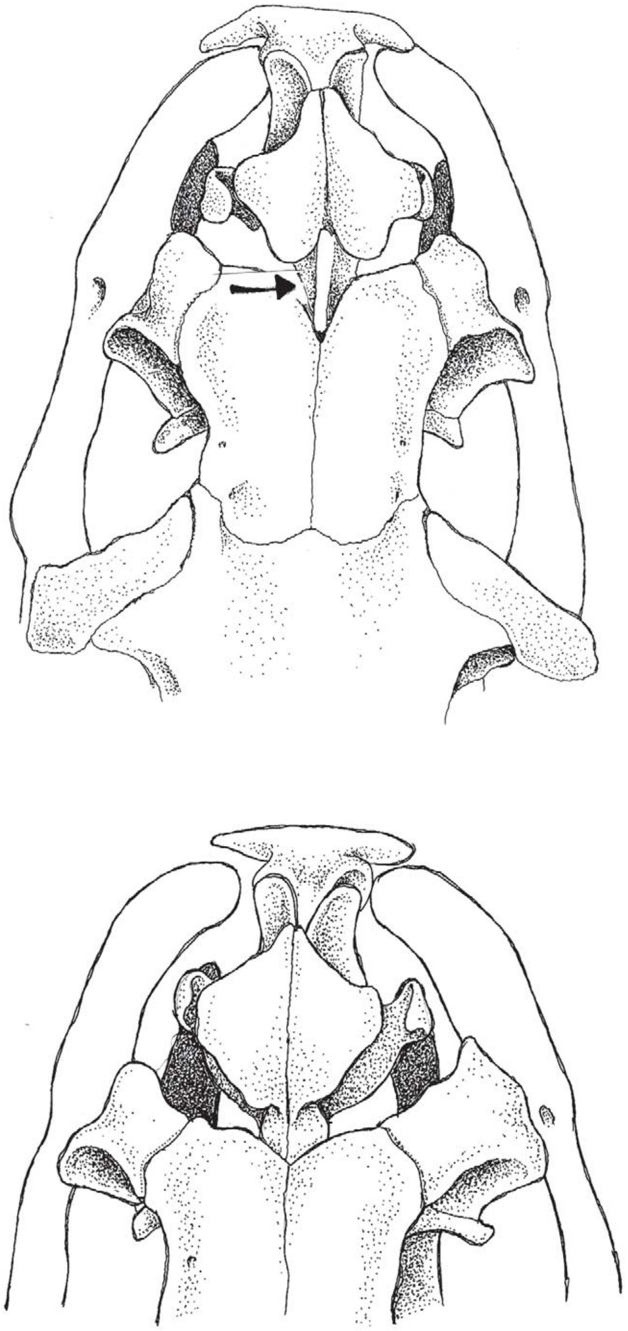

FIG. 1. Dorsal views of skulls in *Nerodia taxispilota* with (upper, LSUMZ 20555), and without (lower, LSUMZ 16851), the postnasal strut (arrow).

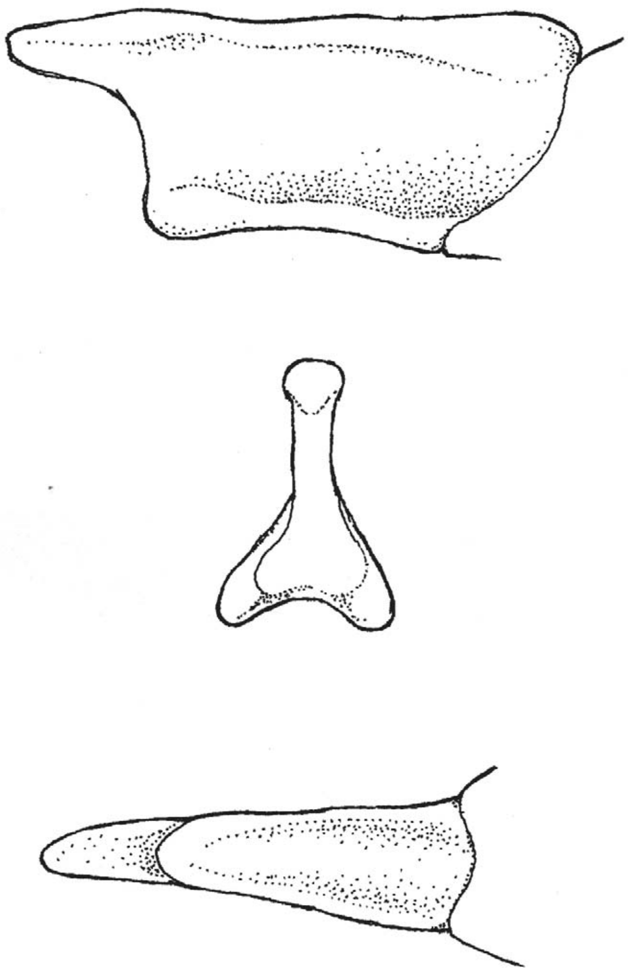

FIG. 2. Lateral, frontal, and ventral views of the postnasal strut in *N. taxispilota* (LSUMZ 34183).

only speculate about the role of the postnasal strut. The most obvious possibility is that by bracing against the frontals posteriorly, the strut serves to limit the dorsal flexion of the nasal component at the prokinetic nasofrontal joint during prey manipulation (Albright and Nelson 1959). Whether or not the strut could also restrict axial rotation at that point is less clear, but it remains a possibility (Cundall and Shardo 1995).

Assuming there is some adaptive advantage to limiting dorsal flexion of the snout in *Nerodia taxispilota*, what might it be? The Brown Watersnake is a catfish specialist (Gibbons and Dorcas 2004) that, in the course of ingesting its prey, must overcome the obstacles posed by the catfish's erected-and-set pectoral and dorsal spines. Richmond (1944) gave a detailed description of how this was accomplished by one large individual he observed closely. When the snake's jaws reached the base of the spines, they slid up them for a short distance, then the snake paused and maintained pressure on them until the struggling fish relaxed the spines. This permitted the snake to close its jaws down on the spines and prevent them from being re-erected.

We suggest that a more rigid snout would more effectively maintain pressure on the catfish spines than could a more flexible snout. Perhaps in the postnasal strut we may be seeing a novel morphological adaptation that is in a stage of evolution where it has become widespread but not yet fixed. Yet, the strut's absence in *Nerodia rhombifer*, equally a catfish specialist (Gibbons and Dorcas 2004), is puzzling. Clearly, a sophisticated study of the strut's function in living *N. taxispilota* will be required to test our speculations.

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Courtship Behavior of Two Treefrog Species, *Aplastodiscus arildae* and *A. leucopygius* (Anura: Hylidae), from the Atlantic Rainforest, Southeastern Brazil

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Complex courtship behaviors in anurans have been described mostly in dendrobatids (e.g., Juncá 1998; Limerick 1980; Roithmair 1992; Wells 1977). Nevertheless, recent studies on reproductive behavior of hylids revealed complex courtship behaviors, mostly in the genus *Aplastodiscus* (e.g., *A. leucopygius*: Haddad and Sawaya 2000; *A. perviridis*: Haddad et al. 2005; *A. eugenioi*: Hartmann et al. 2004). The courtship of these hylids involves mutual tactile stimuli and egg deposition in a subterranean nest previously constructed by the male, who guides the female to the nest.

Visual communication plays an important role in courtship contexts of diurnal frog species (e.g., Haddad and Giaretta 1999; Pombal et al. 1994). Recently, visual signaling has been considered an important type of communication also for nocturnal frogs where this communication seems to be more common than previously thought (Hartmann et al. 2005). Giasson and Haddad (2006), Hartmann et al. (2004), and Heying (2001) described visual signaling during the courtship of *Hypsiboas albomarginatus*, *Aplastodiscus eugenioi*, and *Mantella laevigata* respectively, providing evidence that the courtship behavior of nocturnal frogs is more complex than previously known and visual signals are employed by nocturnal species of frog of different genera or families.

Aplastodiscus arildae belongs to the *Aplastodiscus albofrenatus* species group and *A. leucopygius* to the *A. albosignatus* species group (Faivovich et al. 2005), both restricted to the Brazilian Atlantic rain forest. Information on the courtship behavior of the *A. leucopygius* is available in Haddad and Sawaya (2000). These authors described the courtship as a complex behavioral sequence that involved mutual tactile stimuli and egg deposition in a subterranean nest previously constructed by the male, who guided the female to the nest (reproductive mode 5 according to Haddad and Prado 2005). There is no documentation of the courtship behavior of *A. arildae* since this species occurs at low population densities (Zina and Haddad 2007) making the probability of observation very low. The aims of our study were to describe the courtship behavior of *A. arildae* and compare it with the courtship behavior of *A. leucopygius*. In addition, we provide new information on the visual communication in the courtship behavior of *A. leucopygius*.

Methods.—Our study was conducted in the Serra do Japi (23°14'S, 46°56'W, 1030 m elev.), Municipality of Jundiaí, State of São Paulo, southeastern Brazil, between March 2004 and January 2006. Field observations began after sunset and finished when reproductive activity ended each night. During this period we monitored all the calling males of both species in the studied sites (stream, lake, and swamp). The period of observations had a mean duration of 06 h 47 min ± 2 h 25 min (N = 21; range = 2–9 h) per night. Focal animal observations were used to record behavior (Lehner 1996). We followed the nomenclature proposed by Wells (1977) to classify the different types of calls (advertisement and courtship calls) emitted by both species, according to the social context. To observe courtship behavior, we used headlights with weak batteries to reduce disturbance to the frogs.

Results.—We observed 20 courtship sequences of *Aplastodiscus leucopygius* and only one of *A. arildae*. The courtship behavior of *A. arildae* consisted of a complex sequence of tactile stimuli. The pair behaved as follows (Fig. 1): A—the male was calling parallel to the ground on a leaf 1.5 m above the ground; B—the female jumped onto a leaf next to where the male was calling, and when the male noticed the presence of the female, he stopped emitting the advertisement call; C—the female touched the male's snout with her hand; D—the female repeatedly tapped the male with her snout; E—the female touched the male's snout with her hand; F—the male moved himself slightly and started to move one foot up and down repeatedly, beating it against the leaf; G—the male moved again and positioned himself face to face with the female; H—the female moved one foot up and down repeatedly, beating it against the leaf; I—the male repeated this behavior; J—the female positioned her head above the male's head; L—the male moved slightly preparing himself to get down from the leaf were the couple stayed for two hours; M—the male started a descending journey from his perch, emitting courtship calls; N—the male stopped emitting courtship calls and the female followed the male, touching him with her hand; O—after three hours from the beginning of courtship, the pair reached the ground, and the female continued to follow the male, touching his dorsum with her hand. This courtship occurred during a rainy night over more than nine hours. The pair separated after a branch fell down next to them.

We observed 10 complete courtship sequences (prior to the female approaching the male) of *A. leucopygius*, which had a mean duration of 4 h 30 min ±1 h 20 min (N = 10; range = 2–7 h). These started with the female approaching the male, and ended with the entrance of the pair into the subterranean nest. Another 10 sequences were observed from the moment when the females were already close to the males. During the observation of the journey of the couples to the subterranean nest we observed two behaviors that were not reported by Haddad and Sawaya (2000): 1) both females (N = 5) and males (N = 8) of *A. leucopygius* passed their hands over their eyes and/or blinked when facing each other; and 2) during this interaction, we also observed males performing toe trembling (N = 6). After the oviposition occurred, males abandoned the subterranean nests and females did the same soon after the males. The time that a pair spent in the subterranean nest until the exit of the male averaged 4 h ± 1 h (N = 15; range = 3–5 h). Males of *A. leucopygius* (N = 14) returned to their calling sites three days or more after having been observed in courtship.

Fifteen of 20 courtship sequences observed for *A. leucopygius* ended in oviposition. In three courtship sequences observed during nights of intense rain in December 2004, females came out of the subterranean nest soon after they had entered, and oviposition did not occur. Nests on those occasions were almost entirely full of water. In January 2005, we observed three courtship sequences; two of them were interrupted when the pairs were inside the subterranean nest, due to the incidental interference of the observer trying to visualize the oviposition behavior inside the subterranean nests. In these two situations, we observed the males at the entrance of the nest, while the females were inside with their snouts smeared with mud.

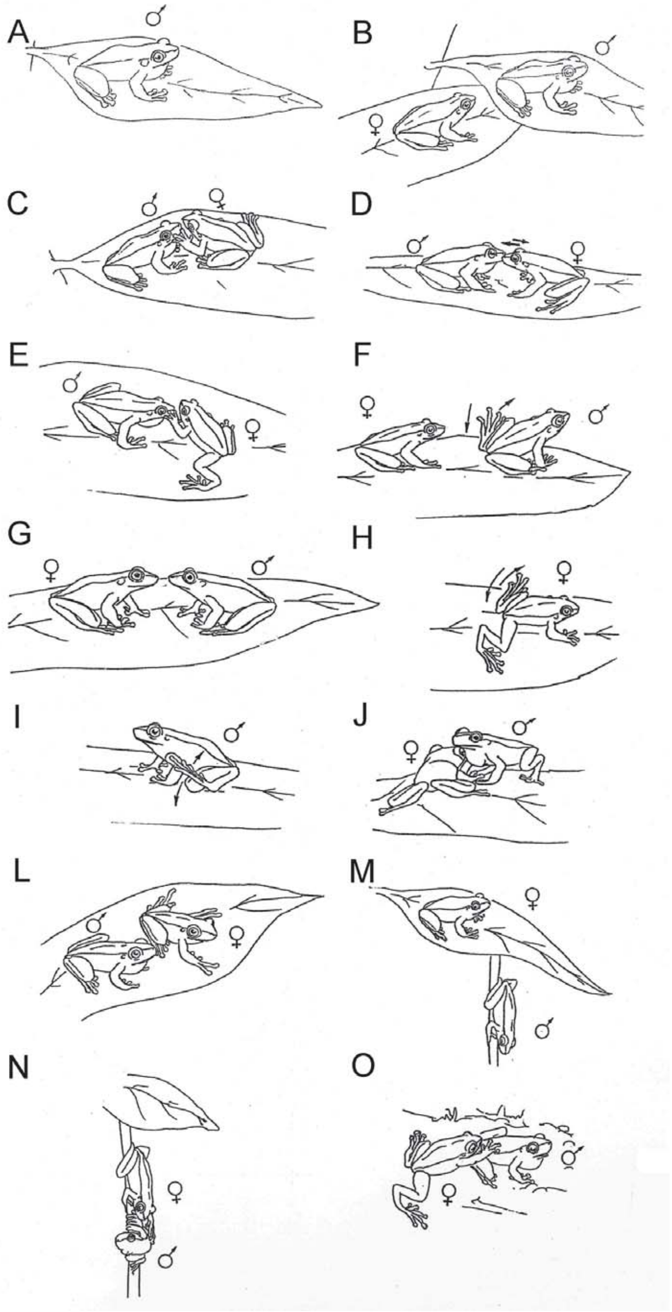

Fig. 1. Behavioral sequence of the courtship behavior of *Aplastodiscus arildae* from the Serra do Japi, Municipality of Jundiaí, São Paulo, Brazil. Letters A– O refer to the behavioral sequence (see text).

On two occasions, an individual of *Hypsiboas bischoffi* (Hylidae) jumped close to the leaf where a male of *A. leucopygius* was emitting advertisement calls. In both occurrences the males of *A. leucopygius* started to emit courtship calls.

TABLE 1. Courtship behaviors (X) observed for different species of *Aplastodiscus*.

Species	Visual signaling				Tactile signaling			Reference
	Toe or fingers trembling	Limbs/foot moved up and down	Eye blinked	Female raised herself on all four limbs	Passed the leg or foot across own body	Female positioned the head above male's head	Male and/or female touched each other with snout or hand	
A. arildae	—	X	—	—	—	X	X	Present study
A. eugenioi	X	X	—	—	X	X	X	Hartmann et al. 2004
A. leucopygius	X	—	X	—	—	X	X	Haddad & Sawaya 2000; Present study
A. perviridis	—	—	—	X	—	—	X	Haddad et al. 2004

Discussion.—Tactile stimuli between male and female and the behavior of guiding the female to the oviposition site are typical of anuran species in which males construct nests before the arrival of females (e.g., *A. perviridis*: Haddad et al. 2005; *Hylodes asper*: Haddad and Giaretta 1999; *A. leucopygius*: Haddad and Sawaya 2000; *A. eugenioi*: Hartmann et al. 2004; *Leptodactylus fuscus*: Martins 1988).

Our observations of the courtship behaviors of *Aplastodiscus leucopygius* were similar to those described by Haddad and Sawaya (2000); however, we registered two more behaviors that were not observed by those authors. Until now, specialized courtship behaviors similar to that observed for *A. leucopygius* and *A. arildae* were described only for *A. perviridis* (Haddad et al. 2005) and *A. eugenioi* (Hartmann et al. 2004). According to Hartmann et al. (2004), *A. eugenioi* produced visual signals during courtship, which are considered an unusual communication mode for nocturnal anurans. Contrasting colors and postural displays in anurans may be related to conspecific visual communication (e.g., Wells 1980a, b). During the courtship of *A. leucopygius* we observed that males and females blinked at each other and/or passed their green hands over their red eyes, a behavior that may involve visual communication. A similar behavior was performed by *Brachycephalus ephippium* (Anura, Brachycephalidae), where the males passed their yellow hands over their black eyes during agonistic interactions (see Pombal Jr. et al. 1994). This behavior, as well as the visual behaviors of *A. leucopygius*, may produce a color contrast for the receiver. According to Pombal et al. (1994), this visual behavior in *B. ephippium* may be derived from a cleaning behavior observed for this species. Descriptions of visual signals are uncommon in frogs and are predicted to be predominantly employed by diurnal species at sites with an unobstructed view (Endler 1992). Leg shaking is involved in visual communication (see Hödl and Amézquita 2001). It was observed during the courtship of *A. eugenioi* (Hartmann et al. 2004) and during aggressive interactions between males of *Aplastodiscus perviridis* (Toledo et al. 2007). In our study, we observed foot shaking behavior in *A. arildae* during the courtship sequence. While this is a visual signal as described by Hödl and Amézquita (2001), we cannot discard the possibility of seismic communication, in which the female or male perceive the presence of other individuals by the propagation of low frequency signals in the substrate or vegetation.

Although visual communication may appear to be less effective than acoustic communication for nocturnal species of frogs, as a consequence of light limitations, the combination of these two communication types might be very important for females to localize the males during the courtship behavior. This may be especially important for species of *Aplastodiscus* because males move constantly from one place to another on their way to the subterranean nest. Acoustic communication is mainly used in long-distance communication (Rand 1985). Visual signaling might be very efficient for short-distance communication in nocturnal frogs (e.g., distance between male and female during the courtship) and might be involved with the coordination of female and male during the journey to the subterranean nest. We did not observe the end of the courtship behavior in *A. arildae*. Because the courtship behavior observed for *A. arildae* is similar to that performed by the other species of this genus (*A. perviridis*: Haddad et al. 2005; *A. leucopygius*: Haddad and Sawaya 2000; *A. eugenoi*: Hartmann et al. 2004) we presume that it ends in a subterranean nest where oviposition occurs. The similarities of the courtship of *A. leucopygius* and *A. arildae* with the other species of the genus (Table 1) support this behavior as being synapomorphic at the genetic level. The perception of an individual by its movements on the vegetation was observed for *A. leucopygius* male, which started to emit courtship calls as soon as another conspecific or heterspecific individual jumped next to them. However, experiments using appropriate equipment to measure seismic signals are necessary to confirm if this additional communication mode is used by this species. In summary, for *A. leucopygius* and *A. arildae* we observed at least three types of male-female communication during courtship behavior (acoustic, visual, and tactile).

During intense rainy nights in December 2004, the courtship sequences of *A. leucopygius* did not end in oviposition. Nests, in these occasions, were almost entirely filled with water. Lack of oviposition following courtship suggests that the females inspect the nests and may reject males if the nests are not adequate. Another fact which suggests that the nests are inspected by females was their snouts smeared with mud, observed when they were already inside the nests. This behavior was not known for the species and could mean that females may not only inspect the nest, but also modify it before oviposition, a behavior previously observed in other species that construct mud nests such as *Hypsiboas faber* (Martins and Haddad 1988).

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Recent Nesting of the American Crocodile (*Crocodylus acutus*) in Everglades National Park, Florida, USA

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The American Crocodile (*Crocodylus acutus*) is one of two native species of crocodilians found in southern Florida, USA. It occurs primarily in estuarine environments in extreme southern mainland Florida and northern Florida Keys (Kushlan and Mazzotti 1989; Mazzotti 1999). In Florida, habitat loss due to development along coastal areas of Palm Beach, Broward, Miami-Dade, and Monroe counties has been the primary factor endangering the American crocodile. This loss of habitat principally affected nesting range of crocodiles, restricting nesting to a small area of northeastern Florida Bay and northern Key Largo by the early 1970s (Kushlan and Mazzotti 1989; Ogden 1978). At this time most remaining crocodiles (about 75% of known nests) were in Florida Bay in Everglades National Park (ENP) or on North Key Largo (25% of known nests), with few sightings (no nests) in Southwest

Florida. The American Crocodile was declared endangered in 1975 by the U.S. Fish and Wildlife Service (Federal Register 40:44149).

In 1978 a third nesting area was discovered at the Florida Power and Light Company, Turkey Point Power Plant site (TP) (Mazzotti 1983). During the 1980s monitoring programs were established for all three nesting locations. These monitoring programs focused on nesting, growth, and survival of crocodiles and led to the discovery of an additional nesting area in the Cape Sable/Flamingo area of ENP. The outlook for crocodiles in Florida is more optimistic today, and currently the Florida population of *C. acutus* is under review for reclassification from endangered to threatened by the U.S. Fish and Wildlife Service (Federal Register 70:15052–15062). In addition to endangered species recovery, the federal government, in partnership with state, local, and tribal governments, has initiated the South Florida Ecosystem Restoration Initiative (SFERI). This is an unprecedented effort to restore and manage ecosystems of southern Florida that have been degraded by human activities. Alternatives for improving water delivery into South Florida estuaries may change salinities, water levels, and availability and suitability of nesting habitat in receiving bodies of water. Continued monitoring will be essential to ensure survival of this endangered species within its changing environment.

Surveys for nesting of *C. acutus* have been conducted in ENP since 1970 (Ogden 1978). Mazzotti (1989, 1999) summarized factors affecting nesting success from 1970 to 1995. The purpose of this paper is to review nesting of *C. acutus* in Everglades National Park to 2004.

Methods.—This study was conducted at the southern tip of mainland Florida from US Highway 1 to and including Cape Sable, ENP (Mazzotti 1999). The mainland has very low relief with many creeks, ponds, small bays, and a few man-made canals and ditches draining into Florida Bay (Mazzotti 1983, 1999). Marl banks that line creeks, canals, and sand beaches on mainland and island shorelines are important as nesting sites for crocodiles (Mazzotti 1999). Vegetation in the study area is primarily mangrove swamp (Olmstead et al. 1981). Higher ground supports tropical hardwoods and buttonwood (*Conocarpus erectus*) (Olmstead et al. 1981). The presence of plants intolerant of flooding is a good indicator of potential nesting habitat for crocodiles (Mazzotti 1989).

Since 1978 consistent survey methods have been used under supervision of one investigator (FJM) to collect the data analyzed here. Crocodile nesting effort (number of nests with eggs) and success (number of nests that produce at least one hatchling) were determined by searching known and potential nesting habitat in ENP. Searches were conducted by skiff, foot, and canoe during April and May for nesting effort and July and August for nesting success. Evidence of nesting activity included tail drags, digging, or scraping. Shells of hatched eggs or hatchlings were considered evidence of successful nests. When nests were located, vegetation, habitat (creek, island, shoreline, or man-made), substrate, distance from shore, nest dimensions, and salinity of adjacent water were recorded. Successful nests produced at least one hatchling. The number of failed eggs and causes of egg failure were noted when evident. Nests that failed to hatch were located by excavating areas of nesting activity at least 30 days after the last known nest hatched for that year.

Trends in numbers of nests in northeastern Florida Bay (1978–2004) and Cape Sable/Flamingo (1986–2004) nesting areas were analyzed using log linear regression models. Trends in numbers of nests in different habitats (island, creek, shoreline, artificial) also were analyzed using log linear regression models. We compared proportion of nests lost to depredation and embryonic mortality during 1985 to 1995 to the proportion of nests lost to those factors during 1997 to 2004 using a Fischer's Exact Right-Sided test. The proportion of nests lost to depredation and embryonic mortality in natural versus artificial surfaces was analyzed using a

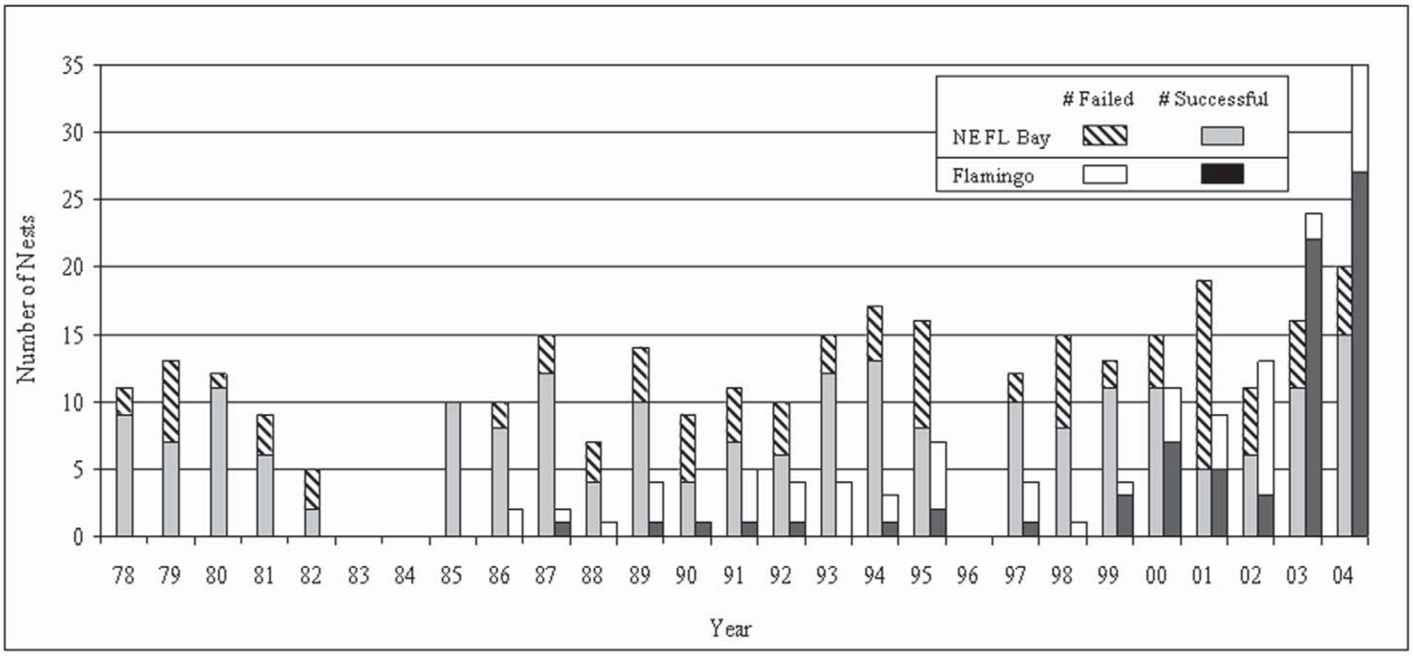

FIG. 1. Summary of American Crocodile nesting within Everglades National Park. Each bar represents the total number of nests at a site for a given year. Nesting surveys were not performed in 1983, 1984, or 1996.

TABLE 1. Summary of locations and habitats of American Crocodile nests in Everglades National Park (modified from Mazzotti 1999).

Habitat/Location	Number (%) of Known Clutches								
	< 1930	1930–1950	1950–1959	1960–1969	1970–1979	1980–1989	1990–1995	1997–2004	Total
Creek	2 (67%)	3 (18%)	1 (8%)	2 (9%)	28 (35%)	12 (13%)	7 (7%)	1 (0.5%)	56 (10%)
Mainland shoreline	1 (33%)	4 (23%)	5 (38%)	16 (69%)	38 (48%)	53 (58%)	55 (54%)	126 (56.7%)	298 (54%)
Island shoreline	0	10 (59%)	7 (54%)	5 (22%)	14 (17%)	17 (19%)	18 (18%)	31 (14%)	102 (19%)
Man-made	0	0	0	0	0	9 (10%)	21 (21%)	64 (28.8%)	94 (17%)
NE Florida Bay	3 (100%)	17 (100%)	13 (100%)	23 (100%)	80 (100%)	82 (90%)	78 (77%)	121 (55%)	417 (76%)
Cape Sable/Flamingo	0	0	0	0	0	9 (10%)	23 (23%)	101 (45%)	133 (24%)
Number of clutches	3	17	13	23	80	91	101	222	550

Pearson Chi-square test.

Results.—The number of crocodile nests observed in ENP increased from 16 in 1997 to 55 in 2004 (Fig. 1). With the exception of a single nest on Shark Point near the mouth of Shark River, the footprint of crocodile nesting remained the same as that reported by Mazzotti (1999). Nesting increased in the historical core area of northeastern Florida Bay at an annual rate of 2.5% from 1978 to 2004 ($P = 0.0006$, $R^2 = 0.4219$). However, most of the increase in crocodile nesting occurred in the relatively new Cape Sable/Flamingo nesting area, where nests increased from 2 in 1986 to a high of 35 nests in 2004, an annual rate of 14.1% ($P = 0.0003$, $R^2 = 0.5648$). Prior to 1995, 90% of crocodile nests ($N = 328$) were located in northeastern Florida Bay. Since 1997, 45% of crocodile nests ($N = 222$) were located in the Cape Sable/Flamingo nesting area (Table 1).

The number of crocodiles nesting in different habitats has also changed (Table 1). The number of creek nests decreased at an annual rate of -4.3% ($P < .0003$, $R^2 = 0.4585$), whereas the numbers of nests on man-made substrates increased at an annual rate of 10.5% ($P = 0.0008$, $R^2 = 0.4956$) (Table 1). All nests on artificial substrates were in the Cape Sable/Flamingo area. Most (70 of 94) nests on artificial substrates were on canal banks. Other artificial nest sites included spoil piles (4), parking lots (9), roadside (10), or canal plugs (1). The number of nests on mainland and island shorelines increased at annual rates of 5.7% ($P < 0.0001$, $R^2 = 0.7026$) and 4.3% ($P = 0.0036$, $R^2 = 0.3250$), respectively, between 1978 and 2004.

Overall nesting success has remained high in ENP (Table 2). The proportion of nests lost to depredation increased slightly and the proportion of nests lost to embryonic mortality decreased slightly in the period 1997–2004 as compared to 1985–1995 (Right-sided Fisher Exact Test, $P = 0.0556$ for depredation and $P = 0.0313$ for embryonic mortality). Depredated nests were distributed randomly between artificial and natural substrates (Pearson Chi-square Test, $P = 0.3546$, $N = 456$), as was embryonic mortality (Pearson Chi-square Test, $P = 0.8153$, $N = 449$).

Discussion.—The number of nests of the American Crocodile in ENP has increased fivefold from 1978 to 2004 and more than doubled since 1997 (Fig. 1). Although a slight increase has occurred in the core nesting area of northeastern Florida Bay, most of this increase can be attributed to the new Cape Sable/Flamingo nesting area of ENP. Most of those nests were on artificial substrates (Table 1). Hence, in ENP as elsewhere in Florida, most of the increase in crocodile nests was on man-made substrates in areas where crocodiles did not nest historically.

Nesting occurred within a few years of creation of peat canal banks created at TP and the Crocodile Lake National Wildlife Refuge (CLNWR; Mazzotti 1983; Ogden 1978). In ENP, crocodiles nested on a canal plug within hours of construction completion (Mazzotti 1999). However, most of the increase in nesting in the Cape Sable/Flamingo area was on canal banks that were created more than 40 years ago (Beard 1938; Lodge 1994). Mazzotti et al. (2007) hypothesized that plugging canals in the Cape Sable/Flamingo area in the 1980s and 1990s to reduce saltwater intrusion and retain fresh water provided more suitable habitat for nesting for the few crocodiles present in the area and for growth and survival of hatchling crocodiles. The rapid increase in numbers of crocodiles nesting in the Cape Sable/Flamingo area since 2000

Table 2. Patterns of nesting success and failure of American Crocodiles observed in Everglades National Park between 1970 and 2004. Successful nests are those that produced at least one hatchling. Data from Ogden (1978), Mazzotti (1989, 1999), and present study.

	1970–1982	1985–1995	1997–2004
Number of nests	104	166	222
% successful (#)	74	62	66 (146)
% depredated (#)	13	23	29 (64)
% infertile or embryonic mortality* (#)	13	10	4.5 (10)
% relocated (#)		5	0.5 (1)
% successful in NE Florida Bay (#)		72	64 (77)
% successful in Cape Sable/Flamingo (#)		29	68 (69)

*most embryonic mortality is caused by flooding and desiccation (Mazzotti 1989, 1999)

may be the result of offspring of the original nesting crocodiles entering the breeding population.

The decrease in creek nests coincides with sea level rise (Mazzotti et al. 2007; Simmons and Ogden 1998). Not only did crocodiles formerly nest more frequently along creek banks, but some of the creek banks were farmed in the early 1900s (Moore 1953a). That suggests that water salinity and water levels were lower than at present. Current estimates of sea level rise suggest that water levels around Florida Bay have been rising at a rate of 38 cm/100 yr since 1932 (Wanless et al. 1994). Canal banks are at higher relative elevations than creek banks, are less susceptible to flooding, and may possibly provide additional nesting habitat as sea level continues to rise.

Although the number of island nests has increased, crocodiles have not returned to nest on many of the islands where they were known to nest in the 1950s (Moore 1953b; Ogden 1978). Instead, crocodiles are now nesting on islands close to the mainland in northeastern Florida Bay. We hypothesize that the overall increase in nests on islands and on the mainland shoreline is related to an increase in relative density of crocodiles in the area. Nesting islands in the southern portion of northeastern Florida Bay were probably used by crocodiles from Key Largo and were abandoned when crocodile habitat on Key Largo was developed (Ogden 1978). Islands in central Florida Bay, like islands in northern Florida Bay, are in an area where we suspect relative density of crocodiles has increased (Mazzotti 1999). Yet, there has not been a corresponding increase in nesting on those islands. One possible explanation is that nesting surveys have shown that elevated nesting beaches are no longer present on any of the islands in central Florida Bay mentioned by Moore (1953b). The cause of the loss of nesting beaches on those islands is unknown but could be the result of storm erosion (Mazzotti 1989), sea level rise, or both.

Nesting success of the American Crocodile in Everglades National Park compares favorably to nesting success of American Crocodiles elsewhere (Arteaga and Gomez 2000; Schubert 2002; Thorbjarnarson 1989) and other species of crocodilians (Allsteadt 1994; Hall and Johnson 1987; Metzen 1978; Webb et al. 1983). In Florida, nesting success in ENP is intermediate between that found at the TP nesting area (highest) and at CLNWR (lowest; Mazzotti et al. 2007). In ENP, nest failure is the result of embryonic mortality caused by flooding or desiccation, and depredation by raccoons (Mazzotti 1989, 1999). For example, nesting in ENP is timed to avoid the wettest and driest times of the year, and embryonic mortality is limited to years with extreme rainfall events (Mazzotti 1999). Sand nests were more susceptible to desiccation and creek nests were most susceptible to flooding. With fewer creek nests embryonic mortality has been reduced (Mazzotti 1999).

Depredation of crocodile nests by raccoons in Florida has only occurred in ENP, despite the presence of raccoons at both of the other nesting areas (TP and CLNWR) (Mazzotti et al. 2007; Moler 1992). One difference among the nesting areas is that, until recently, all nesting at TP and CLNWR was on man-made substrates whereas most nesting in ENP was on natural substrates. However, when nesting on man-made substrates began in ENP, it appeared as if those nests were particularly vulnerable to depredation (Mazzotti 1999). That trend has not continued (this study).

If the pattern of increasing numbers of nests and good nest success continues, the data would support reclassification of the American Crocodile from endangered to threatened. This underscores the importance of long-term monitoring programs for endangered species recovery. The response of nesting crocodiles to the plugging of canals to restore more natural salinity patterns in interior wetlands confirms the value of crocodiles as indicators of ecosystem response to restoration projects. Also, this highlights the value that relatively simple projects can have for endangered species recovery and ecosystem restoration.

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Summer Breeding and Accelerated Larval Development in the Myobatrachid Frog, *Neobatrachus pictus* Peters, 1863

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Anurans living in arid and semi arid environments have to overcome high temperatures and a seasonal lack of water (Bentley 1966). Many arid zone frogs avoid desiccation from high temperatures and water loss by burrowing (Bentley 1966; Main et al. 1959). Some species also form a cocoon for further protection from desiccation and water loss until the next heavy rains that may be three or more months away (Lee and Mercer 1967). Anurans living in arid environments must adapt their breeding strategies to take advantage of water when it is available. Consequently, desert species may not breed for several years (Bragg 1967; Main et al. 1959; Morton et al. 1993). Many species living in arid areas will breed whenever water becomes available regardless of the time of year, usually following heavy rain (Bragg 1967). Hence, they may have non-seasonal but extremely restricted breeding periods usually only lasting two or three days (Bragg 1967; Main et al. 1959). As water is only available for a limited amount of time, metamorphosis is often accelerated, ensuring offspring have enough time to complete development before the water source has dried up (Bragg 1967; Main et al. 1959; Read 1999).

The reproductive biology of some Australian myobatrachid frogs, including those in the genus *Neobatrachus,* is poorly understood. This is especially true when compared to the well-studied North American pelobatids, including *Spea* and *Scaphiopus*, that appear similar in their basic biology and ecology to Australia's myobatrachids, particularly those in the genus *Neobatrachus* (Read 1999). Opportunistic breeding occurs in pelobatids, usually following rain (Bragg 1967; Woodward 1982). Fast development from egg to metamorph (e.g., from 7 to 40 days) occurs in most *Spea* and *Scaphiopus* species (Bragg 1967; King 1960; Voss 1961). The speed of development has been shown to be affected by water levels, water temperature, food availability, and competition and cannibalism from conspecifics (Bragg 1967; Morey and Reznick 2000; Pfennig 1990; Semlitsch and Caldwell 1982). Skeletochronology studies suggest that these frogs are relatively long lived (> 13 years) and may take two or more years to reach maturity (Tinsley and Tocque 1995; Woodward 1982). However, comparable data are lacking for many of the species in the genus *Neobatrachus*.

Herein, I provide some new data on the general reproductive biology, occurrence of summer breeding and accelerated larval development in *N. pictus*. I also highlight similarities between the Australian *Neobatrachus* and the North American pelobatids.

Neobatrachus pictus is a locally common burrowing frog found in southern South Australia and in western Victoria (Cogger 2000). It occurs in a wide range of habitats from open grasslands and mallee woodlands, and in farmed and cleared land (Barker et al.

1995; Robinson 1995), usually near dams, claypans or ditches where water pools after rain (Robinson 1995). Currently, *N. pictus* is thought to breed at any time of the year, usually following heavy rain (> 25 mm) (Roberts 1978). Breeding and calling have been observed in the late austral summer and early autumn (February and March) as well as throughout winter and into the early spring (Roberts 1978). Males call from the water while floating (Roberts 1978). Larval life has been reported to be 4–9 months (Anstis 2002; Barker and Grigg 1977).

Methods and Results.—Frogs were observed at two study sites near Burra (33°42'S, 138°56'E), in the mid-north of South Australia. Site 1, Rosalea, is located approximately 10 km S of Burra and is surrounded by ploughed fields. Site 2 is located on the outskirts of Burra in natural grassland that is grazed by sheep. After a prolonged dry period (< 100 mm in previous 6 months), heavy rain fell consistently between the 18 and 21 January 2007. Total rainfall over the four days was 82 mm at Site 1 and 88 mm at Site 2. One dam was monitored at Site 1 (Dam 1, length × width = 38.8 m × 27.2 m) and two dams located approximately 1 km apart at Site 2, one small (Dam 2, 15.7 × 14.9 m) and the other large (Dam 3, 108 × 33.5 m). All three dams are man made and dug out of clay, and all were dry and empty prior to the rain event. On 23 January the water levels within the dams were measured and depths recorded were 1.7 m, 1.6 m, and > 2 m for Dams 1, 2, and 3 respectively. When possible, all three dams were inspected daily from the onset of rain to monitor larval development.

Breeding observations.—On 21 January *Neobatrachus pictus* called at all 3 dams from ~ 2100 h to at least 0100 h; there were no calls heard prior to 21 January. Ten captured specimens were confirmed to be *N. pictus*, based on their size, call and lack of skin connection from the knee to the side of the body that distinguishes them from other *Neobatrachus* spp. in the region (Roberts 1978), and were released back to their capture locations.

The choruses lasted 5 days, to 25 January, with no frogs heard or observed on or after 26 January. Male *N. pictus* called from the water and the water's edge and their numbers and location within the dam across the 5 nights at Site 1 were visually estimated (Table 1). From 22 to 24 January, egg masses were seen at night but were not visible the following mornings at ~ 0900 h. Amplexus, however, was not observed at any of the dams. Adult *N. pictus* were found over 300 m away from the dam at Site 1. A second frog species, *Limnodynastes tasmaniensis*, was present at Dam 1 from 23 to 25 January in much lower numbers (visual estimate: 15 animals per night). Ambient temperatures were recorded between the 21 to 25 January 2007 using a data logger located at Site 1. Temperatures ranged from 11.3–24.1°C between 2130 h and 0430 h, during the five days of the chorus.

Tadpoles.—Tadpoles were first observed in all three dams on 2 February 2007. Tadpoles aggregated in large groups, 50–100 individuals, in the shallow water and many appeared to come to the water's surface frequently to gulp air. The water at Site 2 was very clear and more than 1000 tadpoles could be seen at each of the dams. However, at Site 1 it was difficult to estimate tadpole numbers due to the muddy water.

Tadpoles were first observed with hind legs on 14 February. Front legs were observed in some individuals on 20 February. Tadpoles with no legs were present until 26 March 2007 at all three dams. However, by 6 April 2007, water levels were very low (< 30 cm) at Dam 1 (Site 1) and Dam 2 (Site 2) and all remaining tadpoles had died, with many seen dead in the shallows and on the banks of the dams.

TABLE 1. Estimated numbers of *Neobatrachus pictus* and their locations around the dam during five breeding nights at Rosalea, Site 1, in South Australia.

Date	No.	Location
21 Jan 2007	60+	Highly visible near waters edge
22 Jan 2007	60+	Highly visible near waters edge
23 Jan 2007	40+	Edge and in middle of dam
24 Jan 2007	20+	Few near edge most in water
25 Jan 2007	20+	Few near edge most in water

Metamorphs.—Metamorphs were first observed at all dams on 26 February 2007, and then were observed nightly until the 5 April 2007. There were no observable differences in metamorphosis rates between the frogs in ploughed land or natural grassland, or between large or small dams. This suggests that *N. pictus* can develop from egg to metamorph in ~ 37 days. On 27 February 2007, 16 metamorphs were collected from Site 1 between 2030 h and 2120 h, from up to 10 m away from the water's edge. The captured metamorphs were measured for snout–vent length, head length (snout tip to posterior tip of jaw articulation), head width (behind eyes and between the tips of the jaw), tibia length (leg flexed), remaining tail (vent to tip of tail) and weight (to the nearest gram) (Table 2). The metamorphs were then returned to their place of capture. Metamorphs were observed over 200 m from the nearest dam. Three specimens were collected and deposited into the South Australian Museum (SAM) (SAM reference numbers: R62503-5).

Discussion.—My study is the first to document summer breeding and accelerated development of *N. pictus* in the semi-arid landscape of South Australia. It is also the first reported case of *N. pictus* breeding in January, and confirms the temporal flexibility in breeding time in this species (Roberts 1978). This observation also highlights the similarities between the *Neobatrachus* of Australia and the North American pelobatids.

Neobatrachus pictus from near Burra, South Australia, had an accelerated rate of metamorphosis compared to other published accounts (Anstis 2002; Barker et al. 1995), reaching froglet stage after only a few weeks (37 days), rather than 4–9 months, if conditions are suitable (Anstis 2002; Barker et al. 1995). Fast meta-

TABLE 2. Metamorph *Neobatrachus pictus* body measurements (N = 16) of specimens collected from Rosalea, Site 1, South Australia.

Body Measurement	Range	Mean (SD)
SVL (mm)	21–27	23.5 (1.46)
Head length (mm)	8–10	8.75 (0.68)
Head width (mm)	8–10	8.75 (0.68)
Tibia (mm)	7–9	8.19 (0.75)
Tail remaining (mm)	3–21	7.56 (4.21)
Weight (grams)	2–3	2.19 (0.40)

morphosis has been recorded for *N. centralis* with metamorphosis taking as little as 17–40 days (Read 1999). This rapid development is comparable with the North American pelobatids living in similar environments (Bragg 1967). The benefits of fast metamorphosis include maximizing recruitment (Newman 1989; Wilbur 1987), and enhanced survival when early developers can attain larger sizes and mature earlier than slow developers (Berven 1990; Smith 1987). It is also an advantage to species living in environments with unpredictable rainfall and areas where water is only available for short periods of time (Bentley 1966). Many species of *Neobatrachus*, including *N. pictus*, may overwinter as tadpoles and develop in the spring (Anstis 2002). However, flexibility in the breeding strategy, as shown by *N. pictus*, may also be present in congeners, possibly allowing breeding or larval development to take place at any time of year if conditions are suitable. Further studies would need to be conducted to fully understand the factors that trigger the accelerated larval development in *N. pictus*.

In my study, there was no apparent difference in the rate of larval development in the dams in natural grasslands and ploughed fields, or between large and small dams. However, I only measured dam depth and size. Other studies have found differences between development rates due to water levels, water temperature, food availability and competition (Bragg 1967; Morey and Reznick 2000; Pfennig 1990; Semlitsch and Caldwell 1982). These factors should be considered in future studies.

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Some Forgotten Descriptions of *Nasikabatrachus* (Anura: Sooglossidae)

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Much excitement was justifiably generated in the recent past in association with the description of a purported new family of amphibians (the Nasikabatrachidae) by Biju and Bossuyt (2003). Dubbed 'the coelacanth of frogs' (Hedges 2003), its sole described member, *Nasikabatrachus sahyadrensis,* is restricted to the Western Ghats complex of Southwestern India, a known biological diversity hotspot (see also Aggarwal 2004; Gadagkar 2004). Another research group described its tadpole and added details of adult morphology and confirmed a relationship with the African Heleophrynidae and the Seychellian Sooglossidae (Dutta et al. 2004). Most recently, Frost et al. (2006) synonymized Nasikabatrachidae under Sooglossidae. Two recent papers have discussed the distribution of this enigmatic frog (Andrews et al. 2005; Das 2006).

These recent papers, however, make no mention of several early papers that described in detail (for the first time), the tadpoles and post-larval stages of *Nasikabatrachus,* including osteological details of adults, and inference to an African relationship.

The first report of tadpoles that are clearly *Nasikabatrachus* is in Annandale and Rao ("1916" 1917), who provided a brief description, based on specimens from Kerala State, Southwestern India. In another paper, Annandale (1918) provided an extended description and measurements, and presented illustrations of the body and mouthparts, tentatively assigning the species to the family Cystignathidae (at present synonymous with Leptodactylidae). Subsequently, Annandale and Hora (1922) remarked on the similarities between their unidentified tadpole, which they considered closely related to *Heleophryne*, and wrote: "No frog of the family Cystignathidae is known from the Oriental Region, but the Batrachia of the hills of the Malabar Zone are still imperfectly studied and the adult of this tadpole is a burrowing form and, therefore, liable to escape notice. The Ethiopian affinities of the fauna of the Malabar Zone are well recognized by Zoogeographers." The larva was also discussed in a paper on convergent evolution of torrent fish and tadpoles by Annandale and Hora (1922). Later, Rao (1938) reexamined some of the early specimens, as well as a metamorph, and inferred a relationship of the Indian frog with the African Heleophrynidae (using *Heleophryne natalensis* as a representative) and Hemisotidae (comparisons made with *Hemisus*), rather than to any Asian taxa, but clearly diagnosed the Indian taxon as different, writing of the justification of "creation of a new genus or even a sub-family for their reception." The Sooglossidae, to which family *Nasikabatrachus* was allocated by Frost et al. (2006) was described by Noble only in 1931. Two other papers which describe the cranial osteology of *Nasikabatrachus* (tentatively allocated to the family Cystignathidae) include Ramaswami (1943) and Ramaswami (1944), while noting its non-confamilial status.

The description (p. 22) and images (Pl. I; figs. 6, 6a) of the tadpoles provided in Annandale (1918) of a species *incertae sedis* match the description of *Nasikabatrachus* provided by Dutta et al. (2004), including: 1) dorsoventrally flat; 2) reduced tail fin; 3) beak with keratinized labial teeth rows; 4) sinistral spiracle; 5) cloacal tube with flap-like extensions ventral to tail fin; 6) ventrally-located suctorial mouth; 7) head large; and 8) the dorsal orientation of the eyes and nostrils. Dutta et al. (2004) mentioned an additional character that is at variance with the description in Annandale (1918)—a white head. Specimens reported in that paper were examined several years after preservation, which might explain the discoloration of head and body, described as "dark grey with small black spots." A uniquely derived character of the Nasikabatrachidae—funnel-shaped cloacal tube—is not mentioned in the early description, perhaps because of the technical limitations of the optics of the time. Both Annandale (1918) and Dutta et al. (2004) describe the tadpoles as being torrenticole in habits. Adult and metamorph descriptions in Annandale (1918) and Rao (1938) match *Nasikabatrachus* in the following: 1) inner metatarsal tubercle spade-like; 2) sternum absent; 3) firmisternal pectoral girdle; 4) lateral end of coracoid wider than median; and 4) hind limbs dark with a white inner metatarsal tubercle.

Aggarwal (2004) pointed out that *Nasikabatrachus* was familiar to the local people, revealing once again the failure of science to pay enough attention to local knowledge. In this short communication, I show that early workers in India, in a series of forgotten papers published nearly a century ago, have remarkably predated the discovery of a new species and genus of an ancient group of frogs. They also arrived at a conclusion on relationships rather similar to that confirmed using contemporary knowledge on morphology and molecular techniques.

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Rediscovery of the Rare Coralsnake *Micruroides euryxanthus neglectus* (Serpentes: Elapidae)

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The New World coralsnakes are currently allocated to three genera: *Micruroides*, *Micrurus*, and *Leptomicrurus* (Campbell and Lamar 2004). The monotypic Sonoran coralsnake (*Micruroides euryxanthus*) is likely the sister taxon to all other New World coralsnakes, and is morphologically distinguished from the other genera by having a single pair of gular shields and by the presence of solid maxillary teeth situated posterior to the fangs. Zweifel and Norris (1955) recognized two subspecies of *M. euryxanthus* (*M. e. euryxanthus* and *M. e. australis*), distributed from southern Arizona and New Mexico south through Sonora and western Chihuahua, Mexico. *Micruroides e. australis* has subsequently been collected from extreme northern Sinaloa, Mexico. In 1967, Roze described the taxon *M. euryxanthus neglectus* on the basis of two male specimens collected between 25–32 km north of Mazatlán, in southern Sinaloa. Since its description, no additional specimens of *M. e. neglectus* have been reported. Furthermore, no specimens of *Micruroides* have been collected from the region intervening the type locality of *M. e. neglectus* in the south and extreme northern Sinaloa, a hiatus of over 400 km.

On 17 July 2006, we obtained a specimen of *Micruroides* from near Cosalá, Sinaloa (24.293°N 106.759°W; 289 m elevation) that we identified as *Micruroides e. neglectus* based on color pattern and scalation (Figs. 1A, B). The specimen is notable in that it is the first known female of the taxon to be deposited in a herpetological collection (Museo de Zoología, Facultad de Ciencias [MZFC], Universidad Autónoma de México: MZFC 19683), and is the first specimen reported since the original description. In most aspects of morphology MZFC 19683 is consistent with the description of the holotype provided by Roze (1967): the specimen has 13 black body rings and 2 black tail rings; black body rings 5–7 dorsal scales long; a pale nuchal ring 3.5 scales long not extending onto parietals; pale body rings 1.5–2 scales long; and 13 unmelanized red body rings. There are a total of 112 red scales along the middorsal line of the body (excluding the tail), which is the highest number reported for *Micruroides*. MZFC 19683 has 226 ventrals (males of *M. e. neglectus* have 206–207), and 24 subcaudals (males have 25–26). The specimen has a snout–vent length of 390 mm and a tail length of 28.9 mm.

Although broadly associated with the arid Sonoran Desert region of southern Arizona and northwestern Mexico, the distribution of *M. euryxanthus* is locally restricted to regions that receive

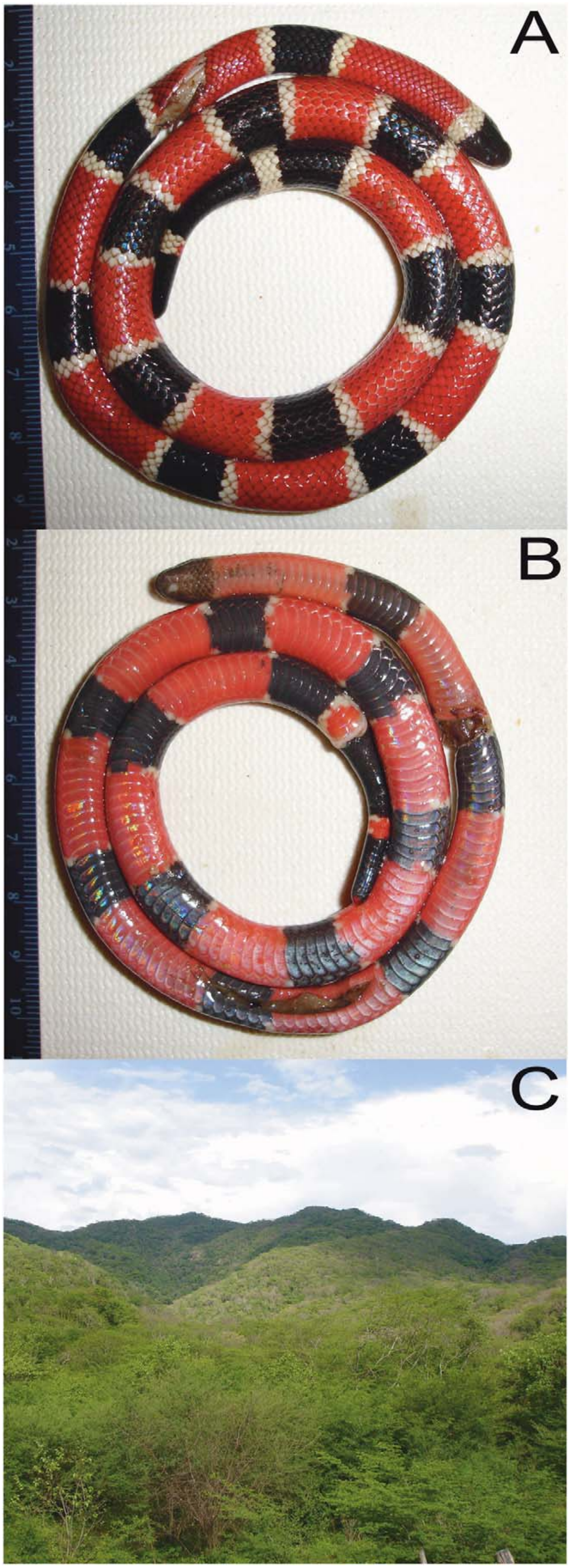

FIG. 1. Dorsal (A) and ventral (B) aspects of *Micruroides euryxanthus neglectus*, adult female (MZFC-19683); (C) tropical deciduous forest near the collecting locality.

relatively high amounts of summer rainfall; thus throughout most of its range its primary habitats are subtropical thornscrub and palo verde cacti desert (*sensu* MacMahon 1985). Over the north to south axis of Sinaloa, the transition from thornscrub to tropical deciduous forest is gradual; the new specimen was obtained from tropical deciduous forest (Fig. 1C), similar to that of the type locality of *M. e. neglectus*. It was found crossing a paved road (Sinaloa Hwy 8) during warm, humid conditions at approximately 2219 h. During the same night, several other snake species were encountered near the collecting locality, including a similarly patterned *Lampropeltis triangulum*.

Most coralsnakes are ophiophagus, consuming primarily small colubrids and typhlopids (Campbell and Lamar 2004). Considerable information exists on the diet of *Micruroides euryxanthus* but not from the extreme southern portion of its distribution. The specimen collected near Cosalá contained the partially digested remains of a small colubrid snake, *Hypsiglena torquata* (MZFC 19684). The snake had been swallowed head-first and only about the posterior third of the body was undigested. As far as we have been able to ascertain, this is the first reported incidence of a non-captive coralsnake consuming *H. torquata* (reviewed in Campbell and Lamar 2004).

The new locality for *M. e. neglectus* is situated approximately 100 km northwest of the type locality in the vast region indicated by Campbell and Lamar (2004) to be of probable, but unknown, occurrence for the species. The new specimen partially fills in this gap in the distribution of *Micruroides*; however, considerable distance still exists between the specimens assigned to *M. e. neglectus* and known *Micruroides* populations to the north. Future collecting efforts will likely substantiate the presence of *Micruroides euryxanthus* throughout Sinaloa. Furthermore, efforts are currently underway to evaluate and revise the taxonomy of all New World coralsnakes, including *Micruroides* (ENS et al., in prep).

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An Anole Lizard Preserved in Colombian Copal

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The term 'copal' is generally used for any hard, semi-fossilized resin produced by diverse broadleaf and coniferous trees found in both the Old and New World. In Colombia, large amounts of resin are often seen hanging from the branches of the leguminous tree *Hymenaea courbaril*, commonly known as the *algarrobo*. Through a process of oxidation and polymerization, this resin gradually hardens—particularly after exposure to sunlight (Lagenheim 1995). The result is a highly durable material named after the Aztec *copalli*, meaning 'resin.' Copal is easily mistaken for amber but is softer and, when heated, burns with a smoky flame (Rice 1980). A drop of a suitable non-polar solvent (e.g., acetone) on copal causes it to become sticky, whereas on true amber there is no reaction. It can take upwards of three to four million years for copal to acquire the properties of amber (Poinar 1992).

Large amounts of fossiliferous material from Colombia are readily available on the market as either semi-fossilized copal or fossilized amber, most of it from the Departamentos de Bolívar, Antioquia, Santander, Boyacá, and Tolima (Poinar 1996). Studies of the nuclear magnetic resonance (NMR) spectra of samples from the Departamento de Santander map almost perfectly to those of modern *H. coubaril*, indicating that they are geologically immature and should be classified as copal (Lambert et al. 1995). In addition, copal from Colombia has always contained recent, extant species of insects (DuBois and LaPolla 1999; Rice 1980).

In the late 1990s a polished piece of Colombian copal, 68.9 mm in length with a diameter of 20.6 mm and weighing 16.3 g, was purchased by Michael Oschin of Temecula, California, from a private collector in Florida (Fig. 1). The copal is from the Departamento de Santander, where most of it comes from near the towns of Bucaramanga, Vélez, and Girón (Poinar 1992, 1996). The piece is unusual for its anole lizard inclusion. The anole is approximately 31 mm in snout–vent length and consists primarily of skin fragments from the left side of the head, the left forelimb, the right forefoot, and the lower two thirds of the body; the latter is represented by a shell of skin and includes approximately the first third of the tail. Skeletal elements include the left maxilla, portions of the left forelimb and right forefoot, the pelvis, parts of the hindlimbs, and a number of tail vertebrae.

In a letter appraising the copal, dated November 16, 1999, James C. Wyatt of Garland, Texas, mentions site visits to the "Amazon Jungle, Santandre [sic] Province, Colombia" by "geologist Allen Gratham of Ardmore, Oklahoma." According to Wyatt, Gratham dated the piece from the Miocene series (23.8–5.2 mya) based on stratigraphy. Wyatt also mentions an unnamed "recent researcher, a geophysical chemist," who estimated the age of the copal at "less than two million years." After Wyatt assigned it a commercial retail value of US $25,000, Oschin donated the copal to the Natural

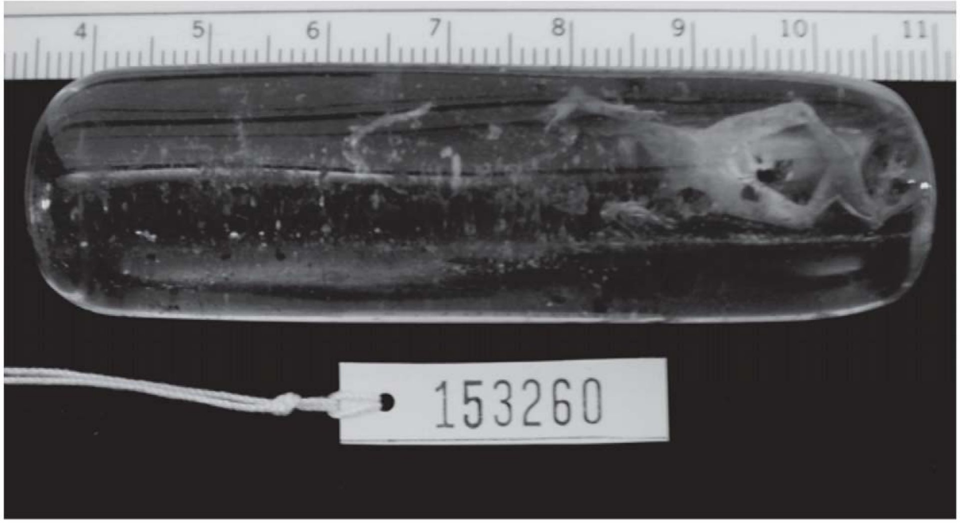

FIG. 1. Copal from Departamento de Santander, Colombia, with anole lizard inclusion (ventral view). Scale bar is in millimeters.

History Museum of Los Angeles County (LACM 153260), where it was included in an exhibit on organisms preserved in amber.

Five resin-preserved anoles have previously been documented (Böehme 1986; de Queiroz et al. 1998; Lazell 1965; Polcyn et al. 2002; Rieppel 1980), although others are known to exist. All five specimens are preserved in amber from the Dominican Republic, two of which were described as new species: *Anolis electrum* Lazell 1965, and *A. dominicanus* Rieppel 1980. The present study is unique in that it examines the first known resin-preserved anole from South America.

Materials and Methods.—The anole inclusion was X-rayed in the Ichthyology Section of the Natural History Museum of Los Angeles County with Faxitron Model 43855C, set at 2.5 mA and 30 kV. Exposure settings were at 60, 120, 180, and 240 sec. The radiograph images were then scanned and enhanced with the Microsoft computer program PhotoDraw. In the Museum's Section of Mineralogy, a 1.0 mm section was sliced from one end of the copal with a Buehler Isomet Precision Saw and sent to Beta Analytic Inc. in Miami, Florida, for radiometric analysis. The rest of the copal was transferred to the Section of Ichthyology for digital photomicrography. Using a Polaroid DMC 1 digital camera in tandem with a dissecting microscope, photographs were taken at 120× magnification of the left loreal region of the head, and at 250× magnification of the left forelimb, left forefoot, and base of the tail. The photographs were later enhanced using PhotoDraw and the following details noted: condition of scales on the anterior portion of the forelimb; condition of middorsal scales at the base of the tail; number of loreal rows under the second canthal; proximity of subocular scale rows relative to supralabials; number of supralabials to below center of eye; and number of subdigital lamellae under fourth toe of left forefoot.

Results.—The X-rays revealed the presence of transverse processes on the autotomic caudal vertebrae (Fig. 2), identifying the specimen as a β-anole (Etheridge 1959). These anoles have been found to be the most derived among the polychrotids (Poe 2004).

The following diagnosis was made from the digital micrographs: scales on anterior portion of forelimb unicarinate (Fig. 3A); middorsal scales at base of tail keeled and slightly enlarged (Fig. 3B); six loreal rows under second canthal, suboculars separated from supralabials by one row of scales, and eight supralabials to below center of eye (Fig. 3C); and 16 subdigital lamellae under fourth toe of left forefoot (Fig. 3D).

The results of the radiocarbon dating were reported in pMC (percent modern carbon) units rather than years BP (before present). With a measured radiocarbon age of 115.4 ± 0.4 pMC, the sample had more ^{14}C in it than the modern reference standard. This excess is attributed to thermonuclear bomb testing during the 1950s (D. Hood, in litt.).

Discussion.—The copal was still respiring carbon post-1950s, implying that the specimen was alive within the last 50 yrs. Of the three possible species of β-anoles currently known from the Departamento de Santander—*A. auratus*, *A. sulcifrons*, and *A. tropidogaster* (Ayala 1986), *A. auratus* was eliminated because of its large, keeled ventrals. *Anolis sulcifrons* was also ruled out because of its smooth supradigital scales (Myers 1971). After comparison with preserved specimens from Colombia, the copal anole agrees most closely with *A. tropidogaster*.

The results of this study emphasize the need for qualified scientists in preventing the misinterpretation of copal specimens. In

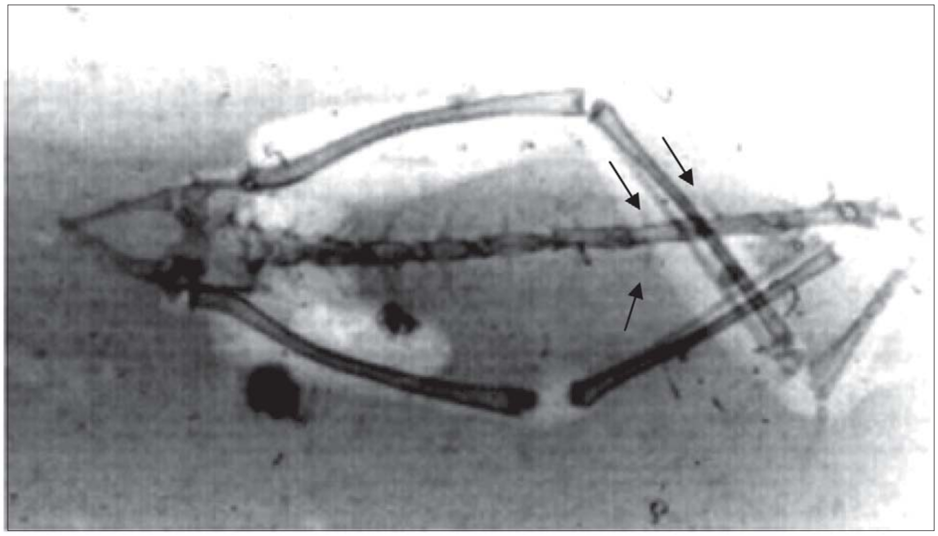

FIG. 2. X-ray radiograph of specimen, showing pelvic region with elements of the hindlimbs and tail. Arrows indicate the presence of transverse processes on the autotomic caudal vertebrae.

this instance, commercial fossil collectors and dealers were initially responsible for the authentication of the copal. The appraisal letter alone contained a number of egregious mistakes. To begin with, the Departamento (not Provincia) de Santander lies within the Valle del Magdalena and is entirely isolated from the Amazonian region by the Cordillera Oriental de Colombia. Second, the name of the geologist from Ardmore, Oklahoma, is Allen Graffham (not Gratham), of Geological Enterprises, Inc. (DuBois and LaPolla 1999). Finally, determining the age of copal based solely on stratigraphy can be highly misleading, as copal is easily re-deposited by water (it floats) or during landslides (DuBois and LaPolla 1999).

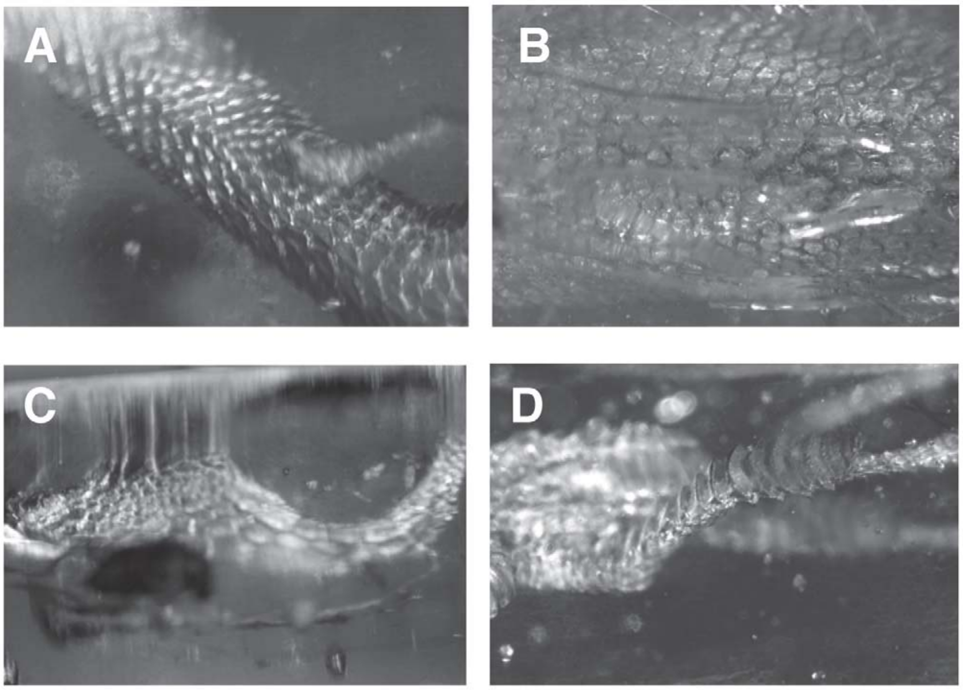

FIG. 3. (A) Scales on left forelimb (250× magnification); (B) dorsal scales at base of tail (250×); (C) scales of loreal region (120×); (D) subdigital lamellae under fourth toe of left forefoot (250×).

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APPENDIX 1

Specimens Examined

Anolis auratus.—COLOMBIA: Dept. Antioquia: Santa Fe de Antioquia: LACM 131456–59. Dept. Cesar: 15 km S Bosconia, Finca el Diamante: LACM 114534. Dept. Córdoba: 15 km S Lorica (El Campano) on Río Sinú: LACM 131460–64. Dept. La Guajira: Colombia Nuevo, 28 km E Palomino: LACM 131465–66; 2 km E Río Palomino, near mouth: LACM 114533. Dept. Magdalena: Parque Nacional Tayrona, western end: LACM 114535–36. Dept. Sucre: 4 km E Tolú, Hacienda la Estanzuela: LACM 114537–38. Dept. Vichada: Tuparro: LACM 131467–70.

Anolis tropidogaster.—COLOMBIA: Dept. Cesar: 15 km S Bosconia, Finca el Diamante: LACM 114542. Dept. Chocó: W bank Río Atrato, below Bellavista: LACM 51543–44. Dept. Córdoba: Río Esmeralda, approx. 25 km from mouth: LACM 114539, 114546–47; Río Esmeralda, 4 km above mouth: LACM 114541; upper Río Napipí, 45 min by canoe (going upstream) below mouth of Río Merendo (tributary of Napipí): LACM 42170; Río Sinú, 2 km below jct with Río Esmeralda: LACM 114540. Dept. Magdalena: Río Magdalena: LACM 131477–80. Dept. Sucre: 4 km E Tolú, Hacienda la Estanzuela: LACM 114532. Dept. Tolima: Mariquita, forest next to town: LACM 42220.

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Genetic Verification of Possible Gigantism in a Southern Toad, *Bufo terrestris*

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Ectothermic vertebrates are well known for indeterminate growth, a process by which animals continue to grow throughout life, although the rate of growth slows with age. Maximum size is a morphological characteristic of amphibians and reptiles that is useful in species identification (Conant and Collins 1998), but because of indeterminate growth, older, larger individuals are occasionally found, necessitating periodic revisions of the size information available for species. Examples of true gigantism (abnormally large size) have not been reported in amphibians, probably because it is difficult to know whether an exceptionally large-sized individual represents the far end of the normal size distribution of a species or whether some other phenomenon is operating such as acromegaly, a genetic anomaly that influences the overproduction of growth hormones (Ferone et al. 2004).

The maximum reported size of *Bufo terrestris* is 113 mm SVL (Conant and Collins 1998). On 18 December 2003, Brenda Boland found a large toad (Fig. 1) in her yard near the town of Wacissa, Jefferson Co., Florida (30°21'31"N, 83°59'14"W). The female toad (sex later determined by dissection) measured 150 mm SVL and weighed 193.6 g. This specimen is 33% longer than the previous maximum SVL reported for *B. terrestris* and about 1335% larger by weight than the average Southern Toad (14.5 g) determined by weighing a sample of 10 live adults (8 males, 2 females) from a site (30°21'08"N, 84°18'30"W) 33 km to the west in adjacent Leon County, Florida. The normally pronounced knobs and high cranial crests, diagnostic for *B. terrestris*, were present but extremely exaggerated in this individual; dark, dorsal spots contained one to three warts, themselves larger than normal (Fig. 1). Although the external morphology of the giant toad was consistent with that of *B. terrestris*, we wanted to verify this with genetic data. Therefore, we compared its mtDNA with samples of known *B. terrestris* and previously published sequences of *B. americanus*, *B. fowleri*, and *B. terrestris* by Masta et al. (2002).

FIG. 1. Giant *Bufo terrestris* female with normal-sized adult female on her back.

Toes were preserved in 95% ethanol from 5 *Bufo terrestris* collected on 4 March 2002 in Leon County, Florida just south of Tallahassee (30°21'08"N, 84°18'30"W). One toe from the large toad was collected on 5 June 2004. All samples were stored in 95% ethanol until DNA was extracted. DNA was extracted from each individual using a Qiagen® DNEasy Tissue Kit. For each individual, DNA was PCR amplified for a mitochondrial genome region that began at the 3' end of 16S gene and spanned tRNA$^{Leu(UUR)}$, ND1 gene, tRNA^{Ile}, tRNA^{Gln}, tRNA^{Met}, and to the 5' end of ND2 gene using primers Bw16S-L and BwND2-H developed by Masta et al. (2002). This region was chosen because primers had been developed and because sequence data were available on GenBank for *B. americanus*, *B. fowleri*, and *B. terrestris*.

PCR products were prepared for sequencing using a Qiagen® QIAquick PCR Purification Kit to remove carried over primers, dNTPs, buffers, enzymes, and non-target DNA. Purified products were then used in sequencing reactions. Sequencing reactions for each primer and individual were performed using ABI Prism® BigDye Terminator Cycle Sequencing Ready Reaction Kit (Applied Biosystems). These products were ethanol precipitated, dried, and resuspended in Template Suppression Reagent (Applied Biosystems) in preparation for loading into an automated DNA sequencer. Nucleotide sequence data were then collected using an ABI Prism® 310 Genetic Analyzer and DNA Sequencing Analysis Software™ Version 3.4.5 (Applied Biosystems). Sequences were aligned and edited using Sequencher™ version 4.1.4 (Gene Codes Corporation).

Two individuals each of the three morphologically similar toad species were haphazardly chosen from Table 1 of Masta et al. (2002) with the following GenBank accession numbers: *B. americanus* (AF462491; AF462500), *B. fowleri* (AF462507; AF462522), and *B. terrestris* (AF462529; AF462530).

A total of 1062 bases were sequenced and aligned for 5 *B.*

terrestris and the large toad. Of these, 757 overlapped with sequences from the *Bufo* study of Masta et al. (2002). The sequence data for the 5 *B. terrestris* and gigantic toad had identical nucleotides at all 1062 positions. Based on the alignment of the four toads in this study and six GenBank sequences, six species-specific positions occurred within the 757-base segment of overlap. All identified the four toads in this study as *B. terrestris* (i.e., the nucleotide at each of the six positions were the same as the two *B. terrestris* from GenBank and differed from *B. americanus* and *B. fowleri* from GenBank.

Because this toad is so much larger than one would expect from a normal distribution of *Bufo terrestris* SVLs, we believe it is not simply the largest toad of its kind but represents a case of abnormal growth. Several causes are possible. Interspecific hybridization is unlikely because only *B. quercicus*, a tiny species, is sympatric with *B. terrestris* in the area where our giant toad was found. If our giant toad's father (mtDNA tells us the mother was a *B. terrestris*) was an escaped or naturalized alien species such as *B. marinus*, we should have seen some morphological expression of his genes, but in all external characteristics, the giant toad has only *B. terrestris* morphology. Moreover, the large natural size difference between a female *B. terrestris* and a male *B. marinus* would seem to preclude amplexus in this pair.

Acromegaly results from excessive growth hormone in adults and usually results in an overgrowth of bone and connective tissue that produces coarse facial features, hands, and feet (Van Der Lely et al. 2005). We have found no published studies of acromegaly in cold-blooded vertebrates, so we do not know how acromegaly presents in amphibians except to say that our giant toad does not have any grossly coarse features of the head, hands, and feet. We cannot rule out another possible cause, genome multiplication, because we didn't assay nuclear DNA. The simplest and most likely cause, in our opinion, is gigantism, the result of excessive growth hormone secretion that begins in juvenile humans and other animals (Tortora and Derricksen 2005).

Environmental pollutants such as fertilizers, herbicides, and pesticides have all been shown to influence amphibian growth and development (Boone and Bridges 2003; Halliday 2000; Relyea 2005). We cannot say whether the size of our giant toad is the result of the effects of one or more of these chemical agents, but body deformities, inhibition of larval growth, and survival of populations and species of amphibians are of increasing concerns to herpetologists (Lannoo 2005; Semlitsch 2003).

Abnormal size due to genome multiplication remains to be tested in our giant toad. We have been unable to locate any literature on gigantism or acromegaly in amphibians, so it is important that this example may be the first of its kind to be reported.

We were unsuccessful in getting the toad to breed. She was found dead in her cage on 02 February 2005, preserved in 95% ethanol, and was deposited in the Florida Museum of Natural History (UF 144211) and is available for further study.

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TECHNIQUES

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A Simplified and Inexpensive Method for Extraction and Quantification of Tetrodotoxin from Tissue Samples

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Tetrodotoxin (TTX) is a potent neurotoxin that blocks sodium channels, preventing the propagation of action potentials, causing paralysis and eventually death (Miyazawa and Noguchi 2001). It is perhaps most well known from pufferfish (e.g., Brillantes et al. 2003; Lin et al. 1998), but it is also known to occur in the tissues of newts and other amphibians (reviewed in Daly 2004). Among amphibians, the antipredator defensive role of TTX in the rough-skinned newt (*Taricha granulosa*) has been the subject of extensive study (e.g., Brodie et al. 2002; Hanifin et al. 2003; Hanifin et al. 1999; Lehman et al. 2004). Further, TTX was recently found to be retained in the liver of *Thamnophis sirtalis*, which is a natural predator of T. *granulosa* (Williams et al. 2004). The ecology and function of TTX in other amphibian, and potentially reptilian, species is not well known. Further study of *T. granulosa* and other species with TTX would be enhanced with easier extraction and quantification of TTX, particularly if the method is easily implemented. Here I describe a new technique (tissue sonication) for TTX extraction from tissue samples and the use of a quick and efficient indirect competitive-inhibition enzyme immunoassay (CIEIA) to quantify TTX.

TTX extraction protocols have previously used manual grinding of tissue samples in extraction buffer. This extraction method is labor-intensive and slow, not desirable traits for processing a large number of samples. Further, previous methods of identifying and quantifying TTX include gas chromatography-mass spectrometry and high performance liquid chromatography (HPLC; Noguchi and Mahmud 2001). These techniques require highly specialized equipment and training, and can be both expensive and time-consuming. The improvements I report here should make TTX quantification easier and more accessible to researchers with access to standard molecular biology equipment.

TTX Extraction

Some types of tissues are difficult to manually grind, leading to a physically demanding and time consuming extraction process. Manual grinding also requires a relatively large volume of extraction buffer to accommodate the tissue and pestle in the grinding vessel. By employing a tissue sonifier, the time, physical demand and expense associated with extracting TTX can be reduced. To prepare samples for sonication, a small amount of tissue (e.g., a single egg or a skin sample) is placed in a 2 ml microcentrifuge tube with a screw cap. 400 µL of extraction buffer (0.1 M acetic acid) is added to the microcentrifuge tube. In the case of larger amounts of tissue, more extraction buffer (e.g., 800 µL) may be necessary. Each sample is then sonicated for 15–20 seconds, or until the tissue is completely homogenized, using a sonifier (Branson Sonifier 450) fitted with a microtip probe at a power setting of 3 (medium-low). Care must be taken to not touch the probe to the side of the microcentrifuge tube, as this can melt the plastic. To prevent cross-contamination of samples, the sonicator probe should be cleaned with ethanol and water, and then manually wiped, after each sample is sonicated. Based on working with *T. granulosa* skin samples, 16 samples can be sonicated in less than 10 min; manually grinding the same number of samples may take upwards of 2 h. Following sonication, the homogenized samples are heated for 5 min in a boiling water bath or in a 100°C dry heat block, and then cooled to room temperature. The homogenate is then centrifuged at 13000 rpm for 20 min. After centrifugation, the supernatant is removed in 400 µL aliquots and transferred to Millipore centrifugal filter devices (Ultrafree®-MC, 10000 NMWL filter units). The final step in the extraction process is centrifugation at 13000 rpm for 20 min in the filter units. The extract can then be stored at -80°C until needed.

This protocol differs from previously used protocols primarily in the use of a sonifier to extract TTX from tissue instead of manual grinding, saving a large amount of time. Additionally, tissue sonication lowers expenses by reducing the volume of extraction buffer used, which subsequently lowers the number of costly Millipore centrifugal filter devices. Samples extracted using this protocol can be assayed both by indirect CIEIA (below) and HPLC. I have successfully used this method to extract TTX from *T. granulosa* eggs, and skin samples taken from both *T. granulosa* (5 mm diameter piece of skin) and *Notophthalmus viridescens* (3 mm diameter) using a skin punches (Hanifin et al. 2002).

Indirect CIEIA

Direct and indirect CIEIA methodologies have been developed for quantifying TTX (Kawatsu et al. 1997; Raybould et al. 1992). These methodologies differ in their use of a labeled (direct) or unlabeled (indirect) anti-TTX antibody. A labeled antibody is bound to a chromagenic enzyme (e.g., alkaline phosphatase), and the addition of a particular substrate (e.g., p-nitrophenyl phosphate (pNPP)) results in a color change indicating the amount of antibody present. However, only an unlabeled anti-TTX antibody is available commercially (Hawaii Biotech, Inc.), making the indirect (rather than direct) CIEIA is necessary. The method described here (indirect CIEIA) uses an unlabeled anti-TTX antibody and a secondary antibody that is bound to alkaline phosphatase to elicit a color change.

The TTX assay procedure begins by attaching TTX to the wells of a 96-well immunoassay plate. However, TTX does not bind to the surface of a plate because it is such a small molecule; therefore it must first be chemically conjugated to bovine serum albumin (BSA, Sigma, Inc.) with the aid of formaldehyde (F), forming the BSA-TTXF complex. To create the BSA-TTXF, the following ingredients are mixed in an amber glass vial: 700 µL of 1 mg/mL TTX in 1% (v/v) acetic acid, 300 µL 1M sodium acetate buffer (pH 7.4), 179 µL of 33.6 mg/mL bovine serum albumin (BSA) in 1M sodium acetate buffer, and 41 µL 37% formaldehyde. The vial is then sealed and incubated on a shaker at 37°C for 3 days. The solution is then dialyzed against four 1 L changes of phosphate buffered saline (PBS) spaced approximately evenly over 3 days at 4°C. The concentration of BSA in the solution is then determined spectrophotometrically using an extinction coefficient of 0.667 mg·cm/mL at 280 nm, with the spectrophotometer blanked with PBS. The solution can then be stored at 4°C and diluted to 10 µg/mL in PBS as needed for the assay.

The TTX assay procedure is outlined in Table 1. On each plate, a positive and a negative control are run, in addition to TTX stan-

Table 1. Instructions for the indirect CIEIA to measure TTX concentration.

1. Add 100 µL of 10 µg/mL BSA-TTXF, diluted in PBS, to each well of a 96-well microtiter plate (Nunc MaxiSorp).
2. Coat wells by incubating overnight at 4°C or at room temperature for 1 hour.
3. Wash all wells 3 times with 300 µL per well of PBS-T (PBS with 0.5 mL/L Tween-20®).
4. Block each well with 200 µL of 1% BSA in PBS (PBS+BSA) for one hour at room temperature.
5. Wash all wells 3 times with 300 µL per well of PBS-T.
6. Add 50 µL of sample or standard, diluted in PBS+BSA, to their assigned wells.
7. Add 50 µL of anti-TTX antibody, diluted to 2 µg/ml in PBS+BSA, to all wells except positive and negative controls.
8. Incubate plate for 1 hour at room temperature.
9. Wash all wells 3 times with 300 µL per well of PBS-T.
10. Add 100 µL per well of alkaline phosphatase-labeled goat anti-mouse IgG + IgM (H+L) conjugate, diluted in PBS+BSA, to all wells except the positive and negative controls.
11. Incubate for 1 hour at room temperature.
12. Wash all wells 3 times with 300 µL per well of PBS-T.
13. Add 200 µl per well of 1mg/ml pNPP solution.
14. Add 50 µl of goat anti-mouse IgG+IgM to the positive control wells.
15. Incubate at room temperature, protected from light, for 20 min.
16. Determine absorbance of each well at 405 nm.

dards and the samples of unknown TTX concentration. The positive control verifies that the chromagen pNPP (Sigma, Inc.) and secondary antibodies are functional. The negative control verifies that no color change occurs when no secondary antibodies are present. The protocol outlined in Raybould et al. (1992) was followed with the following exceptions: plates were coated with BSA-TTXF overnight at 4°C; plates were blocked with 1% BSA in PBS for 1 hr at room temperature; plates were washed 3 times with PBS-T (PBS with 0.5 mL/L Tween-20®) prior to application of pNPP. The following concentrations or dilutions were used: 10 μg/mL BSA-TTXF diluted in PBS; 2 μg/mL anti-TTX murine monocolonal antibody (Hawaii BioTech, Inc.) diluted in PBS+BSA; 1:4000 dilution of alkaline phosphatase-labeled goat antimouse IgG + IgM (H+L) (Jackson ImmunoResearch, Inc) diluted in PBS+BSA. TTX standards, diluted in 1% BSA in PBS, are used at the following concentrations (ng/mL): 100, 75, 50, 25, 10. After addition of pNPP to the wells, the plate is incubated at room temperature, away from light, for 20 min. The absorbance at 405 nm of each well is then read on a microplate reader. A strong linear relationship between absorbance and the log of the concentration for each standard is found between 10 and 100 ng/mL (Fig. 1). The linear equation from this standard curve is used to calculate the concentration of TTX in all the samples from the absorbance values of the corresponding wells. For accurate results, samples must be diluted into this linear range. The dilution factor used must then be accounted for when calculating the unknown concentrations. There is a negative relationship between absorbance and TTX concentration because this is a competitive inhibition assay—the strongest color change is seen in those wells that contained samples without TTX.

Following the protocol of Raybould et al. (1992) for preparation of a BSA-TTXF conjugate and the indirect CIEIA as described here, one is able to assay 40 samples (in duplicate) per microtiter plate. All samples, standards and controls are run in duplicate (or triplicate, etc.) to allow determination of variation in the readings.

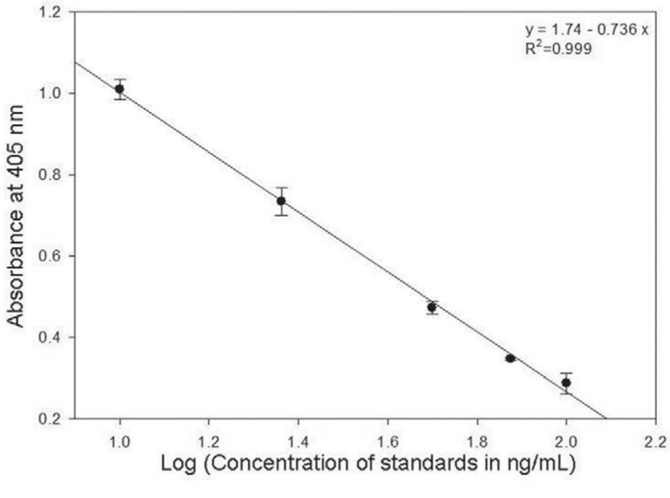

FIG. 1. An example standard curve for the linear portion of the curve (10 to 100 ng/mL). The mean absorbance values (± 2 S.E.) of two wells per concentration are shown. The equation shown in the upper right hand corner is used to calculate the log TTX concentration (x) of samples based on the absorbance value (y) for each well. The log concentration is then converted back into regular units (ng/mL).

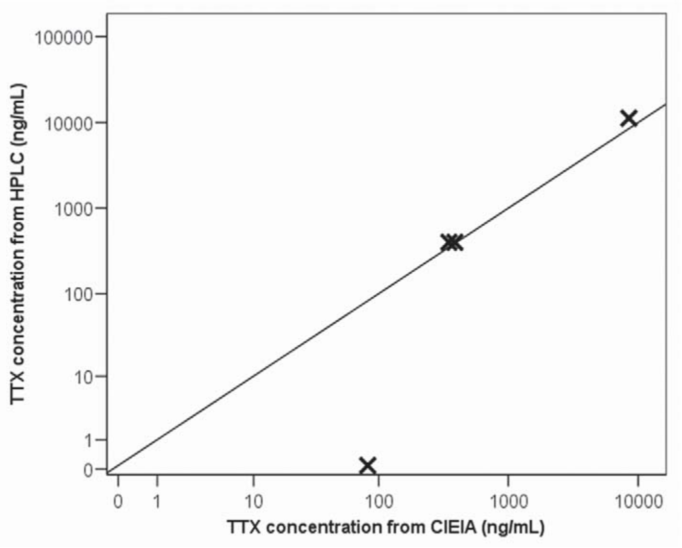

FIG. 2. Concentrations of TTX (ng/mL) in samples assayed by both CIEIA (x-axis) and HPLC (y-axis). These samples (provided by C. T. Hanifin) were from *T. granulosa* skin, extracted using manual tissue grinding and assayed by conventional HPLC techniques (Hanifin et al. 1999). The line is a 1-to-1 line illustrating identical results from CIEIA and HPLC; points fall along the line if both assay methods yield the same concentration.

One plate takes approximately 22 h to complete as described, but this could be reduced to approximately 6 h if the plate is coated with BSA-TTXF for 1 h at room temperature; careful record-keeping allows multiple plates to be run at the same time. Further, plates can be coated with BSA-TTXF and blocked with 1% BSA in PBS in advance, and stored at 4°C for a few days.

Results from this indirect CIEIA method are remarkably similar to those obtained using HPLC (Fig. 2). Samples tested were provided by C. T. Hanifin, from *T. granulosa* skin samples that were manually ground for TTX extraction and assayed using conventional HPLC methods (Hanifin et al. 1999). The primary discrepancy between the two methods is found at a low concentration of TTX, where the indirect CIEIA is more sensitive than HPLC. Samples with high TTX concentrations can be carefully diluted into the appropriate concentration range.

One potential limitation of CIEIA is that it does not allow identification of TTX analogs or structurally similar compounds that can be identified by HPLC (e.g., Yotsu-Yamashita and Mebs 2001). The quantification of TTX by CIEIA should not be affected by TTX analogs because the anti-TTX antibody does not bind to TTX analogs (Raybould et al. 1992), so there is no risk of false positives. Even when TTX analogs are identified by HPLC they are not quantified because the necessary standards are unavailable (C. T. Hanifin, pers. comm.), making this a limitation common to both TTX quantification methods. Thus, CIEIA is appropriate for TTX quantification but inappropriate for identification of TTX analogs that may be present.

Indirect CIEIA, as described here, provides a quantification method for TTX that is not only efficient but also easily employed by any researcher in a university or laboratory setting. No special equipment is needed other than a plate reader capable of reading at 405 nm, and plate washer for more efficient washing between steps. The collective cost of this equipment is well below the cost of that needed to quantify TTX via HPLC. Further, individuals do not need much training to perform the indirect CIEIA because only general laboratory protocols (e.g., use of a pipette) and common reagents are used. It should be noted that particular care must be taken in the handling of samples and disposal of TTX waste, as is required for any TTX use. Implementation of the TTX extraction and assay procedures may require institutional approval.

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A Technique to Collect and Assay Adhesive-free Skin Secretions from Ambystomatid Salamanders

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Salamander skin secretions are effective defenses against both vertebrate and invertebrate predators (Arnold 1982; Barach 1951; Brodie 1983; Brodie et al. 1979; Digiovanni and Brodie 1981; Ducey and Brodie 1983; Pough 1971; Rand 1954). These secretions arise from granular glands located on the skin's surface (Brodie and Gibson 1969) and are generally a combination of adhesive compounds and noxious chemicals that act in a synergistic manner with stereotypical behaviors to effectively protect the salamander from predation (Brodie 1977). This combination of adhesiveness and noxiousness is often seen in the ambystomatid salamanders, which are known for their distinctive antipredator postures (Brodie 1977, 1983). Although the granular gland secretions of ambystomatids are distasteful to humans (Brodie 1983), shrews (Brodie et al.,1979), moles (Anderson 1963), and Sprague-Dawley rats (Mason et al. 1982), we know little about the chemical composition of their defensive secretions (Williams and Anthony 1994).

Research on the nature of granular gland chemistry has been extensively investigated in anurans (Clarke 1997; Daly 1998; Daly et al. 1987), but is notably sparse among urodeles (Brodie 1983; Williams and Anthony 1994) with a few exceptions (Brandon and Huheey 1981; Buchwald et al. 1964; Habermehl 1971). The adhesive nature of ambystomatid secretions often thwarts chemical investigations of granular gland secretions, and this has stymied secretion chemistry from progressing beyond the identification of proteinaceous material (Brodie and Gibson 1969; Hamning et al. 2000; Williams and Anthony 1994). Flocculence from adhesive components presents a challenge to further isolation of active compounds, and has hampered the testing of solutions at known concentrations (Hamning et al. 2000; Williams and Anthony 1994). Characterization and identification of the chemicals in granular gland secretions of salamanders may enable a deeper understanding of their evolutionary relationships as well as the evolution of salamander antipredator mechanisms. Therefore, we developed methods to (i) isolate adhesive-free secretion from ambystomatid salamanders, and (ii) assay distastefulness of known concentrations of this secretion. This technique allows us to differentiate between the adhesive and noxious effects of salamander skin secretions against a reliable and consistent control.

We used three adult Jefferson's Salamanders (*Ambystoma jeffersonianum*), collected in Tompkins County, New York in 2000, five Spotted Salamanders (*A. maculatum*), collected in Tompkins County, New York and four near St. Louis, Missouri in 2000, and three Tiger Salamanders (*A. tigrinum*) collected near Portal, Arizona in 2000.

Salamanders were housed in clear plastic boxes (10 cm tall × 40 cm long × 20 cm wide) and provided with inverted black plastic food trays for shelter, and a substrate of moist paper towels. *A. tigrinum* specimens were part of a captive population that was fed crickets *ad libitum* once every two weeks during the duration of their captivity. Their secretions were collected at approximately six months into captivity. Although other amphibians obtain their defensive compounds from the diet (Daly et al. 1997a; Daly et al. 1997b), we did not expect this to have a significant effect on ambystomatid secretion composition because their secretions are proteinaceous (Williams and Anthony 1994). Peptides and proteins are generally produced endogenously and not derived from the diet (Apponyi et al. 2004). *A. jeffersonianum* and *A. maculatum* were locally collected during the breeding season, held overnight, sampled the next morning, and released within 24 h. Mean weight (± standard deviation) of salamanders was 6.3 ± 4.3 g (SVL: 5.5 ± 1.1 cm) for the *A. jeffersonianum*, 13.0 ± 4.3 g (SVL: 7.8 ± 1.3 cm) for the *A. maculatum*, and 49.0 ± 1.0 g (SVL: 12.5 ± 0.5 cm) for the *A. tigrinum*. All animals maintained or gained weight during captivity; no unhealthy salamanders were used in the study. Salamanders were not sexed because sexual dimorphism has yet to be described in the defensive chemistry of any amphibian.

As our predator we used Red Swamp Crayfish (*Procambarus clarkia*) obtained from Carolina Biological Supply Company (Burlington, North Carolina) and kept in plastic ice-chests. They were fed carrots and dry dog or cat food pellets *ad libitum* approximately twice per week. Mean weight (± standard deviation) of the twenty crayfish was 28.5 ± 6.3 g. Although they do not likely prey upon adult ambystomatids, crayfish are predators of many larval amphibians (Axelsson et al. 1997; Formanowicz and Brodie 1982; Gamradt and Kats 1996; Gamradt et al. 1997; Holomuzki 1989) and potentially might attack recent metamorphs that possess defensive glands. Furthermore, crayfish possess traits that make them good generalized predators for laboratory studies: they are omnivorous and use chemical cues to locate food (Dunham et al. 1997).

We collected crude secretions from individual salamanders by applying a benign electrical stimulus to the skin (Grant and Land 2002; Hamning et al. 2000; Tyler et al. 1992; Williams and Anthony 1994). We used a Transcutaneous Amphibian Stimulator (TAS) developed by Grant and Land (2002) to deliver the electrical stimulus, which ranged from 10 to 15 V pulsed for 2 msec at a frequency of approximately 50 Hz. We focused our collection efforts on the tail ridge of all species (Fig. 1) because it and the parotoid glands on the head contain the richest secretions (Williams and Larsen 1986). Before stimulation each salamander was lightly moistened with distilled water to facilitate transmission of the stimulus. Secretions were washed off the skin with approximately 50 ml distilled water and funneled into a flask.

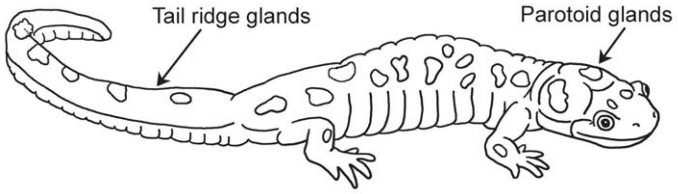

FIG. 1. Granular gland rich areas of a typical ambystomatid salamander (parotoid glands on head and areas of the tail ridge) are indicated with arrows. Illustrated by JBG.

Amphibian skin secretions consist of four major groups: biogenic amines, bufogenines and bufotoxins, alkaloids, and peptides and proteins (reviewed in Barthalmus 1994; Clarke 1997; Daly and Witkop 1971; Erspamer 1984, 1994). Preliminary high performance liquid chromatography (HPLC) data suggested that peptides and a *N,N*-dimethyl homolog of serotonin, bufotenine, were the major compounds in the secretion (Grant, unpubl. data). Because bufotenine and many amphibian skin secretion peptides are soluble in both water and methanol (Brodie and Gibson 1969; Daly et al. 1987; Erspamer 1984, 1994; Hamning et al. 2000; Mason et al. 1982; Williams and Anthony 1994), these were chosen as extraction solvents.

Crude aqueous extracts were filtered through glass wool to remove adhesive components of the secretion because they prevent proper measurement of the concentration of active components (Brodie and Gibson 1969). This aqueous solution was lyophilized (freeze-dried) to remove water and any remaining traces of adhesive compounds. The dried residue was washed twice with methanol then filtered through glass wool to remove suspended particulates, which were assumed to primarily consist of inactive adhesive flocculent. The methanolic extract was dried under nitrogen to obtain the residual weight of adhesive-free secretion obtained from each salamander. All solvent-free samples were stored in Teflon-lined vials at 0°C until use, at which time adhesive-free secretion from all fourteen salamanders was pooled to provide an adequate amount of material for testing during these pilot studies. The combination of secretion at this stage did not effect the extraction methods because we performed it post-extraction.

We used a modified method of Lindquist (1992) to make agar pellets suitable for testing feeding responses of the crayfish. Pellets consisted of water, agar, a crayfish feeding stimulant (0.25 g Fancy Feast™ salmon cat food mixed with 5 mL water then filtered through cheesecloth), and food coloring (green or blue). Control pellets were made by boiling 5 mL of water with 0.10 g of agar until the agar dissolved completely. Five ml of feeding stimulant solution plus one drop of blue food coloring were added to the hot agar solution to make a total of 10 ml. This solution was cooled to between 40°C and 45°C and immediately pipetted into prepared PVC molds (described below). The solution was cooled prior to pipetting into PVC molds to prevent leakage from under the PVC mold. Treated pellets were made by boiling 5 mL of water with 0.10 g of agar until the agar dissolved completely. Five ml of 9.6 mg/ml aqueous adhesive-free extract (AFS) were mixed with 0.25 g feeding stimulant then added to 5 mL of 45°C agar solution and one drop of green food coloring to make a total of 10 ml. This solution was mixed well and pipetted into prepared PVC molds where it solidified (described below). This preparation resulted in 10 ml of agar solution at a concentration of 4.8 mg/ml adhesive-free extract. Crayfish are essentially green blind (Crandall and Cronin 1997; Wald 1968) and did not demonstrate a color preference for either blue or green dyed pellets in our preliminary trials (unpubl. data, 1 h trials, blue pellet remaining wt. = 0.12 g ± 0.02 g; green pellet remaining wt. = 0.11 g ± 0.02 g; Wilcoxon rank sum test: N = 12, *Z* = -0.5449, P = 0.59). Therefore, we dyed all control pellets blue, and all treated pellets green in the secretion assays.

Pellet molds were made by cutting polyvinyl chloride (PVC) pipe (6.35 mm inner diameter) into 8-mm long sections with a band saw. The ends of the sections were filed to clean, flat edges. Dark gray, 7.62 cm × 7.62 cm PVC squares were used to anchor two circles (6.35 mm diameter) of adhesive backed, hook end Velcro® 7.5 cm apart along the diagonal of the square (Fig. 2). These Velcro® circles fit snugly into the piece of PVC molding and prevented semi-cooled agar solution from leaking out during the solidification process.

Pellet molds were filled with either treated (green) or untreated (blue) agar solution until a dome formed on top of the mold. Pellets were cooled for 20 minutes at room temperature until the agar solution solidified. Excess agar was cut off with a razor blade flush against the PVC mold surface. The PVC molds were carefully lifted off the agar pellets, which were retained in place by the Velcro® circles. Each 8 mm high agar pellet had an approximate volume of 0.25 mL and treated pellets contained 1.2 mg of adhesive-free extract.

Because pellets were molded onto Velcro®, we could not obtain their weight prior to a trial. Therefore, we made 40 untreated pellets (20 green, 20 blue), and sliced them off their Velcro® bases to determine the approximate weight of an intact, uneaten pellet. There was no bias in pellet weight between pellets dyed blue (0.21 g ± 0.003 g, N = 20) and those dyed green (0.21 g ± 0.003 g, N = 20; Wilcoxon rank sum test: N = 20, *Z* = -0.5873, P = 0.56). Therefore, these two dyes were used in all further assays and pellets that weighed less than 0.20 g after crayfish trials were considered to have been sampled by crayfish.

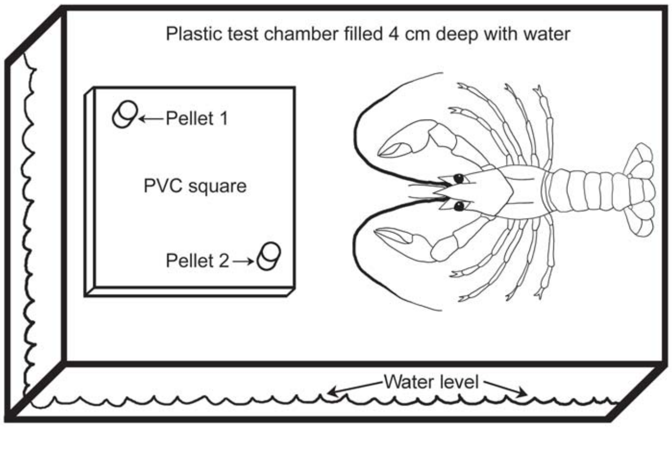

FIG. 2. Schematic representation of the experimental setup. (A) Pellet delivery system consisting of a PVC square with two Velcro® circles. (B) Bioassay chamber used to test crayfish response to treated and untreated pellets. Illustrated by JAE.

We developed a bioassay to determine if crayfish were repelled by AFS. Twenty crayfish were placed in 20 separate plastic containers (9.5 cm tall × 18.5 cm long × 13.0 cm wide) filled with water to a depth of 3 cm. Each crayfish was offered a plastic square to which control and treated pellets were affixed. Squares were placed in the test chamber such that pellet location was randomized with respect to the crayfish, which were allowed to feed for 4 h. Crayfish were prevented from seeing neighboring crayfish during assays. After 4 h we removed the crayfish, sliced pellets off their Velcro® bases with a razor blade, and blotted them dry. Pellets left longer than 5 h began to lose their color, which prevented their identification in cases where crayfish dislodged the pellet from its Velcro® base. All pellets were weighed to the nearest 0.01 g. Trials in which a crayfish did not consume any of either type of pellet were not considered for analysis. Crayfish activity during assays occasionally knocked pellets from the Velcro® base; this necessitated the marking of pellets with treatment-specific dye.

Six of 20 crayfish in the secretion deterrence assay did not eat either type of pellet and were removed from analysis. At 1.2 mg/pellet, adhesive-free salamander skin secretion deterred crayfish feeding as evidenced by a lower remaining pellet weight in control pellets (0.01 g ± 0.01 g, N = 14) than in treated pellets (0.05 g ± 0.02 g, N = 14; two-tailed permutation test for paired replicates: N = 14, P = 0.01). Crayfish avidly ate control pellets and generally avoided treated pellets until nearly all of the control pellet was eaten.

Our methods represent the first and most crucial step in development of a bioassay-guided fractionation scheme necessary to isolate and identify the active chemical compounds of amphibian defensive skin secretions. Bioassay-guided fractionation is an important tool in the identification and chemical characterization of natural chemical products (Debont et al. 1996; Ohta et al. 2000) and will be important in the chemical identification of active components in adhesive-free salamander secretions. Despite over 50 years of research on amphibian skin compounds, very few salamander skin compounds have been identified (Erspamer 1984).

Our approach confirms the antifeedant (*sensu* Eisner et al. 1981) properties of ambystomatid adhesive-free secretion and provides an improved method for quantitatively assaying the effects of salamander skin secretions in general. Brodie et al. (1979) measured predator response after they were offered palatable or unpalatable species. Our approach overcomes difficulties associated with the use of a separate species as the control, and removes the effect of salamander behavior from the effect of secretion. Other research tested aqueous volume/volume secretion solutions of unknown concentrations (Hamning et al. 2000; Mason et al. 1982). Our method eliminates the adhesive components that hamper reproducibility across test subjects due to individual variation among salamanders (Hamning et al. 2000) and loss of secretion as salamander glands are "milked" (Digiovanni and Brodie 1981). Because we pooled secretions from three species, we can not definitively say to which species crayfish were responding. Pooling of secretions from multiple species may cause confounding effects related to synergy among interspecific compounds. This is not expected to diminish the general utility of the method because crayfish response was robust. Our method is generally applicable to most salamanders and will be useful for future studies on the distastefulness of secretion or assay-guided isolation of secretion components.

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Toe-Clipping as an Acceptable Method of Identifying Individual Anurans in Mark Recapture Studies

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Mark-recapture studies are an important and sometimes essential means for developing a detailed understanding of all aspects of amphibian natural history. Toe-clipping has historically been regarded as the most appropriate marking technique for use in many anuran population surveys and ecological research. Unique combinations of multiple digits are removed from the hands and/or feet when the animal is first captured, to allow recognition of each individual (see Donnelly et al. 1994 for a summary). Bogert (1947) first described the procedure, and it has subsequently allowed some individuals to be followed for more than 34 years (Bell and Pledger 2005).

Often toe-clipping has involved amputation above the toe base or webbing (Clarke 1972; Davis and Ovaska 2001; Funk et al. 2003; Lemckert 1996; Reaser and Dexter 1996; Waichman 1992). Current practice by authors Phillott, Skerratt, McDonald and Alford is to remove the toe pad/disc only from a hylid digit or the most distal phalanx from a non-hylid digit. This procedure is more accurately defined as “toe-tipping” rather than “toe-clipping”, as there is a substantial distinction between the length of the digit removed. Frequent surveys can rely on toe-tipping rather than toe-clipping as a reliable means of identifying individuals with minimal tissue regrowth (Lüddecke and Amézquita 1999).

Recently, the appropriateness of toe-clipping frogs has been called into question (Funk et al. 2005; May 2004) when studies by Parris and McCarthy (2001) and McCarthy and Parris (2004) predicted decreased recapture rates following toe-clipping. This was considered due either to mortality arising from digit/limb inflammation and infection (see Golay and Durrer 1994; Lemckert 1996; Reaser and Dexter 1996; Williamson and Bull 1996), disturbance resulting in movement of animals away from the study site, or inability to recapture marked animals. Although Parris and McCarthy (2001) and McCarthy and Parris (2004) only used statistical models to project the effect of toe-clipping on amphibian recapture rates and did not conduct studies to quantify this potential effect, these predictions brought into question the scientific validity and ethical status of toe-clipping (e.g., May 2004) and have led some research and government organizations to refuse permission to use this method. However, there has been little consideration given to the impacts of alternative methods of marking anurans (Funk et al. 2005), no real discussion of how these impacts occur and if they may be overcome, and no assessment of the necessity of toe-clipping for carrying out ecological research that may be critical for species conservation.

The actual reasons for the reduced return rates after toe-clipping described by Parris and McCarthy (2001) and McCarthy and Parris (2004) need to be further explored. Reductions in survival rates (due to infection or limited mobility leading to starvation or increased predation risk) and recapture rates may both contribute to reduced return rates. Actual increases in mortality as a result of toe-tipping or -clipping have not been directly measured, and the validity of the assumption that this is the only factor affecting recapture rates following toe-clipping is questionable. Behavioral changes of several types could lead to decreased recapture rates following toe-clipping. Animals could alter activity patterns or locations within their home ranges, decreasing the probability of recapture. The degree of site fidelity of many amphibians is unknown, and at least some are known to be nomadic (Schwarzkopf and Alford 2002). If toe-clipping increases the probability of animals moving away from the location at which it occurred, it will appear to reduce survival, since survival and emigration rates are very difficult to separate using mark-recapture techniques. Distinguishing the mechanisms responsible for changes in recapture probability following the application of toe-clipping and other marking techniques should be a priority subject for future research.

Even if increased mortality is the cause of decreased returns, it is possible that these increases can be minimized through a more considered approach to toe-clipping. Frequent surveys can rely on toe-tipping rather than toe-clipping as a reliable means of identifying individuals with slow or no tissue regrowth. It has long been

TABLE 1. Alternative marking techniques to toe-clipping/tipping.

Marking Procedure	Advantages	Disadvantages
PIT (Passive Integrated Transponder) Tags	Should not effect mobility[1]	Invasive Requires extensive handling, anaesthesia and recovery[1] Potentially suitable for inducing foreign body tumorigenesis[2] Tags can migrate or be lost[1] Cannot be applied to small frogs[1]
VIE (Visible Implant Elastomer) Tags	Relatively inexpensize[3] Should not effect mobility[4]	Invasive Can be difficult to visualise[3] Requires extensive handling and anaesthesia[3,4] Easiest when amphibians tagged in groups[4]
VIA (Visible Implant Alphanumeric) Tags	Relatively inexpensive Should not effect mobility[4]	Invasive Requires extensive handling, anaesthesia and recovery time[3] Tags can migrate[3] Can be lost[3] Can be difficult to visualise[3]
External Radio Transmitter	Non-invasive Allows researcher to find location of individual[5,6,7]	Normal movements and behaviour may be hindered[5] Skin lesions can occur[6] Restricted to medium to large amphibians[5] Time consuming[5] Limited battery life[5] Expensive[5] Tags can be lost[6]
Internal Radio Transmitter	Allows researcher to find location of individual[5]	Invasive Time consuming[5] Requires extensive handling, anaesthesia and recovery time[6,7] Tags can migrate[8] Tags can be lost[6]
Pattern Mapping	Non-invasive Can be applied to small animals[9]	Limited application due to lack of or limited patterns in many species[10] Temporal inconsistency of patterns in suitable species[9,11] Time consuming[9]
Pressurized Fluorescent Marking	Tagged amphibians do not require capture to identify[12]	Invasive Only reliable for few weeks[12] Can result in immediate mortality [12] Equipment heavy[12]

[1]Lane 2005a, [2]Vogelnest et al. 1997, [3]Nauwelaerts et al. 2000, [4]Lane 2005b, [5]Richards et al. 1994, [6]Werner 1991, [7]Weick et al. 2005, [8]Gray et al. 2005, [9]Donnelly et al. 1994, [10]Lemckert and Shine 1993, [11]Reaser 1995, [12]Schlaepfer 1998

recognized that toe-clipping could negatively affect anurans, and there are current guidelines for amphibian toe-clipping that provide guidance regarding how best to undertake these procedures (e.g., Herpetological Animal Care and Use Committee HACC [2004] and National Wildlife Health Centre NWHC [2001]). Some of the studies reviewed by Parris and McCarthy (2001) and McCarthy and Parris (2004) did not use, or at least did not report, the use of aseptic techniques such as those recommended by the National Wildlife Health Centre (2001) and NSW National Parks and Wildlife Service (2001). These recommend the use of single-use gloves, sterilized stainless steel scissors, and application of the antiseptic Bactine® to minimize infection (though the latter may not be effective for some species such as stream dwelling frogs that immediately wash off the antiseptic when they return to the water after capture). Higher infection rates are likely to occur if unsterilized instruments are used, and diseases may be transferred between multiple individuals if equipment and handling surfaces are not disinfected. The prevention of contamination and infection should be a primary concern in studies using any tagging technique, and toe-tipping/clipping is less likely to result in infection if the above standards are followed.

Alternatively, some increased mortality may result from a loss of mobility due to the loss of toes. This aspect does not appear to have been explored, and we recommend that controlled studies should be undertaken to compare the mobility and survival of clipped versus unclipped frogs. However, even given this lack of knowledge, steps can be taken to minimize any possible effects on mobility. The effect of toe-tipping/clipping on populations can be minimized by careful consideration of frog activities. Species heavily reliant on toes (e.g., arboreal or burrowing species) should be given a minimal number of clips. Removal of the toe pad only, instead of the entire toe, still allows a reliable means of recognition. It is already recommended that toes essential for burrowing, climbing, amplexus or nest excavation should not be not removed (HACC 2004).

May (2004) describes the practice of toe-clipping as "casually barbaric." The relative pain of toe-tipping/clipping has not been assessed or compared with alternative marking procedures. We have rarely observed a clinical pain response after toe-pad removal. While invasive procedures should not be applied without due consideration of the pain and stress caused to the animal, it must be remembered that mammals have a greater capacity to perceive pain than do other vertebrates (Stevens 1992). Toe-tipping/clipping amphibians cannot be considered as causing the equivalent distress and pain as digit amputation in a human or other mammal. We acknowledge that amphibians are able to perceive pain, however we regard the use of anaesthetics, analgesics and sedatives as far more likely to negatively affect an amphibian's homeostasis because it may be difficult to localize effects of applications of chemicals associated with toe-clipping. No single anaesthetic is effective for all amphibians due to their species-specific responses (Fellers et al. 1994) so their use can be both difficult and harmful. Chemical intervention during minor procedures increases handling and recovery time, and is thus likely to impose further stress on animals. In addition, the HACC (2004) regards pain as an adaptive response that reduces the use of an injured limb during recovery, and describes the use of anaesthetics in procedures such as toe-clipping as undesirable. This reduces handling time and allows post-operative, field-released animals to adapt their activity to compensate for the affected limb/s.

While toe-tipping/clipping is the least expensive of the marking procedures suitable for amphibians, the decision to use this method should not be based on cost alone. We believe that toe-tipping/clipping is fast, reliable, and toe-tipping possibly the least stressful marking method for anurans. Furthermore, we note that in many countries, toe-tipping/clipping cannot occur without the approval of animal ethics committees at research institutions.

In recent times a range of alternative techniques have been proposed as suitable means to mark individuals over extended periods. Proponents of alternatives (e.g., May 2004) have provided no evaluation of impacts of the procedures on marked individuals. The only entirely non-invasive technique successfully used to identify individual anurans is pattern mapping by photograph or sketch. Alternative invasive techniques to toe clipping or toe tipping have included dye markers (e.g., Visible Implant Elastomer [VIE] tags and pressurised fluorescent marking techniques), individual recognition tags (e.g., Visible Implant Alphanumeric [VIA] Tags and Passive Integrated Transponder [PIT] tags), radio telemetry transmitters, and branding (using tattoos, silver nitrate, heat, or freezing). The advantages and disadvantages of all procedures are summarised in Table 1. It is clear that all marking techniques carry risks and may have adverse effects on marked animals, so all techniques violate assumptions related to population estimation models. However, more study is required to determine which techniques have the least adverse effects.

All invasive marking techniques have ethical considerations. The value of the work to the species as a whole should be weighed against the potential impacts on individuals. The stress imposed on a limited number of individuals needs to be balanced against the increased knowledge that can be gained for the species. Management plans must be based on an understanding of the natural history of the animal, including site fidelity, home range and longevity, and factors such as disease, which affect survival. Assured recognition of individuals is essential to determine such parameters.

As extinctions of frog species occur with the global emergence of chytridiomycosis, threatened and potentially-threatened populations must be studied to understand the epidemiology of this disease. Prevalence, incidence, survival and transmission rates cannot be calculated without absolute certainty of individual recognition. In the absence of another widely applicable tagging technique, known to have at most small effects on return rates, we suggest that toe-clipping is the only feasible option that can be applied to many species and to all post-metamorph members of a community. Additional research is urgently needed to evaluate the impacts of all marking techniques, and to develop new ones with lower impacts. Until this has been done, we believe that it is more ethical to use toe-clipping in studies aimed at understanding and preventing further loss of anuran diversity than it would be to stand by, leaving many species unstudied, or to use alternative techniques that have not been studied and which may have greater impacts on amphibians.

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Non-Contact Infrared Thermometers Can Accurately Measure Amphibian Body Temperatures

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Body temperature affects almost all biochemical and physiological processes in ectothermic organisms (Hutchinson and Dupré 1992), and thus affects movement, habitat selection and thermoregulatory behavior (Bartelt and Peterson 2005). A variety of devices have been used to determine the body temperatures of amphibians in the field. The most typical is a thermocouple probe connected to a quick-reading thermometer, which has been used to measure skin (Brattstrom 1963; Heath 1975; Lillywhite 1970; Navas 1996; Tracy 1976), oral (Brattstrom 1963; Lillywhite et al. 1973; Lillywhite et al. 1998), or cloacal (Brattstrom 1963; Cabanac and Cabanac 2004; John-Alder et al. 1988; Passmore and Malherbe 1985; Thorson 1955; Vences et al. 2002) temperature. These methods require manual handling of each individual, which may artificially elevate its body temperature (due to conduction; Navas and Araujo 2000), or may alter the behaviour of individuals in studies of a longer duration (i.e., by capture stress).

To date, non-invasive methods of measuring amphibian body temperature that do not require the manual handling of individuals have included the attachment of thermally sensitive radio-transmitters (Bradford 1984; Heath 1975; Seebacher and Alford 2002) and the use of physical models (Bartelt and Peterson 2005; Hasegawa et al. 2005; Navas and Araujo 2000; O'Connor and Tracy 1987; Seebacher and Alford 2002). More recently, an additional method of measuring amphibian body temperature has become available, via the use of hand-held, non-contact, infrared thermometers (e.g., Young et al. 2005). These thermometers have been widely adopted in the medical sciences, and have been shown to accurately measure body temperature in humans (Koçak et al. 1999; Rotello et al. 1996; Terndrup et al. 1997). Despite their promise as a rapid, non-invasive method of measuring amphibian body temperature, their accuracy for measuring amphibian body temperature has not been quantified. We designed this study to determine whether a non-contact infrared thermometer can be used to accurately measure the body temperatures of amphibians.

Materials and Methods.—Our experiment was designed to allow us to measure body temperatures of frogs allowed to experience a wide range of thermal environments in a laboratory setting. We set up three opaque plastic containers (60 cm × 40 cm × 40 cm), each with a small water bowl in the center and a metal fly-screen lid. The containers were housed in a constant temperature room, which maintained ambient temperature between 19.5 and 21.5°C. Relative humidity fluctuated between 64 and 96% (mean 74%). A 150-watt heat lamp was provided at one end of the container during the day (0930–2130 h) in order to provide a heat gradient within the normal temperature range of the species.

Twelve adult Common Green or White's Tree Frogs (*Litoria caerulea*) were captured near Townsville, Queensland, Australia. They ranged from 74.1–91.8 mm SVL and 26–65 g body mass. Prior to experiments, they were maintained in the constant temperature room in which the experiments were carried out, but in smaller containers with no access to heat lamps. Frogs were fed crickets *ad libitum*. Each frog was used in a single run of the experiment. We ran four temporal replicates of the experiment, creating a total of twelve sets of measurements of frog and model temperatures for comparison. Each replicate ran for three days.

Body temperatures of frogs were recorded five times per day (0900, 1100, 1300, 1500, and 1700 h), producing 15 measurements for each of the 12 frogs. The first time (0900 h) was chosen because at that time the frogs had received no source of heat for almost 12 h, and their body temperature should have been similar to a nocturnal reading in the field. Each run of the experiment was set up at least 60 minutes before the first temperature reading was taken, allowing frogs to reach a thermal steady state.

At each reading, frog body temperature was recorded using three techniques. Firstly, temperature was recorded by holding a Raytek ST80 Pro-Plus Non-contact thermometer (RAYST80; "IR thermometer") approximately 5 cm away from the frog and aiming at the lower dorsal area near the thigh. The model of IR thermometer used in this study had a distance to spot ratio of 50:1, and the area measured is delineated by a circle of laser diodes. Emissivity was set on the IR thermometer at 0.95, as it is generally accepted that amphibians have a long-wave emissivity of approximately 0.95–0.97 (Carroll et al. 2005; Tracy 1976), regardless of their color (Nussear et al. 2000; Tracy 1979). In initial trials, we determined that measured frog body temperatures did not vary by more than 0.1°C when the emissivity setting of the IR thermometer was varied between 0.95–1.0.

After taking a reading using the IR thermometer, we then measured skin and cloacal temperatures (in that order) using a small, chromel-alumel "K" type thermocouple (diameter approx. 1 mm) with the tip coated in plastic, attached to a digital thermometer type 90000. To measure skin temperature, the thermocouple was held firmly against the skin on the lower dorsal area near the thigh while the frog remained in its original position in the container. During cloacal temperature measurement, each frog was held by a single leg, while still in the container, and the thermocouple was inserted 10–20 mm inside the cloaca and the reading was taken when the indicated temperature stablized.

Frogs were usually in the water conserving posture immediately prior to temperature measurement, except for several instances at 0900 h. It is probable that there are small differences among individual frogs, related to body size or individual behaviour, that affect how temperatures measured using the three techniques are correlated, so that the measurements for each individual frog are not entirely statistically independent. We therefore did not carry out any hypothesis tests, but concentrated on modelling the relationships between measurements taken using the three techniques, and determining how well our models fit the data. Because all three variables are measured with error, we constructed models of their relationships using major axis regression (Sokal and Rohlf 1995). We determined how well our regression models fit the data by calculating coefficients of determination, using standard correlation analysis.

Room temperatures were recorded every 30 minutes using thermal data loggers (Thermochron iButtons by Dallas Semicondictor, Dallas, Texas USA). Data loggers and thermocouples were calibrated against a high precision mercury thermometer in a magnetically stirred water bath.

Results.—Body temperatures measured using the IR thermometer and both skin and cloacal temperatures measured using the thermocouple probe were highly correlated. The major-axis regression lines relating each type of temperature measurement to the others were all very similar to the line of equality (Fig. 1). The major-axis regression lines never predict a mean difference greater than approximately 0.5°C between any two temperatures in the range of 18–34°C for any pair of measurements.

Discussion.—The surface of basking animals may reach slightly higher temperatures faster and decrease more rapidly after basking ceases than the body core (Remmert 1985). However, we found that skin temperatures measured either by contact thermocouple or IR thermometer were almost always within 0.5°C of cloacal temperatures (Fig. 1); this appears to be relatively common in small ectotherms such as frogs (Wygoda 1984), and other small ectotherms such as lizards (<10–20 g; Jones and Avery 1989). It is likely that the small number of points which depart to a larger-than-usual extent from the lines of equality and regression lines in Fig. 1 were measured on animals that had recently changed from basking to non-basking or the reverse.

We found that cloacal temperature was slightly better predicted by surface temperature as measured by the IR thermometer than it was by skin temperature measured using a thermocouple. This indicates that surface temperatures measured using the IR thermometer should provide accurate indicators of internal body temperatures in most amphibians.

Good quality IR thermometers have long-range optical resolution, allowing measurement of small targets at long distances. As the distance from the object increases, the spot size of the area measured by the unit becomes larger. Therefore, the smaller the target, the closer you must be to it in order to avoid measuring a combination of amphibian and background temperatures. Especially in the field, it is necessary to take the distance to spot ratio into account. When studying small frogs, it may only be possible to measure temperatures at short ranges (< 0.5 m). As the laser is located above the sensor in many models, it is also important to take parallax effects into account when aiming the sensor, as at near distances the point of aim of the sensor will be displaced from the point of aim of the laser diode.

It is likely that IR thermometers will be useful in measuring other small animals, such as reptiles, in the field. As all plants and animals act almost as black-bodies in the middle infrared (Sustare 1979), having an emissivity nearing 1.0, no major changes in the technique will be necessary when used on different species. Indeed, we are presently using IR thermometers successfully for measuring the body temperatures of a number of amphibian species in the field (Rowley and Alford, unpubl. data).

We have shown that non-contact infrared thermometers can be used to accurately determine the body temperatures of amphibians. Benefits of this technique include relatively low cost (approximately US $340), small size and therefore high portability, and the ability to rapidly record the temperature of a large number

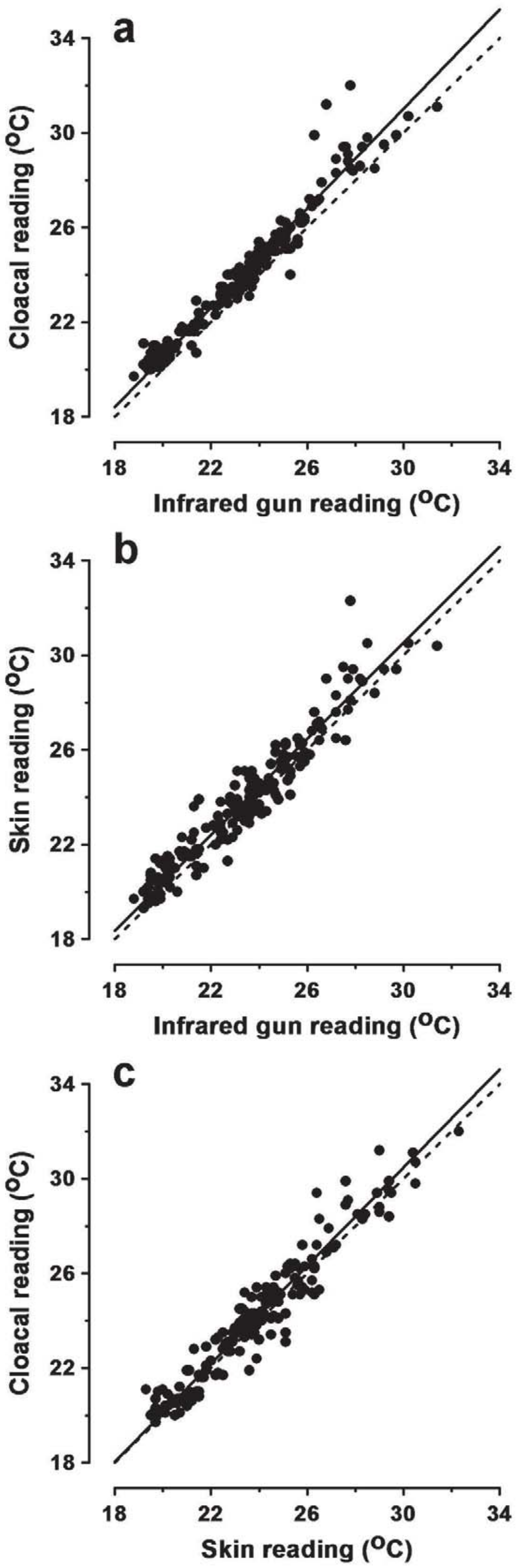

FIG. 1. (a) Measured cloacal temperature as a function of infrared gun reading. Dashed line is at y = x, solid line is the major axis regression $y = 1.052x - 0.535$ with $r^2 = 0.949$. (b) Measured skin temperature as a function of infrared gun reading. Dashed line is at y = x, solid line is the major axis regression $y = 1.014x + 0.1049$, with $r^2 = 0.922$. (c) Measured cloacal temperature as a function of skin temperature. Dashed line is at y = x, solid line is the major axis regression $y = 1.038x - 0.657$, with $r^2 = 0.932$.

of individuals. Perhaps the most important feature of the technique, however, is its ability to record the temperature of amphibians without handling them. This reduces disturbance, which can be important when the same individual is to be measured repeatedly, or when disturbance may cause an animal to abandon a retreat or basking site, exposing it to increased risks of predation or desiccation. In addition, such non-invasive methods of determining amphibian body temperature are likely to be increasingly important due to the need to minimise handling stress and the possibility of disease transmission, particularly when studying species of conservation concern.

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Correct Orientation of a Hand-held Infrared Thermometer is Important for Accurate Measurement of Body Temperatures in Small Lizards and Tuatara

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Measurement of cloacal temperature using a thermocouple (TC) is a standard and long-established method for determining body temperature (T_b) in reptiles. There are some disadvantages, however, to this method. The animal must first be captured and handled, and the thermocouple must be inserted into the cloaca; such manipulations potentially raise the animal's breathing rate (Langkilde and Shine 2006) and, if prolonged, could initiate a stress response involving elevated plasma corticosterone (e.g., Moore et al. 1991). Furthermore, the animal's retreat to a different microenvironment when chased, and/or its subsequent handling, potentially result in an unrepresentative measurement of T_b. An experienced researcher is able to minimize these outcomes in most cases; however, alternative non-invasive methods are desirable.

Useful alternatives for long-term studies of T_b include radiotelemetry and intra-coelomically implanted temperature loggers. While these methods do not require frequent recapture of the animal, they still require the initial attachment of the device, which itself sometimes requires surgery (Charland 1995; Forsythe et al. 2004; Taylor et al. 2004). Consequently, these methods are not suitable for very small animals.

The advent of infrared technology potentially offers a non-invasive alternative for on-the-spot measurement of T_b in small reptiles. Both infrared imaging systems and hand-held thermometers are now available. Imaging systems have proved useful in controlled laboratory environments where relatively large systems can be set up for a long period of time, and if properly calibrated produce highly accurate results (Jones and Avery 1989). Unfortunately these systems are too bulky for use in the field. However, hand-held infrared thermometers (IRT) are available, at much lower cost. These devices consist of a handle, a sensor, and a laser sight. The sensor beneath the laser sight measures infrared radiation of the surface at which the IRT is aimed, and produces a temperature reading precise to about 0.1°C (see Methods), comparable to many thermocouples. Studies using IRT are currently being evaluated for medical purposes, and show promising results for use in some non-critical applications, although some reservations have been expressed (Banitalebi and Bangstad 2002; Hoffman et al. 1999; Leon et al. 2005).

An IRT potentially offers several advantages for measuring T_b in small reptiles. The method has already been used to study temperatures selected by small geckos on a thermal gradient (Christian et al. 1998; Werner et al. 2005) but no rigorous comparison of results with those from a cloacal TC is available. The main aim of the present study was to determine if skin temperature (T_{sk}) measured with an IRT was sufficiently accurate to substitute for the standard method (cloacal TC) for inferring T_b in small lepidosaurian reptiles. Measurements of T_{sk} and T_b were collected both in the field and laboratory from adults of McCann's Skink (*Oligosoma maccanni*), and in the laboratory from juvenile Tuatara (*Sphenodon punctatus*). The usefulness of substrate temperature (T_{sub}, measured with an IRT) as a substitute for T_b on a thermal gradient was also examined for Tuatara.

Methods.—Adult McCann's Skinks of both sexes, including pregnant females (mean mass 3.53 ± 0.11 g), were captured from rock outcrops at Cloverdowns Farm, near Macraes Flat, New Zealand (45°28'S, 170°28'E, 600–700 m elev.). Captures of this diurnal, heliothermic species were made by day during the austral spring (8–14 October 2004). Although a few skinks were captured from basking positions on rocks, cool and windy weather meant that most skinks were under rocks.

Preliminary tests showed that hand capture was necessary to determine T_{sk} because skinks would otherwise escape before the IRT could be brought close enough (ca. 100 mm) for a reading. Upon capture, the field T_{sk} of 36 individuals was immediately taken by an IRT (Raytek, Raynger® model ST80 ProPlus™, Santa Cruz, California), which provides a reading precise to 0.1°C. Accuracy as reported by the manufacturer is ± 2°C between -18 and 23°C and ± 1°C above 23°C for surfaces with an emissivity of 0.95; we verified this by comparison with a thermocouple (see below for model) for surfaces including terracotta tile and paper. We assumed that the skin of the reptiles we studied had a similar emissivity, which appears reasonable as most biological materials have an emissivity in the medium to long infrared of between 0.90 and 0.99 (Willmer et al. 2000). Taking care to ensure that the laser beam avoided the eyes of animals and researchers, the IRT was pointed at the dorsal surface of the skink such that the target laser sights all fell on the posterior abdomen or pelvic region. Adult skinks typical of those studied had a mean width (± SE) at the posterior abdomen of 6.68 ± 0.12 mm (measured later in laboratory, N = 40). During measurement, skinks were held by their pectoral girdle over the surrounding substrate to avoid the handler's body heat from influencing the readings.

Immediately following measurement of T_{sk}, which usually took only a few seconds, a cloacal thermocouple (Digi-Sense® model 8528-40, Cole-Parmer, Niles, Illinois, USA; hereafter, "TC"), which had been calibrated to within 1.0°C against a reference thermometer (SAMA-CT40, Eveready Thermometer Co., West Patterson, New Jersey, USA), was used to measure cloacal T_b. Ambient temperature (T_a) was then measured with the TC at 1 m height in the shade.

Field T_{sk} measured with the IRT was compared with T_b measured with the TC using linear regression analyses and paired *t*-tests. The absolute magnitude of the difference between T_b and T_{sk} was plotted against T_a, and a regression was used to determine whether T_a affected the difference. At the time of measurement, we noticed five readings of T_{sk} to be very different from T_b. We remeasured T_{sk} of these skinks over a different substrate (rock versus grass). The second IRT measurement for these five skinks was always more similar to the TC reading than the first one, and this value was used for analyses (as we show later, the discrepancy was likely due to the way the IRT was oriented relative to the lizard's body rather than to the nature of the substrate per se).

Nine adult *O. maccanni* (pregnant females, mean mass 3.91 ± 0.17 g) were brought to the laboratory and placed on a thermal gradient lined with clean brown paper over a metal base-plate. Individual runways (8.5 × 100 cm) offered a temperature range from 16°C at one end to 34°C at the other end (see Rock et al. 2000 for further details of gradient). After a familiarization period of 14 hours, T_{sk} and T_b were measured up to three times over the following 12 h (1000, 1500 and 2200 h). Measurements of T_{sk} were in most cases obtained without handling, although in a few cases the skinks ran along the gradient and had to be restrained before measurements of either T_{sk} or T_b were taken. Measurements at night (2200 h) were made with the aid of a dim red light. The inclusion of night measurements increased the range of skin/body temperatures selected by the skinks. In total, 19 paired measurements were obtained from 9 skinks, and for the purposes of the comparison between methods these were treated as independent measures (analysis of time-of-day effects on mean T_b will be reported elsewhere). Differences between T_{sk} and T_b were examined using regression analysis and paired *t*-tests.

Ten juvenile *S. punctatus* of approximately 7 months age (mean mass 4.18 ± 0.37 g) were also placed on the thermal gradient. These tuatara had been obtained from eggs laid and incubated in captivity and were maintained indoors under semi-natural conditions of temperature and photoperiod. Data for T_{sk} and T_b were collected and analyzed as for skinks, except that the familiarisation period lasted 8 h and measurements were subsequently collected at five time points (0600, 1000, 1400, 1800 and 2200 h, with 0600 and 2200 h being in darkness). Substrate temperatures available within the gradient ranged from a mean of 13.6°C at the cool end to 33.1°C at the warm end. In addition to measurements of T_{sk} and T_b, at each time point the substrate temperature (T_{sub}) selected by each tuatara was measured by IRT directly alongside a hind limb of the tuatara. In total, 50 paired measurements of T_{sk} and T_b were obtained from ten tuatara, and analyzed as for skinks. The relationship between T_{sub} and T_b was also examined.

Results from the above experiments led us to suspect that background (substrate) temperature had an influence on T_{sk} when the IRT was held at close distance and with a certain orientation (at 90° to the animal's body axis). With such an orientation, the laser sight does not provide an accurate indication of the spot at which infrared radiation is being measured (owing to the offset between laser source and sensor). The manufacturer's instruction booklet alludes to this possibility under a section entitled "Reminders," in which it is recommended that, at distances less than 0.5 m, a manual sight on top of the IRT should be used instead of the laser.

We therefore tested the effect of using either the laser or manual sight for determining T_{sk} (and hence inferring T_b) in skinks. We also tested, using the laser sight, the influence of orientation of the IRT (relative to the skink's body axis) on T_{sk}. For this trial, 20 skinks with a body temperature of about 18°C were placed on a warm ceramic tile with a surface temperature of about 30°C. The first measurement of T_{sk} was made using the laser sight and with the IRT oriented at 90° to the body axis. The second measurement of T_{sk} was made with the IRT in the same position but using the manual sight. The third measurement of T_{sk} was made using the laser sight but with the IRT oriented in-line with the skink's body axis. Finally, T_b was measured with the cloacal TC. All measurements for each skink were completed within about 30 seconds. Paired *t*-tests were used to compare each T_{sk} measurement with T_b.

Results.—By day, wild skinks had cloacal temperatures (T_b, measured with the TC) of between 10.4 and 28.6°C. Skin temperature (T_{sk}, measured with the IRT) showed a significant relationship with T_b ($r^2 = 0.586$, $df = 1, 34$, $P < 0.001$, Fig. 1A). Mean values differed by 1.21 ± 0.62°C ($T_{sk} = 20.53 \pm 0.95$°C, $T_b = 21.75 \pm 0.81$°C) but this difference was not significant (paired $t = 1.996$, $df = 35$, $P = 0.057$). Individual differences ranged up to 12.9°C, even after re-testing over a different substrate. Ambient temperature played a significant, albeit small, role in explaining the absolute magnitude of the difference between T_{sk} and T_b (data not presented; $r^2 = 0.189$, $df = 1, 34$, $P = 0.008$); in other words, the discrepancy between T_{sk} and T_b was reduced at warmer temperatures.

Depending on time of day, skinks on the thermal gradient selected a T_b of between 17.6 and 31.9°C. The relationship between T_{sk} and T_b was highly significant ($r^2 = 0.899$, $df = 1, 17$, $P < 0.001$; Fig. 1B), and mean values for T_{sk} (29.03 ± 1.16°C) and T_b (28.37 ± 0.81°C) did not differ (paired $t = 0.17$, $df = 18$, $P = 0.173$). The maximum discrepancy between T_{sk} and T_b was 4.1°C.

Tuatara on the thermal gradient selected a T_b of between 12.8 and 28.1°C. The relationship between T_{sk} and T_b was highly significant ($r^2 = 0.936$, $df = 1, 48$, $P < 0.001$; Fig. 1C), and mean T_{sk} (21.22 ± 0.63°C) did not differ significantly from mean T_b (20.92 ± 0.57°C; $t = 1.787$, $df = 49$, $P = 0.08$). The maximum discrepancy between T_{sk} and T_b was 3.2°C. The relationship between substrate temperature (T_{sub}) and T_b of tuatara (Fig. 1D) was more variable than that between T_{sk} and T_b, though still highly significant ($r^2 = 0.847$, $df = 1, 48$, $P < 0.001$). Mean T_{sub} and mean T_b came close to differing significantly ($t = 1.979$, $df = 49$, $P = 0.053$), and individual differences ranged up to 5.4°C.

Measurements of T_{sk} made with the IRT oriented at 90° to the skink's body axis were highly influenced by background temperature, regardless of whether the laser sight or manual sight was used (Fig. 2). Mean values for T_{sk} measured in this way differed greatly from T_b measured by TC ($t \geq 17.592$, $df = 19$, $P < 0.001$). However, when T_{sk} was measured with the IRT oriented in line

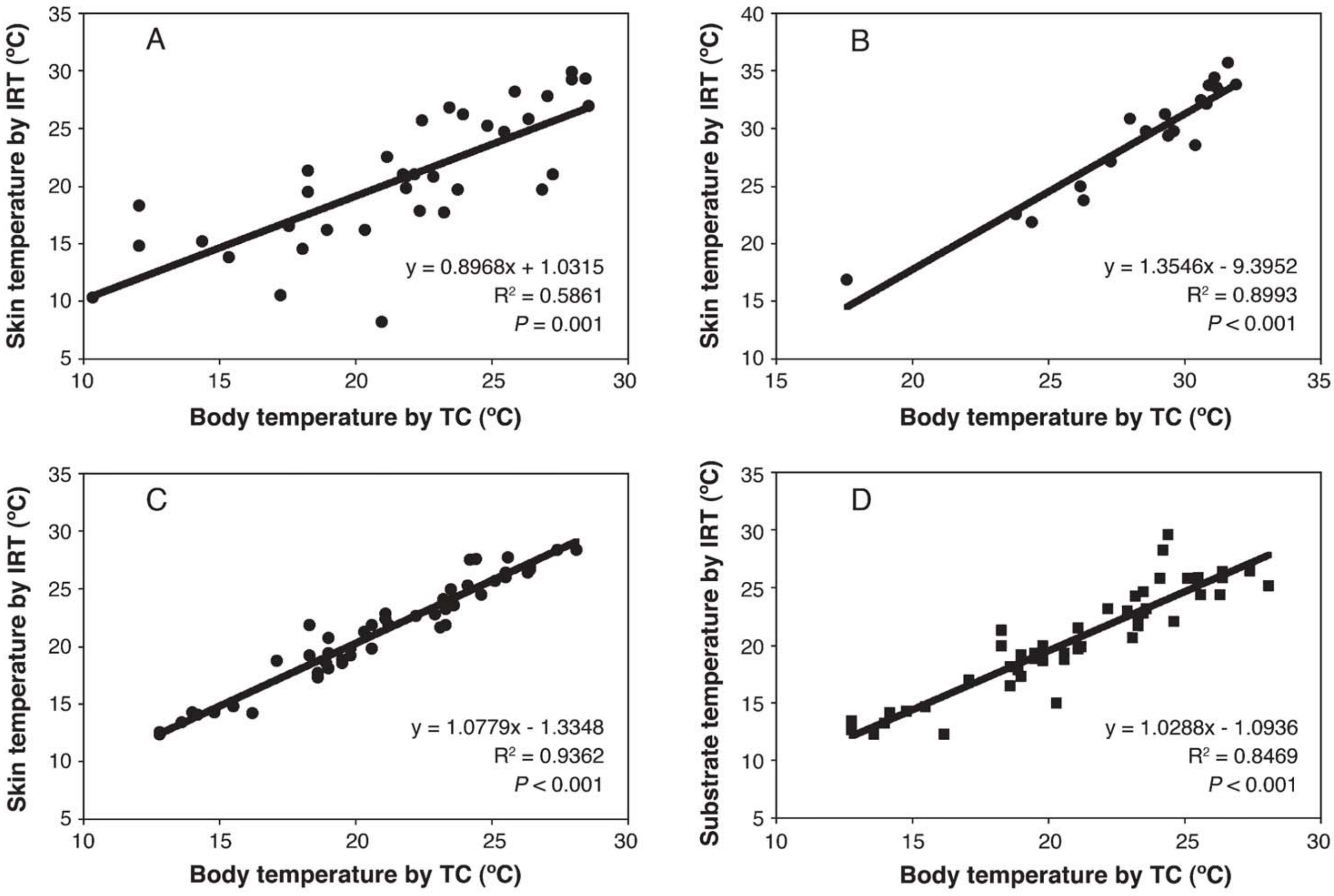

FIG. 1. Comparison of skin temperature (T_{sk}) or substrate temperature (T_{sub}), measured by infrared thermometer (IRT), with cloacal temperature measured by thermocouple (TC), in two small lepidosaurian reptiles. A) Skin temperature of adult McCann's Skinks (*Oligosoma maccanni*) in the field. B) Skin temperature of McCann's Skinks in the laboratory (free choice on thermal gradient). C) Skin temperature of juvenile Tuatara (*Sphenodon punctatus*) (free choice on a thermal gradient). D) Substrate temperature of juvenile Tuatara (free choice on a thermal gradient). Line equations and coefficients are for linear regression. In these data sets, the IRT was used without precise orientation relative to each animal's body axis.

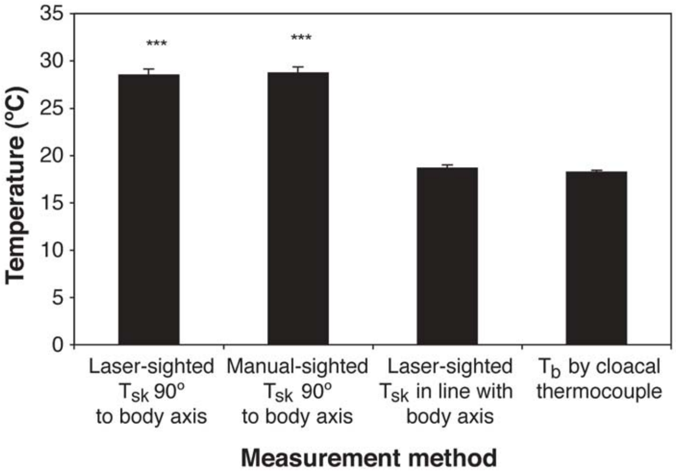

FIG. 2. Mean skin temperature (T_{sk}, measured by IRT) and body temperature (T_b, measured by TC) of the skink *Oligosoma maccanni* on a substrate of about 30°C. The first measurement of T_{sk} was made using the laser sight, with the IRT oriented at 90° to each skink's body axis. The second measurement of T_{sk} with the IRT was made with the same orientation but using the manual sight. The third measurement of T_{sk} was made with the laser sight and with the IRT oriented in line with each skink's body axis. Finally, T_b was measured (N = 20 for all measurements). Bars show standard error. *** indicates significantly different ($P < 0.001$) from T_b by TC.

with the skink's body axis, a much more accurate indication of T_b was obtained ($t = 2.012$, $df = 19$, $P = 0.059$). For the latter comparison, 95% of paired values differed by no more than 1.0°C (maximum difference 3.4°C).

Discussion.—In principle, the infrared thermometer (IRT) offers an attractive and non-invasive method for measuring T_b in small reptiles. In practice, we found its usefulness in the field with *O. maccanni* limited in that it needed to be brought to such a close distance that most animals had to be captured first, removing one advantage over the use of a thermocouple (TC). (In the thermal gradient, however, it was usually possible to measure T_{sk} without animal capture.) We also noted that in the field, although mean T_{sk} measured by IRT and mean T_b measured by TC did not differ significantly, the regression explained only 59% of the variation and there were several large discrepancies (up to 12.9°C) between T_{sk} and T_b. Many skinks had field body temperatures below 23°C, in a range where the accuracy of the IRT is reduced. Nevertheless, the discrepancies we observed were too great to be explained by this factor alone. Discrepancies could have also arisen from a real difference between skin and core body temperature, but we do not believe that thermal gradients of up to 12.9°C could exist over a few millimeters of body tissue in small skinks. This assumption is supported by research on the similar-sized *Lacerta vivipara* (3.5 g), in which core and skin temperatures differed by not more than 0.2°C (Jones and Avery 1989).

The most likely reason for occasional large discrepancies between T_{sk} and T_b in the field is that the IRT was not always precisely oriented in line with the skink's body axis. Thus, the background temperature is likely to have influenced some measurements. Further tests with *O. maccanni* in the laboratory showed that the influence of background temperature was substantial if the IRT was oriented at 90° to the skink's body axis, regardless of whether the laser or manual sight was used. However, with the IRT oriented in line with the skink's body axis, the effect of background temperature was eliminated, as the laser source and infrared sensor were now both in line with the skink's body.

Results for skinks and tuatara on the thermal gradient are consistent with the above interpretation. In these trials, the IRT may not have always been oriented in line with each animal's body axis, thus explaining occasional discrepancies between T_{sk} and mean T_b. However, the discrepancies were smaller than in the field for *O. maccanni*, probably because background temperature on the gradient was in most instances very similar to T_b. Overall, there was no significant difference between mean T_{sk} and mean T_b for either *O. maccanni* or *S. punctatus* on the thermal gradient, and the match between individual values is likely to be further improved with more care in orientation of the IRT.

Two previous studies have used T_{sk} measured with an IRT for inferring T_b selected by small lizards on a thermal gradient. In one study, T_{sk} was assumed to represent T_b of the gecko *Oedura marmorata* (mean species mass ~9–20 g) but no calibration was reported (Christian et al. 1998). In another, T_{sk} was calibrated against T_b for a combined sample of one or more individuals of the geckos *Goniurosaurus kuroiwae kuroiwae* (mean species mass 7.7 g) and *Eublepharis macularius* (mean species mass 47.1 g; Werner et al. 2005). A significant relationship was reported (regression $r = 0.83$; N = 21 measurements; $P < 0.0001$), although occasional discrepancies (magnitude not reported) were noted, especially in small individuals. Neither of these studies reported the orientation of the IRT relative to the lizards' bodies, so the possible influence of background temperature on the measurements is unknown.

Substrate temperature (T_{sub}) on a thermal gradient has sometimes been used as a surrogate for T_b in small reptiles, for example, for the semi-fossorial lizard *Chalcides ocellatus* on a substrate of sand (Daut and Andrews 1993). In our study with tuatara, although substrate temperature was easy to measure with little disturbance to the animal, it was not as precise an indicator of T_b as was T_{sk} measured with the IRT. Discrepancies presumably arise when animals occasionally move on the gradient to a region of cooler or warmer substrate than T_b. Given that further improvements in the accuracy of estimating T_b are probable with precise orientation of the IRT, we recommend measuring T_{sk} directly rather than T_{sub} when accurate estimates of T_b on a thermal gradient are required for small reptiles.

An IRT for measuring T_{sk} has considerable advantages over a cloacal TC for estimating T_b in small reptiles. Handling of animals is essentially eliminated when animals are confined (as on the thermal gradient), and thus the risk of a handling-induced increase in respiration rate (Langkilde and Shine 2006), as well as escape and other negative outcomes, is reduced. This could have benefits for both animals and researchers, making subsequent measures of animal temperature in a repeated-measures design (e.g., where time-of-day effects are of interest; Rock et al. 2000) less affected by previous disturbance. Werner et al. (2005) also pointed out a reduced risk of tail autotomy when using an IRT rather than a TC for measuring selected temperature in small geckos. Although we have not observed tail loss in either of our study species here (or the gecko *Hoplodactylus maculatus*: Rock et al.

2000) when measuring T_b by TC for animals on a thermal gradient, it is certainly true that handling and the risk of escape are reduced using the IRT.

Further studies are needed to assess the potential use of an IRT for inferring T_b in larger reptiles. Although some modeling suggests that reptiles under 30 g should act as though they have zero heat capacity (Bakken 1992), other work suggests that even in reptiles of this small size, lags between skin and core temperature could occur in animals that move into new thermal environments (Seebacher and Shine 2004). Differences between skin and core temperature will depend not only on animal size but also on the extent of temperature equilibration with the environment, and thus on the amount of movement by the animal and the extent to which the environment is thermally heterogeneous (Seebacher and Shine 2004). In a laboratory environment such as a thermal gradient where thermal equilibration is possible, or with sedentary wild animals in relatively homogeneous thermal environments such as adult tuatara emerged in forest, T_{sk} may yet provide a useful substitute for T_b. However, empirical studies are clearly needed before assuming the accuracy of an IRT for inferring T_b in reptiles larger than those studied here.

One area of biomedical interest where use of the IRT has been explored has been the measurement of body temperature in humans. Studies assessing the accuracy of IRT measurements of the inner ear in humans have found discrepancies of 2°C or more compared with the standard rectal temperature measured by a thermometer (Hoffman et al. 1999; Modell et al. 1998; Stavem et al. 1997). Similarly, in a comparison between IRT and TC methods for determining human skin temperature, differences between the two methods were often 1–2°C, precluding the use of IRT for studies where accurate measurements of T_b are necessary (Matsukawa et al. 2000). As in our initial trial with the IRT in the field for *O. maccanni*, a significant regression or correlation between the two measurements was not in itself a guarantee of accuracy (discussed further by Yaron et al. 1995).

In conclusion, the hand-held IRT is very easy, quick and convenient to use. If appropriately oriented when aiming at small reptiles, it records values for T_{sk} that can substitute for measurements of T_b taken with a cloacal TC, with the advantage for animal welfare that handling is reduced. If care is not taken with orientation and aiming, however, then discrepancies (potentially large) may arise due to the influence of background temperature. Our findings illustrate the importance of testing new equipment and methods against previously established methods, to ensure that the quality of data is acceptable for research purposes.

Acknowledgments.—Research was conducted under permits from the New Zealand Department of Conservation and approvals from the University of Otago Animal Ethics Committee. We acknowledge consultation with Ngati Koata regarding studies on tuatara and with Ngai Tahu regarding collection of McCann's Skinks. Our thanks to Lindsay Hazley and the Southland Museum and Art Gallery, Invercargill, for providing tuatara eggs from which juveniles were obtained, Keith and Margaret Philip for access to McCann's Skinks on their property, Karina Holmes and Jack Mace for field assistance, Marion Preest for assistance with equipment purchase, and Marion Preest, Anne Besson and two anonymous reviewers for comments on the MS. Research was supported by a University of Otago Research Grant to Alison Cree.

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Comment on Papers by Hare et al. and Rowley and Alford

There is an uncertainty principle involved in measuring the body temperatures of small ectothermic animals: the mechanics of measuring are likely to affect the quantity measured. To take cloacal or core body temperatures, animals must be captured and handled, or logging or telemetry devices must be implanted or attached. Particularly for small animals with low thermal inertia, capture and handling may mean that body temperature changes before it is measured. Repeated capture and handling may disrupt normal behavior, so that accurate temperatures are measured, but are not relevant to normal behavioral patterns. Implantation or attachment of devices may lead to similar disruptions. Both papers demonstrate that, at least for frogs and small reptiles, the uncertainty can be reduced by measuring temperature using infrared thermometers (IRTs), which allow skin temperatures to be measured without handling. These temperatures are more likely to reflect the outcome of natural behavior, even when measured repeatedly, and to be unaffected by handling, so they should be more accurate estimates of the temperature of an undisturbed animal with normal behavior. This higher accuracy might be preferable to that of temperatures taken using other techniques, even if IRT temperatures were somewhat less precise. However, both papers demonstrate clearly that, if properly used, with an understanding of the parallax problems that arise when using IRTs to measure small areas at close distances, IRTs can provide both precise and highly accurate estimates of skin temperatures of frogs and reptiles. These mirror cloacal temperatures, at least in frogs and relatively small reptiles, and can thus be used as proxies for core body temperature. When it is important to avoid the effects of disturbance and handling, as when body temperatures are to be repeatedly taken during behavioral observations, this technique should prove to be an invaluable addition to the herpetologist's repertoire.

—Ross A. Alford and Jodi J. L. Rowley

Response to "Non-contact Infrared Thermometers Can Accurately Measure Amphibian Body Temperatures" by Jodi Rowley and Ross Alford

We agree with Rowley and Alford about the potential advantages of using an infrared thermometer (IRT) for measuring body temperatures in small amphibians and reptiles: reduced handling means potentially more reliable measurements, less stress to animals, and a reduced risk of disease transmission (especially relevant at present to amphibians)—and that IRTs can also allow more rapid data collection.

We also agree that the offset between the laser sight and infrared sensor raises the issue of parallax when IRTs are used with very small, narrow-bodied species that must be closely approached. This means, as we show, that care is needed when orienting the IRT to ensure that skin temperature, rather than temperature of the background, is what is being measured. This was presumably less of an issue with the larger and more compact frogs with which Rowley and Alford worked than with our small and elongate lepidosaurs.

Collectively, our studies seem broadly complementary, but largely or exclusively laboratory-based. We encourage more work by others to assess the significance of body size, body shape, and movements between different thermal environments on the potential lag between skin temperature (measured by an IRT) and core temperature, and on the practicality of using IRTs in the field with small species, which need to be closely approached.

—Jon Hare, Elaine Whitworth, and Alison Cree

NATURAL HISTORY NOTES

Instructions for contributors to Natural History Notes appear in Volume 38, Number 1 (March 2007).

CAUDATA

AMBYSTOMA OPACUM (Marbled Salamander). **HABITAT**. Typically, adult *Ambystoma* utilize lentic habitats for breeding and egg deposition; such habitats include temporary and permanent ponds, flooded fields, and roadside ditches. However, previous reports indicate that up to six species of *Ambystoma* may utilize lotic habitats (Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington. 587 pp.). Here we provide the first report of lotic habitat use by *Ambystoma opacum*.

On 25 Mar 2006 we encountered a stream pool containing *A. opacum* larvae in the Saline County State Fish and Wildlife Area (37°41'43"N, 88°23'19"W), Equality, Illinois, USA. The pool was ca. 180 cm in length, with a maximum depth of 45 cm and an average flow rate of 3 cm/sec. Initially, no larvae were visible in the pool, but disturbance of a submerged root system resulted in visible larval movement and subsequent identification. Five larvae were visible in the pool and three were collected for species verification. All larvae were between 15–17 mm total length, and none had developed rear legs. We also surveyed all stream pools within ca. 100 m upstream and downstream from the pool where the *A. opacum* larvae were collected, but no additional larvae were found.

To our knowledge, this is the first record of stream use by *A. opacum*. As all previous reports of lotic habitat use by *Ambystoma* concern species that deposit eggs directly into water, our observation is also the first record of lotic habitat use by a species of *Ambystoma* that typically deposits eggs in terrestrial nests (Petranka 1998, *op. cit.*). We thought it plausible that *A. opacum* larvae might have washed into the stream channel from upland ponds during a rain event; therefore, we searched the surrounding upland for > 300 m upstream and downstream from the pool for the presence of temporary ponds. No ponds or dry pond basins were found, and analyses of topographical maps support our observations. Whether adult female *A. opacum* deposited eggs directly into this pool, into terrestrial nests along the pool margin, or in the surrounding upland is unknown. The small sizes of pools in this stream suggest that during dry periods, these stream pools may be reduced to isolated pools similar in appearance to the temporary ponds typically utilized by *A. opacum*. In addition, we failed to encounter fish in this stream, suggesting that larval *A. opacum* could survive in these pools until metamorphosis. Continued monitoring of this stream and surrounding streams in future years will help us determine if our observation represents a single occurrence or a common behavior.

Larvae were verified by Ronald A. Brandon. Specimens were deposited in the SIUC Fluid Vertebrate Collection (SIUC H-08675).

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SIREN LACERTINA (Greater Siren). **DIET.** On 10 Sept 2006, a dead *S. lacertina* was retrieved from a minnow trap in Dry Bay, a 5-ha fishless Carolina bay located on the Dept. of Energy Savannah River Site, Aiken Co., South Carolina, USA. The siren was returned to the laboratory and frozen. On 28 Nov 2006, the siren was dissected and an *Ambystoma talpoideum* (Mole Salamander) was found in its stomach. The siren was 310 mm SVL, 485 mm TL, and mass was 236 g. Its mouth had a maximum vertical gape of ca. 10 mm with a horizontal opening of ca. 15 mm. The remains of the *A. talpoideum* weighed 3.27 g and appeared to be in the early stages of digestion (e.g., the skin was mostly digested, but the organs were relatively identifiable). The head was separated from the rest of the body and was possibly decapitated during mastication. Although *S. lacertina* are known to consume small fish (Hanlin 1978. Copeia 1978:358–360), this is the first report of a non-fish vertebrate consumed by *S. lacertina*.

Salamanders were captured under scientific research permit 56-2003 from the South Carolina Dept. Natural Resources. Funding was provided by the National Science Foundation (Awards DEB-0242874 and DBI-0139572) and the Savannah River Ecology Laboratory under Financial Assistance Award DE-FC09-96SR18-546 between the University of Georgia and the U.S. Dept. of Energy.

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TARICHA GRANULOSA (Rough-skinned Newt). **PREDATION**. On 6 Aug 2006, JRT and SF observed an immature Great Blue Heron (*Ardea herodias*) catch and swallow an adult *Taricha granulosa* at a small pond at Point Reyes National Seashore, Marin County, California, USA (UTM 505530E, 4219240N). The heron was observed at Abbott's Lagoon pond at 1225 h on a clear, sunny day. The heron was seen catching the newt, holding the newt in its bill (Fig. 1), moving to a shallower part of the pond, and then repeatedly dunking the newt in the pond. The heron also dropped the newt a few times, only to pick it back up and proceed to dunk it in the water. After 5–8 minutes the heron tilted its head back and swallowed the newt whole. The heron was photographed >10 min after it ate the newt. This same behavior had been observed by SF on several occasions at the same pond during August. On 12 Aug, a Great Blue Heron was observed by SF eating three newts over a 45 min period. This suggests that the heron survived eating newts, and continued to include newts as part of its diet. We subsequently searched the perimeter of the pond and did not find any dead herons.

FIG. 1. Great Blue Heron (*Ardea herodias*) holding a *Taricha granulosa* in its bill. A single heron was observed eating as many as three newts in 45 min.

The newt can be identified to species from the photo, but we have also conducted 72 amphibian surveys at the pond since 1993. We found *T. granulosa* on 12 occasions and have never found *T. torosa*, the only other *Taricha* present in the area. Based on 1426 amphibian surveys conducted throughout the park since 1993 (309 sites), the nearest known *T. torosa* localities are 8.5 km and 12 km away.

Brodie et al. (1974. Copeia 1974:506–511) described the skin toxins of *T. granulosa* as more toxic than any known substances from the skin of other salamanders. The Common Gartersnake (*Thamnophis sirtalis*) is the only species reported to regularly feed on *T. granulosa*. Of the six species of North American newts, birds have been reported to eat only *T. granulosa* (Lannoo 2005. Amphibian Declines: The Conservation Status of United States Populations. Vol. 2. Univ. California Press, Berkeley, California, xxi + 1094 pp.), and in all cases, the birds had been found dead (Marks and Doyle 2005. *In* Lanoo [ed.], Amphibian Declines: The Conservation Status of United States Populations. Vol. 2, pp. 894–900. Univ. California Press, Berkeley, California). The birds included a Pied-Billed Grebe (*Podilymbus podiceps*), Mallard (*Anas platyrhynchos*), and domestic chicken (*Gallus domesticus*). Brodie (1968. Copeia 1968:307–313) placed the tail of a *T. granulosa* in the rear of the mouth of a Great Blue Heron and reported that the heron was unable to stand upright after 90 sec, and was dead after 120 sec. This suggests that Great Blue Herons have little tolerance for tetrodotoxin and that the apparent washing behavior reported above might be effective at reducing the level of toxin on the skin of the newts. However, Hanifin et al. (1999. J. Chem. Ecol. 25[9]:2161–2175) reported variation in *T. granulosa* toxicity, both within populations and between populations. *Taricha granulosa* at the Point Reyes pond almost certainly have low toxicity.

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ANURA

ASCAPHUS TRUEI (Tailed Frog). **SPIDER PREY**. Few data describe the diet of the postmetamorphic *Ascaphus truei*. Springtails (Collembola), amphipods (Amphipoda), stonefly nymphs (Plecoptera), fly larvae (Diptera), and beetle larvae (Coleoptera) dominated the prey of 11 adult and 39 juvenile *A. truei* from Trinity County, California (Bury 1970. Copeia 1970:170–171). Bury (1970, *op. cit.*) also reported that six juvenile *A. truei* had each taken a spider (Araneae), but these were not identified to species, a condition necessary to properly interpret predator-prey natural history. Here, we report the first observation of spider prey identified to species for adult *A. truei*.

On 14 Aug 2006 at 1530 h, FTW found an adult male (36 mm SVL) *A. truei* along an unnamed headwater tributary of the South Fork Willapa River, Pacific County, Washington (46.5790N, 123.7239W, NAD 27, 224 m elev.). The stream is 2nd-order (*sensu* Strahler 1952. Geol. Soc. Am. Bull. 63:1117–1142), ca. 0.8 m wide, and located within a 55-year old second-growth mixed Western Hemlock (*Tsuga heterophylla*) and Douglas-fir (*Pseudotsuga menziesii*) managed forest on an intrusive basalt geology. The riparian canopy was undifferentiated from Western Hemlock/Douglas-fir vegetation upslope, but the riparian understory was differentiated by scattered Stink Currant (*Ribes bracteosum*), Salmonberry (*Rubus spectabilis*), Lady Fern (*Athyrium filix-femina*), and Fringecup (*Tellima grandiflora*). Skies were clear; air temperature was 18°C. The frog, captured <1 m from the stream, had an adult (ca. 13 mm cephalothorax–abdominal length) male Folding-door Spider, *Antrodiaetus pacificus,* in its mouth. FTW removed the spider from the frog, preserved it, and measured and released the frog at the capture site.

Antrodiaetus pacificus is a soil-dwelling spider in the Suborder Mygalomorphae, which also includes tarantulas (Coyle 1971. Bull. Mus. Comp. Zool. 141:269–402). Though relatively small for a mygalomorph, it is one of the larger spider species in Willapa Hills conifer forests. Females live in burrows, whereas mature males wander seasonally in search of mates. As the species is often recorded from riparian forest habitats in the Pacific Northwest (Parsons et al. 1991. Invertebrates of the H. J. Andrews Experimental Forest, Western Cascade Range, Oregon. V: An Annotated List of Insects and Other Arthropods. USDA Forest Service, GTR, PNW-GTR-290, Portland, Oregon; Johnston 1994. California Forests and Woodlands: A Natural History. Univ. California Press, Berkeley. 222 pp.; Hocking and Reimchen 2002. BMC Ecology 2:4), terrestrial stream-margin wandering of males may make them vulnerable to adult *A. truei*, which can be common in this habitat (Jones et al. 2006. Amphibians of the Pacific Northwest. Seattle Audubon Society, Seattle, Washington. 227 pp.). However, at any given site, availability of male *Antrodiaetus* as prey is likely limited to a few days each year, varying from early August to October for different coastal Washington populations of the spider (Coyle, *op. cit.*; RLC, unpubl. data). Many more common spiders are available as frog prey in this habitat, including some ground dwellers in the same size range as *Antrodiaetus* (e.g., *Cybaeus* spp. [family Cybaeidae], which are abundant much of the year in coastal conifer forests).

The *A. pacificus* was deposited in the Arachnology collection at the University of Washington Burke Museum. This is contribution No. 13 of the Forests and Fish Section of the Washington Department of Fish and Wildlife's Habitat Program Science Division.

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BUFO AMERICANUS (American Toad). **HINDLIMB DEFORMITIES.** Amphibian ecologists and the public have recently given a great deal of attention to the issue of amphibian limb deformities. It has become evident there are many causes of amphibian deformities (e.g., Blaustein and Johnson 2003. Front. Ecol. Environ. 1:87–94; Sessions 2003. *In* Semlitsch [ed.], Amphibian Conservation, pp. 168–186. Smithsonian Press, Washington, D.C.). To better understand the extent and effects of amphibian limb deformities, additional information is needed on the rates of amphibian limb deformities from a variety of locations and species, particularly from ponds that appear relatively undisturbed or contaminated, to provide a better baseline for comparison to mass deformity events.

While collecting information on the performance of metamorphs from three local ponds, we examined several hundred American Toad tadpoles for limb deformities. The three ponds (Spring Peeper, Olde Minnow, and Taylor-Ochs) examined were on the Denison University Biological Reserve (Granville, Licking County, Ohio, USA) and are apparently free from any major pollutants or disturbance (see Schultz and Mick 1998. Ohio Biol. Surv. Notes 1:31–38 for a description of the ponds). We collected American Toad metamorphs from the water's edge of each pond from 2–9 June 2006. Each metamorph was examined for deformities and the type of deformity, if present, was recorded. We found hind limb deformities of varying degrees in two of the three ponds (Table 1). The observed frequencies of hind limb deformities in the three ponds ranged from 0–3.6%. These values fall within the range of frequencies observed in other species for historical records (i.e., prior

TABLE 1. Incidence of hindlimb deformities in American Toad, *Bufo americanus*, metamorphs from three ponds in central Ohio. All deformities were ectromelia of the femur or the tibiafibula (*sensu* Meteyer 2000. Field Guide to Malformations of Frogs and Toads with Radiographic Interpretations. USGS Biol. Sci. Rep. USGS/BRD/BSR-2000-0005).

	N Examined	N Deformed	% Deformed
Spring Peeper Pond	172	1	0.6%
Olde Minnow Pond	215	8	3.6%
Taylor-Ochs Pond	155	0	0%

to 1980) or for relatively undisturbed sites (e.g., Ouellet et al. 1997. J. Wildl. Dis. 33:95–104; McCallum and Trauth 2003. J. Wildl. Dis. 39: 522–528; Eaton et al. 2004. J. Herpetol. 38:283–287). The two ponds (Spring Peeper and Olde Minnow) where we found deformities were also the ponds with the slowest tadpole growth rates, smallest metamorphs, and highest numbers of predators (mosquitofish and dragonfly nymphs) (G. R. Smith et al., unpubl. data).

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BUFO TERRESTRIS (Southern Toad). **ARBOREAL BEHAVIOR**. North American *Bufo* are highly terrestrial ground-dwellers. Only a few accounts describe climbing behavior: a *Bufo americanus* climbing a steep rocky incline in Tennessee, USA (G. Lepera, pers. comm.), *B. marinus* found in natural tree holes in Venezuela (Mijares-Urrutia et al. 1996. Herpetol. Rev. 27:138), and *B. valliceps* in arboreal refugia in Texas, USA (Neill and Grubb 1971. Copeia 1971:347–348). Here, I report an observation of a *B. terrestris* using an arboreal tree cavity as a refuge on Cumberland Island, Camden County, Georgia, USA.

At 2230 h on 23 Sept 2006, I found a funnel-shaped cavity (ca.10 cm wide by 15 cm deep) at a height of ca. 1.6 m on a mature oak (*Quercus* sp.). The cavity likely originated from a branch that broke at its base, with subsequent decomposition of the heartwood. Inside the hollow, I found an adult *Bufo terrestris* resting about 10 cm from the entrance. The toad retreated inside the hollow, which slightly curved towards the trunk of the tree and stopped at what coincided with the middle of the branch. I probed the hollow with a piece of grass in an attempt to determine whether it continued past the curve, but I was unsuccessful in finding an opening. The toad inflated its body, raised its back, and pointed its paratoid glands at me, but did not retreat further.

I was unable to discern how the toad reached the cavity. Because of the relative remoteness of the locality, it is unlikely that humans put it there. Either the toad climbed up the outside of the vertical trunk until it reached the hollow's opening, or it used a vertical open space within the tree's trunk and followed it until it reached the cavity. However, no external opening to such an internal cavity was found at the base of the tree.

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BUFO WOODHOUSII (Woodhouse's Toad). **CANNIBALISM.** Little information exists on the feeding habits of *Bufo woodhousii* although they are presumed to feed on a variety of invertebrates (Lannoo 2005. Amphibian Declines. The Conservation Status of United States Species. Univ. California Press, Berkeley. 1094 pp.). In Kansas, *B. woodhousii* has been reported to feed on bees, beetles, insect larvae, spiders, and ants (Smith 1934. Amer. Midl. Nat. 15:377–528). Smith and Bragg (1949. Ecology 30:333–349) examined the stomach contents of 517 adult and 43 juvenile *B. woodhousii* from Oklahoma and reported no vertebrate remains. However, Smith and Bragg (*op. cit.*) reported the consumption of a small lizard by a juvenile *B. woodhousii* maintained in captivity. In Nebraska, *B. woodhousii* is reported to feed on beetles, ants, spiders, and other invertebrates (Hudson 1942. Nebraska Cons. Bull. 24:1–146).

During summer 2006, 56 *B. woodhousii* were collected at Beckius Pond (41.12529°N, 101.37276°W) Keith Co., Nebraska. Twenty-eight toads were collected during the night (2230–2330 h) on 23 July 2006 and 28 toads were taken during the day (1430–1530 h) on 27 July 2006. Toads were placed in refrigeration until dissection. Toads were euthanized and SVL and gape size were recorded to the nearest mm for each individual. The stomach, small intestine, and large intestine were removed, and the stomach was separated from the rest of the gastrointestinal tract. Each stomach was opened and preserved in 70% ethanol. The stomach contents were examined under a dissecting microscope, and identified into several broad categories and recorded as frequencies of organism ingested. Arthropods were identified to order according to Triplehorn and Johnson (2005. Borror and Delong's Introduction to the Study of Insects. 7th ed. Thomson, Grooks/Cole. 864 pp.).

Toads ranged from 2.9–7.3 cm SVL (mean 4.5 ± 1.2 cm) and gape size 8–28 mm (mean 1.67 ± 0.47 cm). Toads fed on 11 different groups of arthropods; 1944 items were recovered from stomach contents, including Diptera (1440), ants and other Hymenoptera (378), Coleoptera (93), Orthoptera (10), Hemiptera (8), Odonata (6), Pseudoscorpiones (3), Araneae (2), Lepidoptera (2), Homoptera (1), and Isopoda (1). Additionally, three toads contained remains of four smaller *B. woodhousii*. A single male collected at night (SVL 6.7 cm) contained one partially digested *B. woodhousii* (ca. 2.5 cm), and two toads (one female SVL 6.1 cm; one male SVL 6.6 cm) collected during the day contained one and two partially digested *B. woodhousii* (ca. 2.0–2.5 cm), respectively.

Although there are reports of ranids feeding on bufonids (Pearl and Hayes 2002. Am. Midl. Nat. 147:145–152) and ranid cannibalism (Stuart and Painter 1993. Herpetol. Rev. 24:103) we are not aware of any reports of bufonid cannibalism. These are important observations as many bufonids are considered ant and beetle specialists (Clarke 1974. Am. Midl. Nat. 91:140–147; Smith and Bragg, *op. cit.*).

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CHAUNUS ARENARUM (Argentine Toad). **ENDOPARASITES.** *Chaunus arenarum* ranges from northern Jujuy Province to the southern borders of Neuquén Province reaching 2400 m in La Rioja Province, Argentina. The species also occurs in southern Brazil, Uruguay, and Bolivia (Cochabamba) (Cei 1980. Amphibians of Argentina. Monit. Zool., Italia, Firenze, Monogr. 2:1–609). Previous reports of nematodes in *C. arenarum* are in Baker (1987. Mem. Univ. Newfoundland, Occas. Pap. Biol. 11:1–325). The purpose of this note is to report the nematodes *Oswaldocruzia proencai* and *Ophidascaris* sp. in *Chanus arenarum* from Argentina.

Three *C. arenarum* (one male SVL 80 mm and one female 110 mm SVL) from Itaú River (22°20'51"S, 64°05'47.7"W; 483 m elev.), and one male (SVL = 83 mm) from Astilleros (22°23'01"S; 64°06'14.4"W; 493 m), General San Martín Department, Province of Salta, Argentina were collected in Sept 2005. They were deposited in the Herpetology Collection, Fundación Miguel Lillo as 17186–17187, and 17196. The body cavity was opened by a mid-ventral incision and the digestive tract was removed. The esophagus, stomach, and small and large intestines were longitudinally slit and the contents were examined for helminths using a dissecting microscope. Two species of Nematoda were found: *Oswaldocruzia proencai* (1 male, 3 females) in the large intestines and *Ophidascaris* sp. (2 juveniles) in the stomach. They were deposited in the Helminthological Collection, Fundación Miguel Lillo as *O. proencai* (CH 07443; CH 07448) and *Ophidascaris* sp. (CH 07445).

Slimane and Durette-Desset (1995. Revue Suisse Zool. 102:635–653) redescribed *Oswaldocruzia mazzai* as a parasite of *C. marinus* from Argentina, and in so doing reassigned specimens from *C. schneideri* (as *Bufo paracnemis), Leptodactylus ocellatus*, and *L. bufonius* collected in Paraguay by Lent et al. (1946. Mem. Inst. Oswaldo Cruz 44:195–214) to a new species, *Oswaldocruzia proencai*. *Oswaldocruzia proencai* differs from *O. mazzai* in morphology of the cephalic vesicle, that of *O. mazzai* is simple, that of *O. proencai* is in two parts. Hendrikx (1983. Zeits. fur Parasiten. 69:119–126) reported oral infection of toads by *Oswaldocruzia* sp.

Ophidascaris sp. is a member of the Ascaridae, which typically utilizes vertebrates as intermediate hosts in which development to the stage infective to the definitive (final) host occurs (Anderson 2000. Nematode Parasites of Vertebrates. Their Development and Transmission. CABI publishing, Wallingford, Oxon, U.K. 650 pp.). *Oswaldocruzia proencai* and *Ophidascaris* in *C. arenarum* are new host records.

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CHAUNUS MARINUS (Cane Toad). **PREDATION**. *Chaunus marinus* is native to South and Central America and produces cardiac poisons known as bufotoxins in their paratoid glands and skin. In northeastern Australia, Hawaii, the Philippines, South Florida, and the Caribbean, where the species has been introduced, the Cane Toad is noxious or lethal to many vertebrate predators, including quolls (*Dasyurus* spp.), monitor lizards (*Varanus* spp.), snakes, and domestic dogs (Lever 2001. The Cane Toad: The History and Ecology of a Successful Colonist. Westbury, Otley, UK, 230 pp.; Phillips et al. 2003. Conserv. Biol. 17:1738–1747). After a predator bites or mouths a toad, death or temporary paralysis occurs within minutes, with foaming at the mouth, vomiting, and convulsions often being observed (Covacevich and Archer 1975. Mem. Queensland Mus. 17:305–310; Lever 2001, *op. cit*.; Phillips et al. 2003, *op. cit*.).

On a late afternoon in mid-November 2001, we observed an adult Common Opossum (*Didelphis marsupialis*) climb a 5-m tall avocado tree outside our kitchen window in Gamboa (9°07'N, 79°38'W), a small township that borders the Panama Canal and Soberania National Park in central Panama. It was holding in its mouth a large and apparently recently killed Cane Toad, with an estimated SVL 12–13 cm. To our surprise the opossum completely consumed the toad, initially gnawing and swallowing its rostrum and head, and then proceeding to its hindquarters and rear legs, over a period of several minutes. The opossum was 6 m away from us and we watched it closely with 10-power binoculars. The large paratoid glands of the Cane Toad were readily visible, and we anticipated that the opossum would attempt to avoid these, but it consumed the entire toad with apparent impunity.

After the toad was entirely eaten, the opossum remained in the tree and under our observation for about 20 min until darkness approached. As it rested in the tree it thoroughly licked clean its bloody paws and face and showed no signs of poisoning or distress. We do not know the ultimate fate of the opossum, but there was no dead body anywhere in the vicinity the following morning. The Cane Toad is common in the mosaic of lawns and secondary forest in Gamboa, and the combination of its large body size, distinctive head shape, massive paratoid glands, mottled yellow-brown dorsal coloration, and warty skin surface easily discriminate it from other toad species in the area (e.g., *Rhaebo haematiticus, Rhinella alatus* (*typhonius*); Ibañez et al.1999. The Amphibians of Barro Colorado Nature Monument, Soberania National Park, and Adjacent Areas. D'Vinni Editorial Ltd., Bogota, Colombia. 187 pp.). Aside from the resilience of the opossum to Cane Toad poisoning, we were surprised to see the event occurring before nightfall, as both the opossum and Cane Toad are typically nocturnal (Emmons and Feer 1997. Neotropical Rainforest Mammals: A Field Guide. Univ. Chicago Press, Chicago. 307 pp.; Ibañez et al. 1999, *op. cit*.).

We described our observation to various herpetologists including the late Stanley Rand (a Smithsonian Institution herpetologist and long-term resident of Gamboa). None had observed or heard of similar accounts. There are several possible explanations for our observation. It is possible that bufotoxins are toxic to opossums but are manifested only slowly, or that the toad we observed was somehow deficient in toxin production. Alternately, the Common Opossum, whose geographic range in Central and northern South America overlaps broadly with the natural range of the Cane Toad, might have evolved specific resistance to bufotoxins. Perhaps the most plausible explanation, however, is that Common Opossums might be broadly immune or resistant to a wide range of organic toxins. This latter interpretation is supported by the observation that *Didelphis* opossums are immune to the venom of crotalid vipers, on which they are known to prey (R. S. Voss, American Museum Natural History, pers. comm.), and that this immunity is conferred by a so-called Lethal Toxin Neutralizing Factor, originally isolated from *D. virgianus*, which neutralizes a wide range of snake, scorpion, and bee venoms as well as many animal, plant, and bacterial toxins (Lipps 1999. J. Venom. Anim. Toxins 5:56–66). The remarkable physiological tolerance of opossums is in striking contrast to most predatory vertebrates in areas where Cane Toads have been introduced, especially in Australia where no native toads occur, for which the Cane Toad is highly toxic.

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CHAUNUS POMBALI (Pombali's Toad) **PREDATION.** *Chaunus pombali* is found extensively in Minas Gerais State, southeastern Brazil, where this species occurs in the Atlantic rainforest and transition areas with the Cerrado formation (Baldissera et al. 2004. Arq. Mus. Nac., Rio de Janeiro 62:255–282).

During an anuran survey on 30 Aug 2006 in Viçosa, Minas Gerais State (20°45'S, 42°51'W), we observed predation of *C. pombali* by the exotic American Bullfrog (*Rana catesbeiana*). The observation occurred at a permanent dam on the Universidade Federal de Viçosa campus. At 1840 h, we observed an adult male *R. catesbeiana* holding an individual *C. pombali*, with the head and forelimbs protruding out of the mouth. For ca. 5 min. the *R. catesbeiana* remained motionless, then jumped into the water still holding the *C. pombali*. Stomach content analysis of a *R. catesbeiana* collected on 28 Sept 2005 (SUL 147.95 mm, Museu de Zoologia João Moojen de Oliveira, Universidade Federal de Viçosa, MZUFV 6374) from the same locality revealed a whole *C. pombali* (SVL 56.1 mm), indicating that predation on this species is not uncommon.

Rana catesbeiana was introduced into Brazil in the 1930s for commercial breeding. Poor management practices and high survival of individuals in wild habitats have allowed this species to establish viable populations in many regions of the country. Amphibians represent a substantial part of the diet of *R. catesbeiana* (Pearl et al. 2004. Copeia 2004:11–20). Our observations suggest that the poison glands of *C. pombali* do not deter predation by *R. catesbeiana*.

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COPHIXALUS ORNATUS (Ornate Nursery Frog). **CHYTRIDIOMYCOSIS.** Chytridiomycosis is an emerging infectious disease linked to amphibian population declines worldwide (Berger et al. 1998. Proc. Natl. Acad. Sci. 95:9031–9036). The chytrid fungus *Batrachochytrium dendrobatidis*, causative agent of chytridiomycosis, has an incredibly broad host range: it is currently known to infect over 160 amphibian species in two orders and 14 families (Speare and Berger 2004. www.jcu.edu.au/school/phtm/PHTM/frogs/chyglob.htm, updated with recently published accounts). Only seven of these species, however, are direct developers that bypass the free-swimming tadpole stage (*Eleutherodactylus cruentus, E. emcelae, E. melanostictus, E. karlschmidti, E. saltator, E. coqui,* and *Leiopelma archeyi*). Tadpoles are thought to be an important life stage with respect to disease transmission; they stand a high chance of being exposed to the fungus' aquatic zoospores and they do not succumb to chytrid infections, making them likely disease reservoirs (Daszak et al. 1999. Emerg. Inf. Dis. 5:735–748). Currently, there are no records of chytridiomycosis in Australian direct-developing frog species.

On 23 Sept 2005, KMK captured a male *Cophixalus ornatus* that was calling while perched on a leaf 2 m from the edge of Babinda Creek (70 m elev.), in Queensland, Australia. KMK firmly ran a cotton swab over the frog's dorsum, ventrum, sides, thighs, and the webbing of its feet, and used quantitative PCR (Boyle et al. 1994. Dis. Aquat. Org. 60:141–148) to test for the presence of *Batrachochytrium dendrobatidis*. Thirty-one chytrid zoospores were detected on the swab. This represents the first record of chytridiomycosis in an Australian direct-developing frog species, and only the eighth record worldwide.

There are no published reports of population declines in *C. ornatus*, a species whose large geographic range encompasses the localities of many of north Queensland's recent amphibian declines and disappearances, including that of *Taudactylus acutirostris* (the last known individual of which died of chytridiomycosis in 1995; Wright et al. 2001. J. Herpetol. Med. Surg. 11:14–27). Our finding of chytridiomycosis in *C. ornatus* supports the hypothesis that while all frog species may be exposed to the disease, there are ecological differences among sympatric species that might lead to differing disease outcomes, ranging from no effect on the population to mass mortality events and local extinctions (Daszak et al. 1999, *op. cit.*; Hero et al. 2005. J. Zool. Lond. 267:221–232).

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DENDROBATES AURATUS (Green and Black Poison Dart Frog). **LARVAL PREDATION.** *Dendrobates auratus* was intentionally introduced onto the island of O'ahu, Hawai'i in 1932 from Taboga Island, Panama for mosquito control. *Phelsuma laticauda* was accidentally introduced from Madagascar in 1996 to the University of Hawaii at Manoa. Both species are well established in the Manoa Valley.

While observing *D. auratus* tadpole depositions in the axils of a large *Vriesea imperialis* (Bromeliaceae), we often noticed adult *P. laticauda* on the leaves. At 0835 h on 1 Aug 2005, we witnessed an adult *P. laticauda* staring at the water in an upper axil of a large (ca. 1 m diameter at the base) *V. imperialis*. The skies were clear and the temperature was 26.2°C. The *P. laticauda* did not appear to notice our observations and continued to stare at the surface of the water. It moved lower into the axil until its snout was ca. 0.5 cm from the surface and continued to stare at the surface. It did this for ca. 3 minutes. At this point, a *D. auratus* tadpole ca. 2 weeks old (2.5 cm total length) swam to the surface. Almost instantly, the *P. laticauda* struck at the tadpole and pulled it out of the water headfirst. It shook the tadpole back and forth three of four times and cocked its head back and swallowed all but the tip of the tail. It then quickly walked up the leaf and finished swallowing the tadpole. We observed the gecko for ca. 30 min after the predation event before it disappeared into the leaf litter at the base of the bromeliad.

A second predation event occurred at 1200 h on 28 Aug 2005 that was practically identical to the previous event. A different adult *P. laticauda* consumed a *D. auratus* tadpole of comparable size in a different *V. imperialis* ca. 0.4 km away. To our knowledge, this behavior has not been observed in the field. This is probably due to the fact that the natural distribution of these two species does not overlap.

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DISCOGLOSSUS GALGANOI (West Iberian Painted Frog). **PREDATION.** *Discoglossus galganoi* is endemic to the western half of the Iberian Peninsula (Spain and Portugal). Much information exists about predators of adults and juveniles (review in Martínez-Solano 2003. Sapillo pintojo ibérico - *Discoglossus galganoi*. Enciclopedia virtual de los vertebrados españoles. Museo Nacional de Ciencias Naturales, Madrid. www.vertebradosibericos.org; García-París et al. 2004. Fauna Ibérica. 24. Amphibia, Lissamphibia. Museo Nacional de Ciencias Naturales, CSIC, Madrid. 640 pp.), although relatively little is known about predators of the larvae. Aquatic insects, fish, water snakes (*Natrix maura*, *N. natrix*), and amphibians (*Triturus marmoratus*) have been cited as predators of the larvae (García-París 1985. Los Anfibios de España. Publicaciones de Extensión Agraria, Madrid. 287 pp.; Barbadillo 1987. La Guía de Incafo de los Anfibios y Reptiles de la Península Ibérica, Islas Baleares y Canarias. Ed. Incafo, Madrid. 694 pp.; Salvador and García-París 2001. Anfibios Españoles. Canseco Ed., Talavera de la Reina. 269 pp.).

Discoglossus galganoi reproduces in shallow seasonal ponds, thus larvae may suffer high mortality when these ponds dry. It tolerates moderate concentrations of salt in breeding pools, therefore it can breed in marine cliff rainwater pools very close to the sea (Curt and Galán 1982. Esos Anfibios y Reptiles Gallegos. Ed. J. Curt, Pontevedra. 166 pp.; Galán 2003. Anfibios y Reptiles del Parque Nacional de las Islas Atlánticas de Galicia. Faunística, Biología y Conservación. Organismo Autónomo Parques Nacionales, Ministerio de Medio Ambiente, Madrid. 276 pp.). Reproduction in Galicia (northwest Spain) lasts from December until July (Galán and Fernández 1993. Anfibios e Réptiles de Galicia. Ed. Xerais, Vigo. 501 pp.; Vences 1994. Salamandra 30:81–83).

In some marine cliffs near the Hércules Lighthouse in the city of A Coruña (Galicia, northwest Spain; UTM 29T NJ 48 03; 43°23'N, 8°24'W), a population of *D. galganoi* reproduces in a series of small (average 250 × 100 cm; 7 cm average depth, range 1–35 cm) seasonal rainwater pools and run-offs, situated in the cracks and hollows of the cliff rock. These pools are located in the upper region of the marine cliffs, 9–15 m from the sea (depending on the tides). During the frequent storms, they receive spray from the surf, thus during these periods the water salinity is relatively high. The only amphibian that reproduces in these pools is *D. galganoi*. These seasonal pools have practically no larval predators. In this area, *D. galganoi* reproduces from November to June, with larvae present from the end of December until the ponds dry, typically in July (Galán, unpubl. data).

On 12 Jan 2006, at a rain pool (340 × 210 cm; max depth 12 cm; 11 m from the sea) with a rock bottom and 30% of its surface covered with vegetation formed by submerged *Paspalum vaginatum* and small *Armeria maritima* and *Ulex europaeus* shrubs at the edge, where *D. galganoi* larvae were found, one could observe a turnstone (*Arenaria interpres*) pecking at the edge (1230 h). This bird was observed with binoculars, verifying that it was capturing *D. galganoi* larvae with its beak. The turnstone scoured the periphery of the pool, submerging its head to a depth of 4–6 cm to capture larvae. On other occasions, it lifted up the submerged vegetation with its beak, capturing larvae that it found among the submerged stalks. At 1330 h, two turnstones were observed feeding in the same way at this pool and two other nearby ones of similar size, where there were also *D. galganoi* larvae. The density of *D. galganoi* larvae decreased in the pools where the turnstones fed, from an average of 350 larvae per m^2, estimated the previous day, to 62 larvae per m^2 after the predation.

This species of turnstone occupies the coastal cliffs in northern Spain from August until March, where it is a common wintering bird (Cramp and Simmons 1983. The Birds of the Western Paleartic. Vol. 3. Waders to Gulls. Oxford University Press, Oxford. 913 pp.; Díaz et al. 1996. Aves Ibéricas. Vol. 1. No Paseriformes. J. M. Reyero Ed., Madrid. 303 pp.; Penas-Patiño et al. 2004. Guía das Aves de Galicia. 2nd ed. Bahia Ed., A Coruña. 463 pp.). Its diet includes insects, mollusks, crustaceans, plant matter, fish, and carrion; amphibians are unrecorded (Cramp and Simmons 1983, *op. cit.*; del Hoyo et al. 1996. Handbook of the Birds of the World. Vol. 3. Hoatzin to Auks. Lynx Ed., Barcelona. 821 pp.). It frequently gets its food in tidewater pools formed in the rocks of the cliffs and some individuals specialize in certain prey types (Cramp and Simmons 1983, *op. cit.*).

Northwest Spain is one of the few areas where *D. galganoi* and *A. interpres* can be found together. This is true both in terms of location (coastal cliff pools) and time (the reproduction period of the *D. galganoi* and the wintering period of *A. interpres* overlap). Therefore, it seems logical that a bird with an opportunistic winter diet would consume amphibian larvae found near the seacoast.

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ELEUTHERODACTYLUS RIDENS (Pygmy Rainfrog). **PREDATION**. Workers of the large ponerine ant *Paraponera clavata* typically forage on small to medium-sized arthropods or collect pieces of plants or nectar (Janzen and Carroll 1983. Univ. Chicago Press, pp. 752–753.) but have been suspected of predating small vertebrates (Fritz et al. 1981. Biotropica 13[2]:158–159). Under experimental conditions (Fritz et al. 1981, *op. cit.*) individual *Paraponera* have been shown to sting and kill unidentified *Eleutherodactylus* that were restrained and presented to these ants. Here we present the first record of *P. clavata* potentially predating on *Eleutherodactylus ridens* under natural conditions.

At 0845 h on 6 Dec 2005, TE observed a single *P. clavata* transporting a dead adult male *E. ridens*. This observation was made in primary forest near Selva Verde Lodge in the vicinity of Guaria, Heredia Province, Costa Rica (10°26'59.6"N, 84°04'02.3"W). The insect was found on a leaf of a ca. 50 cm high plant (Maranthaceae), holding the already dead *E. ridens* in its mandibles and maneuvering its prey through the vegetation. It is possible that a recently dead individual was scavenged, although it is more likely that the ant stung and killed the frog, as Fritz et al. (*op. cit.*) demonstrated that the sting and powerful poneratoxins of *P. clavata* are sufficient to kill *Eleutherodactylus* spp. *Eleutherodactylus ridens* is abundant in the area (TL, pers. obs.) and is commonly found sleeping on low vegetation during the day, primarily relying on crypsis to avoid detection by predators and only fleeing when the leaf it is resting on is moved by a potential predator (TAL, pers. obs.). Foraging *P. clavata* would be able to readily approach and attack sleeping *E. ridens* as their small size and low body weight would not trigger an escape response by the frog.

Photographs of this event have been deposited in the media collection of the Division of Vertebrate Zoology at the Yale Peabody Museum of Natural History (YPM HER M 1142–43).

FIG. 1. Adult male *Eleutherodactylus ridens* being transported by a ponerine ant (*Paraponera clavata*), vic. of Guaria, Heredia Province, Costa Rica.

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HYLA ARENICOLOR (Canyon Treefrog). **DIET**. Although there have been several recent studies on various aspects of the ecology of *Hyla arenicolor* (e.g., disease, Bradley et al. 2002. J. Wildl. Dis. 38:206–212; parasites, Goldberg et al. 1996. J. Parasitol. 82:833–835, Sladky et al. 2000. J. Zoo. Wildl. Med. 31:570–575, Jung et al. 2000. Herpetol. Rev. 32:33–34; thermoregulation and water economy, Preest et al. 1992. Herpetologica 48:210–219, Snyder and Hammerson 1993. J. Arid. Environ. 25:321–329), there are few, if any, reports on its diet. Here we report observations on the stomach contents of six *H. arenicolor* collected during 2003 and 2004 from Milpillas, Municipio Chínipas, Chihuahua (N = 1; 27°12'9.7"N, 108°38'47.3"W; WGS 84; 1259 m elev.), Huisivo, Chihuahua (N = 1; 27°23'39.9"N, 108°32'36.0"W; WGS 84; 469 m elev.); km 17 Creel-San Rafael, Municipio Urique, Chihuahua (N = 1; 27°40'1.1"N, 107°44'42.7"W; WGS 84; 2233 m elev.), and Yécora, Sonora (N = 3; 28°22'4.0"N, 108°55'32.6"W; WGS 84; 1545 m elev.) (see Lemos-Espinal et al. 2004. Bull Chicago Herpetol. Soc. 39:107–109; Smith et al. 2005. Bull Chicago Herpetol. Soc. 40:45–51). All six individuals contained identifiable stomach contents. The diet of *H. arenicolor* contained a fairly large diversity of organisms (Table 1). Numerically, termites and beetles were the most important prey, but volumetrically, beetles and orthopterans were most important.

TABLE 1. Stomach contents of 6 *Hyla arenicolor* from Chihuahua and Sonora, México.

Prey type	Prey Items N	(%)	Volume cm^3	(%)	Number of Stomachs
Coleoptera	6	(30)	0.72	(45.3)	3
Dermaptera	1	(5)	0.14	(8.8)	1
Homoptera	1	(5)	0.12	(7.6)	1
Hymenoptera (ants)	1	(5)	0.01	(0.6)	1
Isoptera	10	(50)	0.03	(1.9)	1
Orthoptera	1	(5)	0.57	(35.9)	1

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LEPTOBRACHIUM SMITHI (Smith's Litter Frog). **ANTIPREDATOR BEHAVIOR**. *Leptobrachium smithi* is a megophryid frog described from "Ton Nam Plu Waterfall" Khao Chong, Trang Province, southern Thailand (7°34'N, 99°49'E, 260 m elev.) (Matsui et al. 1999. Japan J. Herpetol. 18:19–29). Distribution includes Thailand, Myanmar, India, Bangladesh, and Laos (Nabhitabhata et al. "2000" [2004]. Checklist of Amphibians and Reptiles in Thailand. Office Environmental Policy and Planning. 152 pp.; Das et al. 2004. Asiatic Herpetol. Res. 10:245–246;

FIG. 1. An adult male *Leptobrachium smithi* exhibiting antipredator behavior.

Sengupta et al. 2001. J. Bombay Nat. Hist. Soc. 98[2]:289–291; Asmat et al. 2003. Univ. J. Zool. 22:141–143; Stuart 2005. Herpetol. Rev. 36:473–479). Defensive behavior in *L. smithi* has not been reported previously.

On 30 June 2006, an adult male *L. smithi* was collected as it called in hilly evergreen forest (47 Q 0700022, UTM 1834963, 714 m elev.) at Nong Mae Na Protected Unit of Thung Salaeng Luang National Park, Khao Khor District; Phetchabun Province by Y. Chuaynkern and C. Inthara. While being manipulated for photographs, the frog assumed an antipredator behavior when touched near the vent. The individual arched its back with its head elevated ca. 90°, the eyes were bulged which prominently displayed the contrasting orange and black eye color (Fig 1). The limbs were outstretched and the frog remained motionless. A somewhat similar behavior is well known in *Bombina variegata*, with the frog resting on its belly, the chin elevated, and the bright orange palms and soles of the feet upturned (Duellman and Trueb 1986. Biology of Amphibians. McGraw-Hill Book Co., New York. 670 pp.).

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LEPTODACTYLUS MELANOTUS (Sabinal Frog). **DIET**. Little is known about the ecology of *Leptodactylus melanotus*. Here we report observations on the stomach contents of seven *L. melanotus* collected during 2004 from Río Mayo at the gates of Presa Mocuzari, Sonora, México (27°13'25.6"N, 109°6'30.6"W; WGS 84; 90 m elev.) (see Smith et al. 2005. Bull Chicago Herpetol. Soc. 40:45–51). Of the seven individuals, five contained identifiable stomach contents, one contained unidentifiable stomach contents, and one had an empty stomach. Table 1 lists the prey items. Numerically, beetles and collembolans were the most important prey items, but volumetrically beetles were the most important.

TABLE 1. Stomach contents of *Leptodactylus melanotus* from Sonora, México.

Prey Type	Prey Items N	(%)	Volume cm^3	(%)	Number of Stomachs
Coleoptera	9	(45)	0.13	(10.5)	3
Collembola	8	(40)	0.03	(68.4)	1
Hymenoptera (ants)	1	(5)	0.01	(15.8)	1
Araneae	2	(10)	0.02	(5.3)	2

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OSTEOPILUS SEPTENTRIONALIS (Cuban Treefrog). **DIET**. Anurans are generally cited as the prey and not the predators of aeshnid dragonflies (Buskirk 2000. Ecol. 81:2813–2821; Caldwell et al. 1980. Oecologia 46:285–289). Dragonflies have been occasionally recorded in *Osteopilus septentrionalis* diet (0.6 % of stomachs examined), but the species taken were not identified (Meshaka 2001. The Cuban Treefrog in Florida. Univ. Press Florida, Gainesville. 192 pp.). Here we document the first observation of *O. septentrionalis* preying on the dragonfly *Anax junius* (Green Darner).

Osteopilus septentrionalis and *A. junius* have been observed on many occasions to perch on the window shutters of the Environmental Learning Center at Rookery Bay National Estuarine Research Reserve, Collier County, Florida, USA. At ca. 1130 h on 14 July 2006, TMB observed an adult female *O. septentrionalis* (6.4 cm SVL) capture and eat an adult (7.8 cm TL) female *A. junius*. Conditions at the time were hot (33°C) and humid (65% RH), with light wind (5 mph), high pressure (1018.6 mb) and overcast. The treefrog lunged at the dragonfly with its mouth open and its tongue pad protracted. The dragonfly was captured sideways, and its wings and abdomen protruded from the treefrog's mouth. Subsequently, the treefrog used its forelimbs to push the prey headfirst into its mouth. Handling time was ca. 15 min. The treefrog was immediately captured, and subsequent dissection revealed a rapid digestion of the *A. junius* abdomen and no other prey within the stomach, few fat bodies, and a nearly gravid reproductive status.

Osteopilus septentrionalis is a sit-and-wait predator capable of eating very large prey (Meshaka 2001, *op. cit.*). The wide variety of prey items in the diet of *O. septentrionalis* indicates that it is not a specialized feeder, but Coleoptera and Blattaria are the prevailing categories of items in stomach contents (Meshaka 2001, *op. cit.*). *Anax junius* is one of the largest (60–80 mm) dragonflies in South Florida (Dunkle 1989. Dragonflies of the Florida Peninsula, Bermuda, and the Bahamas. Gainesville, Florida, Scientific Publishers. 154 pp.). The geographic range of *A. junius* overlaps with that of *O. septentrionalis*. Although it is unlikely to be preyed upon by the smaller native treefrogs, the depredated individual was ca. 122% of the predator's body length, and average body sizes of female *O. septentrionalis* exceeding 6 cm are typical of Florida populations (Meshaka 2001, *op cit.*). Furthermore, the *O. septentrionalis* was yolking and had little fat development. Thus, it would seem that in chance encounters between these species on sultry days or near dusk, even large *A. junius* are susceptible to the depredations of *O. septentrionalis*, and in turn mature females are provided with a nutritious meal.

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PLEURODEMA NEBULOSA (NCN)**. REPRODUCTION.** *Pleurodema nebulosa* occurs in the arid areas of western Argentina, from Catamarca to Rio Negro (Cei 1980. Amphibians of Argentina. Monit. Zool. Ital. [NS]. Monogr. 2, 609 pp.). Herein we present the first data on the reproductive ecology of *Pleurodema nebulosa* in Argentina. Our study area was located 40 km N of San Juan City on National Route N40. This area is in the Monte Phytogeographic Province (Cabrera and Willink 1980. Biogeografía de América Latina. O.E.A. Washington, DC. 109 pp.). Dominant vegetation includes *Prosopis* sp., *Bulnesia retama, Solanum eleagnifolium, Caparis atamisquea, Grabousquia obtusa,* and *Tamarix gallica*.

Individual male and female *P. nebulosa* were captured by hand after heavy rains occurred in the area on 17–18 and 20 Jan 2004. Ovarian mass was determined by weighing to 0.001 g. The number of mature ova was calculated by counting a subset of the entire mass, and ova diameter was measured to 0.02 mm under a binocular magnifying glass. Testicular volume was calculated using the formula for an ellipsoid sphere (Dunham 1983. *In* Huey et al. [eds.], Lizard Ecology, pp. 261–280. Harvard Univ. Press, Cambridge, Massachusetts).

The mean number of mature ova was 547 (SD = 318.3, range = 175–962, N = 11); mean ova diameter was 0.91 mm (SD = 0.13, range = 0.74–1.2 mm, N = 11). As female size increases so does fecundity, i.e., the number of ovules produced increases (R^2 = 0.55, p <0.0059). Mean testicular volume was 2.39 mm^3 (SD =1.36, range = 0.55–5.8 mm^3, N = 22). A positive and significant relationship exists between testicular volume and SVL (R^2 = 0.54, p <0.00005) and between testicular volume and mass of the individuals (R^2 = 0.57, p <0.00002).

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PLEURODEMA TUCUMANA (NCN). **REPRODUCTION.** *Pleurodema tucumana* is a small leptodactylid frog that occurs in northern and west-central Argentina (Lavilla et al. 2000. Categorización de los Anfibios y Reptiles de la República Argentina. Asoc. Herpetol. Arg. 97 pp.). Information on the species is restricted to preliminary data on reproduction (Perotti 1997. Rev. Chilena Hist. Nat. 70:277–288). Herein, we report the first reproductive data of the species from Chaco Phytogeographic Province, Distrito Chaco Serrano in western Argentina (Cabrera and Willink 1980. Biogeografía de América Latina. O.E.A. Washington D.C. 109 pp.).

We collected 30 *P. tucumana* (20 males and 10 females) from the Las Tumanas River (30°52'S, 67°19'W. 750 m elev.), Valle Fértil Department at 137.5 km from San Juan city during January 2000. Flora at the study site was dominated by *Schinopsis haekeana* and *Aspidosperma quebracho-blanco*. Frogs were captured by hand, preserved, and deposited in the Facultad de Ciencias Exactas, Físicas y Naturales of the Universidad Nacional de San Juan Collection (MCN-UNSJ4100-4129).

Mean SVL of males (N = 20) was 32.7 mm (range 27–35 mm; SD 1.68 mm), mean body mass was 3.34 g (1.18–4.96 g; SD 0.82 g), and mean testicular volume was 0.83 mm^3 (0.31–1.27 mm^3; SD 1.44 mm^3). SVL was not associated with testicular volume (r_s = -0.025; p = 0.91) nor body mass (r_s = 0.16; p = 0.49).

Mean SVL of gravid females (N = 10) was 37.3 mm (range 36–39 mm; SD 1.05 mm), mean body mass was 5.16 g (3.37–6.77 g; SD 1.07 g), mean mature ovum count was 993 (255–2933; SD 838), mean mature ovum diameter was 0.68 mm (0.04–0.98 mm; SD 0.37 mm), mean ovary mass was 0.33 mg (0.04–1.1 mg; SD 0.33 mg), and mean factor of ovarian size was 22.2 (0.29–34.1; SD 22.8). The mature ovum count was not correlated with SVL (r_s = 0.33, p = 0.35) nor body mass (r_s = 0.56, p = 0.08). There was a significant relationship between mature ovum diameter and mature ovum count (r_s = 0.74, p = 0.01). The ovary mass averaged 6.8% of the body mass in females.

The reproductive data presented herein for *P. tucumana* from Chaco serrano is similar to that from Chaco semiarid (Perotti 1997, *op. cit.*).

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RANA CATESBEIANA (American Bullfrog). **DIET**. On 27 Aug 2006, three adult *R. catesbeiana* were collected from Big Muskego Lake (42°51.241'N, 88°07.456'W), Muskego, Waukesha County,

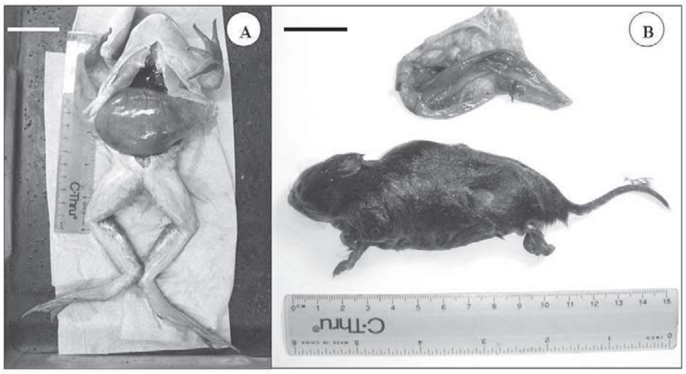

FIG. 1A. Adult male *Rana catesbeiana*; note the distended stomach. Bar = 40 mm. 1B. Adult male meadow vole, *Microtus pennsylvanicus*. Bar = 25 mm.

Wisconsin, USA. Frogs were captured by hand with the help of a headlamp (ca. 030 h). All frogs were euthanized and SVL and gape size were recorded to the nearest mm for each individual. The stomach, small intestine, and large intestine were removed, and the stomach was separated from the rest of the gastrointestinal tract. Each stomach was opened and contents examined under a dissecting microscope. A male *R. catesbeiana* (SVL 13.5 cm; gape size 5.2 cm) had a greatly distended stomach (Fig. 1a), which contained a small mammal (Fig. 1b). The two other specimens had empty stomachs.

The mammal was identified as an adult male meadow vole, *Microtus pennsylvanicus* (Jackson 1961. Mammals of Wisconsin. Univ. Wisconsin Press. 504 pp.). The vole was 11.5 cm in total length; 4.8 cm tail length; hind foot 20 mm with six plantar tubercles; was dark brown above, and somewhat paler below with short ears (length 11 mm from notch). Few reports exist on species identification of small mammals in bullfrog stomachs (Lannoo 2005. Amphibian Declines. The Conservation Status of United States Species. University of California Press, Berkeley. 1094 pp.), and no reports exists of *R. catesbeiana* feeding on small mammals in Wisconsin (Vogt 1981. Natural History of Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, and Friends of the Museum, Inc., Milwaukee, Wisconsin, 205 pp.).

We thank M. and G. Bolek for allowing access to the field site, S. Gardner, T. Haverkost, D. Tinnin, and A. Jiménez-Ruiz, Harold W. Manter Laboratory of Parasitology, Univ. Nebraska State Museum, for identification of the meadow vole, and M. Bolek for comments on the manuscript.

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RANA YAVAPAIENSIS (Lowland Leopard Frog). **REPRODUCTION**. *Rana yavapaiensis* typically exhibit a bimodal breeding season in Arizona. Most reproductive activity occurs in early spring (February–April), with a second season of lesser activity in late September and October (Sartorius and Rosen 2000. Southwest. Nat. 45:267–273). In Arizona, winter months are generally periods of relatively low activity with no reports of reproductive behavior (Sredl 2005. *In* Lannoo [ed.], Amphibian Declines: The Conservation Status of United States Species, pp. 596–599. Univ. California Press, Berkeley, California). The only documented January reproduction in *R. yavapaiensis* was at –38 m elev. in the Coachella Valley, California (Ruibal 1959. Copeia 1959:315–322; reported as *Rana pipiens*).

On 29 Dec 2005, 2115 h, at Walnut Springs, a tributary to the Verde River, Mazatzal Mountains, Maricopa County, Arizona (UTM 3750734N, 451734E, NAD 27, 1119 m elev.), JBV observed an amplexing pair of *R. yavapaiensis* and heard several adult males calling. On 6 Jan 2006, there were two freshly laid *R. yavapaiensis* egg masses in the spring pool. We believe this is the first report of reproductive activity in mid-winter (December or January) in Arizona. Walnut Springs is a thermally stable system (T_w = 17°C on 29 Dec 2006) and perhaps provides a suitable microhabitat for successful winter breeding. Therefore, reproductive patterns in *R. yavapaiensis* might be more labile than previously thought, depending on local conditions.

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SMILISCA FODIENS (Lowland Burrowing Treefrog). **DIET**. Little is known about the ecology of *Smilisca fodiens* beyond reports of its distribution (Sullivan et al. 1996. Great Basin Nat. 56:38–47), endoparasites (Goldberg et al. 1999. Great Basin Nat. 59:195–197), cocoon formation (Ruibal and Hillman 1981. J. Herpetol. 15:403–408), and metabolism (Taigen et al. 1982. Oecologia 52:49–56). To our knowledge there have been no reports on its diet. Here we report observations on the stomach contents of 15 *S. fodiens* collected during 2004 from Valle de Tacupeto, Sonora, México (28°15'20.5"N, 109°18'1.9"W; WGS 84; 435 m elev.) (see Smith et al. 2005. Bull Chicago Herpetol. Soc. 40:45–51). Of the 15 individuals, nine contained identifiable stomach contents, five contained unidentifiable stomach contents, and one had an empty stomach. Table 1 lists the prey items. Numerically and volumetrically, beetles were the most important prey, followed by orthopterans. Beetles were found in seven of the nine stomachs containing identifiable stomach contents. It seems that the diet of *S. fodiens* at this site is made up primarily of beetles.

TABLE 1. Stomach contents of *Smilisca fodiens* from Sonora, México.

	Prey Items		Volume		Number of
Prey Type	N	(%)	mm^3	(%)	Stomachs
Coleoptera	17	(70.8)	3.26	(56.4)	7
Hymenoptera (ants)	4	(16.7)	1.20	(20.8)	2
Lepidoptera	1	(4.2)	0.08	(1.4)	1
Orthoptera	1	(4.2)	0.21	(3.6)	1
Odonata	1	(4.2)	1.03	(17.8)	1

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TESTUDINES

ACTINEMYS MARMORATA (Pacific Pond Turtle). **EGGS**. As with nearly all turtles, *Actinemys marmorata* typically deposits its eggs in a terrestrial, excavated nest (Ernst et al. 1994. Turtles of the United States and Canada. Smithsonian Inst. Press, Washington DC, 578 pp.). On 11 August 2006, six eggs of *A. marmorata* were found submerged in a natural pool (4 m long, 2.5 m wide, and 0.8 m deep) along a tributary of Adobe Creek, Sonoma County, California, USA. The six eggs were not damaged or predated and were located under water 12 cm deep within 30 cm of the shoreline. The eggs were slightly dispersed from each other. Most eggs had a slight silt deposit on the shell, suggesting that the eggs were not recently deposited. At this pool two *A. marmorata* adults had been observed basking on a log three weeks earlier. There were no signs of depredated turtle nests around the bank of the pool.

Weight and size of eggs: 11.3 g, 35.4 mm (total length), 22.9 mm (largest width); 12.3g, 36.4 mm, 23.9 mm; 10.8 g, 35.4 mm, 22.9 mm; 12.9 g, 36.4mm, 24.9 mm; 10.1g, 34.3 mm, 23.9 mm; 11.7g, 36.4 mm, 22.9 mm. Mean weight was 11.5 g, and mean length 35.7 mm, and width 23.6 mm.

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ACTINEMYS MARMORATA (Pacific Pond Turtle) and ***TRACHEMYS SCRIPTA ELEGANS*** (Red-eared Slider). **REPRODUCTIVE BEHAVIOR**. Attempted mating between native and introduced turtle species in the wild rarely has been documented (e.g., Ernst et al. 1994. Turtles of the United States and Canada, Smithsonian Inst. Press, Washington, D.C.), let alone between different genera. Although there have been several observations of aggressive behavior between Pacific Pond Turtles (*Actinemys marmorata*) and various species of sliders (*Trachemys* spp.), mostly in association with competition for prime basking sites (Spinks et al. 2003. Biol. Cons. 113:257–267), this is apparently the first documentation of attempted mating between the two.

On 9 May 2005, one of us (BML) observed an attempted mating between a male Pacific Pond Turtle and a female Red-eared Slider (*Trachemys scripta elegans*). The observation occurred along Oso Creek in the City of Mission Viejo, south Orange County, California (USA). Habitat consisted of a large pool formed at the base of a rip rap outflow structure where 1.2-m corrugated metal pipes conduct stream flow under the Interstate 5 freeway. Large willow (*Salix* sp.) and Western Sycamore (*Platanus racemosa*) trees overhang a portion of the pool partially shading the area. Several partially submerged rocks (riprap) and emergent logs provide suitable basking sites. The source of water is primarily urban runoff, with residential developments and a golf course along Oso Creek immediately upstream (on the other side of the freeway).

At approximately 0900 h, the two turtles were observed swimming together parallel to the edge of the pool, with the male Pond Turtle swimming on top of the female Slider, his head and legs fully extended. The female appeared to be intentionally moving away from the male, and moved out of the water onto the shore, with the male partially on her back. The male continued his pursuit of the female, mounting and balancing on the carapace of the female while they were out of the water. At this time the male was continuously probing the tip of his tail back and forth along the posterior edge of the female's plastron attempting copulation (at which he appeared to be successful). The female finally returned to the water and the male slid off her back as she swam away. The entire encounter lasted approximately two to three minutes and was photographed with a hand-held, digital camera.

Only two adult male *A. marmorata* were observed in the habitat during a total of eleven visits to the site through the spring and summer of 2005; the second male was observed basking in a pool approximately 300 m downstream. Because Pacific Pond Turtles are relatively long-lived (Jennings and Hayes 1994. Amphibian and Reptile Species of Special Concern in California. California Dept. of Fish and Game, Inland Fisheries Division, Contract No. 8023. 255 pp.), adults may persist for many years in degraded, human-modified habitats where upland habitat suitable for egg deposition is absent, resulting in an adult-biased age structure (Jennings and Hayes, *op. cit.*). It is possible that the Oso Creek population at this location has been reduced to two adult males, and the attempted mating by the male only occurred because conspecific female turtles were unavailable.

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ACTINEMYS (=CLEMMYS) MARMORATA MARMORATA (Northwestern Pond Turtle). **COURTSHIP BEHAVIOR.** Courtship behavior of the southern subspecies *A. m. pallida* has been observed in the field in May, June, and late August and in captivity in late August and early September (Buskirk 1991. *In* Beaman et al. [eds.], Proceedings of the First International Symposium on Turtles and Tortoises: Conservation and Captive Husbandry, pp. 16–23. Chapman University, Orange, California; Goodman 1997. The Biology of the Southwestern Pond Turtle [*Clemmys marmorata pallida*] in the Chino Hills State Park and the West Fork of the San Gabriel River. Master's thesis, California State Polytechnic University, Pomona, California; Holland 1988. Herpetol. Rev. 19:87–88). Here I provide a detailed description of the courtship behavior of *A. m. marmorata* observed in the wild, and note the timing of two other observations of probable courtship behavior.

At 1215 h on 19 September 2003, while snorkeling in the south fork of the Trinity River near Hyampom, California (UTM 465160E, 4474972N), I observed two *A. m. marmorata* engaged in presumed courtship activity. I was floating near the left bank, hidden by overhanging vegetation, where I had a clear view of two turtles below without them noticing me. The water was clear and sunlit from directly overhead, and visibility was excellent. Water temperature was 15.3°C and air temperature was 23.4°C.

Both turtles were adults, of similar size, and the genders were easily discerned from standard dimorphic characters. The female was resting on the bottom of the pool on sandy substrate. She was orientated away from the left bank with her head and forelimbs retracted beneath the carapace. Her hind limbs were partially extended and in firm contact with the substrate. The male was facing the female, scratching the anterior of her carapace with the claws of his forelimbs. He would first scratch three times with the left forelimb, three times with the right, then three times with both forelimbs simultaneously, and then repeat this cycle. The scratching was usually in sets of three. He did this for about a minute then he reared up on his hind limbs with his anterior raised off the substrate at about a 45° angle and waved both forelimbs side to side in a symmetrical manor for 10–15 seconds. This action seemed to push him up and backward until he was nearly vertical on his hind limbs. Then he would stop waving, settle back down to the bottom of the pool in front of the female, and within a few seconds, resume scratching on her carapace following the same pattern as previously described. He went through this cycle of scratching and front limb waving three times. After a few minutes of this behavior the female extended her head and forelimbs, turned approximately 120° to the left, and began walking downstream. The male quickly followed. The female only moved about 2 m downstream before he swam over the top of her carapace and settled down in front of her, again face to face, blocking her forward movement. She tucked back into her shell, in the same position previously described, with hind limbs extended like braces. The male immediately began the scratching behavior, again following the same pattern of threes. This lasted for several minutes, until the female's head protruded from under her carapace and she suddenly turned 180° and began to walk quickly upstream as if attempting to flee the male. The male followed and swam up over her and settled down on the substrate facing her, again blocking her forward progress. At this point the two turtles were directly below me at about 1.5 m in depth. The male once again resumed the scratching and waving behavior, but during the first bout of waving the female looked up, appeared to see me and immediately fled, swimming along the bottom towards the middle of the river and deeper water. The male watched her flee, but did not follow. She took refuge beneath large submerged boulders near the deepest part of the river (ca. 5 m away and 5 m deep). Once the female was out of sight, the male slowly turned and began to swim toward the surface as if surfacing to breathe. He came straight up towards me in a relaxed manor. At about 30 cm from my face mask, he looked straight at me, paused a second, then fled rapidly to the deep water mid-channel. He went under a boulder about 3 m from the female's retreat. Although I had remained motionless during the encounter to avoid detection and thus did not consult my wristwatch for exact timings, the entire observation lasted approximately 8 minutes.

In late May, 1994, I briefly observed a similar interaction on the mainstem of the Trinity River near Junction City, California, but in this instance the male turtle noticed my presence in less than a minute and both turtles attempted to flee. Similar courtship behavior was observed by James Bettaso (USFWS) in the South Fork Trinity River, near the confluence of Surprise Creek near dusk on 28 September 2005. Observations of courtship behavior in both spring and fall are consistent with previous reports.

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CHELODINA* sp.** (Kimberley Long-necked Turtle) and ***EMYDURA AUSTRALIS (Northwest Red-faced Turtle). **PREDATION**. Freshwater turtles have been noted as prey taken by pelicans, jabirus, hawks, sea eagles, and wedge-tail eagles (Worrell 1966. Australian Snakes, Crocodiles, Tortoises, Turtles, and Lizards. Angus and Robertson, Sydney). However, published life history data that quantify turtle species, number, and size classes taken by avian predators are lacking. Here we report on predation by White-bellied Sea Eagles (*Haliaeetus leucogaster*) on two turtle species of inland rivers in northwestern Australia.

During turtle surveys of the Kimberley Plateau (by ADT and NNF) in June 2006, residents from Tirralintji Station (SW, BW) reported carcasses of freshwater turtles predated by White-bellied Sea Eagles at the Traine River (-17.198°S, 126.436°E). A partial carcass of *Chelodina* sp. (reconstructed straight-line carapace length [SCL] estimated at 18 cm) was beneath an eagle nest on the southern bank. Beneath a feeding station tree on the northern bank were shells of four *Chelodina* (16.4, 18.8, 19.1, 19.8 cm SCL) and one *Emydura australis* (16.2 cm SCL). Voucher specimens were deposited with the Western Australia Museum (specimen numbers pending). Several carcasses had injuries to the anterior carapace as described for bird-predated adult *Chelodina rugosa* reported by Cann (1989. Australian Freshwater Turtles. Beaumont Publ. Pty. Ltd, Singapore).

The lengths of these predated turtles was compared to the size range of turtles trapped from the same pool and a nearby section of the Traine River (-17.195°S, 126.456°E). The trapped sample of *Chelodina* sp. ranged from 18.0 to 21.3 cm SCL (N = 3) and *E. australis* ranged from 12.9 to 22.3 cm SCL (N = 23). The carcass sizes reported here are similar to lengths of carcasses recovered at sea eagle nests at other inland and coastal locations (Clark 1982. J. Field Ornithol. 53:49–51; Mitchell et al. 2006. Herpetol. Rev. 37:216–217; Woodall 1982. Sunbird 12:11–14). Taken together, these observations suggest that small freshwater turtles generally comprise a minor dietary resource of large coastal raptors.

Tirralintji residents observed that the sea eagles reside locally only for nesting, and migrate elsewhere after the young fledge. The billabong is from 190 to 275 km distant from coastal areas near Flatback Turtle (*Natator depressus*) nesting and/or developmental habitats. Given that sea eagles are identified predators of juvenile Flatbacks (Walker 1991. Mar. Turt. Newsl. 55:6), two speculative scenarios may apply—foraging tactics developed for juvenile Flatback Turtles at sea would facilitate switching to similar-sized freshwater turtles, or the opposite scenario. Tirralintji residents noted that eagle predation occurred during the late dry season (September–November) when turtles often migrate over-land from drying billabongs to permanent pools. Further observations will be necessary to determine whether turtle predation by eagles is a localized phenomenon due to unique site characteristics at the pool, or possibly represents opportunistic scavenging.

We thank Earthwatch Institute, Australia for funding and field volunteers. Specimens were collected with permission of the Australian Wildlife Conservancy (property owners and managers) and also the Tirralintji community (traditional owners). Fieldwork was facilitated by T. Vigilante of Kimberley Land Council and S. Legge of Australian Wildlife Conservancy. J. Mitchell and R. Welsh gave helpful critique on an early draft. Surveys were covered by animal ethics board approval of the University of Canberra and collecting permit SF5344 from the Department of Conservation and Land Management, Western Australia.

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CHELUS FIMBRIATUS (Matamata). **REPRODUCTION.** On 21 September 2006 we found a clutch of *Chelus fimbriatus* eggs in the Caño Guaritico, at the Estación Biológica El Frío (Apure, Venezuela; UTM: 0508375 N; 0872150 W). The ten egg clutch was found at the edge of the stream (7 cm above the water level), inside a hole excavated by fishes locally called "bagres" (Loricariidae: *Hypostomus plecostomus*, *Liposarcus multirradiatus,* and *Glyptoperichthys gibbiceps*). The hole was partially collapsed by stream flow, which allowed us to find the clutch. There were no signs of depredation. The eggs were transferred to a polyurethane box filled with sand and taken to the biological station. The eggs were spherical, with a smooth, white shell. Egg diameter in this clutch ranged from 37.8 to 39.4 mm (mean 38.4 mm); egg mass ranged from 33.5 to 36.5 g (mean 34.9 g). Although the deposition date of this clutch is unknown, it is earlier than most previous reports, such as October in Colombia (Medem 1969. Caldasia 8:341–351) and October–November in Venezuela (González Ortiz, in Mondolfi 1955. Memorias Sociedad Ciencias Naturales La Salle 15:177–183; Lasso, pers. obs.). This report is apparently the earliest date for a clutch of *Chelus fimbriatus* in the wild, although in all cases the reported dates for egg laying coincide with decreasing water levels at the start of the dry season.

Clutch size reported here is smaller than clutches reported by Medem (*op. cit.*), Mondolfi (*op. cit.*) and Hausmann (1968. Int. Turt. Tort. Soc. J. 2[4]:18–19, 36), who note a range of 12–28 eggs. Our egg size data agree with those compiled by Pritchard and Trebbau (1984. Turtles of Venezuela, SSAR, Ohio), who reported that egg diameter ranged from 3.4 to 4.0 cm.

We thank Javier Castroviejo, Ramón Nieves, and Franklyn Silva for field assistance, and Julio García for helping with translation.

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CHRYSEMYS PICTA BELLII (Western Painted Turtle). **COLORATION**. Variations in pigmentation, independent of subspecies characteristics, have been observed in many indigenous populations of *Chrysemys picta* throughout North America. These variations have been attributed to a number of biotic and abiotic factors such as sexual cycles, age, differences in habitat quality such as minerals or tannins in the water, or variable substrate colors (Rowe et al. 2006. Herpetol. Rev. 37:293–298). Here we report the first published account of reticulate blue coloration in *C. picta*. On 9 September 2005, we captured a large male *C. picta bellii* (171 mm PL) in an irrigation ditch adjacent to the South Platte River in Brush, Colorado (Morgan County). In addition to the usual red and black markings, this individual displayed distinct blue reticulate coloration along the marginal scutes. This coloration was especially striking on the inframarginal scutes and bridge. These reticulate blue marking appeared to have completely replaced the yellow markings typically found on these scutes. On 28 May 2006, two other *C. picta* males (141 mm and 142 mm PL) displaying similar blue coloration, were captured in a small pond near Limon, Colorado (Elbert County) ca. 160 km S of the Morgan County location. Although reticulate melanism is well documented for older males of this subspecies (Ernst et al. 1994. Turtles of the United States and Canada. Smithsonian Inst. Press, Washington DC. 578 pp.), it is not known if the blue reticulation pattern follows a similar pattern of expression. To date, no females have been discovered with similar coloration. Differences in habitat quality and distance between these two locations make it unlikely that environmental conditions alone would account for this unusual color pattern.

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CYCLEMYS DENTATA (Asian Leaf Turtle). **FIRE SCARS**. On 25 November 2004, during a larger study on freshwater turtles in Loagan Bunut National Park (LBNP) (03°44'–03°N, 114°09'–114°17'E), Sarawak, Malaysia, a small adult *Cyclemys dentata* (straight carapace length 130 mm) was collected, measured, and released. On the left side, marginals III–VII were damaged; scutes were partially missing, and portions of marginals V–VII missing (Fig. 1). All edges of the remaining portions of the marginals appeared to have undergone trauma presumably from exposure to fire. The injury was not new and had apparently healed.

Cyclemys dentata is known to occur in both highlands and, more commonly, in lowlands near small streams and ponds throughout Southeast Asia. Out of five individuals located at LBNP, all but one were found in secondary forest and the burnt individual was found on the eastern edge of the park, near an oil palm plantation. Fire is a common, yet controversial, tool used in the region to quickly clear brush and weeds for planting, particularly on oil palm and pulp wood plantations (Kinnaird and O'Brien 1998. Conserv. Biol. 12:954–956). Fires are routinely set at or near the end of the southwest monsoon, which corresponds to the dry season, and has

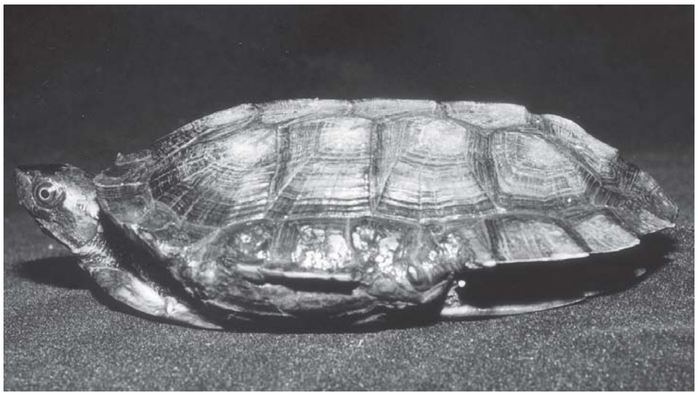

FIG. 1. View of the left aspect of an individual of *Cyclemys dentata* showing scarred and missing marginals.

been known to affect other turtle species in the region (Mitchell et al. 2005. Herpetol. Rev. 36:169).

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DERMOCHELYS CORIACEA (Leatherback Seaturtle). **DIET**. Leatherback Seaturtles are dietary specialists, consuming planktonic gelatinous prey such as medusae (Scyphozoa, Siphonophora), salps and pelagic tunicates (Bjorndal 1997. *In* Lutz and Musick [eds.], The Biology of Sea Turtles, pp. 199–232. CRC Press, Boca Raton, Florida). Small quantities of other organisms are sometimes identified in gut contents, such as amphipods, other crustaceans, and fish, thought to have been consumed coincidentally together with commensal jellyfish (Frazier et al. 1985. J. Herpetol. 19:159–160). Here, we report the consumption of two new dietary items for this species

On 5 April 2005, an adult female Leatherback Seaturtle (CCL= 143.0 cm), was found stranded and dead on San Luis Beach, Canelones, Uruguay (34°46'34"S, 55°35'18"W). The turtle was probably captured by a trawling vessel of the Uruguayan fleet, evidenced by a rope tied around its front flippers, used to discard the animal off the ship (Martin Laporta, pers. comm.). We examined the contents of the digestive tract and identified remains of the jellyfish *Lychnorhiza lucerna* (Scyphozoa, Rhizostomeae) and seven spider crabs *Libinia spinosa* (Decapoda, Majidae). The crabs were determined to be juveniles because of the relatively small size of their carapaces (10.8–18.2 mm. length, 8.7–14.5 mm. width, N = 7). Additionally, an adult Weakfish (*Cynoscion guatucupa*) (size = 250 mm) was also found in the esophagus of the turtle.

Lychnorhiza lucerna is a scyphozoan jellyfish that belongs to the Order Rhizostomeae, Superfamily Inescapulatae (Mianzan and Cornelius 1999. *In* D. Boltovskoy [ed.], South Atlantic Zooplankton, pp. 513–559. BACKHUYS Publishers, Leiden). It is common in the region, with a known geographic range that extends from San Clemente del Tuyú, Argentina, north to the Guyanas (Mianzan 1989. Inv. Mar. CICIMAR Vol. 4 nº 1). However, to our knowledge this is the first report of *L. lucerna* consumption by *D. coriacea*. A mutualistic-commensalistic relationship between the spider crab and *L. lucerna* has been documented in Uruguay by Vaz-Ferreira (1969. Bol. Soc. Zool. Uruguay 2:64–66), indicating that the crabs were ingested incidentally with the jellyfish. We believe that the presence of a Weakfish in the turtle's digestive tract is likely to be accidental, and suspect that was ingested while the turtle was captured within the trawl net.

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ERYMNOCHELYS MADAGASCARIENSIS (Madagascan Side-necked Turtle). **DIET**. A number of authors (Siebenrock 1903. Abhandlungen der Senckenberg Naturforschenden Gesellschaft 27: 241–259; Vaillant and Grandidier 1910. *In* Histoire Physique, Naturelle et Politique de Madagascar, Paris, Librarie Hachette 17:1–86; Decary 1950. Les reptiles Chapitre III. La faune malgache. Paris: 77–89; Tronc and Vuillemin 1973. Bulletin de l'Academie Malgache, T. 51/1:190–224) described *Erymnochelys madagascariensis* as carnivorous, feeding primarily on molluscs, arthropods, fish, and amphibians. More recent studies (Kuchling and Mittermeier 1987. IUCN SSC 2:121–124; Jenkins et al. 1990. Expedition Final Report, Oxford Univ.: 13 pp.; Kuchling 1993. Salamandra 28:231–250) suggested the species was omnivorous because significant amounts of plant material were found in sampled guts. These authors identified three main components in the turtle's diet; animal matter (mostly made up of the small gastropod, *Melanoides tuberculata*), fish, and green shoots and roottips of the reed *Phragmites mauritaunicus*. However, these data were collected over short time periods and are not representative of all ages, sizes, or habitats. In 1998–2000 the first author completed a study of the dietary preferences of the species by analyzing stomach contents (stomach flushing: Legler 1997. Herpetologica 33:281–284) and fecal samples of turtles trapped or accidentally collected at Ankarafantsika National Park, Madagascar, as part of his PhD thesis research (García 2005. DICE Institute, University of Kent, Canterbury. 299 pp.). A total of 298 stomach samples from 243 turtles and a total of 499 fecal samples from 72 turtles were collected from seven localities during the study period.

Juvenile and mature turtles differed in percentage animal and plant material identified in gut samples (juveniles: 59% animal and 41% plant; matures: 28% animal, 72% plant), but no significant differences were found between sexes. Aquatic arthropods and then seeds, fruits, and freshwater snails were the main items in the diet in juvenile turtles. In mature turtles, the most common items were fig fruits, seeds, nuts, and freshwater snails. This study suggests that *E. madagascariensis* at this site were more carnivorous in the smaller class sizes (<125 mm PL), shifted to opportunistic, omnivorous feeding habits as they got larger (125–200 mm

PL), and finally become opportunistic herbivores as adults (>200 mm PL), although they did continue to opportunistically take animal prey.

During the study period three fecal samples from juvenile *E. madagascariensis* revealed remains of the scorpion *Grosphus hirtus* Kraepelin (Lourenço and Goodman 2006. Zool. Anz. 244:181–185). The first sample was from a juvenile #215 (105 mm PL) caught at Antsilomba Lake (16°16'25.2"S, 46°43'04.3"E) on 22 February 1999. The second sample came from juvenile #585 (160 mm PL) on 3 March 2000 from the locality of Ambarindahy (16°15'11.7"S, 046°43'21. 8"E), and the third sample was collected from juvenile #711 (75 mm PL) at Lake Antsilomba on 13 March 2000.

This is the first record of turtles preying on scorpions in Madagascar, and possibly the first record of turtles eating scorpions anywhere (McCormick and Polis 1990. *In* The Biology of Scorpions, pp. 294–320. Stanford, Stanford Univ. Press).

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GOPHERUS POLYPHEMUS (Gopher Tortoise). **MORTALITY**. *Gopherus polyphemus* has declined precipitously in range and numbers in Florida and recently was state-listed as a "threatened" species under the Florida Wildlife Code (Chap. 39, Florida Administrative Code). At ca. 1000 h on 27 July 2006, GK observed a 23 cm carapace length male *G. polyphemus* between the North-South railroad tracks on the eastern boundary of Savannas Preserve State Park (SPSP) in St. Lucie County, Florida (Fig. 1). The tortoise seemed uninjured, but was deceased. Eastern Box Turtles (*Terrapene carolina*) were recently shown to have great difficulty escaping railroad tracks, with overheating to critical levels likely to occur in 4.5–5 h (Kornilev et al. 2006. Herpetol. Rev. 37:145–148). Similarly, the most logical explanation for the Gopher Tortoise death would be entrapment between the tracks, followed by critical overheating and/or dehydration (high and average temperatures for the previous day had been ca 31°C and 28°C, respectively). Recent re-contouring of the railroad track right-of-way corridor with crushed rock had coincidentally created "ramps" (Fig. 2) increasing the feasibility for tortoises to scale the track rail to reach the interior portion of the tracks. Alternatively, access to the interior of the tracks could have been accomplished at the crossing intersection at nearby Walton Road, 186 m south of where the carcass was found, with the tortoise continuing to move along the tracks, instead of escaping by retracing its route. Turtle species with superior climbing abilities to *G. polyphemus* might be more able to escape entrapment between the 19 cm high rails (if they are of sufficient size). For example, Engeman (*in press*, J. Kansas Herpetol.) observed a 33 cm carapace-length *Apalone spinifera* climb a series of 14 stairs, each 18–19 cm high, indicating that such an individual might be able to escape the railroad tracks.

FIG. 1. Deceased *Gopherus polyphemus* found between railroad tracks at Savannas Preserve State Park, Florida. Photo by G. Kaufmann.

FIG. 2. View of tracks showing re-contouring of right-of-way with crushed rock, possibly allowing easier access to the interior of the tracks by *G. polyphemus*. Photo by G. Kaufmann.

Tortoises are subject to a variety of anthropogenic sources of mortality, with collisions with vehicles the most apparent for *G. polyphemus* in southeastern Florida State Parks (HTS, pers. obs.). Vehicles have likewise been well-documented as hazards for the related *G. berlandieri* (Engeman et al. 2004. Herpetol. Rev. 35:54–55), and *G. agassizii* (e.g., Boarman and Sazaki 1996. *In* Evink et al. [eds.], Trends in Addressing Transportation Related Wildlife Mortality, pp. 179–184. State of Florida Dept. Transportation, Tallahassee, Florida; Luckenbach 1982. *In* Bury [ed.], North American Tortoises: Conservation and Ecology, pp. 1–38. USFWS Wildl. Res. Rpt. 12). Additional causes of anthropogenic mortality for *Gopherus* spp. have included entanglement in wire fences (Engeman et al. 2004, *op. cit.*), although we have not detected this for *G. polyphemus* during fenceline searches in nearby Jonathan Dickinson State Park. Similarly, numerous patrols down the SPSP track corridor since Jan 2004 have not identified railroad related tortoise mortality prior to this observation. Therefore, we speculate that the re-contouring of the railroad track right-of-way may have had made track entrance more likely for *G. polyphemus*.

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HYDROMEDUSA TECTIFERA (South American Snake-necked Turtle). **COPULATION**. The freshwater chelid turtle *Hydromedusa tectifera* is distributed in rivers and streams of northeastern Argentina, Paraguay, eastern and southeastern Brazil, and part of Uruguay (Cei 1993. Mus. Reg. Sci. Nat. Torino Monogr. 14). The province of Córdoba (central Argentina) is home to a population that is isolated from the species' core distribution area and inhabits streams in the central region of the Sierras (Cabrera 1998. Las Tortugas Continentales de Sudamérica Austral. Privately printed, Córdoba, Argentina. 108 pp.). We report three observations of copulation of this species in two streams in Córdoba. In all observations, males were on top of females, grabbing them with the front and rear claws by the carapace edge, and continuously biting the central region of the neck. Males folded the tail to have it closer to the tail of the female. Copulation lasted less than 60 minutes on all three occasions. After copulation, the male released the female, which then swam rapidly away. The first copulation was observed at 2100 h on 11 October 2005 (spring) in Toro Muerto stream (31°23.5'S, 64°35.8'W). The specimens (carapace length 243 mm, male; 257 mm, female) were submerged at a depth of 40 cm, in a river section with sandy substrate, at a water temperature of 16.5°C and air temperature of 10°C. On 4 August 2006 (winter), we made a second observation, at 2015 h in Toro Muerto stream (31°22.7'S, 64°36.3'W). The specimens (carapace length 264.6 mm, male; 256.9 mm, female) were submerged at a depth of 30 cm, on a rocky, well vegetated substrate. Water temperature was 9°C and air temperature 3.5°C. The third observation was made in Tanti stream (31°21.2'S; 64°33.9'W) at 1920 h on 5 September 2006 (winter). The specimens (carapace length 240 mm, male; 251.2 mm, female) were submerged at a depth of 90 cm, on a rocky bed with sand and submerged aquatic vegetation. Water and air temperatures were 17°C and 20°C, respectively. *Hydromedusa tectifera* is one of the least documented reptile species in Argentina, especially concerning aspects of its ecology. This is apparently the first description of copulation of this species in the wild.

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KINOSTERNON SCORPIOIDES (Scorpion Mud Turtle). **BEHAVIOR.** Semiaquatic mud turtles (genus *Kinosternon*) are broadly distributed in a variety of habitats from eastern North America to northern Argentina. The southern two-thirds of this range is occupied by its largest member, *Kinosternon scorpioides,* of which various regional subspecies have been described based upon head and plastron coloration, extent of carination of the carapace, plastral seam ratios, and adult size (Ernst and Barbour 1989. Turtles of the World. Smithsonian Inst. Press, Washington DC. 313 pp.). The natural history of this species is not well known; its penchant for turbid shallow water, including anthropogenic habitats, outside of rain forests in northern South America is noted in the most exhaustive account of the species to date (Pritchard and Trebbau 1984. The Turtles of Venezuela. SSAR Contrib. Herpetol. No. 2, 403 pp. + 47 color plates + 16 maps).

On 11 November 1999 six specimens of *K. scorpioides* were found in a roadside pool and in a roadside ditch between Mariscal Estigarribia, Depto. Boquerón, and Parque Nacional Defensores del Chaco, Dept. Alto Paraguay, Paraguay. The GPS coordinates are 21°29'885"S, 59°52'736"W and 21°11'184"S, 59°45'188"W. The first individual was seen from a moving vehicle as it sat motionless, possibly basking, on the far embankment of the pool at 1115 h. Seconds later, upon my approach, the turtle moved quickly upwards, away from the water, towards the dense, spiny vegetation locally known as "chañar" consisting of various species of *Bromelia, Dyckia,* and *Aechmea*. More than 2 h later, in a roadside ditch stretching to the horizon, movement seen from the vehicle prompted investigation. Within 2 minutes, three searchers found 5 *K. scorpioides* (2 males, 2 females, 1 juvenile) in water no deeper than 30 cm. As they were pursued, two of the turtles emerged from the water body, climbed the embankment, and moved towards the adjacent chañar. The larger male and one female bore several ticks in the soft parts of their anterior portions, whereas the juvenile's carapace had a dense growth of algae.

There appear to be few literature records of aquatic turtles (i.e., those known to largely live and feed in aquatic habitats) purposely seeking immediate refuge away from the water. In this case, the spiny vegetation may have offered better protection from predators than did the open, shallow water.

Terrestrial refugia are apparently used by non-estivating aquatic chelonians elswhere in the Gran Chaco, in most of which there is no permanent surface water. In January 1987 and 1988, 7 of 26 specimens of *Acanthochelys pallidipectoris* were found beneath broad leaves of living bromeliads on dry land during the rainy season in nearby northern Argentina, in the vicinity of abundant, seasonal shallow bodies of water (Monguillot and Fabius 1993. Bol. Soc. Zool. Uruguay 2nda época 8:196–203). The seeking of terrestrial refugia (rather than nearer aquatic habitat) upon release by the third species of non-terrestrial chelonian in the region, *A. macrocephala,* following capture in shallow water has been recently documented by Métrailler (2006. Manouria 9[33]:26–32). This observation took place in February 2002.

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LEPIDOCHELYS KEMPII (Kemp's Ridley Seaturtle). **DEVELOPMENTAL HABITAT**. Kemp's Ridley Seaturtle is unique because it nests primarily on a single beach in Tamaulipas, Mexico (Rancho Nuevo), and it nests during the day in large groups called *arribadas*. Unfortunately, the population was severely reduced by the 1960s from intense egg harvesting and further reduced by the 1980s because of incidental capture in commercial fishing gear (Márquez-M. et al. 2005. Chelon. Conserv. Biol. 4[4]:761–766).

Studies describing the coastal developmental habitats of hatchling and juvenile Kemp's Ridley Seaturtles are important to scientists, conservationists, and resource managers for drafting sound recovery plans. A newly discovered developmental habitat has recently been described in Gullivan Bay, Ten Thousand Islands, southwestern Florida, USA (Witzell and Schmid 2004. Gulf Mexico Sci. 22:54–61; see also Schmid and Barichivich 2005. Chelon. Conserv. Biol. 4[4]:828–834). This area is centered just north of the Everglades National Park boundary. After the original turtle research was completed in Gullivan Bay, a visual survey was conducted southwards through the Everglades Park because tagging data suggested that the Gullivan Bay turtles were possibly transient.

The survey was conducted from December 2003 to August 2004. Each survey consisted of five individual days and was conducted bimonthly from a 7.6-m flat-bottom commercial fishing vessel. Each day typically lasted from 0700 h to 1600 h with two persons in the vessel at all times looking for turtles. We moved southwards from the village of Goodland through Gullivan Bay into the Everglades National Park, stopping in likely places and waiting for Ridleys to surface to breathe. We stayed within 1 km of the shore and frequently stopped at passes between islands where ridleys often congregate and waited at least 4–6 h before moving southwards to a new location. It was impossible to synoptically survey the entire area because stormy weather conditions frequently dictated where we could safely go. All sightings were recorded using a portable global positioning system (GPS).

There were 92 immature Ridley, 24 Loggerhead (*Caretta caretta*), 2 Green (*Chelonia mydas*), and 2 unknown turtle sightings recorded. Because of the possibility of duplicate sightings, these figures do not represent an actual turtle census, but they do indicate that Ridleys are utilizing this entire coast as developmental habitat. Turtles were seen on each survey in sea surface temperatures ranging from 17.3°C in December to 31.1°C in August. The sightings extended from Gullivan Bay to Lostmans River, a distance of approximately 68.6 km (Fig. 1). We were not able to safely travel beyond this point in this particular vessel so we do not know if Ridleys inhabit the waters further south in the Park. Immature Kemp's Ridleys were sometimes seen in small groups of 2–3 individuals but never consistently in the same locations, and no particular area seemed to consistently be more productive than other areas. This indicates possible movement throughout the entire area as they feed. There were proportionately more sightings in the north because we traveled through this area more often as we moved southward from Gullivan Bay (Fig. 1).

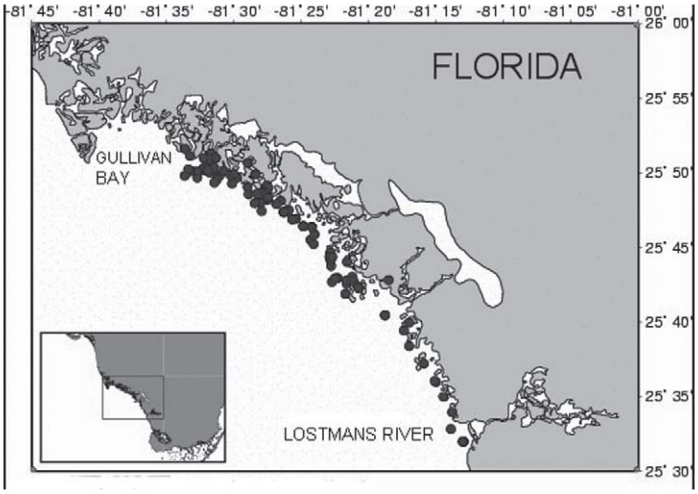

Fig. 1. Sightings of immature Kemp's Ridley Seaturtles from Gullivan Bay to Lostmans River, Ten Thousand Islands, Southwest Florida.

This stretch of Florida coast is the largest developmental habitat for immature Kemp's Ridley turtles discovered to date (76 km including Gullivan Bay). This habitat remained hidden until now because the area is remote and because there is little opportunity for turtles to be impacted by human activities (e.g., commercial fishing or channel dredging). Additionally, the coastline is not conducive for turtle strandings to be found due to the dense mangrove habitat, so the presence of these turtles remained unknown to sea turtle researchers until now. The other developmental habitats reviewed by Witzell and Schmid (*op. cit.*) are all important for the continued expansion of the population but they are relatively insignificant in size and possibly importance compared to the potentially huge habitat of the Ten Thousand Islands along the southwestern tip of Florida. This area will become more important as the population continues to rebuild and it is critical that it remain as pristine and undisturbed as possible. Fortunately, this area is protected from commercial fishing and coastal development by the Everglades National Park and it is suggested that National Park personnel be involved in the Kemp's Ridley Recovery Team as they draft a new Recovery Plan.

I thank the many volunteers from the National Marine Fisheries Service Laboratory in Miami who participated in the survey, M. Finn for logistical support, and to SEATURTLE.ORG for providing the Maptool graphics program.

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MACROCHELYS TEMMINCKII (Alligator Snapping Turtle). **TERRESTRIAL REFUGIUM.** With the exception of nesting, *Macrochelys temminckii* has rarely been reported leaving the water (Ernst et al. 1994. Turtles of the United States and Canada. Smithsonian Inst. Press, Washington, D.C., 578 pp.; Ewert 1976. Herpetologica 32:150–156). The few reported occurrences have been described as basking attempts (Ewert 1976, *op. cit.*; Farr et al. 2005. Herpetol. Rev. 36:168; Shelby and Jensen 2002. Herpetol. Rev. 33:304). On 7 July 2006 at 1251 h in the East Fork of Cadron Creek, Arkansas (USA), a male *M. temminckii* (354 mm carapace length, 309 mm carapace width) was located out of the water. This turtle was part of an ongoing telemetry project and was located every 3–5 days prior to and after the aforementioned observation. Between 2 July (previous location) and 7 July 2006, the turtle left the water and entered an exposed beaver den within the bank of the stream. The opening to the burrow was located under a large maple tree (*Acer* sp.) and was ca. 200 mm from the water. The

TABLE 1. Air, stream, and burrow temperatures for a *Macrochelys temminckii* refugium. All values are mean ± SD. Statistical differences, determined by a Tukey test, are indicated by letters.

	Air Temperature (°C)	Stream Temperature (°C)	Burrow Temperature (°C)
Mean	26.3 ± 3.6 ^{A}	25.7 ± 0.7 ^{B}	21.8 ± 0.5 ^{C}
Maximum	40.7	26.7	22.8
Minimum	17.3	24.1	20.3

entrance to the burrow was 450 mm in width and 250 mm in height. The burrow depth and width was unknown, but the turtle was located ca. 3 m from the burrow entrance using a long pole. Within 300 mm of the entrance, the burrow angled upward at ca. 30°. Humidity was high enough within the burrow to cause droplets of water to form on overhanging roots and the substrate was slightly muddy. On first location of the turtle (7 July 2006), the burrow temperature was 4.5°C cooler than the stream temperature.

On 17 July 2006, the turtle was still within the burrow. At this time a temperature sensitive data logger was launched and placed within the burrow ca. 3 m from the burrow entrance, directly next to the turtle. In addition, a temperature sensitive data logger was launched and placed directly outside of the burrow to record air temperature and another was placed in the stream (1 m in depth and ca. 2 m from the burrow entrance).

Between 9 August and 15 August 2006, the turtle left the burrow. On 15 August 2006 the turtle was located in the water ca. 20 m from the burrow entrance. The turtle had remained in the burrow for 33–44 days. A summary of the data collected during this time are shown in Table 1.

It is believed that the turtle was using the burrow as a form of refuge from the unfavorable conditions within the stream (e.g., high temperatures, shallow waters, and open canopy). Riedle et al. (2006. Southwest. Nat. 51:35–40) also reported *M. temminckii* using beaver dens and lodges within the stream, but did not determine if these turtles were completely submerged within the water or were perhaps above water level. A female *M. temminckii* was also found to use a beaver den within the bank of the stream during this study, but it was believed that this turtle was below the water level at the reported time. This female remained in the burrow from 27 May 2006 to 17 July 2006. During this time, the same burrow was occupied twice by one other female.

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STERNOTHERUS ODORATUS (Stinkpot). **MORPHOLOGY**. During amphibian surveys on 14 April 2005 at 2000 h, a kyphotic adult female Stinkpot (Fig. 1) was observed resting on the bottom of the north end of Manlove Lake in northern Fayette County, Indiana, USA, at a depth of ca. 50 cm. This was the only Stinkpot observed during three nights (ca. 6 h) of shallow-water surveys in April 2005. She was captured by hand, measured (maximum carapace length 93 mm, maximum carapace width 73 mm, maximum carapace height 60 mm, maximum plastron length 78 mm), euthanized by freezing, dissected for reproductive data (seven 14 mm preovulatory follicles plus eight 8–10 mm secondary follicles present, suggesting two potential clutches), preserved in fixative, and deposited in the Florida Museum of Natural History (UF 150163). This is the only kyphotic Stinkpot observed among approximately 1000 captures in Indiana (e.g., see Smith and Iverson 2002. Amer. Midl. Nat. 148:185–189). Kyphosis in *S. odoratus* has previously been reported by Hartweg (in Nixon and Smith 1949. Turtox News 27:28–29) but without any details. In addition, Saumure (2001. Chelon. Conserv. Biol. 4:159) reported a kyphotic adult male from Ontario, Canada in 1984. Osteopathologic study of this most recent specimen might shed light on the cause of this rare phenomenon in turtles (reviewed by Saumure 2001, *op. cit.*). This turtle was collected under a Scientific Research Permit issued by the Indiana Department of Natural Resources.

FIG. 1. Kyphotic adult female *Sternotherus odoratus* from Indiana.

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TERRAPENE CAROLINA (Eastern Box Turtle). **THREATS.** On 9 June 2005 at 1435 h an adult male *Terrapene carolina* was observed (TPC) consuming a red paintball. The turtle appeared to have broken the paintball open and was consuming the liquid paint inside. The specimen was held for two hours, during which time it appeared normally active. It was then released. The site of this observation was at a recreational paintball facility in a forested area of the coastal plain of southeastern Virginia. Further observations in the area revealed numerous unspent and spent paintballs of many colors including; orange, red, pale green, bright green, blue and purple. No other box turtles were observed in the area at this time.

Terrapene carolina is omnivorous, selecting a wide array of food items (Ernst et al. 1994. Turtles of the United States and Canada. Smithsonian Inst. Press, Washington, DC). Braun and Brooks (1987. Amer. Midl. Nat. 117:312–318) observed that color of fruits eaten by box turtles varied widely and included red, yellow, blue, purple, and black, essentially the same colors as paintballs. Items documented in the diet of *T. carolina* that might resemble a paintball include blackberries (*Rubus* sp.), mayapples (*Podophyllum peltatum*), blueberries (*Vaccinium* sp.), grapes (*Vitis* sp.), wild strawberries (*Fragaria virginiana*), and black cherries (*Prunus serotina*) (Mitchell 1994. The Reptiles of Virginia. Smithsonian Inst. Press., Washington, DC). In addition, Ernst et al. (1994 , *op. cit.*) note that they also consume plums, tomatoes, and ground cherries. These fruits are similar in size, texture, color, and/or shape, to a paintball.

The ingredients of paintballs vary according to manufacturer and may include polyethylene glycol, glycerol (glycerin), gelatin, sorbitol, dipropyleneglycol, mineral oil, dye, ground pig skin, and water (Donaldson 2003. Veterinary Medicine 98:995–997). There is little information on the potential effects of some of these ingredients on reptiles, but Donaldson (2003, *op. cit.*) reviewed cases of ingestion by dogs and noted vomiting, ataxia, diarrhea, tachycardia, blindness, seizures, and tremors, among other symptoms. In two cases the dogs were euthanized because their central nervous system signs did not respond to treatment. Therefore, it is possible that consumption of paintballs could be harmful to turtles and/or other reptiles and wildlife. This observation adds to the growing body of literature on reptiles negatively interacting with litter, recently reviewed by Walde et al. (2007. West. N. Am. Nat. 67:147–149). Although box turtles remain locally common in Virginia, many are lost each year to road mortality and collection as pets, and populations generally are in decline because of habitat destruction and fragmentation (Mitchell 1994, *op. cit.*).

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TRACHEMYS DORBIGNI (Brazilian Slider). **DIET.** Juveniles of *Trachemys dorbigni* feed on insects and aquatic vegetation, while adults are predominately carnivores (Gallardo 1977. Reptiles de los Alrededores de Buenos Aires. EUDEBA/Lectores, Bs. As. 213 pp.; Gallardo 1982. Anales de Parques Nacionales 15:65–75) or opportunists (Cabrera 1998. Las Tortugas Continentales de Sudamerica. Edic. Indep., Córdoba. 108 pp.). An opportunist grazer generally feeds on the most available and abundant food resource (Holland 1985. Herpetol. Rev. 16:112–113). Here we report *Trachemys dorbigni* feeding on *Limnoperna fortunei* (Golden Mussel), a bivalve native to Southeast Asia and introduced in the Delta do Jacuí region (Rio Grande do Sul, Brazil), in the 1970s (Mansur et al. 2002 Rev. Bras. Zool. 20[1]:75–84). *Limnoperna fortunei* exhibits a fast life cycle, with rapid sexual maturation and the capability for rapid dispersal. Additionally, it displays gregarious behavior, apparently lacks natural predators in the region, and, as an invasive species, is considered a major cause of the loss of biological diversity where it has been introduced (Ziller 2006. *In* http://www.sobrade.com.br/textos/trabalhos.htm. acc. 20061013). Golden Mussels can cause the extinction of native bivalve species, death of macrophytes by root suffocation, modification of the planktonic community, increase in fish fragility, and economic damage (e.g., clogging of pipes in urban water systems in the vicinity of the delta) (Neves et al. 1997. *In* Benz and Collins [eds.], Aquatic Fauna in Peril: The Southeastern Perspective, pp. 43–85. Southeast Aquatic Research Institut. Spec. Publ. 1, 554 pp.).

We observed the feeding habits of *T. dorbigni* from September 2004 to March 2005, while working on the Chelonia-RS Project (long-term research about biology and conservation of freshwater turtles in southern Brazil), in the State Park of Delta do Jacuí (29°53'–30°03'S, and 51°28'–51°13'W – Rio Grande do Sul State, Brazil). Observations occurred at fixed sites on the margin of a silt canal (Pintada Island) heavily impacted by human activities. To facilitate fecal analysis, eight turtles (4 males and 4 females) were captured in baited traps and placed individually in plastic buckets with clean water. These animals were kept in the buckets for a maximum of 24 h to allow collection of fresh feces and then returned to the capture site. Fecal matter was isolated by filtration, fixed in 70% alcohol, and separated and analyzed using a dissecting microscope.

Brazilian Sliders will feed on sessile mollusks attached to dock pilings, as well as on those attached to ship's hulls. To remove the prey from the substrate, a turtle places the anterior limbs on the mollusk mass, and stabilizes its position with the posterior limbs. At the same time, it engulfs a mollusk shell in its mouth and retracts its head inside the carapace, breaking the mollusk from its attachment point. This predation appeared to target the Golden Mussel, as the species was present in all samples. Fecal analyses supported the visual observation of predation on the Golden Mussel, and showed that the animals also feed on native gastropods (Family Hydrobiidae), *Trichodactylus* sp. (Crustacea), plant material (Poacea, Angiospermae), and also ingest sand and synthetic material (fish line).

These results demonstrate the importance of *Trachemys dorbigni* as a potential biological regulator of *Limnoperma fortunei*.

We thank Fundação O Boticário de Proteção à Natureza (FBPN), Instituto Gaúcho de Estudos Ambientais (INGA), and Secretaria Estadual do Meio Ambiente (SEMA) for financial and logistic support.

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TRACHEMYS DORBIGNYI (Brazilian Slider). **HATCHLING OVERWINTERING**. Turtles have evolved diverse strategies to maximize the success of incubation and the survival of hatchlings. In some species, hatchlings may postpone emergence from the nest after hatching, at times overwintering below ground and emerging in spring. This habit is known for several species of emydid turtles, including species of *Trachemys* from the northern hemisphere (Aresco 2004. J. Herpetol. 38:249–256; Tucker and Paukstis 1999. J. Herpetol. 33:608–615). Here we report the first known occurrence of this behavior for *Trachemys dorbignyi*, the most southerly distributed species of the genus.

Sampling over 13 years in southern Brazil had demonstrated that *T. dorbignyi* nest between the months of October and January

(Spring and Summer) (Bager 2007. Herpetologica. In press), and have an incubation period of approximately 95 days. All nest monitoring to date suggested that hatchlings leave the nests soon after hatching.

A *T. dorbignyi* nest was found opportunistically on 19 September 2006 (spring) when we were monitoring a nesting area in southern Rio Grande do Sul State - Brazil (UTM 22J x = 0370303mE; y = 6484280mN). The nest, constructed in argillo-arenaceous soil, had a narrow opening to the surface, presumably made by hatchlings which had left the nest previously. Four living hatchlings and egg shells, but no dead hatchlings or infertile eggs, were found. The hatchlings had lost the caruncle ("egg tooth"), and the abdominal yolk scar was totally closed, indicating a long post-hatching period. This observation was deemed an unusual instance of overwintering, as the majority of slider hatchlings in this area leave the nests immediately after total absorption of the residual yolk, still possessing a caruncle and with clear separation between the abdominal scutes at the yolk scar.

The hatchlings had an average maximum carapace length of 32.0 ± 2.2 mm (N = 4) and average 13.5 ± 0.6mm (N = 4) carapace height. These hatchlings were smaller than those measured in other localities in southern Brazil (average carapace length = 35.1 ± 1.3m; average carapace height = 16.8 ± 0.7mm [N = 77], unpubl. data).

Considering the latest nesting date known for the species in this region (10 January), hatching would usually occur by late April or early May (Autumn). In this area the lowest winter temperature does not reach the freezing point; average low temperature during July (coldest month) is 12.3°C (range 11–13.6°C). Considering that this species occurs in northern Argentina, where winter temperatures can fall below 0°C, future studies could determine if the hatchlings in the nest are tolerant of freezing temperatures.

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TRACHEMYS SCRIPTA ELEGANS (Red-eared Slider). **COLORATION**. A turtle captured alive in Lake Springfield in Springfield, Illinois, USA, on 21 August 2005, displayed an unusual color pattern morph. UTM coordinates are as follows using NAD27CONUS map datum in zone 16: N 0257716m, E 4429578m. The turtle is a female with the following physical measurements: carapace length = 166 mm, carapace width = 127 mm, carapace height = 63 mm, plastron length = 155 mm; total mass = 700 g. The turtle has an unusually high density of yellow pigment on the carapace, head, legs and tail. This is the only turtle discovered out of several thousand turtles captured to display these particular characteristics in our trapping in Illinois. Yellow pigment formed a thick ring around the outer carapace margin and formed dense blotches on the first two pleural scutes on both the right and left side with yellow comprising greater than half the area of the scute. In addition, the head, tail and legs lack the typical dark green with black and yellow stripes, which instead are all yellow separated by thin black stripes. The characteristic red patch is present behind the eye, along with a thin red stripe running horizontally across the snout. Similar color variations in wild *T. scripta* have been reported (Cagle 1947. Nat. Hist. Misc. 6:1–3; Tucker et al. 1995. Bull. Chicago Herpetol. Soc. 30[7]:148–149), as well as for *Chrysemys picta* (Harding 1982. Herpetol. Rev. 13:19).

FIG. 1. Top: Dorsal view of carapace depicting large yellow blotches on the first two pleural scutes and thick yellow ring around the marginal scutes. Bottom: Anterior view showing absence of dark green skin with black and yellow stripes replaced by yellow broken up by thin black stripes and narrow red bridge across the snout between the eyes.

The color pattern on this turtle is consistent with some of the so-called "pastel" color morph Red-eared Sliders which are commonly offered in the pet trade industry. Because Lake Springfield is highly accessible to the public and located within an urban area, it is plausible that a "pastel" Red-eared Slider was introduced here. However, because these pigmentation anomalies can occur under natural conditions, there is no way to be certain of this turtle's origin. The turtle was photographed, marked, and released.

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TRACHEMYS SCRIPTA (Red-eared Slider Turtle). **PREDATION**. Predation on waterfowl and other birds by Common Snapping Turtles (*Chelydra serpentina*) is well known, but avian predation by other aquatic turtles is rarely reported (Pryor 1996. Wilson Bull. 108:190–192; Ernst et al. 1994. Turtles of the United States and Canada, Smithsonian Inst. Press, Washington, DC). Here I report an observation of predation of an adult passerine by aquatic emydid turtles.

At approximately 1400 h on 31 May 2002, an agonistic encounter was observed between two adult male Red-winged Blackbirds (*Agelaius phoeniceus*) on the surface of a small pond in Greer County, Oklahoma (USA). While viewing the dispute through field glasses, three adult Red-eared Sliders (*Trachemys scripta elegans*) were observed swimming toward the two birds. When the turtles got within approximately 3 m, one of the birds flew away. The second bird stayed on the surface of the water with wings spread and beak agape, apparently exhausted. A third male Red-winged Blackbird attacked the water-bound male, but retreated almost immediately, perhaps noticing the turtles nearby. After the second aggressor retreated, all three turtles disappeared beneath the water, and seconds later the remaining blackbird disappeared as well. An incomplete bird carcass floated back to the surface less than a minute after being pulled under water, and the turtles were not observed again.

With the exception of waterfowl, predation of adult birds by turtles is apparently an unusual and opportunistic event. The fact that three turtles were involved likely does not necessarily suggest cooperation, but is perhaps an indication of the high densities of Red-eared Sliders in this and other nearby ponds

I thank Joy Yoshioka and Wesley Webb for assistance in the field, and Oklahoma Department of Corrections for access to the ponds where the above observations were made.

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TRACHEMYS SCRIPTA ELEGANS (Red-eared Slider). **KYPHOSIS**. Turtle research at the Great Rivers Field Station of the Illinois Natural History Survey has resulted in the capture of more than 25,000 individual Red-eared Sliders (*Trachemys scripta elegans*) in west-central Illinois and neighboring Missouri. These turtles have included a number of specimens with unusual carapace morphologies that likely represent extremes in range of morphologies for turtle shells, including kyphotic individuals (Tucker 1997. Bull. Md. Herpetol. Soc. 33:171–177). Most kyphotic turtles have the highest point on the carapace located at vertebral scute two or three on the front half or middle of the carapace (e.g., Plymale et al. 1978. Southwest. Natur. 23:457–462; Rhodin et al. 1984. Brit. J. Herpetol. 6:369–373; Stuart 1996. Bull. Chicago Herpetol. Soc. 31:60–61), but see Fig. 1, an unusual four-year old male. Our large sample sizes allow a robust estimate of the frequency with which kyphosis occurs in this slider population.

Kyphosis in naturally occurring sliders is apparently rare. We found 14 turtles (0.06%) that we identified as kyphotic among 21,786 turtles captured in Calhoun and Jersey Counties in Illinois between 1994 and 2006. Males (N = 8) and females (N= 6) were equally likely to be kyphotic ($\chi^2 = 0.29$, 1df, $P = 0.5830$). Kyphosis seems to be uncommon in other turtles as well but the rate of occurrence varies considerably. Five of 929 (0.5%) Lancaster County, Pennsylvania Painted Turtles (*Chrysemys picta*, Ernst 1971. J. Herpetol. 5:216–220) were kyphotic. Stuart (*op. cit.*) found a single kyphotic Western Painted Turtle (*Chrysemys picta belli*) among 429 total captures (0.23% of sample). A single Spotted Turtle (*Clemmys guttata*, Ernst 1976. J. Herpetol. 10:25–33) among 207 (0.5%) examined was kyphotic. Spinal deformities occur in sea turtles at a low rate. Only 0.03% of more than 11,000 turtles of five species were kyphotic (Rhodin et al., *op. cit.*).

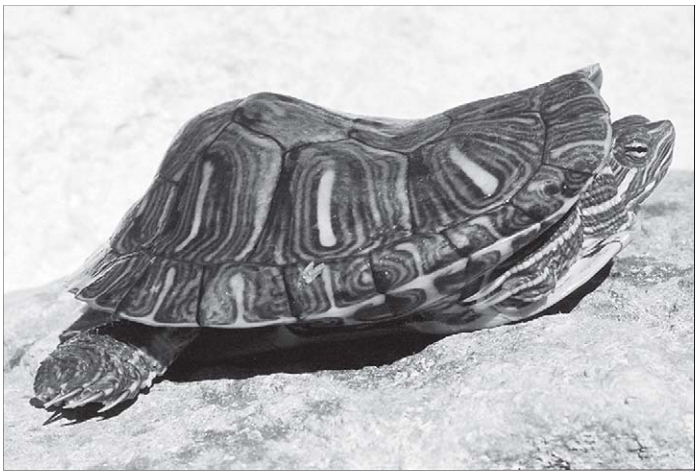

FIG. 1. An unusually shaped Red-eared Slider (*Trachemys scripta elegans*) juvenile male collected at Long Lake, Jersey County, west-central Illinois.

Despite the frequency with which kyphotic turtles have been reported in the literature, virtually nothing is known of the etiology of the condition. Various hypotheses have been advanced from problems with yolk retraction (Williams 1957. Herpetologica 13:236) to premature fusion of the shell (see Stuart, *op. cit.* and Saumure 2001. Chelonian Conserv. Biol. 4:159 for recent reviews). Only experimental manipulation will lead to an understanding of the basis for kyphosis. Such experiments will be difficult given the apparent rarity of the condition. It is, however, important to record the frequency of occurrence of kyphosis in various species of turtles because variation in rates of occurrence may shed light on the cause of the condition and the effect on individual turtles. Thus, the relatively high rate (2.6%) of kyphosis in a small sample of Common Musk Turtles (*Sternotherus odoratus*, Saumure, *op. cit.*) may be noteworthy or simply reflect the small sample studied (N = 39). The variation in rate of occurrence (0.03–2.6%) reported here further underscores the need for data on large samples from more species. It may be that smaller turtles (*C. picta, C. guttata,* and *S. odoratus*) are more likely to exhibit kyphosis than are larger turtles (*T. scripta* and sea turtles). Rate of occurrence among the small-bodied turtles is roughly 10 times that for larger-bodied species (0.23% to 2.6% versus 0.03% to 0.06%, respectively). Perhaps yolk retraction is more difficult among smaller turtle hatchlings or errors in shell development have more profound effects in small turtles. Any hypothesis, however, is premature until more species are studied.

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CROCODYLIA

CROCODYLUS INTERMEDIUS (Orinoco Crocodile). **JUVENILE FEEDING.** *Crocodylus intermedius* is one of the most critically endangered crocodilians (Rodríguez and Rojas 2003. Libro Rojo de la Fauna Venezolana, IUCN. 2nd. ed, Fundación Polar/PROVITA, Caracas. 472 pp.). It occurs in the Orinoco River Basin in Venezuela, and has been the focus of captive breeding and habitat protection policies (Thorbjarnarson 1988. Proc. World Conf. Breeding Endangered Species Captivity 5:307–314). Few data exist on the feeding behavior of juvenile crocodiles (*Crocodylus acutus* [Thorbjarnarson 1989. *In* Hall (ed.), Crocodiles: Their Ecology, Management and Conservation, pp. 228–258. A Special Publication of the Crocodile Specialist Group IUCN/SSC. Gland, Switzerland]; *C. johnstoni* [Webb et al. 1982. Aust. J. Zool. 30:877–899]; *C. niloticus* [Games 1990. *In:*Proc. Ninth Working Meeting Crocodile Specialist Group. Vol. 1, pp. 251–267. IUCN. Gland, Switzerland]; *C. porosus* [Taylor 1979. Aust. Wildl. Res. 6:347–359; Davenport et al. 1990. J. Zool. Lond. 220:569–592]), but no published data exist on the feeding behavior of juvenile *C. intermedius*. Hence, here I report an observation of juvenile *C. intermedius* feeding.

I made the observation at Fundo Pecuario Masaguaral, a cattle ranch with a crocodile farm (Blohm 1982. *In* Proc. Fifth Working Meeting IUCN/SSC Crocodile Specialist Group, pp. 267–285. Gland, Switzerland) in State of Guárico in the Central Llanos of Venezuela (8°34'N, 67°35'W; elev. 60–75 m). The Central Llanos are lowlands (below 75 m elevation) with a well-defined wet season (May–Nov) dominated by open grasslands interspersed with deciduous forests (Troth 1979. *In* J. Eisenberg [ed.], Vertebrate Ecology in the Northern Neotropics, pp.17–30. Smithsonian Inst. Press, Washington, DC). At 2000 h (at night), I encountered a juvenile *C. intermedius* (ca. 2.5 months old, 38 cm total length) holding an adult dead male *Bufo granulosus* (ca. 4.5 cm SVL) with its jaws in a water-filled truck track ca. 9 cm deep on an unpaved road. The juvenile *C. intermedius* was in the water, with only its head above the surface, holding the dead toad with its jaws, which first I noticed when I captured the juvenile. The toad was flaccid, belly down, head inward, body axis almost parallel to the *C. intermedius*' jaws axis, with only the toad's hind legs being visible outside the crocodile's jaws. The juvenile *C. intermedius* discarded the toad following capture, presumably because it has been disturbed.

Bufo granulosus males usually call from the ground around puddles (Hoogmoed and Gorzula 1979. Zool. Mededelingen 54:183–216), so the male *Bufo* may have been vocalizing. The juvenile *C. intermedius* escaped from an enclosure two months before this observation was made but displayed no signs of injury or starvation, suggesting that it was feeding regularly on its own. The juvenile was subsequently returned to its enclosure.

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SERPENTES

ALSOPHIS ANOMALUS (Hispaniolan Brown Racer). **MAXIMUM SIZE.** On 24 June 2006, at Fondo Paradí, Parque Nacional Jaragua, Pedernales Province, Dominican Republic, about 1.5 km from the main road to Pedernales (town) at 17°48'11.93"N, 71°26'49.47"W, the body of an *Alsophis anomalus* that had been killed by locals was found by Miguel Landestoy, Pedro Genaro Rodríguez, and Enrique Ureña. It had a total length of 2743 mm and a SVL of ca. 2000 mm, which exceeds by a substantial margin the maximum SVL (1770 mm) reported in Schwartz and Henderson (1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Univ. Florida Press, Gainesville. 720 pp.). This species is infrequently encountered despite a relatively extensive distribution on the western half of Hispaniola (Powell and Henderson 1998. Cat. Amer. Amphib. Rept. 659:1–2). Given that *A. anomalus* is the largest species in the genus, this specimen also constitutes a size record for the genus, for West Indian colubrids, and probably for any xenodontine colubrid (rivaled only by *Clelia clelia*). Total length of the specimen was

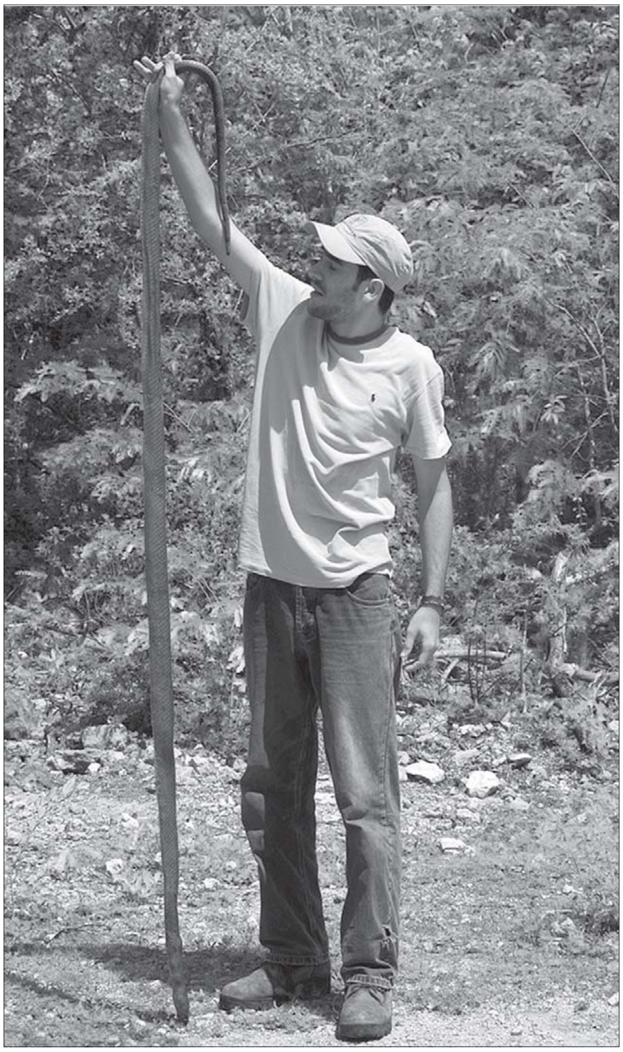

FIG. 1. *Alsophis anomalus* of record length. Miguel Landestoy, holding the snake, is 1855 mm (73 inches) tall. Photograph by Pedro Genaro Rodríguez.

measured in the field (Fig. 1). Although the specimen was easily identifiable, by the time it was recovered for preservation it could only be saved as a skeleton. It has been deposited in the University of Puerto Rico-Rio Piedras (UPRRP 6492).

We thank S. Blair Hedges, Jorge Brocca, Nicolas Corona, and Eladio Fernandez for facilitating recovery of the specimen.

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BOTHROPS MATTOGROSSENSIS (Mato Grosso Lancehead). **PREDATION**. *Bothrops mattogrossensis* is a terrestrial, medium-sized pitviper that inhabits open areas adjacent to semidecidual forests in seasonally flooded open plains (Martins et al. 2002. *In* Schuett et al. [eds.], Biology of the Vipers, pp. 307–328. Eagle Mountain Publishing, Eagle Mountain, Utah). On 21 Oct 2005 at ca. 0805 h, we found an adult *B. mattogrossensis* (ca. 70 cm SVL) being attacked by a *Buteogallus urubitinga* (Great Black Hawk) in a grassy field in the Brazilian Pantanal (19°27'10.5"S, 56°35'27.3"W, elev. 107 m), Mato Grosso do Sul State. The hawk gripped the pitviper by the head and, upon our approach, flew away to semideciduous forest carrying the snake in its talons. Raptors are important predators on reptiles; however, Burrowing Owls are the only published predators of *Bothrops* species (Martins et al. 2003. Herpetol. Rev. 34:147–148; Valdujo and Nogueira 2000. Herpetol. Rev. 31:45). Moreover, snakes are uncommon prey for *B. urubitinga*, which prey primarily on frogs and lizards, but also consume birds (Lewis and Timm 1991. Ornitologia Tropical 2:37).

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CONIOPHANES FISSIDENS (Brown Spotbelly). **REPRODUCTION.** *Coniophanes fissidens* is known from San Luis Potosí and Michoacán, Mexico through Central America to central Ecuador (Savage 2002. The Amphibian and Reptiles of Costa Rica: A Herpetofauna Between Two Continents, Between Two Seas. The University of Chicago Press. 934 pp.). Zug et al. (1979. Smithsonian Cont. Zool. 300:1–20) and Solorzáno (2004. Snakes of Costa Rica. Distribution, Taxonomy and Natural History, Instituto Nacional de Biodiversidad [INBio], Costa Rica, 791 pp.) reported on reproduction of female *C. fissidens*. The purpose of this note is to present the first information on the testicular cycle of *C. fissidens* from a histological examination of museum specimens.

Twelve *C. fissidens* (mean SVL = 299 mm ± 35 SD, range = 225–339 mm) from Costa Rica and Mexico were examined from the herpetology collection of the Natural History Museum of Los Angeles County, (LACM), Los Angeles, California. Snakes were collected during 1959–1985. Specimens examined by province (Costa Rica) and state (Mexico) were: Costa Rica: Cartago (LACM 150451, 150456, 150459, 150460); Heredia (150455, 150458); Puntarenas (150452–150454, 150466); Mexico: Chiapas (38179, 114063). The left testis and a portion of the vas deferens were removed for histological examination. Tissues were embedded in paraffin and histological sections were cut at 5 µm. Sections were mounted on glass slides and stained with Harris' hematoxylin followed by eosin counterstain. Slides were examined to determine the stage of the testicular cycle.

The testes of all males were undergoing spermiogenesis (= sperm formation). The lumina of the seminiferous tubules were lined by spermatozoa or several rows of metamorphosing spermatids. Monthly samples of spermiogenic males were: January (1), February (1), March (1), April (2), June (1), July (1), September (1), October (2), December (2). The vasa deferentia contained sperm. The smallest reproductively active male measured 251 mm (LACM 150454) and was collected in March. While samples were not available from all months, the presence of males undergoing spermiogenesis from most of the year indicates an extended period of spermiogenesis.

Other snakes from Costa Rica also exhibited extended periods of sperm formation: *Dendrophidion vinitor* (Goldberg 2003. Trans. Illinois State Acad. Sci. 96:295–300); *Drymobius margaritiferus* (Goldberg 2003. Texas J. Sci. 55:195–200); *Ninia maculata* (Goldberg 2004. Texas J. Sci. 56:81–84); *Erythrolamprus bizona, E. mimus* (Goldberg 2004. Texas J. Sci. 56:171–174); *Micrurus nigrocinctus* (Goldberg 2004. Carib. J. Sci. 40:420–422); *Hydromorphus concolor* (Goldberg 2006. Bull Maryland Herpetol. Soc. 42:169–170); *Geophis godmani* (Goldberg 2007. Bull Chicago Herpetol. Soc. 42:7–8). *Coniophanes fissidens* should be added to this group. Subsequent examinations of the testicular cycles of additional snake species are needed to determine the prevalence of prolonged periods of spermiogenesis in Central American snakes.

I thank Christine Thacker (LACM) for permission to examine snakes. Specimens from Costa Rica are part of the CRE collection donated to LACM by Jay M. Savage in 1998.

Submitted by **STEPHEN R. GOLDBERG,** Department of Biology, Whittier College, Whittier, California 90608, USA; e-mail: sgoldberg@whittier.edu.

CROTALUS CERASTES (Sidewinder). **ATTEMPTED FEEDING** and **MORTALITY**. The diet of *Crotalus cerastes* consists largely of lizards and rodents (Brown and Lillywhite 1992. *In* Campbell and Brodie, Jr. [eds.], Biology of the Pitvipers, pp. 279–308. Selva, Tyler, Texas; Funk 1965. Herpetologica 21:15–17). Antelope squirrels (*Ammospermophilus* sp.) are among the rodents that have been recorded as prey of *C. cerastes* (Funk, *op. cit.*). Moore (1978. Copeia 1978:439–442) suggested that only very large

C. cerastes were capable of feeding on White-tailed Antelope Squirrels (*A. leucurus*). Here, we document an instance of a *C. cerastes* attempting to ingest an *A. leucurus*, which resulted in the death of both animals.

On 2 April 2001, one of us (BC) found a pair of courting *C. cerastes* on the eastern edge of the Kelso Dunes in Mojave National Preserve, San Bernadino County, California, USA. The pair was captured and the female (567 mm SVL; 133 g) was implanted with a radio-transmitter, released, and tracked until 31 May 2001 (the end of the spring field season). During this period she moved an average of 4.8 m/day. On 28 August 2001 (the beginning of the autumn field season), the signal was again located. The snake was 157.4 m from her 31 May location and was below ground in a dune stabilized by Big Galleta Grass (*Pleuraphis rigida*). The signal remained stationary throughout the entire autumn and following spring field seasons. We excavated the dune on 21 May 2002 and discovered the mummified body of the snake with the remains of an *A. leucurus* in her mouth. The pair was lying on their backs in a burrow system about 20 cm from the nearest entrance. The head of the snake was twisted slightly to her left and her mouth held the antelope squirrel around the shoulder.

It is unclear exactly how the snake died, but it is possible that after engaging her teeth to begin feeding, she was constrained by the position of the squirrel in the burrow and was unable to either continue swallowing or release the prey item. In this scenario, the cause of death would either be starvation or suffocation. Alternatively, the burrow might have collapsed as a result of movements associated with feeding, resulting in suffocation. Both specimens are deposited in the Soda Springs Desert Studies Center, Zzyzx, California (*Crotalus cerastes*, SSDSC 59; *Ammospermophilus leucurus*, SSDSC 60).

We thank J. Patton, A. Brumbaugh, the Columbus Zoo, and Ohio State University for assistance.

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ELAPHE GUTTATA EMORYI (Great Plains Ratsnake). **DIET.** *Elaphe guttata emoryi* eats a wide variety of prey including rodents, ground nesting birds, and occasionally lizards (Werler and Dixon 2000. Texas Snakes: Identification, Distribution, and Natural History, University of Texas Press, Austin, Texas. 437 pp.). On 7 October 2006 (1100–1130 h) we collected an adult male *E. g. emoryi* (154 mm SVL, 72 mm TL, 124 g) under green briar vines in a live oak motte at Camp Bowie National Guard Training Facility (31°35'44.6"N, 098°53'58.7"W, 429 m elev.), Brown County, Texas, USA. The snake had an adult female *Sceloporus olivaceus* (103 mm SVL, 153 mm TL, 44 g) in its stomach that was consumed headfirst. The lizard and snake are deposited in the Angelo State Natural History Collection (ASNHC 14192-93), Angelo State University, San Angelo, Texas.

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MASTICOPHIS FLAGELLUM (Eastern Coachwhip). **REPRODUCTION**. The reproductive ecology of *Masticophis flagellum* in the northwestern Gulf Coastal Plain near the convergence of the borders of northeast Texas, southeast Oklahoma, southwest Arkansas, and northwest Louisiana is poorly understood. Two *M. flagellum* clutches from northern and central Arkansas contained 14 and 18 eggs (Trauth et al. 1994. Proc. Arkansas Acad. Sci. 48:196–209). Clutches from Oklahoma contained 7, 12, and 13 eggs, and were oviposited from early to mid-July (Carpenter 1958. Herpetologica 14:113–115). A single female (1160 mm SVL, 322 g) from Smith County, Texas laid a clutch of 11 eggs on 29 June 1988 (Ford et al. 1990. Texas J. Sci. 42:355–368). Eggs from that clutch were 4.47 (SD = 0.29) cm long, 2.33 (SD = 0.05) cm wide, and weighed 15.3 (SD = 9.61) g.

On 14 June 2006, a female *M. flagellum* (1154 mm SVL, 1484 mm TL, 465.2 g [mass taken prior to egg removal]) was recovered from a rubbish pile ca. 4 km from the Arkansas-Texas border along George Thomas Road (33.33098-N, 94.0852-W, elev. 129 m, Datum: NAD27) and ca. 0.75 km S of the junction of this road with Fricks Road in the Liberty Eylau region of Texarkana, Bowie County, Texas. The animal was placed in cool storage (2.5°C) until 15 June 2006 when it was removed for photography. After approximately 30 min at 30°C the animal was listless and its vent appeared dilated for oviposition. I placed the animal in a 40 L aquarium with a lid, water, and a terra cotta flower pot as a shelter. On 16 June 2006 at about 0830 h the specimen was found dead. Fourteen eggs were dissected from the abdominal cavity, weighed with an electronic balance, and measured using Vernier calipers. Mass of individual eggs (mean = 11.16 g, SE = 0.097) was not normally distributed (Anderson-Darling: A^2 = 0.739, P = 0.041), whereas length (mean = 37.88 mm, SE = 0.377; A^2 = 0.213, P = 0.815) and diameter (mean = 22.82 mm, SE = 0.213; A^2 = 0.383, P = 0.347) were normally distributed. Eggs had the following measurements based on their location in the oviduct: Cranial (N = 5): mean mass = 11.1 g (SE = 0.1), mean length = 36.5 mm (SE = 0.5), mean diameter = 22.9 mm (SE = 0.2); Middle (N = 5): mean mass = 11.3 g (SE = 0.22), mean length = 38.3 mm (SE = 0.5), mean diameter = 22.5 (SE = 0.2); Caudal (N = 4): mean mass = 11.1 g (SE = 0.2), mean length = 37.2 (SE = 1.0), mean diameter = 23.2 (SE = 0.7). Although the absolute mean dimensions of eggs located centrally in the reproductive tract seemed larger, the position of the eggs in the reproductive tract was not a significant indicator of an egg's mass (Kruskal-Wallace: H = 1.09, *df* = 2, P = 0.580), length (ANOVA: F = 0.71, *df* = 13, P = 0.501), or diameter (ANOVA: F = 0.730, *df* = 13, P = 0.504).

The timing of reproduction by this female mirrors observations in northeast Arkansas and southeast Oklahoma (Carpenter, *op. cit.*; Trauth et al., *op. cit.*) and is only two weeks earlier than observed in Smith County, Texas (Ford et al., *op. cit.*). The clutch size in this observation is identical to the observation from Smith County, Texas, comparable to the observations from southeast Oklahoma, and smaller than that observed in northeast Arkansas. Mean egg mass in this clutch is nearly 4 g lighter than observed in Smith County, Texas, despite the fact that our female is only 6 mm smaller. After data collection, the eggs were held at ambient temperature and misted daily until signs of mold appeared accompanied by a foul odor (18 June 2006). At this time the eggs were fixed in 10% formalin and deposited in a private (MLM) teaching-research collection. This observation fills a geographical void in our knowledge of the reproductive biology of *M. flagellum* in this region.

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MASTICOPHIS SCHOTTI SCHOTTI (Schott's Whipsnake). **DIET.** Although documentation of the feeding habits of *Masticophis schotti schotti* is lacking (Werler and Dixon 2000. Texas Snakes: Identification, Distribution, and Natural History. University of Texas Press, Austin, Texas. 437 pp.), its diet is assumed to be similar to that of other *Masticophis*, which prey chiefly on lizards and birds. At 1730 h on 28 October 2006, I collected a DOR adult female *M. s. schotti* (945 mm SVL, 425 mm TL, 162 g) 1.1 mi N of the intersection of Texas Hwy 16 and Farm Road 2295 on Hwy 16 (27.59304°N, 098.65605°W, 193 m elev.) in Duval County, Texas, USA. The snake had an adult male (TD = 15 × 6 mm) *Peromyscus leucopus* in its stomach that was consumed headfirst. The mouse's measurements were: total length 178 mm, tail length 80 mm, hind foot 18 mm, ear 15 mm, and it weighed 23 g. The snake (ASNHC 14197) and mouse (ASNHC 13039) are deposited in the Angelo State Natural History Collection, Angelo State University, San Angelo, Texas.

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MEHELYA NYASSAE (Black File Snake). **FEEDING.** On the evening of 23 February 2006 a female *Mehelya nyassae* (450 mm SVL, 44 mm tail length, 30 g) was discovered swallowing an *Acontias plumbeus* (Giant Legless Skink; 252 mm SVL, 44 mm tail length, 34 g) on the road in Mtunzini, South Africa. The two animals had been recently hit by a vehicle and both were dead. The anterior 150 mm of the skink had been swallowed by the snake before the snake had been hit by the vehicle and thus it is unclear whether the snake would have completely ingested the prey. Shine et al. (1996. J. Zool. London 240:327–340) indicate that the diet of *M. nyassae* consists largely of scincid lizards, but did not record any members of the subfamily Acontinae in the diet of this species. Shine et al. (*op. cit.*) also report the mean prey mass to predator mass ratio as being 0.15 with a maximum ratio of 0.45. Assuming that this snake would have completely ingested the prey item, this feeding record would represent a prey mass to predator mass ratio of 1.14, well exceeding the reported range.

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NOTECHIS SCUTATUS (Australian Tiger Snake). **CANNIBALISM.** Incidental cannibalism in young snakes is frequently observed in captivity in a wide range of species, and usually occurs while the animals are being fed in a communal space. High frequency of cannibalism has been previously reported in *Notechis scutatus* from island populations during feeding events (Worrel 1963. Reptiles of Australia. Angus and Robertson, Sydney. pp. 132). Cannibalism between young *N. scutatus* was also recorded in the absence of food (Firmage and Shine 1996. Amphibia-Reptilia 17:55–65).

In March 2006, four pregnant female *N. scutatus* were captured on Williams Island, South Australia (35°01'54"S, 135°58'28"E) and two pregnant females were captured at Herdsman Lake, Western Australia (31°55'16"S, 115°48'17"E). In April 2006, 79 *N. scutatus* were born in captivity to these six females. Island neonates (22.8 ± 1.9 cm SVL, 8.9 ± 1.5 g; N = 50) and mainland neonates (17.8 ± 0.7 cm SVL, 4.4 ± 0.3 g; N = 29) significantly differed in snout–vent length ($F_{1,77} = 183.4$; $P < 0.01$) and in body mass ($F_{1,77} = 256.4$, $P < 0.01$) at birth. All snakes were housed individually under standardized conditions and fed dead mice every two weeks.

In the course of conducting other experiments, the now two-month-old snakes (body mass ranging from 4–11 g) were kept in groups of 3–16 individuals in small plastic boxes for three days. Cannibalism was observed on seven occasions, always in the absence of food stimuli and several days from the last feeding event. Victims ranged from 41% lighter up to 25% heavier, and from 17% shorter up to 11% longer than their attackers. Island snakes (Williams Island, South Australia) as well as mainland snakes (Herdsman Lake, Western Australia) displayed cannibalism. Island snakes preyed upon island snakes (2 occurrences) as well as mainland snakes (3 occurrences), while mainland snakes only consumed mainland snakes (2 occurrences), possibly reflecting the much larger size (and presumably strength) of island juveniles compare to their mainland counterparts (see above). Biting and other fighting behaviors were often observed, once involving two snakes biting a third individual. In most instances, snakes were separated by hand before cannibalism could occur. No bitten snakes seemed to suffer in an observable way from the effect of their attacker's venom. This report indicates that island and as well as mainland young *N. scutatus* are capable of cannibalism in captivity. There is no evidence that cannibalism occurs in the wild in this species. However it seems likely that some Island Tiger Snakes would display such behavior, especially in the absence of small prey items such as frogs (*Crinia*) and skinks (*Ctenotus*) that are the staple diet of mainland neonates (Aubret et al. 2004. Amphibia-Reptilia 25:9–17).

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PSAMMOPHIS LEIGHTONI TRINASALIS (Fork-marked Sand Snake) and ***PSAMMOPHIS NOTOSTICTUS*** (Karoo Sand Racer). **ENDOPARASITES.** *Psammophis leightoni trinasalis* occurs in eastern Namibia, Botswana, and northern South Africa; *P. notostictus* occurs in the Cape provinces and Southern Free State, South Africa through Namibia to southern Angola (Branch 1988. Field Guide to Snakes and other Reptiles of Southern Africa. Ralph Curtis Books, Sanibel Island, Florida. 399 pp.). To our knowledge, there are no reports of helminths from these snakes. The purpose of this note is to establish the initial helminth lists for *P. leightoni* and *P. notostictus*.

Twenty *P. leightoni trinasalis* from southern Africa (SVL = 431 mm ± 151 SD, range: 165–637 mm) and 4 *P. notostictus* (SVL = 453 mm ± 39 SD) deposited in the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California were examined: (*P. leightoni trinasalis* LACM 77106, 77107, 77463, 77660, 77661, 84178–84188, 84190–84193; *P. notostictus* LACM 77657–77659, 127500). A mid-ventral incision was made in the posterior third of the body and the coelomic cavity was searched for helminths. Nematodes were cleared in lactophenol and identifed from wet-mounts. Cestodes were stained in Delafield's hematoxylin, mounted in Canada balsam, coverslipped and identified from whole-mounts. Two species of Cestoda were found in *P. leightoni trinasalis*: *Oochoristica truncata* in LACM 77106 (prevalence, % infected/sample = 5%; mean intensity, mean number helminths per infected individual = 1.0) and *Mesocestodes* sp. in LACM 77660, 84181 (prevalence = 10%, mean intensity = 11.5 ± 0.72, range = 11–12), and one species of Nematoda, *Polydelphis anoura* in LACM 84180, 84181, 84185, 84187 (prevalence = 20%, mean intensity = 2.5 ± 2.4 SD, range = 1–6). One species of Cestoda was found in *P. notostictus*, *Mesocestoides* sp. in LACM 77657, 77659 (prevalence = 50%, mean intensity = 67.0 ± 11.3, range = 59–75). Helminths were deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland as *P. leightoni trinasalis*: *Oochoristica truncata* (USNPC 99514), *Mesocestoides* sp. (USNPC 99515), *Polydelphis anoura* (USNPC 99516); *P. notostictus*; *Mesocestoides* sp. (USNPC 99513).

Oochoristica truncata is widespread in reptiles from southern Africa and has been reported from agamid, chameleonid, gekkonid, and scincid lizards, as well as boid and colubrid snakes (Goldberg and Bursey 2004. Afr. Zool. 39:111–114). *Psammophis* presumably becomes infected by ingesting prey harboring larvae of *O. truncata*. *Mesocestoides* is a cosmopolitan genus with a unique larval form, the tetrathyridium, commonly found in reptiles, birds, and mammals, which is infective to the predatory definitive hosts (Schmidt 1985. Biology of the Acanthocephala. Cambridge University Press, Cambridge, U.K. 519 pp.). Reports of tetrathyridia of *Mesocestoides* sp. in amphibians and reptiles are summarized in Goldberg et al. 2004 (Comp. Parasitol. 71:49–60). *Polydelphis anoura* is a widespread nematode reported from snakes from both the New and Old World (Baker 1987. Occas. Pap. Biol. Univ. Newfoundland 11:1–327; Ernst and Ernst 2006. SSAR Herpetol. Circ. 34. 86 pp.). Snakes are presumably infected by ingesting rodents harboring larvae (Anderson 2000. Nematode Parasites of Vertebrates. Their Development and Transmission. CABI Publishing, Wallingford, Oxon, U.K. 650 pp.). *Psammophis leightoni trinasalis* represents a new host record for *Oochoristica truncata*, *Mesocestoides* sp., and *Polydelphis anoura*. *Mesocestoides* sp.; *Psammophis notostictus* represents a new host record for *Mesocestoides* sp.

We thank Christine Thacker (LACM) for permission to examine snakes.

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PYTHON MOLURUS BIVITTATUS (Burmese Python). **CLUTCH SIZE**. *Python molurus bivittatus* is the largest of three subspecies of *P. molurus*, all of which are native to Southeast Asia. Through popularity in the exotic pet trade and subsequent release or escape of captive specimens, *P. m. bivittatus* has established a viable breeding population within Everglades National Park (ENP), Florida, USA. This is of particular concern from a management stand point, given that clutch sizes for *P. molurus* have been reported as high as 107 eggs (Wall 1921. Ophidia Taprobanica or Snakes of Ceylon. Government printer, Colombo. 66 pp.). In contrast, the two largest native snake species present in ENP, the Eastern Indigo Snake (*Drymarchon corais couperi*) and the Eastern Diamondback Rattlesnake (*Crotalus adamanteus*) have much smaller reproductive capability, producing an average of ca. 8–9 eggs (range = 5–12; Ernst and Barbour 1989. Snakes of Eastern North America. George Mason University Press, Fairfax, Virginia. 282 pp.) and 15.7 live young (range = 4–28; Timmerman 1989. Unpubl. master's thesis, Univ. of Florida, Gainesville. 81 pp.), respectively. However, most accounts for *P. molurus*, in particular *P. m. bivittatus*, have been from captive animals with information on reproduction in the wild scant. Here, we report the first account of clutch sizes of wild-caught female *P. m. bivittatus* from ENP.

Using egg, oviductal, and ovarian follicle counts from females (Everglades National Park, EVER-8888: overall accession no. for python project) recovered and examined between 5 March 2004 and 17 March 2006, we found mean clutch size of *P. m. bivittatus* within ENP to be 35.8 ± 3.4 (N = 8; range 19–46). Females ranged in size from 266–462 cm total length, with the two largest females 462 cm and 385 cm total length producing the largest clutch sizes of 46 eggs each (one of shelled eggs and the other oviductal). Four females for which data were available had a mean total egg mass to female body mass ratio before oviposition of 17.6 ± 4.1%. For most species of snakes, clutches can account for between 10–45% of a female's mass before oviposition or birth, with an average of 30% (Greene 1997. Snakes: The Evolution of Mystery in Nature. University of California Press, Berkeley. 351 pp.). Clutch sizes reported here agree with previous observations that suggest average clutch sizes for *P. molurus* generally range from 29–50 eggs (Cox et al. 1998. A Photographic Guide to Snakes and other Reptiles of Peninsular Malaysia, Singapore and Thailand. Ralph Curtis Books, Sanibel Isle, Florida. 144 pp.) with larger clutch sizes associated with larger females (Greene, *op. cit.*).

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33314, USA; and **RAY W. SNOW**, South Florida Natural Resources Center, Everglades National Park, 40001 State Road 9336, Homestead, Florida 33034, USA.

SIBON LONGIFRENIS (Drab Snaileater). **DIET**. *Sibon longifrenis* is a small, nocturnal, arboreal snake that is reported to be a terrestrial gastropod specialist (Solorzano 2004. Snakes of Costa Rica. Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica. 791 pp.). Congeners, *S. argus* and *S. nebulatus*, have been reported to eat centrolenid and hylid frog eggs, respectively (Ryan and Lips 2004. Herpetol. Rev. 35:278). At 2100 h on 8 October 2005 we encountered an adult male *S. longifrenis* (383 mm SVL, 162 mm TL, 9.3 g) in the process of consuming an egg mass of *Cochranella albomaculata* at Gosner Stage 20 (Gosner 1960. Herpetologica 1960:183–190). The snake was located ca. 2.75 m up on a mossy vine overhanging Rio Maria (Panama Province, Panama). Within 10 minutes we located an additional adult male *S. longifrenis* (396 mm SVL, 173 mm TL, 9.0 g) moving among branches ca. 3.5 m above the stream. The second snake contained an obvious food bolus. We manually palpated the food item from the gut and identified it as an egg mass of *C. albomaculata* at Gosner Stage 10. Both snakes and their gut contents were collected and assigned field numbers (AHS F-1913 and F-1911).

At the time of the observation, *C. albomaculata* was going through a seasonal breeding event where we observed multiple amplectic pairs, as well as recently deposited egg masses. In addition to the *S. longifrenis* consuming eggs, we also located a juvenile female *Leptodeira septentrionalis* (282 mm SVL, 75 mm TL, 4.9 g) moving through vegetation above the stream that had eaten a *C. albomaculata* egg mass at Gosner Stage 10. The *Leptodeira* specimen was collected and deposited in the Museo de Vertebrados de la Universidad de Panama (MVUP-1874), and the *C. albomaculata* egg mass was deposited in the Southern Illinois University at Carbondale Museum (H-2636).

This is the first report of *S. longifrenis* feeding on egg masses. Our report provides further evidence that members of the genus *Sibon* are not strictly terrestrial mollusk and earthworm eaters (Kofron 1985. Copeia 1985:164–174), but rather "goo-eaters" as reported by Greene (1997. Snakes: The Evolution of Mystery in Nature. University of California Press. Berkeley. 351 pp.). Based on our observation and the two published observations (Ryan and Lips, *op. cit*.) of *Sibon* spp. eating egg masses, these snakes may opportunistically consume whatever egg masses are available at the time, since all observations were during breeding events of the species consumed. Egg masses might constitute a seasonally abundant, clumped food source for a genus that typically feeds on other prey types, e.g., mollusks and earthworms.

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SISTRURUS CATENATUS (Eastern Massasauga). **REPRODUCTION**. Organisms must allocate available resources among the competing demands of maintenance, growth, and reproduction. Allocation among these demands often can be shifted in response to changing environmental conditions (Lourdais et al. 2003. J. Zool., Lond. 259:123–129). This observation coupled with observations of ova atresia and the apparent disappearance of embryos in captive, gravid females has lead researchers to postulate that resorption can offset the extreme costs of reproduction in female squamates (see Blackburn et al. 1998. J. Morphol. 235:97–108). However, no direct evidence substantiating this inference exists (Blackburn et al. 2003. J. Morphol. 256:219–234). The female squamate uterus is not morphologically capable of enzymatic degeneration, although degeneration of embryos situated outside of the uterus (ectopic embryos) may occur (Blackburn et al. 1998, *op. cit*.). Ectopic embryos are rare (constituting 2% of embryos in some snake populations), and typically are the result of either an injury sustained during a previous breeding season or a dysfunction at ovulation (Shine 1977. Aust. J. Zool. 25:655–666). Oocytes may occasionally migrate through the infundibulum into the peritoneal cavity where embryogenesis can still occur before degeneration (Shine 1977, *op. cit*.).

On 25 July 2002, we encountered a gravid female *Sistrurus catenatus* at Eldon Hazlet State Park, Clinton County, Illinois, USA. An ultrasound on 29 July 2002 at the Saint Louis Zoological Park by staff veterinarians revealed four seemingly viable embryos and one unfertilized oocyte. On 22 August 2002, the female birthed three offspring (two viable, one stillborn) and one unfertilized oocyte. The discrepancy in number prompted a postpartum ultrasound on 30 August 2002, which revealed one embryo was not passed. This embryo was not located in the reproductive tract, but rather, in the peritoneal cavity. Following veterinary recommendation, we monitored the female in captivity where she was provided food and water *ad libitum*. A follow-up ultrasound on 14 October 2002 revealed complete embryonic degeneration and a large amount of fluid in the peritoneal cavity. The female died in captivity from unknown causes approximately one month later. Complications resulting from embryonic degeneration can neither be substantiated nor ruled out.

Although the exact cause of this ectopic pregnancy and factors pertaining to the death of the female remain unknown, it is evident that ectopic embryos can reach full embryogenesis before degeneration. Though the morphology of the oviduct is incapable of resorption (Blackburn et al. 1998, *op. cit*.), it is unknown whether females are capable of resorption of ectopic embryos.

We thank the Illinois Department of Natural Resources, U.S. Army Corps of Engineers, St. Louis Zoo, and numerous volunteers for assistance.

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THAMNOPHIS COUCHII (Sierra Gartersnake). **PREDATOR-PREY INTERACTION**. Recent studies have demonstrated that populations of the Common Gartersnake (*Thamnophis sirtalis*) have evolved variable amounts of resistance to tetrodotoxin (TTX), a powerful neurotoxin found within newts of the genus *Taricha* (Brodie and Brodie 1999. Bioscience 49:557–568). Production of TTX in the Rough-skinned Newt (*Taricha granulosa*) and associated resistance in *T. sirtalis* form the basis of a complex coevolutionary relationship between these two species (Brodie et al. 2002. Evolution 56:2067–2082). Within the range of *T. granulosa*, sympatric populations of *T. sirtalis* exhibit a wide spectrum of TTX-resistance that is present in some populations, and absent in others (Brodie et al. 2002, *op. cit*.). It remains unclear if, and to what extent, other species pairs of *Thamnophis*/*Taricha* exhibit TTX-mediated parallel co-evolutionary relationships. While conducting surveys along Cold Springs Creek in the Greenhorn Mountains (Tulare County, California) on 7 June 2000, C. R. Feldman and J. V. Vindum observed an adult *Thamnophis couchii* (CAS 212868) in the process of consuming a juvenile *Taricha torosa* (CAS 212869). This observation and subsequent lab studies demonstrate that TTX-resistance evolved independently in *T. couchii* (Brodie et al. 2005. J. Chem. Ecol. 31:343–356). Herein, we report an additional field observation of predation between these two species from another locality, over 300 km northwest of the Cold Springs Creek site.

On 8 October 2003 at 1257 h, while conducting amphibian surveys along the North Fork Mokelumne River, Calaveras County, California (38°27'39"N, 120°26'39"W; ca. 793 m elev.), ACP observed a subadult *T. couchii* (ca. 23 cm SVL) at the base of a sedge (*Carex* sp.) clump, in a shallow area. The snake had recently captured a juvenile *T. torosa* (ca. 3 cm SVL; Fig. 1). After ca. 5–6 minutes, the *T. couchii* had completely consumed the newt, tail-first. Following ingestion, the snake swam downstream and showed no outward behavior (e.g., paralysis or poor locomotor function) to indicate TTX poisoning from the ingested newt.

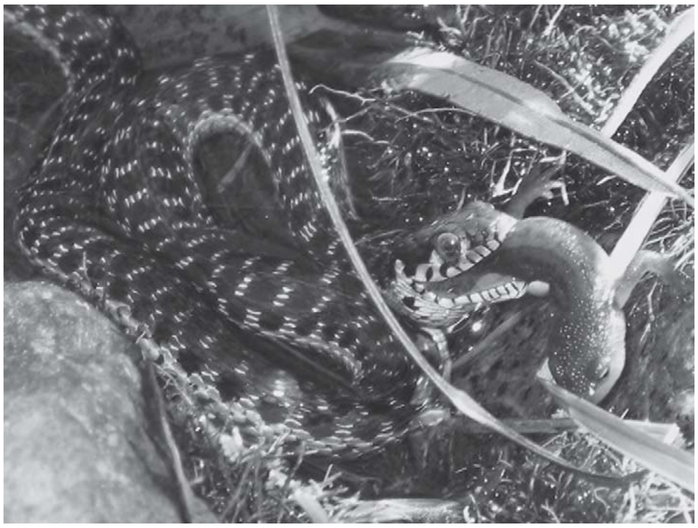

FIG. 1. A subadult Sierra Gartersnake (*Thamnophis couchii*) consuming a juvenile California Newt (*Taricha torosa*) from the North Fork Mokelumne River, California.

Newt prey from both field observations were juveniles, which typically have less TTX by surface area, than the average adult newt (Brodie et al. 2005, *op. cit*.). However, snakes from these observations differed in size: the *T. couchii* reported by Brodie et al. (2005, *op. cit*.) was an adult snake (48 cm SVL), while the snake reported here was a subadult (ca. 23 cm SVL). *Thamnophis sirtalis* are able to assess the toxicity of newts relative to their own resistance prior to ingestion, and symptoms of TTX-poisoning can occur as soon as one minute after prey capture (Williams et al. 2003. Herpetologica 59:155–163). We suspect that snakes from this locality may have elevated resistance to TTX, because the snake completely ingested the newt within an exposure time of at least 5–6 minutes (the newt was already captured upon initial observation), and because the snake swam away following ingestion. Alternatively, this population of *T. torosa* may exhibit uncharacteristically low levels of TTX, thus enabling *T. couchii* to consume them. The geographic structure of resistant/non-resistant populations within areas of sympatry of two coevolved species is believed to be an important component within such systems (Brodie et al. 2002, *op. cit*.). The geographic structure of the *Thamnophis sirtalis*/*Taricha granulosa* system resembles a mosaic of hotspots and coldspots within areas of sympatry and it seems possible that similar structure is present in the *Thamnophis couchii*/*Taricha torosa* system. The North Fork Mokelumne site is ca. 324 km northwest of the Cold Springs site within the Sierra Nevada of California and appears to be a resistant population. In a feeding ecology study of *T. couchii* from the North Fork Feather River (ca. 494 km northwest of the Cold Springs site), *T. torosa* was not identified in 102 prey items recovered from over 170 captured snakes (K. Wiseman, unpubl. data), even though both species are common locally and often encountered in the same microhabitats.

Fieldwork was conducted as part of Pacific Gas and Electric Company's Mokelumne River Project (FERC No. 137). We thank E. D. Brodie Jr., E. D. Brodie III, B. L. Williams, D. G. Mulcahy, C. R. Feldman, and P. Balfour for discussion and review of this note.

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THAMNOPHIS COUCHII (Sierra Gartersnake). **PREDATION**. *Thamnophis couchii* is a highly aquatic species that inhabits streams, rivers, meadow ponds, and reservoirs of the Sierra Nevada of California from the Pit River drainage south to the western edge of the Tehachapi Mountains, with several populations east of the Sierran crest at Owens Valley, and along the Walker, Truckee, and Carson rivers in Nevada (Rossman et al. 1996. The Garter Snakes: Evolution and Ecology. Univ. of Oklahoma Press, Norman. 332 pp.; Stebbins 2003. A Field Guide to Western Reptiles and Amphibians, 3rd ed. Houghton Mifflin Co., New York. 533 pp.). Despite the fact that this species is frequently encountered within its range, there are few reports detailing its ecological relationships with other species. To our knowledge the only documented predator of *T. couchii* is the Red-tailed Hawk (*Buteo jamaicensis*; Fitch 1949. Amer. Midl. Nat. 41:513–579). Herein, we report on two ophidian predators of *T. couchii* and discuss other likely predators.

On 10 June 2004 at 1615 h an adult *Coluber constrictor* (500 mm SVL; 630 mm TL) was captured ca. 5 m from the right bank of the North Fork Feather River near Shady Rest Area, Butte County, California (39°50'56.7"N, 121°23'38.6"W; 457 m elev.). The sluggish snake regurgitated a subadult *T. couchii* (330 mm TL; 10 g) which had been consumed head-first and was still alive following palpation. The snakes were released at the site (photos on file with KDW). The air temperature was 25.5°C (clear, sunny) and the water temperature was 16.5°C.

On 23 July 2004 at 1257 h a dead, adult *Diadophis punctatus* (422 mm SVL; 484 mm TL; CAS 231463) was found with a partially ingested subadult *T. couchii* (455 mm SVL; 549 mm TL; deposited with CAS 231463) at the same general locality as the *Coluber* observation (39°50'55.3"N, 121°23'38.2"W). The *D. punctatus* had ingested 65 mm of forebody of the *T. couchii* (11.8% of the gartersnake's TL) before it died (Fig. 1). The combined mass of both snakes was 22.8 g (preserved weight). The air temperature was 32.5°C (clear, sunny) and the water temperature was 22.0°C. The decomposed and dessicated snakes were found partially submerged in an edgewater along a lateral cobble bar. A small water release occurred on the morning of 23 July 2004 from above Cresta Dam, which likely inundated the snakes following death. Based on the level of decomposition, we estimate that the snakes died 2–3 days earlier.

Other likely, but as of yet undocumented predators of *T. couchii* include Great Blue Herons (*Ardea herodias*; Fitch, *op. cit.*; R. W. Hansen, pers. comm.; A. Lind, pers. comm.), Raccoons (*Procyon lotor*; Fitch *op. cit.*), and skunks (*Mephitis mephitis* and *Spilogale putorius*; Fitch, *op. cit.*). Introduced Signal Crayfish (*Pacifasticus leniusculus*) are also likely predators of *T. couchii* where the two species come into contact. On 24 June 2003 at 1910 h, during underwater video monitoring of *Rana boylii* egg masses on the North Fork Feather River, a signal crayfish was observed attacking (the crayfish crawled out beneath an egg mass and "pinched" the snake's tail with its cheliped) a subadult *T. couchii* that had briefly come to rest adjacent to an egg mass (our unpubl. data). Similar aggressive behavior was observed between a crayfish (species unknown) and *Thamnophis atratus hydrophilus* on 4 September 1986 at 1610 h at Hurdygurdy Creek in Del Norte County, California. A neonate *T. a. hydrophilus* (215 mm SVL; 284 mm TL; 5.0 g) was observed struggling in a shallow (9 cm deep) portion of the creek. When several rocks were moved around the struggling snake, a crayfish retreated from the snake's injured tail (A. Lind, pers. comm.). Although these aggressive behaviors do not demonstrate a predator/prey relationship, crayfish have been observed capturing and consuming other species of gartersnakes both in the field (*Orconectes virilis*/*Thamnophis elegans*; Weaver 2004. Herpetol. Rev. 35:278) and in controlled laboratory settings (*O. virilis*/*Thamnophis cyrtopsis*; Fernandez and Rosen 1996. Arizona Game and Fish Department, Heritage Fund IIPAM Project No. I94054, Phoenix, Arizona. 56 pp.).

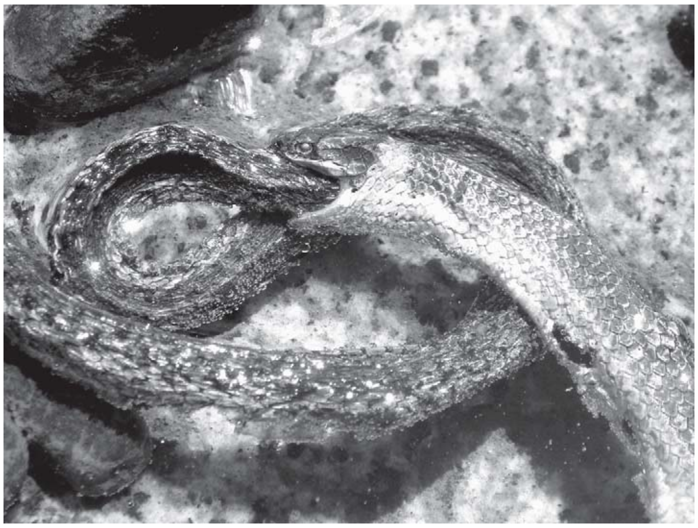

FIG. 1. An adult *Diadophis punctatus* (CAS 231463) which died while consuming a subadult *Thamnophis couchii*. The pair were found dead on 23 July 2004 on the North Fork Feather River, Butte County, California.

We thank R. W. Hansen, A. J. Lind, J. V. Vindum, and C. R. Feldman for their input. Field work was conducted in support of the Federal Energy Regulatory Commission's #1962 hydroelectric relicesening project.

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THAMNOPHIS HAMMONDII (Two-striped Gartersnake). **FORAGING BEHAVIOR.** *Thamnophis hammondii* is considered one of the most aquatic of the gartersnakes and is closely associated with creeks and impoundments (Fitch 1940. Univ. California Publ. Zool. 44:1–150) with a diet consisting largely of both the larvae and transformed stages of amphibians (*Spea, Bufo, Rana, Pseudacris*) and small fish (*Oncorhynchus*, *Gasterosteus*, *Eucyclogobius*, and *Cottus*) (Jennings and Hayes 1994. Amphibian and Reptile Species of Special Concern in California. Final report contract no. 8023, California Department of Fish Game. 255 pp.; Rossman et al. 1996. The Garter Snakes: Evolution and Ecology. Univ. of Oklahoma Press, Norman. 332 pp.). Little is known regarding the foraging behavior of *T. hammondii* (Rossman et al., *op. cit.*). Herein, we describe the details of a predation sequence (approach, strike, and capture) observed in a natural setting.

On 13 March 1996 we observed an adult *T. hammondii* (ca. 45 cm SVL) preying on *Xenopus laevis* larvae (ca. 25 TL) in a seasonal cattle pond (ca. 50 m × 18 m, 0.75 m deep) in Dulzura, San Diego County, California, USA (32.62491°N, 116.77640°W, 475 m elev.). Except for several open areas maintained by a pair of swimming Mallards (*Anas platyrhnchos*), the majority of the pond's surface was covered by dense mats of well-established submergent vegetation (*Potamogeton illinoensis*, *Ranunculus aquatilis*). Centered in one of the open areas (ca. 0.5 m diameter) a school of *X.*

laevis larvae (N = 15–20) were observed about 10 cm below the surface. As nektonic filter-feeders, *X. laevis* larvae form essentially stationary schools near the surface of deeper water rather than hiding in the shallows (Wassersug and Hessler 1971. Anim. Behav. 19:386–389). An adult *T. hammondii* revealed its presence in the column of open water when it slowly protruded its rostrum above the water surface (duration not noted). Upon drawing its head down and slightly backwards in a slow and deliberate fashion, it formed (presumably resumed) an ambush position about 15 cm below the surface. With its tail anchored in stable aquatic vegetation, the greater part of its length was compressed into side by side loops from which the snake would periodically, quickly lunge (strike) forward. After each lunge the body was compressed again in preparation for the next lunge, sometimes remaining virtually motionless for ~2 minutes. Upon apprehending a *X. laevis* larva, the snake would retreat out of sight into the dense aquatic vegetation for ~1.5 minutes, and then reappear in the same place facing the same direction to resume its ambush position. This sequence of events continued for 25 minutes (N = 6 forward lunges: 2 successful captures, 4 misses) until observations ended.

The predation sequence of the snake does not fit into any of the foraging behavioral categories developed for *Thamnophis* snakes by Drummond (1983. Behaviour 86:1–30). The detailed Drummond study was the first to develop standard foraging behavioral categories for aquatic foraging snakes. In a subsequent study, Lind and Welsh (1994. Anim. Behav. 48:1261–1273), studying *T. atratus*, added two additional foraging categories to the Drummond scheme. We term the above reported underwater sit-and-wait predation sequence 'underwater ambush' and define it as: body completely submerged, tail anchored to a rigid object, strikes directly at prey. We propose that underwater ambush be considered an additional foraging mode for species of *Thamnophis*.

Additional reports of *Thamnophis* species foraging underwater while anchoring their tail have been made (*T. atratus*; Boundy cited in Rossman et al., *op. cit*.), although further details were not provided. In regard to *Thamnophis* species orienting their head towards prey and slowly compressing their body into a series of opposite loops in preparation of a forward strike, it has been reported in *T. couchii* during controlled underwater *ex situ* attack trials (Alfaro 2002. Funct. Ecol. 16:204–215).

Although other North American aquatic snake species (e.g., *Nerodia sipedon*) are known to anchor their tail to assist in underwater prey capture, they weave open jawed with a back and forth sweeping motion actively searching for prey, as opposed to the sit-and-wait strategy, as described above. Random searching with open mouth (open-mouthed searching, *sensu* Drummond 1983, *op. cit*.) is believed to be a strategy based on a combination of chemo and tactile senses (Drummond 1985. Anim. Behav. 33:206–215; Schaeffel and de Queiroz 1990. Copeia 1990:50–58), while forward-strike strategies (e.g., underwater ambush) are dependent on visual acuity (Alfaro, *op. cit*.; Drummond, *op. cit*.).

Additionally, single elements of the underwater ambush mode described above (e.g., anchoring of the tail, organizing the trunk into high amplitude loops, or lunging directly at prey with entire body underwater) have all been observed individually for *Thamnophis* by other investigators under controlled conditions (Alfaro 2002, *op. cit*.; Drummond 1983, *op. cit*.). Based on previous observations of single elements, and our observation of the combination of elements in a natural setting, it is likely that the underwater ambush strategy, reported here as a novel foraging behavior, is not an uncommon mode of foraging behavior for other aquatic specialist *Thamnophis* species while preying on nektonic prey (e.g., fish, *X. laevis* larvae) in the wild.

We thank A. Lind, H. Drummond, P. Medica, J. Funk, E. Camp, S. Mullin, and D. Wood for assistance.

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THAMNOPHIS PROXIMUS (Western Ribbon Snake). **FORAGING BIOLOGY**. Although nocturnal foraging in or near ponds has been reported for *Thamnophis proximus*, Rossman et al. (1996.The Garter Snakes: Evolution and Ecology. University of Oklahoma Press, Norman, Oklahoma. 332 pp.) note the absence of scavenging behavior during road surveys in Texas and indicate that, although chemosensory cues are important for finding locations with prey, sight and motion play integral roles in the isolation of individual prey items by *Thamnophis*. On 21 May 2005, I drove a ca. 2.5 km section of Mecom-McCreit Road (near Hull, Liberty County, Texas, USA) between 2130 h and 2345 h. A thunderstorm had recently passed and during my survey light rains continued and air temperature measured 20.5°C. *Bufo valliceps* and *Hyla cinerea* were present on the road in an estimated density of several hundred per kilometer, many of which were DOR. During this time I observed seven adult *Thamnophis proximus* active on the road. Two were found attempting to ingest anurans. A female (621 mm SVL, 808 mm total length, 62.3 g) was collected at 2158 h near a portion of the road that was partially covered with water (30°10'03.5"N, 94°40'08.8"W). The snake was attempting to swallow a DOR *Bufo valliceps* (52 mm SVL, 18.1 g) breech. The toad's viscera were exposed and its skull crushed. The snake fled and continued to hold onto the toad even after capture. It was later released to the roadside near the point of collection. To the best of our knowledge, this represents the first observation of scavenging of road-killed anurans in this species.

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TRIMORPHODON BISCUTATUS (Western Lyresnake). **DIET**. *Trimorphodon biscutatus* is a common species in the regenerating tropical dry forests of Guanacaste Province, Costa Rica. It is one of the most frequently encountered snakes in the secondary forests in and around the administration area of Sector Santa Rosa, Área de Conservación Guanacaste (10.84°N, 85.62°W, 295 m elev.), and often is observed crawling along the ground at night or foraging in scrubby vegetation 1–2 m above the ground. Although *T. biscutatus* has been described as primarily terrestrial (Savage 2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna

Between Two Continents Between Two Seas. Univ. of Chicago Press., Chicago, Illinois. 934 pp.), it has been observed to climb trees when disturbed.

On the night of 7 October 2001, I watched a *T. biscutatus* consume a *Nyctidromus albicollis* (Common Pauraque; University of Kansas Digital Archive, KUDA 1863). Total length of the *T. biscutatus* was estimated at 130–140 cm from scaled photographs (not shown), while *N. albicollis* average ca. 22–28 cm total length and 55 g (Latta and Howell 1999. *In* Poole and Gill [eds.], The Birds of North America, No. 429, The Birds of North America, Inc., Philadelphia; Stiles and Skutch 1989. A Guide to the Birds of Costa Rica. Comstock Publishing Associates, Ithaca, New York. 656 pp.). The snake had swallowed ca. 25% of the *N. albicollis* at the time I encountered it, and the bird was no longer moving. From the body position of the snake, the bird appeared to have been constricted before swallowing. The snake took 45 more minutes to finish swallowing the bird.

Nyctidromus albicollis is a sit-and-wait predator that commonly sits on open ground (particularly road edges) waiting for insect prey to pass above it. I encountered the pair on a very low traffic road in a site known to be frequented by an individual *N. albicollis*. As the beginning of the encounter was not observed it is possible that the *N. albicollis* was killed by something else and scavenged by the snake, however it seems most likely that the bird was captured while foraging for insects.

Submitted by **JEFFREY A. KLEMENS**, Department of Biology, University of Pennsylvania, Philadelphia, Pennsylvania 19104-6018, USA.

TROPIDOPHIS MORENOI (NCN). **SIZE RECORD**. The previously reported measurements for *T. morenoi* (Hedges et al. 2001. J. Herpetol. 35:615–617) are 295 mm SVL and 45 mm tail length (holotype CZACC 4.5492; Colecciones Zoológicas del Instituto de Ecología y Sistemática, La Habana, Ciudad de La Habana province, Cuba; ex-collection IB 2493 from ex-Instituto de Biología, Cuba) and 285 mm SVL and 44 mm tail length (paratype CZACC 4.5493; ex-collection IB 2942). The type locality is Dolinas de Cueva de Humboldt, Caguanes, Villa Clara Province, Cuba (22°50'04"N, 80°12'02"W). This site now lies within Sancti Spíritus Province. An adult female of the genus *Tropidophis* (CZACC 4.12052) was collected by J. Salas (unknown date) from the same locality. It was identified by the senior author as *T. morenoi* on 20 January 2004 and is the first specimen of *T. morenoi* reported since the species description (Hedges et al., *op. cit.*). This specimen measures 359 mm SVL and 57 mm TL, exceeding the previous records by 64 mm SVL and 12 mm TL. Measurements of the head are not possible to determine because the head and neck are damaged. Coloration, scale counts, and measurements are the similar to those reported for the holotype and paratype.

We thank Elier Fonseca for suggestions on the manuscript.

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GEOGRAPHIC DISTRIBUTION

Instructions for contributors to Geographic Distribution appear in Volume 38, Number 1 (March 2007, p. 95). 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: ARKANSAS: Faulkner Co.: 6.9 km S Damascus (Sec. 29, T8N, R13W). 28 October 2006. Henry W. Robison. Verified by S. E. Trauth. Arkansas State University Herpetological Museum (ASUMZ 30640). New county record filling a distributional hiatus in the Arkansas River valley between Conway and White counties (Trauth et al. 2004. Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, Fayetteville. 421 pp.). This salamander has now been reported from 68 of 75 (91%) counties of the state (Robison 2006. Herpetol. Rev. 37:481; Trauth et al., *op. cit.*).

Submitted by **HENRY W. ROBISON**, Department of Biology, Southern Arkansas University, Magnolia, Arkansas 71754, USA (e-mail: hwrobison@saumag.edu) and **CHRIS T. McALLISTER**, Department of Physical and Life Sciences, Chadron State College, Chadron, Nebraska 69337, USA (e-mail: cmcallister@csc.edu).

AMBYSTOMA OPACUM (Marbled Salamander). USA: TENNESSEE: Hamilton Co.: Moccasin Bend National Park/ Archaeological District, Chattanooga (35.04003°N, 085.34193°W). 10 April 2007. Matthew B. Smith, Timothy J. Gaudin, and Thomas P. Wilson. Verified by Enrico Walder, Senior Herpetologist and Assistant Curator of Forests, Tennessee Aquarium. The University of Tennessee at Chattanooga Natural History Museum (UTCA 191). Adult female collected posthumously from leaf litter while surveying mammals. A second live female *A. opacum* collected two days later from a pitfall trap and released in same area. Represents first verified record for Hamilton County (Redmond and Scott 1996. Atlas of Amphibians in Tennessee. The Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. 94 pp. http//www.apsu.edu/amatlas/; Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington and London, 587 pp.). Collection made under Tennessee Wildlife Resources Agency Permits 1534 and 1944 and National Park Service Scientific Research and Collecting Permit CHCH-2007-SCI-0002.

Submitted by **MATTHEW B. SMITH**, **TIMOTHY J. GAUDIN**, and **THOMAS P. WILSON**, Department of Biological and Environmental Sciences, The University of Tennessee at Chattanooga, 615 McCallie Avenue, Chattanooga, Tennessee 37403, USA.

NECTURUS MACULOSUS (Mudpuppy). USA: ILLINOIS: Greene Co.: Mudpuppy live-captured by Shawn Shewmake on hook and line. Macoupin Creek, 25 m downstream of Reddish Ford Bridge (N 715732 and W 4337970, zone 15 using NAD27CONUS map datum in UTMs). 27 March 2007., TL 419 mm (INHS Herpetological Photograph 2007.27). Verified by Chris

Phillips, Illinois Natural History Survey. First county record (Phillips 1999. Field Guide to Amphibians and Reptiles of Illinois. Illinois Nat. Hist. Surv., Manual 8. Champaign, Illinois. 300 pp.). Macoupin Creek is channelized and 15 m wide at the site, and its steeply eroded banks are bordered by an agricultural field with a 3-m buffer strip vegetated by Silver Maple *Acer saccharinum*, American Sycamore *Platanus occidentalis*, and various understory species (typical of a soft-maple floodplain forest community).

Submitted by **CHAD R. DOLAN** and **JOHN K. TUCKER**, Illinois Natural History Survey, Great Rivers Field Station, 8450 Montclair Ave., Brighton, Illinois 62012, USA; and **JAMES T. LAMER**, Department of Biological Sciences, Western Illinois University, 1 University Circle, Macomb, Illinois 61455, USA.

SIREN INTERMEDIA NETTINGI (Western Lesser Siren). USA: ARKANSAS: Jefferson Co.: 7.2 km S Pine Bluff (Sec. 15, T7S, R9W). 27 November 2006. Henry W. Robison. Verified by S. E. Trauth. Arkansas State University Herpetological Museum (ASUMZ 30641). New county record partially filling a tri-county distributional gap between Cleveland, Grant and Monroe counties (Robison 2006. Herpetol. Rev. 37:484; Trauth et al. 2004. Amphibians and Reptiles of Arkansas. Univ. Arkansas Press, Fayetteville. 421 pp.).

Submitted by **HENRY W. ROBISON**, Department of Biology, Southern Arkansas University, Magnolia, Arkansas 71754, USA (e-mail: hwrobison@saumag.edu); and **CHRIS T. McALLISTER**, Department of Physical and Life Sciences, Chadron State College, Chadron, Nebraska 69337, USA (e-mail: cmcallister@csc.edu).

ANURA

BARBOURULA BUSUANGENSIS (Philippine Discoglossid Frog). PHILIPPINES: BALABAC ISLAND: Barangay: Indalawan; Tugas Creek, 30 m elev. 01 March 2007. Pierre Fidenci. California Academy of Sciences photo voucher (CAS-HPV 42). Verified by Hallie Brignall. First record for Balabac Island. Known records are from Busuanga and Palawan (Alcala and Brown 1998. Philippine Amphibians. An Illustrated Fieldguide. Bookmark, Inc., Makati City. xii + 116 pp.; Fidenci 2006. Herpetol. Rev. 37:98). The closest known occurrence is in Palawan, > 70 km N of Balabac (Fidenci 2004. Herpetol. Rev. 37:98). Adult observed at 2030 h on bank, 10 cm from water, in large creek (8 m wide, 0.1–1 m deep) with a mixture of sand, silt, gravel, and boulder as substrate. The creek is surrounded by secondary forest and banana plantation.

Submitted by **PIERRE FIDENCI**, ESI, 755 Bush Street #302, San Francisco, California 94108, USA; e-mail: pfidenci@endangeredspeciesinternational.org.

HYLA GRATIOSA (Barking Treefrog). USA: MISSISSIPPI: Smith Co.: Found on road at night. County Road 504 W of Pineville (32°08'07"N, 89°24'19"W). 11 July 2006. Tony Gamble and Mike Bush. Verified by Andrew M. Simons. JFBM 15169. New county record (Mitchell 2005. *In* M. Lannoo [ed.], Amphibian Declines: The Conservation Status of United States Species, pp. 455–456. University of California Press, Berkeley, California; Minnis 1998. Mississippi Herpetological Atlas and Mississippi Gap Analysis Program, http://www.cfr.msstate.edu/gap/atlas.htm, accessed 19 April 2007).

Submitted by **TONY GAMBLE** and **MICHAEL BUSH**, Bell Museum of Natural History, University of Minnesota, 100 Ecology, 1987 Upper Buford Circle, St. Paul, Minnesota 55108, USA (e-mail: gambl007@umn.edu).

KALOPHRYNUS INTERLINEATUS (Striped Sticky Frog). BANGLADESH: MYMENSINGH DIVISION: Madhupur National Park (24°41'N, 90°07–08'E, 134–136 m elev.). 29–30 June 2006. A. H. M. Ali Reza and S. Mahony. Wildlife Laboratory, Department of Zoology, Jahangirnagar University, Savar, Dhaka (JU 0026, 0028). Photograph deposited at USDZ, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC [IMG].1.3). Verified by Indraneil Das. Western range extension, and first country record for genus and species. Nearest known population ca. 380 km NE in Orang National Park, Assam (Dutta et al. 2000. Hamadryad 25:67–74). Supported by Cleveland Metroparks Zoo and Rufford Foundation to the second author, which partially supported the first author. Bangladesh Forest Department issued permission (CCF [Wildlife]/2M–47/2006) for this work to the second author.

Submitted by **STEPHEN MAHONY**, 3 Park View Lawns, Greenpark, Clondalkin, Dublin 22, Ireland. (e-mail: stephenmahony2@gmail.com); and **A. H. M. ALI REZA**, Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409, USA (e-mail: ali.reza@ttu.edu).

KALOULA TAPROBANICA (Sri Lankan Bull Frog). BANGLADESH: MYMENSINGH DIVISION: Madhupur National Park (24°41'N, 90°08'E; 136 m elev.). 30 June 2006. A. H. M. Ali Reza and S. Mahony. Wildlife Laboratory, Department of Zoology, Jahangirnagar University, Savar, Dhaka (JU 0029). Photograph deposited at USDZ, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC IMG].1.2). Verified by Indraneil Das. First verified locality for Bangladesh. Nearest population reported from Kolkata, West Bengal, India, > 200 km to SW of this locality (Dutta 1997. Amphibians of India and Sri Lanka. Odyssey Publishing House, Bhubaneswar. xiii + 343 + xxii pp.). Supported by Cleveland Metroparks Zoo and Rufford Foundation to the first author, which partially supported the second author. Bangladesh Forest Department issued permission (CCF (Wildlife)/2M–47/2006) for this work to the first author.

Submitted by **A. H. M. ALI REZA**, Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409, USA (e-mail: ali.reza@ttu.edu); and **STEPHEN MAHONY**, 3 Park View Lawns, Greenpark, Clondalkin, Dublin 22, Ireland (e-mail: stephenmahony2@gmail.com).

MICROHYLA BUTLERI (Tubercled Pygmy Frog). INDIA: MIZORAM: Sairang (23°48'38.5"N, 92°39'09.8"E), 57 m elev., SVL 31–34 mm; 04 December 2004. Department of Zoology Museum, North Eastern Hill University. SP 37–38. Saipari Sailo, H. T. Lalremsanga and R. N. K. Hooroo. Verified by Saibal Sengupta. Previously reported from China, Myanmar, Thailand, Laos, Cambodia, Vietnam, and Peninsular Malaysia and Singapore (Berry 1975. The Amphibian Fauna of Peninsular Malaysia. Tropical Press, Kuala Lumpur. 130 pp.; Boulenger 1900. Ann. Mag.

Nat. Hist., ser. 6, 7:186–193; Lim and Lim 1992. A Guide to the Amphibians and Reptiles of Singapore. Singapore Science Centre, Singapore; Stuart 1999. *In* Duckworth et al. [eds.], Wildlife in Lao PDR: 1999 Status Report, pp. 43–67. IUCN/WCS/CPAWM, Vientiane; Taylor 1962. Univ. Kansas Sci. Bull. 43:267–599). New record for India.

Submitted by **H. T. LALREMSANGA** (e-mail: htlrsa@yahoo.co.in), **SAIPARI SAILO** (e-mail: spsailo@yahoo.co.in), and **R. N. K. HOOROO**, Department of Zoology, Developmental Biology Laboratory, North Eastern Hill University, Shillong 793 022, Meghalaya, India (e-mail: rnkhnehu@hotmail.com).

OSTEOPILUS SEPTENTRIONALIS (Cuban Treefrog). USA: GEORGIA: Chatham Co.: Savannah, house on Windward Island at 79 Rio Road (31.976°N, 81.186°W). 23 September 2004. Diane M. Butler. Verified by Kenneth Krysko. Florida Museum of Natural History, University of Florida (UF 142332). One adult female (111 mm SVL) was collected at the base of a sliding glass door in the backyard of the house. Cuban Treefrogs occur throughout much of Florida's peninsula (Meshaka et al. 2004. The Exotic Amphibians and Reptiles of Florida. Krieger Publ. Co., Malabar, Florida. 155 pp.; Meshaka 1996. Herpetol. Rev. 27:37–40) and appear to be established as far north as Jacksonville on the Atlantic Coast (Krysko et al. 2005. Herpetol. Rev. 36:85–87), Cedar Key on the Gulf Coast (Johnson et al. 2003. Herpetol. Rev. 34:381), and Gainesville in the center of the peninsula (Krysko et al. 2005. Herpetol. Rev. 36:85–87). This is the first documented occurrence of a Cuban Treefrog in Georgia (J. Jensen, pers. comm.). The closest known record for the species is from Duval Co., Florida (Krysko et al. 2005. Herpetol. Rev. 36:85–87), approximately 180 km S of Savannah, Georgia.

Submitted by **STEVE A. JOHNSON**, Department of Wildlife Ecology and Conservation, University of Florida—IFAS Plant City Education Center, 1200 North Park Rd., Plant City, Florida 33563, USA; e-mail: tadpole@ufl.edu.

OTOPHRYNE PYBURNI. BRAZIL: AMAZONAS: Municipality of São Gabriel da Cachoeira, Parque Nacional do Pico da Neblina: Bebedouro velho (0°41'54"N; 65°55'41"W, 418 m elev.), 15 August 2005. Coleção de Anfíbios e Répteis, Instituto Nacional de Pesquisas da Amazônia, Manaus, Amazonas, Brazil (INPA-H 16473, SVL 46.8 mm; body mass in life 11 g). Bebedouro novo (0°45'21"N; 65°57'55"W, 847 m elev.), 17 August 2005 (INPA-H 16472, SVL 48.2 mm; body mass in life 11 g) and (INPA-H 16474 SVL 52.1 mm; body mass in life 13.5 g); 22 August 2005 (INPA-H 16475 SVL 20.1 mm; body mass in life 0.7 g). Three specimens were collected in dense closed canopy montane forest and one in dense closed canopy submontane forest near right bank of forest stream by V. T. Carvalho and L. Bonora and verified by R. de Fraga. This species occurs from Vaupés and Amazonas, Colombia, across the lowlands of southern Venezuela and through the Guianan region to Amapa, Brazil (Campbell and Clarke 1998. Herpetologica 54:301–317). In Venezuela this species was reported in Sierra Parima, 1100 m elevation (Barrio 1999. Herpetol. Rev. 30:173). Our record is 362 km and 358 km from these records reported in Sierra Parima. First state records, extends the known distribution 446 km and 440 km (airlane) east, respectively, from the type locality in the Vaupés, Wacará, SW Colombia (01°09'N, 69°55'W) (Campbell and Clarke, *op. cit.*).

Submitted by **VINICIUS T. DE CARVALHO** (e-mail: viniciustc@ig.com.br)**, LUCÉIA BONORA** and **RICHARD C. VOGT,** Instituto Nacional de Pesquisas da Amazônia – INPA, Coleção de Anfíbios e Répteis – Campus II. Av. André Araújo, 2936. C.P. 428. CEP 69.083-000 Manaus, Amazonas, Brazil.

PLEURODEMA MARMORATA (Andean Four-eyed Frog, Sapito de cuatro ojos andino). CHILE: TARAPACA: I Región, Quebe, ca. 180 Km NE of city of Iquique (19°27'18.0"S; 68°48'34.1"W), 3958 m elev.; 12 April 2007. M. A. Méndez, M. Sallaberry, and L. Pastenes. Herpetological Collection of Departamento de Biología Celular y Genética de la Universidad de Chile, Santiago, Chile (DBGUCH 0704038 juvenile). Lauca Sur (18°22'37.6"S; 69°20'49.0"W), 4232 m elev.; 14 April 2007. Same collectors. DBGUCH 0704058, adult. All verified by A. Veloso. Previously known from Caquena, Parinacota, Chungara, and Putre, XV Región (Cei 1962. Batracios de Chile. Ediciones de la Universidad de Chile, Santiago, Chile. cviii + 128 pp.; Veloso et al. 1981. *In* Veloso and Bustos [eds.], El Hombre y los Ecosistemas de Montaña I. La Vegetación y los Vertebrados Inferiores de los Pisos Altitudinales entre Arica y Lago Chungará, pp. 135–169). New record from Quebe extends southern range ca. 145 km S of Putre, the closest locality previously known (Cei 1962, *op. cit.*; Veloso and Navarro 1988. Boll. Mus. Reg. Sci. Nat. Torino 6:481–539).

The study was supported by the Grants PG-025-06 and MULT 05-04/2, University of Chile, and Fondecyt 1061256-2006.

Submitted by **MICHEL SALLABERRY A.**, Departamento de Ciencias Ecológicas, Facultad de Ciencias, Universidad de Chile, Las Palmeras 3425, Ñuñoa, PO Box 653, Santiago, Chile (e-mail: msallabe@uchile.cl); **LUIS PASTENES O.**, **CLAUDIO CORREA Q.**, and **MARCO A. MÉNDEZ T.**, Laboratorio de Genómica Evolutiva, INTA, Universidad de Chile, Macul 5540, PO Box 138-11, Santiago, Chile (e-mail: mmendez@uec.inta.uchile.cl).

PSEUDACRIS CLARKII (Spotted Chorus Frog). USA: TEXAS: Sterling Co.: 16.9 road km S of junction of US 87 and TX 163 on TX 163 (31°41'8.30"N, 101°3'29.10"W). 14 April 2007. D. Laurencio, M. T. Hill, and T. J. Hibbitts. Verified by James R. Dixon. TCWC 91803, 91804. New county record (Dixon 2000. Amphibians and Reptiles of Texas, 2nd ed. Texas A&M University Press, College Station, Texas. 421 pp.).

Submitted by **DAVID LAURENCIO**, **MICHAEL T. HILL**, and **TOBY J. HIBBITTS**, Texas Cooperative Wildlife Collection, Department of Wildlife and Fisheries Sciences, 2258 TAMU, Texas A&M University, College Station, Texas 77843-2258, USA (e-mail: norops@tamu.edu).

PSEUDACRIS PACIFICA (Pacific Treefrog). USA: WASHINGON: Franklin Co.: Route 261, 50 m W of Lyons Ferry Park entrance (46°35.574'N, 118°13.198'W) 171 m elev. 15 October 2006. Robert E. Weaver. Verified by Kenneth V. Kardong. Voucher specimen deposited in the Central Washington University Department of Biological Sciences Herpetology Collection (CWU 1694). Adult (35 mm SVL, 4.8 g) collected while crossing Route 261 at 2039 h during a period of light precipitation. Ambient temperature at time of collection was 15.5°C. First county record. This record fills a gap in distribution data, as localities for this species have been reported for all other counties in Washington State (Hallock and McAllister 2005. Washington Herp Atlas. http://www.dnr.wa.gov/nhp/refdesk/herp/).

Submitted by **ALEX DORNBURG** (e-mail: dornburgalex@yahoo.com) and **ROBERT E. WEAVER**, School of Biological Sciences, Washington State University, Pullman, Washington 99164, USA (e-mail: weaverr@wsu.edu).

SPEA BOMBIFRONS (Plains Spadefoot). USA: TEXAS: Crane Co.: 4.54 air km N, 2.88 air km W of junction of FM1601 and FM 1233 (31°34'00.3"N, 102°30'58.3"W). 13 April 2007. D. Laurencio, M. T. Hill, and T. J. Hibbitts. Verified by James R. Dixon. Texas Cooperative Wildlife Collection, TCWC 91801, 91802. New county record (Dixon 2000. Amphibians and Reptiles of Texas, 2nd ed. Texas A&M University Press, College Station, Texas. 421 pp.).

Submitted by **DAVID LAURENCIO**, **MICHAEL T. HILL**, and **TOBY J. HIBBITTS**, Texas Cooperative Wildlife Collection, Department of Wildlife and Fisheries Sciences, 2258 TAMU, Texas A&M University, College Station, Texas 77843-2258, USA (e-mail: norops@tamu.edu).

SYLVIRANA LEPTOGLOSSA (Long-tongued Frog). BANGLADESH: MYMENSINGH DIVISION: Madhupur National Park (24°41'N, 90°08'E, 134–136 m elev.). 03 July 2006. S. Mahony and A. H. M. Ali Reza. Wildlife Laboratory, Department of Zoology, Jahangirnagar University, Savar, Dhaka (JU 0031). Photograph deposited at USDZ, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC [IMG].1.4). Verified by Indraneil Das. First locality record for Mymensingh Division and western range extension for species. Only other Bangladesh population recorded in Chittagong Division (ca. 230 km to SE) with no locality details, specimen numbers or voucher photographs (Asmat et al. 2003. Univ. J. Zool., Univ. Rajshahi, Bangladesh 22:141–143). Supported by Cleveland Metroparks Zoo and Rufford Foundation to the second author, which partially supported the first author. Bangladesh Forest Department issued permission (CCF [Wildlife]/2M-47/2006) for this work to the second author.

Submitted by **STEPHEN MAHONY**, 3 Park View Lawns, Greenpark, Clondalkin, Dublin 22, Ireland (e-mail: stephenmahony2@gmail.com); and **A. H. M. ALI REZA**, Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409, USA (e-mail: ali.reza@ttu.edu).

SYRRHOPHUS CYSTIGNATHOIDES (Rio Grande Chirping Frog). USA: TEXAS: Nacogdoches Co.: Nacogdoches; 1203 Ferguson (31°36'48.36"N; 94°39'05.22"W). 1 August 2006. Toby J. Hibbitts and Daniel Saenz. Verified by James R. Dixon. Texas Cooperative Wildlife Collections, TCWC 91544. This invasive species is now widespread in residential areas in much of southeast Texas. New county record (Dixon 2000. Amphibians and Reptiles of Texas, 2nd ed. Texas A&M University Press, College Station, Texas. viii + 421 pp.).

Submitted by **TOBY J. HIBBITTS**, Texas Cooperative Wildlife Collections, Department of Wildlife and Fisheries Sciences, Texas A&M University, 2258 Tamu, College Station, Texas 77843-2258, USA (e-mail: thibbitts@tamu.edu); and **DANIEL SAENZ**, Wildlife Habitat and Silviculture Laboratory, Southern Research Station, USDA Forest Service, Nacogdoches, Texas 75962, USA.

TESTUDINES

CHELYDRA SERPENTINA (Snapping Turtle). USA: TEXAS: Nolan Co.: 1.0 road km N of Interstate 20 on US 80 at exit of Business 84 (to Roscoe) (32°26'53.5"N,100°30'56.8"W), 730 m elev. 10 May 2006. David Laurencio, Laura R. Laurencio, and Nicole Smolensky. Verified by Toby J. Hibbitts. Texas Cooperative Wildlife Collection, TCWC 91336. New county record (Dixon 2000. Amphibians and Reptiles of Texas, 2nd ed. Texas A&M University Press, College Station, Texas. 421 pp.).

Submitted by **DAVID LAURENCIO** (e-mail: norops@tamu.edu), **LAURA R. LAURENCIO**, and **NICOLE SMOLENSKY**, Texas Cooperative Wildlife Collection, Department of Wildlife and Fisheries Sciences, MS 2258, Texas A&M University, College Station, Texas 77843-2258, USA.

STERNOTHERUS ODORATUS (Stinkpot). USA: WISCONSIN: Oconto Co.: town of Underhill. Northeast corner of Berry Lake, off of Highway HH (44°53'40.6"N, 88°28'31.6"W). April 16 (N = 5) and 17 (N = 6) 2007. Lee Meyers and Rod Lange. Verified by Christopher A. Phillips. INHS 2007b. New county record. Extends range of species in Wisconsin (Casper 1996. Geographic Distributions of the Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum. 87 pp.). Eleven individuals captured in a fyke net over two days, along with several *Chrysemys picta* and *Chelydra serpentina*. All individuals surveyed were associated with a portion of the lake possessing a soft mud bottom with adjacent marsh along the lake periphery. These observations complement the finding of a shell from a deceased individual in the same area on 06 November 2004 (Brian Ewart and Randy Korb).

Submitted by **BRIAN EWART,** 14415 Berry Lake N. Shore Rd, Gillett, Wisconsin 54124, USA; **RANDY KORB,** PO Box 1963, Green Bay, Wisconsin 54305, USA; **LEE S. MEYERS** and **RODNEY M. LANGE**, Wisconsin Department of Natural Resources, 2984 Shawano Avenue, Green Bay, Wisconsin 54307-0448, USA; and **JOSHUA M. KAPFER**, Department of Biological Sciences, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53211, USA.

TERRAPENE ORNATA ORNATA (Ornate Box Turtle). USA: NEBRASKA: Rock Co.: 1.6 km W Bassett off US 20 (DOR). 09 May 2007. C. T. McAllister. Verified by S. E. Trauth. Arkansas State University Herpetological Museum (ASUMZ photographic voucher 30668). 8.0 km E Bassett off US 20 (DOR). 11 May 2007. C. T. McAllister. Verified by S. E. Trauth. ASUMZ photographic voucher 30669. New county record partially filling a distributional hiatus in the northcentral sandhills of Nebraska between Antelope and Brown counties (Lynch 1985. Trans. Nebraska Acad. Sci. 13:33–57).

Submitted by **CHRIS T. McALLISTER**, Department of Physical and Life Sciences, Chadron State College, Chadron, Nebraska 69337, USA; e-mail: cmcallister@csc.edu.

LACERTILIA

ANOLIS EQUESTRIS (Knight Anole). USA: FLORIDA: Monroe Co.: Key West, 323 Whitehead Street (24°33'23.699"N, 81°48'18"W, WGS84; elev. < 1 m). 14 May 2007. Andrew P. Borgia and Kenneth L. Krysko. Verified by Kevin M. Enge. Florida Museum of Natural History (UF 151192). New island record and extends the range ca. 140 km SW of the closest known locality on Plantation Key (Achor and Moler 1982. Herpetol. Rev. 13:131). Juvenile found wounded on wall below banyan tree.

Submitted by **KENNETH L. KRYSKO**, Division of Herpetology, Florida Museum of Natural History, Dickinson Hall, University of Florida, Gainesville, Florida 32611, USA (e-mail: kenneyk@flmnh.ufl.edu); and **ANDREW P. BORGIA**, P.O. Box 4346, Key West, Florida 33041, USA.

CNEMIDOPHORUS TIGRIS (Western Whiptail). USA: TEXAS: Gaines Co.: 21.9 air km S jct US Hwy 62/180 and NM/TX state line (32°31'29.6"N; 103°03'43.9"W). 12 June 2006. David Laurencio and Toby J. Hibbitts. Verified by James R. Dixon. Texas Cooperative Wildlife Collections, TCWC 91476–91478. New county record (Dixon 2000. Amphibians and Reptiles of Texas, 2nd ed. Texas A&M University Press, College Station, Texas. 421 pp.). The specimens were collected during research on *Sceloporus arenicolus* with funding from Texas Parks and Wildlife Department.

Submitted by **TOBY J. HIBBITTS**, **DAVID LAURENCIO**, and **LEE A. FITZGERALD**, Texas Cooperative Wildlife Collections, Department of Wildlife and Fisheries Sciences, Texas A&M University, 2258 Tamu, College Station, Texas 77843-2258, USA (e-mail: thibbitts@tamu.edu).

COLOBOSAUROIDES CEARENSIS. BRAZIL: PIAUÍ: Parque Ambiental Paquetá (03°58.828'S; 042°05.659'W): Municipalidade de Batalha, 10 September 2004. M. Basto da Silva, V. Rodrigues, L. Barreto, and W. A. Rocha. Museu Paraense Emilio Goeldi, Belém, Pará, Brazil (MPEG 23022–23025). Verified by T. C. S. Ávila-Pires. Previously known only from Maciço do Baturité, Fortaleza, Ubajara and Serra da Aratanha localities in Ceará state, Brazil (Soares and Caramaschi 1998. Bol. Mus. Nac. Zool. 388:1–8.) First state record, extends distribution 200 km from Ubajara (Ceará), the nearest, previously known locality.

Submitted by **MARCÉLIA BASTO DA SILVA** (e-mail: marceliabasto@uol.com.br); **VALDEMAR RODRIGUES** (e-mail: desertpi@uol.com.br), Departamento de Biologia - CCN, Universidade Federal do Piauí, Campus da Ininga, Av. Ininga s/n, 64049-550, Teresina PI, Brazil; **LARISSA BARRETO** (e-mail: lara@elo.com.br), Departamento de Oceanografia e Limnologia, Universidade Federal do Maranhão, Campus do Bacanga, Av. dos Portugueses s/n, 65080-040, São Luís MA, Brazil; and **WÁLDIMA ALVES DA ROCHA**, Museu Paraense Emilio Goeldi, Pós-graduação em Zoologia. Av. Perimetral, 1901, C.P. 399, 66040-170 – Belém PA, Brazil (e-mail: waldima@yahoo.com.br).

CYRTOPODION HETEROCERCUM HETEROCERCUM (Asia Minor Thin-toed Gecko). IRAN: MARKAZI PROVINCE: NW Arak City (34°07'45"N, 49°41'37"E, 1800 m elev.). 10 June 2006. Aria Herpetological Institute, Tehran, Iran (ARIA1001). 23 June 2006 (ARIA1002). Omid Mozaffari. Verified by S. C. Anderson. One juvenile and one adult male collected at night from a courtyard under a lamp. First record for Markazi Province. Nearest locality is Hamedan, Hamedan Province, ca. 200 km NW of the present locality (Anderson 2000. The Lizards of Iran. SSAR Contributions to Herpetology, Vol. 15. Ithaca, New York. vii + 442 pp.; 25 pl.). Second record from Iran.

Submitted by **OMID MOZAFFARI**, No.21 Taleghani 3 Street, Ashrafi Esfehani Highway, Tehran, Iran 14699-76599; e-mail: omozaffari@yahoo.com.

GONATODES HUMERALIS. BRAZIL: PIAUÍ: Municipalidade de Batalha, Parque Ambiental Paquetá (03°58.828'S; 042°05.659'W). 13 August 2004. M. Basto da Silva, V. Rodrigues, and W. Alves da Rocha. Universidade Federal do Piauí, Teresina, Piauí, Brazil (LZUFPI 0472–0474; in semi-deciduous forest). Verified by T. C. S. Ávila Pires. The distribution was restricted to the Amazonian Region and the states of the Maranhão and Mato Grosso (Ávila-Pires 1995. Zoologische Verhandelingen 299:1–706). First state record, extends known distribution 200 km E from Timon, state of Maranhão, the nearest locality previously mentioned (Silva et al. 2006. *In* XXVI Congresso Brasileiro de Zoologia).

Submitted by **MARCÉLIA BASTO DA SILVA** (e-mail: marceliabasto@uol.com.br); **VALDEMAR RODRIGUES** (e-mail: desertpi@uol.com.br) Departamento de Biologia - CCN, Universidade Federal do Piauí, Campus da Ininga, Av. Ininga s/n, 64049-550, Teresina PI, Brazil; and **WÁLDIMA ALVES DA ROCHA**, Museu Paraense Emilio Goeldi, Pós-graduação em Zoologia, Av. Perimetral, 1901, C.P. 399, 66040-170 – Belém PA, Brazil (e-mail: waldima@yahoo.com.br).

HEMIDACTYLUS MABOUIA (Amerafrican House Gecko). BAHAMAS: ELEUTHERA: Governor's Harbour, North Shore Drive, 2.0 km E Queens Hwy (25°11.9739'N, 76°13.56402'W; datum WGS84). 11 March 2007. Kenneth L. Krysko, Travis M. Thomas, and Eric F. Schrieber. UF 150826. Verified by Josiah H. Townsend. First record for Eleuthera (Krysko and Borgia 2005. Herpetol. Rev. 36:468). We also collected this species in Governor's Harbour at North Shore Drive, 7.0 km SE Queens Hwy (25°10.44'N, 76°11.2824'W) on 11, 12, 15 March 2007 (UF 150829, 150865–66); North Shore Drive, 1.3 km E Queens Hwy (25°12.0432'N, 76°13.98558'W) on 14 March 2007 (UF 150844–49); and Banana Beach (25°14.03358'N, 76°16.3368'W) on 15 March 2007 (UF 150850). All specimens were collected under bark of Australian Pine trees (*Casuarina equisetifolia*) during the daytime and on building walls at night. This species has also been found recently on Long Island, Great Exuma Island, New Providence Island, and San Salvador Island (Krysko and Borgia, *op. cit.*; R. Franz, pers. comm.).

Submitted by **KENNETH L. KRYSKO** (e-mail: kenneyk@flmnh.ufl.edu) and **TRAVIS M. THOMAS,** Division of Herpetology, Florida Museum of Natural History, Dickinson Hall, University of Florida, Gainesville, Florida 32611, USA.

HEMIDACTYLUS MABOUIA (Amerafrican House Gecko). COSTA RICA: SAN JOSÉ: La Uruca. 21 August 2006. Ana M. Monge. Verified by Jay M. Savage. Collection of Laboratorio de

Recursos Naturales y Vida Silvestre (LRNV 000152). First record for Costa Rica, and according to Köhler (2003. Reptiles of Central America. Herpeton, Offenbach, Germany. 367 pp.), this exotic species is presently known elsewhere in Central America from Panamá and Honduras.

Submitted by **JUAN ABARCA** (e-mail: antinosedal@yahoo.es) and **ANA M. MONGE,** Laboratorio de Recursos Naturales y Vida Silvestre, Universidad Nacional, Heredia, Costa Rica (e-mail: ammocr@gmail.com).

HEMIDACTYLUS MABOUIA (Amerafrican House Gecko). USA: FLORIDA: ALACHUA CO: Gainesville, University of Florida campus, Museum Road & Newell Drive (29°38'42.114"N, 82°20'35.592"W, Datum WGS84). 20 November 2006. Kenneth L. Krysko. UF 150119. Gainesville, 704 SW 16th Avenue (29°38'8.18"N, 82°19'55.3"W, Datum WGS84). 06 and 08 May 2007. Louis A. Somma. UF 151218–19, respectively. Gainesville, 990 SW 16th Avenue (29°38'8.71"N, 82°20'16.47"W, Datum WGS84). 9 May 2007. Louis A. Somma. UF 151220. Gainesville, 1111 SW 16th Avenue (29°38'11.25"N, 82°20'14.67"W, Datum WGS84). 12, May 2007. Louis A. Somma. UF 151221–22. Gainesville, 1100 SW 16th Avenue (29°38'11.27"N, 82°20'14.32"W, Datum WGS84). 15 and 16 May 2007. Louis A. Somma. UF 151224–25, respectively. Gainesville, 1001 SW 16th Avenue (29°38'11.51"N, 82°20'10.8"W, Datum WGS84). 12 May 2007. Louis A. Somma. UF 151223. All specimens verified by Kevin M. Enge. New county record and northernmost known localities in Florida (Meshaka et al. 2004. The Exotic Amphibians and Reptiles of Florida. Krieger Publ. Co., Malabar, Florida).

Submitted by **KENNETH L. KRYSKO**, Florida Museum of Natural History, Division of Herpetology, University of Florida, Gainesville, Florida 32611, USA; and **LOUIS A. SOMMA**, Department of Zoology, PO Box 118525, 223 Bartram Hall, University of Florida, Gainesville, Florida 32611-8525, USA (e-mail: las@zoo.ufl.edu).

HEMIDACTYLUS TURCICUS (Mediterranean House Gecko). USA: TEXAS: TRINITY CO.: 4218 FM 357, Kennard (31°15.570'N, 95°02.853'W). Collected on 18 July 2006. TCWC 91800. Verified by Toby Hibbitts. New county record (Dixon 2000. Amphibians and Reptiles of Texas, 2nd ed. Texas A&M Univ. Press, College Station, Texas. 421 pp.). Specimen collected at a residence.

Submitted by **CORY K. ADAMS**, Southern Research Station, USDA Forest Service, Nacogdoches, Texas 75965, USA.

HETERODACTYLUS LUNDII. BRAZIL: BAHIA: Municipality of Mucugê, Caraíbas Farm (13°08'09"S, 41°24'15"W). 8 December 2005. 1100 m elev. M. A. de Freitas and T. F. Santos Silva. Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZUSP 95588). Verified by A. J. Suzart Argôlo. Previously known only from the type locality in the southern portion of the Serra do Espinhaço, Minas Gerais state, Brazil (Bertoluci 1998. *In* Machado et al. [eds.], Livro Vermelho das Espécies Ameaçadas de Extinção de Minas Gerais, pp. 442–443. Fundação Editora Biodiversitas, Belo Horizonte, Brazil). First state record, extends known distribution ca. 700 km N from Serra da Piedade, Caeté, Minas Gerais, Brazil (Bertoluci 1998, *op. cit.*)

Submitted by **MARCO ANTÔNIO DE FREITAS,** Programa de Pós-graduação em Zoologia, UESC (Universidade Estadual de Santa Cruz) CEP 46.500-000 Rodovia Ilhéus/Itabuna, Ilhéus, Bahia, Brazil (e-mail: philodryas@hotmail.com); **THAÍS FIGUEIREDO SANTOS SILVA**, Biogeographia publicações e consultoria ambiental, Rua E quadra D lote 11, Jardim Aeroporto, CEP 42700-000, Lauro de Freitas, Bahia, Brazil (e-mail: thaisfsilva@hotmail.com); and **MIGUEL TREFAUT RODRIGUES**, Instituto de Biociências, Museu de Zoologia da Universidade de São Paulo (USP) CEP 05586-060, São Paulo, SP, Brazil (e-mail: mturodri@usp.br).

LEIOCEPAHLUS CARINATUS (Northern Curly-tailed Lizard). USA: FLORIDA: MONROE CO.: Key West, 3700 Northside Drive (24°34'11.69"N, 81°45'25.398"W, Datum WGS84). 09 February 2006. Kim Gabel. UF 150934. Verified by Kevin M. Enge. New island record. Southernmost verified locality in the United States and extends known range of this species ca. 82 km S of previous southernmost record in Islamorada, Lower Matecumbe Key (Meshaka et al. 2006. J. Kansas Herpetol. 17:6). Big Pine Key, 263 Ship's Way (24°40'26.641"N, 81°22'5.941"W, Datum WGS84). 29 March and 04 May 2007. Jeanette Hobbs. UF 150933 and 151170, respectively. Verified by Kenneth L. Krysko. New island record and ca. 45 km NE of our Key West locality.

Submitted by **KENNETH L. KRYSKO**, Florida Museum of Natural History, Division of Herpetology, University of Florida, Gainesville, Florida 32611, USA; and **KIM GABEL**, UF/IFAS/Monroe County Extension, 1100 Simonton Street, Suite 2-260, Key West, Florida, USA; and **JEANETTE HOBBS**, 263 Ship's Way, Big Pine Key, Florida 33043, USA.

LIOLAEMUS FITZINGERI. ARGENTINA: SANTA CRUZ: DEPARTAMENTO RIO CHICO: Ruta Nacional 40, 99.6 km N Tres Lagos, 3 km N Estancia La Siberia, dunes on east shore of Lago Cardiel (48°57'S; 71°01"W 399 m elev.) 16 January 2007. L. J. Avila, C. H. F. Perez, C. Zanotti, J. W. Sites, Jr. Museo de La Plata herpetological collection (MLP.S 2598); Luciano Javier Avila/Mariana Morando-CENPAT Herpetological collection (LJAMM 7340, 7343). Verified by D. R. Perez. Previously known from southern Chubut and northern and eastern Santa Cruz provinces (Cei 1986. Reptiles del Centro, Centro-oeste y Sur de la Argentina. Herpetofauna de las Zonas Aridas y Semiaridas. Monograph 4. Museo Regionale di Scienze Naturalli Torino. 427 pp.). Southwesternmost record for the species and new department record, extends the known distribution 250 km S from nearest locality on southern coast of Lago Buenos Aires (Avila et al. 2006. Biol. J. Linn. Soc. 89[2]:241–275). This record is a notable geographic extension for the species in the area. Lago Cardiel sand dunes are apparently isolated from any other suitable habitat for *Liolaemus fitzingerii* and sampling efforts in other surrounding areas were unsuccessful, suggesting that this population is a remnant of a larger distribution in the past.

Submitted by **LUCIANO J. AVILA, CRISTIAN H. F. PEREZ, MARIANA MORANDO**, CENPAT-CONICET, Boulevard Almirante Brown 2825, U9120ACF, Puerto Madryn (Chubut), Argentina (e-mail: avila@cenpat.edu.ar); and **JACK W. SITES**, Jr., Integrative Biology, 401 WIDB, Brigham Young University, Provo, Utah 84602, USA.

LIOLAEMUS LAURENTI. ARGENTINA: MENDOZA PROVINCE: Lavalle Departament: 11 km. SW from Encón, San Juan Province, 32°17'22.7"S, 67°52'34.3"W. 01 February 2006. C. S. Abdala, J. S. Abdala, and J. O. Abdala. Herpetological Collection Fundación Miguel Lillo, Tucumán, Argentina (FML 18106–107). Verified by F. Lobo. Known from southern central Catamarca, central and southwestern La Rioja, and eastern San Juan (Etheridge 1992. Boll. Museo Reg. Sci. Nat., Torino 10[1]:1–19). First province record, extends the range 90 km SW from 4 km W of Bermejo, San Juan Province (Etheridge and Espinoza 1997. Herpetol. Rev. 28:160–161).

Submitted by **CRISTIAN ABDALA**, CONICET - Instituto de Herpetología de la Fundación Miguel Lillo, Miguel Lillo 251, 4000, Tucumán, Argentina (e-mail: popper@tucbbs.com.ar); **FLAVIO MARTINEZ** (e-mail: martinezflavio@yahoo.com.ar) and **LEONARDO MUÑOZ**, Dirección de Recursos Naturales Renovables, Almirante Brown s/n, Parque Gral. San Martín Mendoza, CP 5500, Argentina.

LYGOSOMA BOWRINGII (Bowring's Supple Skink). BANGLADESH: COMILLA DISTRICT: Lalmai-Tipperah Hills (23°22'N, 91°07'E), 12 July 2006. S. Mahony and A.H.M. Ali Reza. Wildlife Laboratory, Department of Zoology, Jahangirnagar University, Savar, Dhaka (JU 0050). Photograph deposited at USDZ, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC[IMG].2.1). Verified by Indraneil Das. First record for Bangladesh and western range extension from nearest populations in Myanmar (of which the border is > 240 km w of Comilla) (Das 2002. A Photographic Guide to Snakes and Other Reptiles of India. New Holland Publishers [UK] Ltd., London. 144 pp.). Supported by Cleveland Metroparks Zoo and Rufford Foundation to the second author, which partially supported the first author. Bangladesh Forest Department issued permission (CCF [Wildlife]/2M–47/2006) for this work to the second author. Thanks are due to Md. Kamal Hossain from JU for his enthusiastic assistance in the field.

Submitted by **STEPHEN MAHONY**, 3 Park View Lawns, Greenpark, Clondalkin, Dublin 22, Ireland (e-mail: stephenmahony2@gmail.com); and **A. H. M. ALI REZA**, Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409, USA (e-mail: ali.reza@ttu.edu).

NOROPS SAGREI (Brown Anole). USA: ALABAMA: LEE CO.: Opelika, Plant World Nursery. 7509 Lee Road 146. Approximately 100 m NW of Parkers Crossroad (intersection of Lee Rd 146 & Lee Rd 166). Collected first by Roger Birkhead, then by John Steffen, verified by Craig C. Guyer. Voucher specimens deposited in Natural History Museum at Auburn University (AU 37296, 37297). First published record for Alabama. Nearest localities are 286 km SE in Valdosta, Georgia (Echternacht et al. 1995. Herpetol. Rev. 26:107) and 270 km SE in Panama City, Florida (Means 1990. Herpetol. Rev. 21:96). On 23 January 2006, RB collected a solitary male (AU 37293). On 25 March 2006, JS sighted a minimum of 30 adult males and 20 adult females in approximately one hour search time. Animals were seen perching on plant scaffolding, nursery walls and tables, and at least one pair was seen copulating on greenhouse scaffolding.. Brown Anoles are common invaders throughout Florida (Lee 1985. Copeia 1985:182–194), and have recently been found in Georgia (Echternacht et al., *op. cit*; Campbell and Hammontree 1995. Herpetol. Rev. 26:107), Louisiana (Platt and Fontenot 1994. Herpetol. Rev. 25:33), and Texas (Krusling et al. 1995. Herpetol. Rev. 26:108). It is speculated that lizards in Georgia and Louisiana have colonized these localities when transported as propagules from Florida plant nurseries. This current sighting definitively implicates plant nurseries as propagules for colonization.

Submitted by **JOHN STEFFEN** and **ROGER BIRKHEAD**, 331 Funchess Hall, Department of Biological Sciences, Auburn University, Auburn, Alabama 36849, USA.

PLESTIODON OBSOLETUS (Great Plains Skink). MÉXICO: SONORA: Municipality of Hermosillo, 34 km (by Son. Hwy 104) E Hermosillo (29.049928°N, 110.604418°W). 4 July 1991. Adrian Quijada and Ivan Parra. Verified by C. H. Lowe. UAZ 49170. First record for the Municipality of Hermosillo, extending the range ca. 146 km (airline) SW from the vicinity of Gúasabas, Sonora (Cliff 1953. Copeia 1953:186–187). The lizard was found in a transition zone between Sonoran Desert scrub and Sinaloan thorn scrub.

Submitted by **ADRIÁN QUIJADA MASCAREÑAS**, Facultad de Biología, Universidad Michoacana de San Nicolás de Hidalgo (UMSNH), Ciudad Universitaria, Morelia 58030, Michoacán, México; **ERIK F. ENDERSON**, Drylands Institute, PMB 405 2509 North Campbell Avenue, Tucson, Arizona 85719, USA (e-mail: erikenderson@msn.com); **IVAN PARRA-SALAZAR**, School of Natural Resources, 325 Biological Sciences East, University of Arizona, Tucson, Arizona 85721, USA; and **ROBERT L. BEZY**, Herpetology, Natural History Museum of Los Angeles County, Los Angeles, California 90007, USA.

SCINCELLA GEMMINGERI (Forest Ground Skink) MÉXICO: CHIAPAS: Municipality of Tuxtla Gutiérrez: Km 12.7 on Tuxtla Gutiérrez–Cañón del Sumidero road (16°48'31.4"N, 93°05'21.6"W), 1186 m elev. 12 November 2004. Alberto Mendoza Hernández and Roberto Luna Reyes. Instituto de Historia Natural y Ecología, Chiapas (IHNHERP 3377, 3383, 3384). Verified by Luis Canseco Márquez. First state record, extending its known range ca. 121 km NE of Rodulfo Figueroa, Oaxaca (MZFC 15558; García-Vázquez 2004. Revisión Taxonómica del Genero *Scincella* [Lacertilia: Scincidae] de México. Unpubl. thesis, Univ. Autón. de Puebla, Puebla). The specimen was collected in tropical deciduous forest.

Submitted by **ROBERTO LUNA-REYES,** Dirección de Investigación, Instituto de Historia Natural y Ecología, Tuxtla Gutiérrez, Chiapas; **URI OMAR GARCÍA-VÁZQUEZ** and **ANDRÉS ALBERTO MENDOZA-HERNÁNDEZ,** Museo de Zoología, Facultad de Ciencias, UNAM, A.P. 70-399, México D.F. 04510, México (e-mail: urigarcia@gmail.com).

TUPINAMBIS QUADRILINEATUS (Teiu). BRAZIL: DISTRITO FEDERAL: Ponte Alta de Cima: Gama (16°01'S, 48°12'W). 09 November 2006. G. B. Figueiredo, W. E. Salmito, and T. C. S. Guimarães. Verified by G. R. Colli. Coleção Herpetológica da Universidade de Brasília, Brazil (CHUNB 49442, adult male collected in a gallery forest from Cerrado). Previously known in Brazil only from the states of Tocantins (Mesquita et al.

2006. Copeia 2006:460–471), Mato Grosso, and Goiás (Colli et al. 1998. Herpetologica 54:477–492). First record for the State of Distrito Federal, extends known distribution ca. 82 km NW from Pirenópolis, Goiás State, the nearest previous record (Colli et. al., *op. cit.*).

Submitted by **TAINAH C. S. GUIMARÃES** (e-mail: tainah.correa@gmail.com), **GIOVANNI B. FIGUEIREDO** (e-mail: calangoboca@yahoo.com.br), and **WALFRIDO E. SALMITO** (e-mail: walbsb@hotmail.com), Departamento de Zoologia, Universidade Católica de Brasília, Prédio São Gaspari Bertoni, QS 07, Lote 01, EPTC, 72030-170, Águas Claras, Distrito Federal, Brazil.

UTA STANSBURIANA (Side-blotched Lizard). USA: TEXAS: Cochran Co.: 4 road km N FM 769 on State Line Road (33°36'22.6"N; 103°02'42.3"W). 10 June 2006. David Laurencio and Toby J. Hibbitts. Verified by James R. Dixon. Texas Cooperative Wildlife Collections, TCWC 91462–91464. New county record, closest known populations are in Roosevelt County, New Mexico. (Dixon 2000. Amphibians and Reptiles of Texas, 2nd ed. Texas A&M University Press, College Station, Texas. 421 pp.). The specimens were collected during research on *Sceloporus arenicolus* with funding from Texas Parks and Wildlife Department.

Submitted by **TOBY J. HIBBITTS, DAVID LAURENCIO**, and **LEE A. FITZGERALD,** Texas Cooperative Wildlife Collections, Department of Wildlife and Fisheries Sciences, Texas A&M University, 2258 Tamu, College Station, Texas 77843-2258, USA (e-mail: thibbitts@tamu.edu).

SERPENTES

BOTHROPS ALTERNATUS. BRAZIL: RIO DE JANEIRO: Três Rios municipality (22°07'S, 43°12'W). 05 July 1960. Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (MNRJ 8337). Verified by R. Fernandes. Species previously known from northern and central Argentina (provinces of Buenos Aires, Catamarca, Córdoba, Corrientes, Chaco, Entre Rios, Formosa, La Pampa, Misiones, San Luis, Santa Fe, Santiago del Estero, and Tucumán), throughout Uruguay, southern Paraguay, and southern, southeastern, and central Brazil (States of Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Minas Gerais, Mato Grosso, and Goiás) (Campbell and Lamar 2004. The Venomous Reptiles of the Western Hemisphere, Vol. 1. Cornell Univ. Press, Ithaca, New York. p. 366; Hoge and Belluomini 1960/62. Mem. Inst. Butantan 30:97–102; Nogueira and Valdujo 2001. Herpetol. Rev. 32:58). First state record, ca. 120 km SE from the closet previous record (Minas Gerais: Barbacena municipality; Hoge and Belluomini, *op. cit.*).

Submitted by **ADRIANO LIMA SILVEIRA** (e-mail: biosilveira@yahoo.com.br) and **PAULO R. EVERS JR.,** Setor de Herpetologia, Departamento de Vertebrados, Museu Nacional, Universidade Federal do Rio de Janeiro, Quinta da Boa Vista, São Cristóvão, CEP 20940-040, Rio de Janeiro, RJ, Brazil (e-mail: pauloevers@hotmail.com).

CHARINA BOTTAE (Rubber Boa). USA: IDAHO: Lewis Co.: Mission Creek Rd, 1.8 km N of Slickpoo (46°19.014'N, 116° 42.665'W). 24 September 2006. Robert E. Weaver. Verified by Kenneth V. Kardong. Voucher specimen deposited in the Central Washington University Department of Biological Sciences Herepetology Collection (CWU 1693). Juvenile female collected DOR (265 mm SVL, 13.6 g). First county record. Although regional field guides depict the distribution of *Charina bottae* as continuous throughout the Pacific Northwest (Storm et al. 1995. Reptiles of Washington and Oregon. Seattle Audobon Society, Seattle, Washington. 176 pp.), several counties in north-central Idaho form a significant gap in distribution data for this species (Nussbaum et al. 1983. Amphibians and Reptiles of the Pacific Northwest. University of Idaho Press, Moscow, Idaho. 332 pp.). This locality fills a gap between the nearest record in Nez Perce Co., 12.1 km NW near Lewiston, and historical records in Adams Co.

Submitted by **ROBERT E. WEAVER** (e-mail: weaver@wsu.edu) and **ALEX DORNBURG** (e-mail: dornburgalex@yahoo.com), School of Biological Sciences, Washington State University, Pullman, Washington 99164, USA.

CHIRONIUS QUADRICARINATUS. BRAZIL: BAHIA: Municipality of Mucugê, Caraíbas Farm (13°08'09"S, 41°24'15"W). 15 December 2005. 1100 m elev. M. A. de Freitas and T. Figueiredo Santos. Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZUSP 15049). Verified by A. J. Suzart Argôlo. Previously known from south-central Brazil, including São Paulo, Mato Grosso, Minas Gerais, Rio de Janeiro, and southeastern Bahia state (Dixon et al. 1993. Revision of the Neotropical Snake Genus *Chironius* Fitzinger [Serpentes, Colubridae]. Museo Regionale di Scienze Naturali – Torino; Argôlo 1998. Herpetol. Rev. 29:175). Second record of the species from northeastern Brazil, extends its distribution ca. 400 km N of Canavieiras, Bahia state (Argôlo 1998, *op. cit.).*

Submitted by **MARCO ANTÔNIO DE FREITAS,** Programa de Pós-graduação em Zoologia, UESC (Universidade Estadual de Santa Cruz) CEP 46.500-000 Rodovia Ilhéus/Itabuna, Ilhéus, Bahia, Brazil (e-mail: (philodryas@hotmail.com); **THAÍS FIGUEIREDO SANTOS SILVA,** Biogeographia Publicações e Consultoria Ambiental, Rua E quadra D lote 11, Jardim Aeroporto, CEP 42700-000, Lauro de Freitas, Bahia, Brazil (e-mail: (thaisfsilva@hotmail.com); and **MIGUEL TREFAUT RODRIGUES,** Instituto de Biociências, Museu de Zoologia da Universidade de São Paulo (USP) CEP 05586-060, São Paulo, SP, Brazil (e-mail: mturodri@usp.br).

CROTALUS INTERMEDIUS GLOYDI (Oaxacan Small-headed Rattlesnake). MÉXICO: VERACRUZ: Municipality of Atzompa: 3 km S of Atzompa (18°43'7.9"N, 97°12'20.9"W), 2571 m elev. 02 May 2004. Uri Omar García Vázquez. Verified by Luis Canseco Márquez. Colección Herpetológica del Museo de Zoología Alfonso L. Herrera, Facultad de Ciencias, UNAM (MZFC 19841). New state record, extending the known range of this subspecies slightly east of localities in southeastern Puebla (Campbell and Lamar 2004. Venomous Reptiles of the Western Hemisphere. Cornell Univ. Press., Ithaca, New York. 870 pp.). The snake was found in pine-oak forest.

Submitted by **ROBERT W. BRYSON, JR.**, School of Life Sciences, University of Nevada, Las Vegas, 4505 Maryland Parkway, Las Vegas, Nevada 89154-4004, USA (e-mail:

brysonjr@unlv.nevada.edu); and **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).

DENDRELAPHIS NGANSONENSIS (Nganson Bronzeback). CHINA: YUNNAN: Lung Ling Ting. 21 March 1917. Roy C. Andrews and Edmund Heller. AMNH R–21045. HAINAN ISLAND: NODOA. January 1922–July 1923. Clifford H. Pope. Verified by Gernot Vogel. AMNH R–27754. First country record. Currently known from Ngan Son (Bac Kan Province, type locality), Tam Dao (Vinh Phuc Province), Cuc Phuong N.P., Ky An-Ke Go and Chin Xai (Ha Tinh Province), Phong-Nha - Khe Bang N.P. (Quang Binh Province), Bach Ma (Thua Thien-Hue Province), and "Col des Nuages, near Tourane" (= Danang), Vietnam (Bourret 1936. Les serpents de l'Indochine. Henri Basuyau, Toulouse. Vol. 2., pp. 505; Ziegler and Vogel 1999. Russ. J. Herpetol. 6:199–208; Ziegler et al. 2004. Hamadryad 28:19–42). Also recorded from Laos from the "mountainous provinces of Xieng-Khouang" (= Xien Khoang Province) (Deuve 1970. Serpents du Laos. Office de la Recherche Scientifique et Téchnique Outre–Mer. Memoires ORSTOM No. 39, Paris. 251 pp.). Pope (1935. The Reptiles of China. Natural History of Central Asia. Vol. 10. American Museum of Natural History, New York. li + 604 pp.; 27 pl.) referred to these specimens as *Dendrophis boiga boiga*. New record for China (Daming 2002. Atlas of Reptiles of China. Henan Publishing House of Science and Technology, C.W.P. Zhengzhou. 346 pp.; Zhou and Yu 2002. Sich. J. Zool. 21:236–238).

Submitted by **PHILIP NICODEMO, JR.**, Cook College at Rutgers University, New Brunswick, New Jersey, USA (e-mail: philnico@eden.rutgers.edu); and **RAOUL H. BAIN**, Center for Biodiversity and Conservation, Division of Zoology (Herpetology), American Museum of Natural History, W79th Street at Central Park West, New York, USA (e-mail: bain@amnh.org).

HYPSIGLENA TORQUATA (Night Snake). USA: WASHINGTON: Columbia Co.: Tucannon River Rd (46°26.792'N, 117°46.165'W). Alex Dornburg. Verified by Kenneth V. Kardong. Voucher specimen deposited in the Central Washington University Department of Biological Sciences Herpetology Collection (CWU 1695). Adult female (285 mm SVL, 11.4 g) collected DOR 15 October 2006. First county record. Until very recently, few specimens of *H. torquata* have been recorded from SE Washington, and confusion surrounds the official regional documentation of this species. Some regional field guides show a single record for Asotin Co., and none for Columbia Co. (Nussbaum et al. 1983. Amphibians and Reptiles of the Pacific Northwest. University of Idaho Press, Moscow, Idaho. 332 pp.), while some report no specimens from Asotin Co., but one for Columbia Co. (Hallock and McAllister 2005. Washington Herp Atlas http://www.dnr.wa.gov/nhp/refdesk/herp/). Regardless, no voucher specimens (photo or otherwise) exist for either county. Given this confusion and the absence of any voucher, we consider this to be the first specimen recorded from Columbia County, Washington.

Submitted by **ROBERT E. WEAVER** (e-mail: weaverr@wsu.edu), and **ALEX DORNBURG** (e-mail: dornburgalex@yahoo.com), School of Biological Sciences, Washington State University, Pullman, Washington 99164, USA.

LAMPROPELTIS CALLIGASTER (Prairie Kingsnake). USA: TEXAS: Montgomery Co.: 1.6 road km N of junction of FM 149 on FM 1774 (30°10'45.12"N, 95°41'50.28"W). 5 April 2007. D. G. Henderson. Verified by Toby J. Hibbitts. Texas Cooperative Wildlife Collection, TCWC 91799. New county record (Dixon 2000. Amphibians and Reptiles of Texas, 2nd ed. Texas A&M University Press, College Station, Texas. 421 pp.).

Submitted by **DAVID G. HENDERSON**, Department of Philosophy, 314 Bolton Hall, Texas A&M University, College Station, Texas 77843-4237, USA; e-mail: d-henderson@philosophy.tamu.edu.

PLATYCEPS TAYLORI (Taylor's Racer). ERITREA: Gahtelay (15°31'N, 39°10'E), caught in a dry wadi. 08 November 2006. Beat Schätti. MHNG 2680.55. Verified by Andreas Schmitz. Northernmost known locality of the species and first record from N of Danakhil depression; extends range by at least 400 km northwest of closest record from Assab (Largen and Rasmussen 1993. Trop. Zool. 6[2]:313–434).

Submitted by **BEAT SCHÄTTI**, Apartado postal 383, San Miguel de Allende, 37700 Guanajuato, Mexico; e-mail: beatschaetti@hotmail.com.

PYTHON MOLURUS BIVITTATUS (Burmese Python). USA: FLORIDA: Monroe Co.: Key Largo, 0.27 mi E CR 905 and Loquat Drive, Dagny Johnson Key Largo Hammock Botanical State Park (25°10'28.158"N, 80°21'58.92"W, WGS84; elev. < 1 m). 13 April 2007. Daniel U. Greene, James G. Duquesnel, Joanne Potts, and Clay Degayner. Verified by Kenneth L. Krysko. Florida Museum of Natural History (UF 151037). First record from the Florida Keys (Snow et al. 2007. *In* R. W. Henderson and R. Powell [eds.], The Biology of Boas and Pythons, pp. 416–438. Eagle Mountain Publ., Eagle Mountain, Utah). A single male python (200 cm SVL, 5.7 kg) found while radio-tracking a Key Largo woodrat (*Neotoma floridana smalli*). Necropsy revealed the radio collar and animal, along with a second (non-collared) *N. f. smalli*, which is both Federally and State listed as Endangered. Because of the potential threat that *Python molurus* poses to native species in Florida, especially on small islands, this record heightens concern for the endemic and endangered fauna in the Florida Keys (Reed 2005. Risk Analysis 253:753–766).

Submitted by **DANIEL U. GREENE**, Daniel B. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, Georgia 30602-2152, USA (e-mail: greened@warnell.uga.edu); **JOANNE M. POTTS**, Centre for Research into Ecological and Environmental Monitoring, University of St. Andrews, St. Andrews, Fife, FY16 9LZ, Scotland (e-mail: Joanne@mcs.st-andrews.ac.uk); **JAMES G. DUQUESNEL**, Florida Department of Environmental Protection, John Pennekamp Coral Reef State Park, P.O. Box 487, Key Largo, Florida 33037, USA (e-mail: james.g.duquesnel@dep.state.fl.us); and **RAY W. SNOW**, Everglades National Park, 40001 State Road 9336, Homestead, Florida 33034, USA (e-mail: Skip_Snow@nps.gov).

RAMPHOTYPHLOPS BRAMINUS (Brahminy Blindsnake). USA: FLORIDA: Alachua Co.: Gainesville: SR 121 N of intersection with SR 24 (1911 SW 34th St.) (29°38'04.07"N, 82°22' 15.55"W). 16 May 2007. Collected by Louis A. Somma. Verified by Kenneth L. Krysko, Florida Museum of Natural History, University of Florida. One adult within a termite colony, beneath rock. UF 151211; additional specimens (UF 151212–14) were also found. All specimens were collected between 1200–1240 h at the Division of Plant Industry (DPI), Florida Department of Agriculture and Consumer Services. In 2006, another adult *R. braminus* was collected by an employee at this site, near a greenhouse, and was kept in captivity until it escaped. *Rhamphotyphlops* is occasionally encountered by employees of DPI and it may be expanding its range, as there is one specimen (UF 147001) collected from the University of Florida campus (Powell Hall) adjacent to the DPI site (29°38'7.9080"N, 82°22'12.4320"W) on 10 May 2006, by J. Weber.

The first evidence of this species from Gainesville is an unpublished single specimen record (29°39'23.0761"N, 82°22'33.0240"W), from November 1999, I. A. Minno (UF 120116). The first published account referenced a specimen found at the USDA lab on the University of Florida campus (Townsend et al. 2002. Herpetol. Rev. 33:75). Although these specimens reported here do not expand the range of this species, they establish the presence of a population of *R. braminus* in Gainesville, Alachua Co. This Southeast Asian, parthenogenic typhlopid has been collected from at least 17 counties in Florida (Ernst and Brown 2000. Herpetol. Rev. 31:256; Ernst and Ernst 2003. Snakes of the United States and Canada. Smithsonian Inst. Books, Washington, DC; Meshaka et al. 2004. The Exotic Amphibians and Reptiles of Florida. Krieger Publ. Co., Malabar, Florida; Krysko et al. 2005. Herpetol. Rev. 36:85–87).

Submitted by **LOUIS A. SOMMA**, Department of Zoology, PO Box 118525, 223 Bartram Hall, University of Florida, Gainesville, Florida 32611-8525, USA; e-mail: las@zoo.ufl.edu.

RAMPHOTYPHLOPS BRAMINUS (Brahminy Blindsnake). MÉXICO: OAXACA: Municipality of Villa de Tututepéc de Melchor Ocampo, Río Grande (16°00'45"N, 97°25'59"W), 29 m elev. 03 January 2007. Martín Cruz Santiago. Verified by Adrian Leyte-Manrique. Colección Herpetológica del Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Hidalgo (CIB-CH1376). First record for the municipality and a 205 km range extension S of the only other verified Oaxacan record from Cuicatlán (Mendoza Quijano et al. 1994. Herpetol. Rev. 25:34), which is located on the Gulf versant of the state. The closest known localities to this record are from adjacent Guerrero (Dixon and Hendricks 1979. Zool. Verh. 173:1–39). Literature records indicate that this exotic species has become well established along the Pacific lowlands from Sinaloa (Dixon and Hendricks, *op. cit.*), Jalisco (Dundee and Flores-Villela 1991. Herpetol. Rev. 22:26), Michoacán (Duellman 1965. Univ. Kansas Publ. Mus. Nat. Hist. 15:629–709), Guerrero (Dixon and Hendricks, *op. cit.*), into Oaxaca. Casas-Andreu (2004. *In* Garcia-Mendoza et al. [eds.], Biodiversidad de Oaxaca, pp. 375–390. Inst. Biol. UNAM, México, D.F.) indicated that this species occurs on the Pacific coastal plain of Oaxaca, but cites no localities. The snake was found crawling on a street in the town of Río Grande.

Submitted by **VICENTE MATA-SILVA**, Department of Biological Sciences, University of Texas at El Paso, 500 West Avenue, El Paso, Texas 79968, USA; **AURELIO RAMIREZ-BAUTISTA**, Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Hidalgo, A.P. 1-69 Plaza Juárez, Pachuca Hidalgo, C.P. 42001, México; and **JERRY D. JOHNSON**, Department of Biological Sciences, University of Texas at El Paso, 500 West Avenue, El Paso, Texas 79968, USA (e-mail: vmata@utep.edu).

RAMPHOTYPHLOPS BRAMINUS (Brahminy Blindsnake). USA: TEXAS: NACOGDOCHES CO.: Nacogdoches, 134 North Church St. (31°36'13.38"N, 94°39'09.84"W). 29 July 2006. William B. Godwin. Verified by James R. Dixon. Texas Cooperative Wildlife Collections, TCWC 91545. This is the second known locality for this species in the state. New county record and second state record (Dixon 2000. Amphibians and Reptiles of Texas, 2nd ed. Texas A&M University Press, College Station, Texas. 421 pp.; J. R. Dixon, pers. comm.).

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Discovery of an Introduced Population of *Discoglossus pictus* Beyond its Known Distributional Range

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The introduction of invasive species is, after habitat destruction, the second most important cause of biodiversity loss on the planet (Devine 1998; IUCN 2000; Mack et al. 2000). The main problems related to the introduction of invasive species are competition with local fauna, introduction of pathogens and genetic pollution of autochthonous populations (Arano et al. 1995; Butterfield et al. 1997; Dodd and Seigel 1991; Elton 1958; Manchester and Bullock 2000). According to one estimate, 39% of all known extinctions that have taken place in the last 300 years have been as a result of the introduction of exotic species (Guijarro 2001). Especially injurious are the introductions of invasive species that disperse well and adapt quickly to new environments (Kolar and Lodge 2001; Sax and Brown 2000).

Discoglossus pictus is a North African species that was intro-

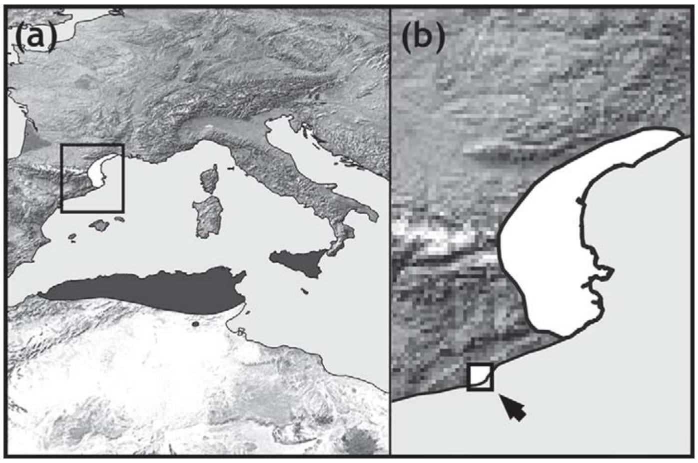

FIG. 1. Distribution of *Discoglossus pictus* in the western Mediterranean basin (left) and in the northeastern Iberian Peninsula (right). The black arrow shows the new 10 × 10 UTM (31T DF21) occupied by *D. pictus*.

duced from Algeria to a small village in Continental Europe (Banyuls Sur Mer), approximately 100 years before present (Wintrebert 1908), and now has a continuous range extending > 7000 km^2, from SW France to NE Iberia (Fig. 1) (Barbadillo et al. 1999; Fradet and Geniez 2004; Geniez and Cheylan 1987; Knoepffler 1962; Lanza 1989; Llorente et al. 1995, 1997; Montori et al. 2007; Salvador and García-París 2001; Wintrebert 1908). New data on the distribution of the introduced population of *D. pictus* suggest that it is extending its range at a similar rate to other amphibians (Leblois et al. 2000; Llorente et al. 1995, 2002; Montori et al. 2007). These studies indicate that populations have progressed within the province of Girona 60 km to the west and 140 km to the south in the last century, being its southern expansion the most accentuated (Montori et al. 2007). This progress has moved the southern limit of the distribution range of *D. pictus* in Iberia on the north of Barcelona province (Fig. 1).

In this study we report a recent introduction event of *Discoglossus pictus* in the Llobregat River Delta, 60 km south of its present distribution range, and discuss the effects that this introduction might have on the local amphibian fauna, as well as the possibility that this new population might act as a new focus of dispersal towards the south.

This study was part of a larger project on the short and long-term ecological and biological impact that the creation of new infrastructures has on the local amphibian fauna of the Llobregat River Delta (Llorente 2005). Between 2004 and 2005, extensive field surveys were carried out by means of habitat transects with constant capture effort. All amphibian species could be easily identified with the only exception of several specimens of the genus *Discoglossus* found during the surveys. The genus *Discoglossus* includes seven relatively similar species all found in the Mediterranean Basin: *Discoglossus galganoi* and *D. jeannae*, endemic to the Iberian Peninsula, *D. montalentii* and *D. sardus*, endemic to the Tyrrhenian islands, *D. scovazzi* endemic to North Africa, *D. nigriventer* endemic to Israel (probably extinct) and *D. pictus*, found in North Africa, with introduced populations in continental Europe and some Mediterranean islands (Fromhage et al. 2004; Zangreti et al. 2006). Fortunately, all seven species are easily diagnosable through the comparison of the mitochondrial 16S rRNA gene region (Zangreti et al. 2006; Fromhage et al. 2004).

Genomic DNA was extracted from small non-invasive pieces of tissue from three specimens of *Discoglossus* sp. from the Llobregat Delta and from two specimens of *Discoglossus pictus auritus* from a population in Riudarenes, Girona province. All samples were processed following standard protocols described in Carranza et al. (1999). Gene fragments were amplified by the polymerase chain reaction (PCR) and were sequenced using the same standard protocols and conditions as in Carranza et al. (1999, 2000). Primers 16Sa 5'- CGC CTG TTT ATC AAA AAC AT-3' and 16Sb 5'-ACG TGA TCT GAG TTC AGA CCG G-3' were used in amplification and sequencing of approximately 558 base pairs (bp) of the 16S rRNA gene (Palumbi 1996). The 16S rRNA mtDNA sequences from the Llobregat Delta and the population from Girona were aligned together with 16S rRNA sequences from all seven extant species of *Discoglossus* downloaded from Genbank (AY333712 – AY333724; Fromhage et al. 2004) using ClustalX (Thompson et al. 1997) with default parameters (gap opening = 10; gap extension = 0.2), and their sequences compared with the computer program PAUP* 4.0b10 (Swofford 1998).

The first observations of *Discoglossus* sp. in the Llobregat Delta occurred on 21 April 2004 at 41°17'15.71"N, 02°06'7.78"E (see Fig. 2). Other surveys carried out in 2004 near this location detected three new individuals and, in 2005, 11 individuals (two males, eight females and one juvenile) and one breeding site where tadpoles and metamorphs were detected. The collected specimens were housed in museological institution of the University of Barcelona (Animal Biodiversity Resource Center - www.ub.es/crba/). All observations of *D. pictus* in the Llobregat River Delta were close to water—in floodplains, drainage channels, and pools.

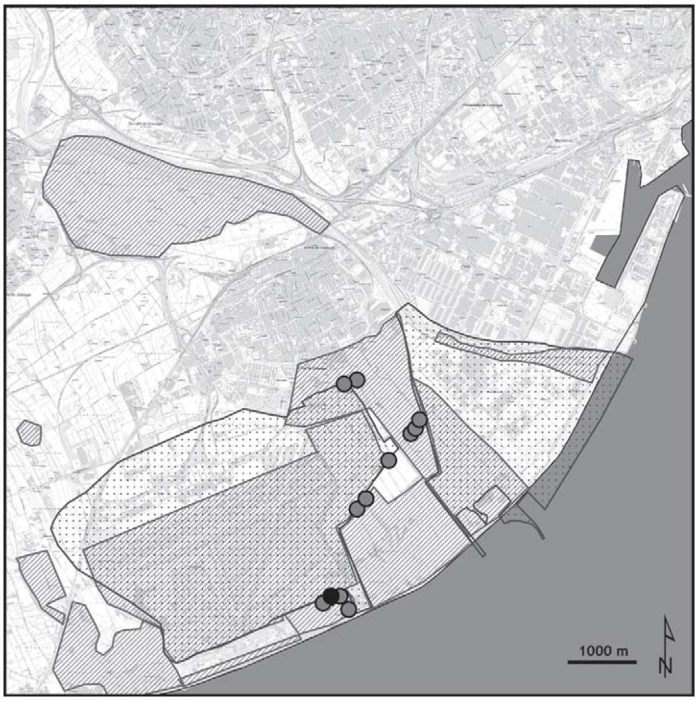

FIG. 2. Specific localities (gray circles) known for *Discoglossus pictus* in the Llobregat River Delta. Breeding locality marked with a black circle. Reticulated areas represent prospected zones cover by the study.

The mitochondrial DNA sequence analysis of three specimens (see above) from the Llobregat Delta showed that all of them were identical in the 558 bp of 16S rRNA sequenced to the specimen of *Discoglossus pictus auritus* from Girona (the control population) and showed two differences with the sample of *Discoglossus pictus auritus* from France (Genbank accession number AY333723), which is also part of the population that was introduced into continental Europe in the Nineteenth Century (Wintrebert 1908). These results expand 60 km further south the known distribution range of *D. pictus* (Fig. 1), and suggest that this is probably another case of human-mediated introduction. Two possible origins of introduced individuals are suggested. One is the indirect introduction by heavy machinery coming from northeast of Catalonia during the construction of new infrastructures in Delta. Second possible origin is voluntary introduction of individuals. In the surrounds of Barcelona it is usual to detect punctual introductions of herpetological species. For example *Triturus marmoratus* and *Lissotriton helveticus* were cited in Barcelona Metropolitan Park out of their distribution ranges.

The Llobregat Delta is located within the potential distribution area estimated by Montori et al. (2007) for this species. This will probably facilitate the establishment of a large viable population that might serve as a springboard for future expansions to other suitable habitats further south. We have verified that the species has been successfully reproducing in the Llobregat Delta, since several juveniles, metamorphs and tadpoles were found in this area.

This new introduced population implies the existence of a second centre of expansion that makes management of the species difficult. Moreover, this area has experienced a substantial decrease in its amphibian diversity as a result of the recent disappearance of three species (*Epidalea calamita*, *Bufo bufo*, and *Pelobates cultripes*) through habitat disturbance and deterioration of water quality. Future surveys in this area will indicate if the range of the species is expanding and if it has been able to establish new populations or, on the contrary, its dispersal has not progressed further. New metamorphs were detected during 2007 proving the persistence of the new population

When the introduction of an allochtonous species takes place, it is important to monitor it from the beginning. This fact facilitates the planning of immediate management measures. The reason for concluding the presence of *Discoglossus pictus* in the Llobregat Delta is the result of a human-mediated introduction and not natural range expansion is because the present expansion front of *D. pictus* in Catalonia is relatively distant (60 km to the north), without intermediate populations. Although the Llobregat River Delta is within the calculated potential distribution range for this species in Catalonia (Llorente et al. 1995; Montori et al. 2007), at the present expansion rate estimated for *D. pictus* (1.53 km/year ± 0.8 km; Montori et al., *op. cit.*), it would take approximately 30 years to disperse naturally to the Llobregat Delta from its closest populations located in the northern limit of the Barcelona province (see Fig. 1).

Acknowledgments.—We are grateful to Pere Albornà, Sabina Artal, and Dani Burgas for their help in this field survey. This work was funded by the Departament de Medi Ambient, Generalitat de Catalunya, project number: FBG302577. Scientific research permits were issued by the Departament de Medi Ambient, Generalitat de Catalunya.

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Herpetological Review, 2007, 38(3), 359.

Range Extensions for Eight Species of Turtles in Gasconade, Osage, and New Madrid Counties, Missouri

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During a 2006 Wisconsin-type fyke net turtle exclusion device study conducted in Gasconade, Osage, and New Madrid counties, Missouri, ten new county records for turtles were established. The specimens listed below represent the first reported occurrence of the species within the county listed. Turtles were photographed and records were submitted to University of Missouri-Columbia (UMOC) collection. All voucher photographs were verified by Jeffrey T. Briggler and catalogued into the collection. Except where specified all animals were captured by the authors. All records were found within the ranges predicted by Ernst et al. 1994.

Apalone mutica mutica (Midland Smooth Softshell). Gasconade Co: Gasconade River, Sec. 20 T44N R6W. 01 June 2006. UMOC 1083P.

Apalone spinifera hartwegi (Western Spiny Softshell). Osage Co: Gasconade River, Sec. 34 T43N R7W. 19 May 2006. Collected by Zach Fratto and Phil Pitts. UMOC 1073P.

Chelydra serpentina serpentina (Eastern Snapping Turtle). Gasconade Co: Gasconade River, Sec. 20 T44N R6W. 01 June 2006. UMOC 1062P.

Graptemys ouachitensis ouachitensis. (Ouachita Map Turtle). Gasconade Co: Gasconade River, Sec. 20 T44N R6W. 01 June 2006. UMOC 1062P.

Graptemys pseudogeographica pseudogeographica (False Map Turtle). New Madrid Co: Donaldson Point Conservation Area, Sec. 6 T22N R15E; Bottomland Hardwood Mississippi River floodplain water body. 16 May 2006. University of Missouri-Columbia collection 1057P. Gasconade Co: Gasconade River, Sec. 20 T44N R6W. 01 June 2006. UMOC 1064P.

Pseudemys concinna concinna (Eastern River Cooter). Gasconade Co: Gasconade River, Sec. 20 T44N R6W. 01 June 2006. UMOC 1068P.

Sternotherus odoratus (Stinkpot). Osage Co: Gasconade River, Sec. 31 T43N R7W. 14 June 2006. University of Missouri-Columbia collection 1072P. Gasconade Co: Gasconade River, Sec. 22 T44N R6W. 28 June 2006. UMOC 1061P.

Trachemys scripta elegans (Red-eared Slider). Gasconade Co: Gasconade River, Sec. 20 T44N R6W. 01 June 2006. UMOC 1070P.

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BOOK REVIEWS

Herpetological Review, 2007, 38(3), 360–365.

The Frogs of New Guinea and the Solomon Islands, by James Menzies. 2006. Pensoft Publishers, Sofia, Bulgaria (www.pensoft.net). x + 346 pp., 48 pp. pls. Hardcover. 45.00 € (approx. US $62). ISBN 954-642-273-8.

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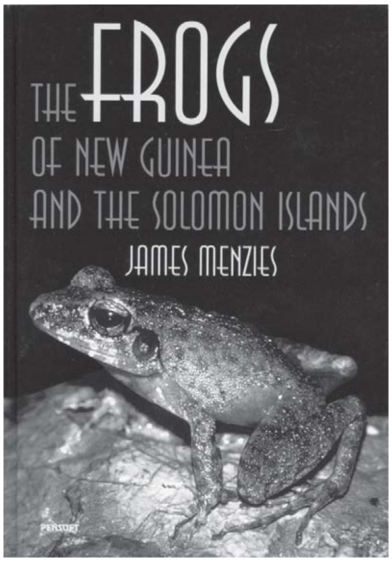

The Papuan region comprises New Guinea and immediately adjacent islands, and the Bismarck, Admiralty, Solomon, and Aru islands. It contains a unique biota recognized since the time of Alfred Wallace. Its frog fauna is among the world's largest, with ~350 species described to date and an approximately equivalent number no doubt waiting to be discovered or described. Yet it is also among the poorest known anuran faunas in the world because of its large size, difficulty of geographic access, and paucity of researchers. Among those researchers is Dr. James Menzies, who taught for most of his career at the University of Papua New Guinea and who has probably the greatest amount of wide-ranging field experience with that region's frog fauna. He has now produced a book treating the frog fauna of this region that is a tremendous expansion of his 1975 *Handbook of the Common Frogs of New Guinea*, which has long been out of print and was, as the title suggests, of more limited scope. Included in the new treatment are mention of all 331 frog species known by the end of 2005 to occur in the Papuan region or in the Moluccas for those genera (e.g., *Callulops*, *Litoria*, *Oreophryne*, *Platymantis*) having a few relatives that have filtered westward.

The book is divided into seven sections of widely varying length. An introduction gives the goal of the book to "discuss the frog fauna of New Guinea in its regional context by assembling all that is recorded in the literature." This is followed by sections treating 2) the diversity and biology of Papuan frogs; 3) background information on the topography, geology, climate, and vegetation of the region; 4) origin and biogeography of Papuan frogs; 5) a brief discussion of the layout for the systematic accounts; 6) the systematic accounts themselves, which comprise the large majority of the book; and 7) a one-page description of how to preserve frogs. The sections are followed by an appendix providing spectrograms of many Papuan frog calls, distribution maps for selected genera and species, a glossary of some terms used in the book, a gazetteer of many place names referred to in the book, references cited in the text, and an index. Tacked on too are two pages of newly described species either overlooked in the original compilation (6 spp., p. 346) or described after the book was sent to press (5 spp., p. 273). The meat of the book, of course, are the systematic accounts. Each includes scientific name, author, and year of description; complete citation for the original description; a brief diagnosis of the species (or genus, in some cases); ecological notes; and verbal description of the geographic range. Frequently, descriptions of the acoustic impression of a species' call is provided, which makes interpretation of the spectrograms easier. Species accounts are typically brief; poorly known species frequently verge on telegraphic owing to paucity of available information.

I am sorry to report the book to be disappointing and frustrating at many levels. It is replete with errors of fact, logical inconsistencies, poor writing and editing, and omission of useful information. It is difficult to choose where to begin but I will start with the less important points and proceed to the more important.

Spelling, grammatical, and writing errors are common throughout the book. The first are most often a minor annoyance but the few cases involving species or place names could confuse the novice. Into this category fall "valkuriorum" for "valkuriarum" throughout p. 10, "Carstenz" for "Carstensz" on p. 15, "macosceles" for "macrosceles" on p. 90, "Bainings" for "Baining" on p. 91, "nexippus" for "nexipus" on p. 90, and "elkae" for "elkeae" on pp. 107 and 342.

Spelling inconsistencies are of modest frequency. In this category fall "San Cristobal" vs. "San Christobal" on pp. 80 and 81 as well as "Jayawija", "Jajawijaya", and "Jayawidjaya" on pp. 262 and 264. Most annoying is the consistent use throughout the book of "Guenther" as author following a species name, with "Günther" invariably used in the subsequent line providing complete reference for the original description. Too, it would have been helpful to distinguish A. Günther from R. Günther. Punctuational mistakes are common; in particular, commas are seemingly randomly interspersed throughout the text.

Menzies makes the useful distinction throughout the taxonomic accounts of providing both maximum male and female body sizes. This is important because females are larger than males for most Papuan frogs. However, this standard is inconsistently applied and accounts for several species in which both sexes are known provide only one body size measurement (e.g., *Nyctimystes pulcher*, p. 165); in other cases accounts don't specify sex, leaving the reader to guess to which the information is intended to apply (e.g., *Litoria quadrilineata*, p. 122). Too, the information is usually provided as, e.g., "HBf" but sometimes as "HB female". When he notes that female hylids are up to 30% larger than males (p. 100), he presumably is referring to HB length and not mass.

The writing style in many sections of the book is poor or awkward and leads to confusing, nonsensical, or misleading statements. As one example among many: "Call consisted of a series of double notes contrasting with other species in the *gracilenta* group, with simple notes" (p. 107). Another from p. 37: "The Pliocene was a time of mountain building when the Miocene 'Mobile Belt' Islands became consolidated and developed into the central mountain ranges of present day New Guinea, although the south-eastern 'tail', which remained separated by a gap, where the Watut-Bulolo River Valleys now lie." This is especially common in the introductory chapters but improves considerably by the time the microhylid species accounts occur. In other parts, the language is unnecessarily vague: we learn, for example, on p. 15 that New Guinea is one of the largest islands in the world, but not the second-largest island in the world nor the largest tropical island; we discover on p. 17 that the major rivers of northern New Guinea were marine incursions until recently, but we do not learn how recently; we are told on p. 25 that the vegetation seen "on the ground" is likely to be quite different from vegetation-classification systems of Thornthwaite (1948) and Holdridge et al. (1971) but we are not told why. The descriptions of call variables (p. 11) are also unnecessarily brief and not particularly helpful to the uninitiated. Such lack of specificity detracts from the book.

Numerous internal inconstencies occur in the book. A sampling of these include implied polyphyly of Papuan microhylids (p. 37) vs. stated monophyly (p. 39); discussion of alpine vegetation and alpine-dwelling frogs under the section labelled "Species of the subalpine regions (>3000 m)" (p. 45); inclusion of the Owen Stanley Mts. in the range of *Lechriodus aganaposis* on p. 61 but its omission from Map 2; the claim for eight and for seven genera of Papuan ranids in the same paragraph on p. 64; including *Platymantis acrochordus* for comparison with *Discodeles malekuna* in one sentence and then inadvertently comparing it with *P. myersi* in the next (p. 82); noting that *Platymantis nexipus* has longitudinal skin folds (p. 94) while later claiming the dorsum to be smooth (p. 95); calling *Litoria exophthalmia* "mostly green" (p. 102) while the Plate 61 shows a mostly brown frog; stating that the *Litoria nigropunctata* complex is characterized by extensively webbed fingers (p. 114) while ignoring that *L. rubrops* (p. 117) and *L. vocivincens* (p. 119), both members of that group, have fingers with only basal webbing; inclusion of Milne Bay and Popondetta in the range of *Litoria congenita* (p. 122) while omitting them from Map 9; remarking that color in life of *Litoria exophthalmia* is unrecorded (p. 127) while providing a color photo of the species in life (Plate 61); claiming *Litoria modica* to have longer legs on average than *L. pratti* (p. 139) while providing a range of TL/SV for the former (0.52–0.60) that comfortably brackets the single value given for the latter (0.56); stating that *Nyctimystes papua* is smaller than *N. oktediensis* (p. 157) while providing identical HBm values for each; writing "although not known to be sympatric, their distributions overlap" (p. 227); claiming that each of *Hylophorbus picoides* and *H. wondiwoi* is the largest of Günther's new species (p. 250 and p. 252, respectively); and noting that *Xenobatrachus tumulus* occurs only in the Adelbert Mts. (p. 266) but is sympatric with *X. zweifeli* (p. 266), which is only known from the Bewani and Hunstein Mts. The plate numbers cited for the photos of *Litoria leucova* and *L. majikthise* (p. 144) do not accord with the names attached to those plates.

Menzies usefully provides a glossary of some scientific terms at the end of the book. However, some of these—holotype, terrane—are mistakenly defined. Other terms used in the book—acromiohumeralis muscle, adherent tongue, alary processes, centric fission, clavicle, diplasiocoelous, firmisternal, lumbar, mandibular bones, mandibular depressor muscle, maxillary bones, megathermal, mesohumid, mesothermal, nasal bones, omosternum, perhumid, premaxillae, presacral, procoelous, procoracoid, sacral diapophyses, sacrum, subhumid, symphyses, urostyle—are omitted from the glossary and remain undefined in the text. Two terms of non-obvious meaning, "bidomicilic" and "ecological vicars" are frequently used in the book but do not appear in the glossary, although the former is defined on p. 33, at its second usage. Similarly, the term "mid-green" is used (p. 105) but its meaning is unclear – "mid" in terms of hue? saturation? intensity? Geographic terminology is largely relegated to a series of footnotes scattered from pp. 6–33. More profitably, this fragmented approach should have been eschewed in favor of an introductory paragraph explaining the terms involved. This is frequently required in treatments of the Papuan region because of the many possible ways of parsing the assorted geographical and political entities involved.

A useful attribute of the book is the inclusion of a gazetteer for most mentioned place names. However, several localities mentioned in the book (e.g., Ok Tedi, Astrolabe Bay, Mt. Kerewa) are not included, nor are historically important localities (e.g., Bernhard Camp, Moroka, Lorentz River) whose inclusion would have provided a useful service to beginning researchers. Nonetheless, this is a resource not frequently available elsewhere and is a valuable addition making it easier for the novice to locate numerous place names used in the text and throughout the primary literature.

In a few cases, important literature is left uncited. James (1997) is mentioned on p. 36 but not included in the Literature Cited. On p. 181, it is noted that *Choerophryne* is similar to *Albericus* but the paper first arguing and presenting evidence for this relationship (Burton 1986) is not cited. Tyler and Davies' (1978) partitioning of *Litoria* into 37 heuristic species groups is largely followed by Menzies but without attribution. In a few instances, literature is mis-cited (e.g., Kraus and Allison 2001, p. 183, first paragraph). More problematic is that a few sources are incorrectly referenced. Most common of these is that the Global Amphibian Assessment for Papuan frogs, which involved nine specialists meeting at Bishop Museum in February 2003 (this reviewer did not attend) and which has a widely available summary of findings properly cited as a web source (Global Amphibian Assessment. http://www.globalamphibians.org/) is routinely cited by Menzies as "Richards (2003)." This improper citation slights the contributions made by the numerous other participants in the meeting, implies the existence of a finished product from 2003, and ignores the updated information made available on the website since that time. Similarly, the report properly cited as Allison et al. (1998) is variously cited by Menzies as either "Mack (1998)," e.g., on p. 107, or as "Richards (in Mack 1998)," e.g., on p. 121.

Of greater consequence for the uninformed reader are numerous errors of fact, most of which are concentrated in three different sections of the book: the discussion of geology, section on frog biogeography, and the species accounts themselves. I will discuss each in turn, leaving more relatively minor errors of fact to Table 1.

Menzies bases his discussion of the geological history of the Papuan region primarily on seven prior papers and books. He does consult the immensely useful and detailed summary of Pigram and Davies (1987) but fails to note the refinements provided by Pigram and Symonds (1991) and Davies et al. (1996, 1997). Menzies' summary of this history has several errors of fact or implication, the latter deriving from omission of detail. On p. 17, he notes that the central ranges of New Guinea "consist largely of uplifted marine sediments." This is formally true but neglects to emphasize their geological diversity: they are in fact a mix of lithified limestone, ophiolitic, and volcanically derived terranes as well as remnant continental microplates. On p. 21 and again on p. 37, he implies that the central dividing ranges are due to tectonic activity during the last 10 million years (MY), but in fact uplift of these regions extends back to the Oligocene at ca. 30 MY. He claims (p. 29) that New Guinea "has consisted of isolated island chains that have had a checkered history, and only became joined at the last fall in sea level, some 15–10,000 years ago." This is a thoroughly false way of perhaps trying to convey that New Guinea consists of the northern margin of the Australian Craton, onto which have been sequentially sutured two separate island arcs. However, as noted above, those arcs accreted during the past 30 MY, not the past 15,000. The most recent docking event, involving the Huon Peninsula, occurred approximately 5 MY. Further, since sea levels have risen in the past 15–10,000 years, it is difficult to understand how New Guinea has not been recently fragmented into separate islands if their former uniting into a single island was due to lowered sea levels. The answer, of course, is that fluctuating sea levels had nothing to do with the amalgamation of New Guinea; plate tectonics did. Menzies' terminology for these two island-arc systems can also be somewhat confusing. The more recent arc system, now forming the north coast ranges of New Guinea and including New Britain and the Solomon Islands, is the "Solomons Arc." Menzies refers to different components of this system as either the "Melanesian Arc" (p. 19), a somewhat misleading and outdated term (cf. Polhemus and Polhemus, 1998), or the "East Philippine Arc" (p. 20). Lastly, the Southeast Peninsula was formed as an offshore composite of diverse accreted terranes during the Late Oligocene and later sutured to the margin of New Guinea. This biogeographically important detail goes unmentioned in the book.

The section discussing biogeographic patterns of Papuan frogs is largely speculative, and much of it is inconsistent and incredible at face value. Conjectures in this vein include that the myobatrachids *Lechriodus* and *Mixophyes* are old invasions from Australia displaced more recently by the Asian-derived microhylids (p. 32). Such ancient invasion and displacement are hard to reconcile with the close, congeneric relationships among these Papuan and Australian myobatrachids vs. the diversity of a microhylid clade containing 170 described species and 15 endemic genera. Rapid evolution indeed! There is a 2+ page discussion of whether frogs can cross marine barriers that doesn't lead anywhere much. Despite the indubitably rare nature of such events, biogeographic evidence (not discussed by Menzies) makes it clear that such events must sometimes occur (e.g., Vences et al. 2003) and no other explanation seems credible for the arrival of Oriental families of frogs (e.g., Microhylidae, Ranidae) into the Papuan region. The presence of two microhylids on New Britain is argued to be due to a "limited migration" during the Pliocene (p. 38) but the larger ensemble of 18 Australian microhylids and the large radiation of New Guinean *Litoria* and *Nyctimystes* are relegated to presumed Pleistocene invasions (p. 38). Discussion of "routes for exchange" (p. 35–36) appears a type of informal Croizatean track analysis and it is unclear whether these tracks are intended to signify overseas dispersal routes, land bridges, patterns of island-arc accretion, or a mix of all.

Biogeographic discussions should necessarily be based on understanding of phylogenetic relationships. Little such work has been done on Papuan frogs, but Menzies either misinterprets the work so done or repeats the errors of prior workers. Hence, he argues repeatedly (pp. 39, 75) that *Platymantis* is not proven monophyletic, citing an unpublished thesis by Norris (2002). But Norris did not test *Platymantis* monophyly, nor even that of the Solomon Islands species; hence, Menzies' inference is invalid. On p. 41, he discusses the "entry" of *Oreophryne* into New Guinea, implying a polyphyletic origin of the Papuan microhylids that is belied by the literature (Savage 1973; Tyler 1979; Burton 1986; Frost et al. 2006 [the last, of course, unavailable to Menzies when composing this book]), and his claim that the ancestor of the direct-developing Papuan clade probably had tadpoles (p. 33) is an unparsimonious interpretation for a presumed monophyletic clade. Most confusing of all, perhaps, is his choice to repeat a conjecture attributed to Norris (2002) that the ranid genus *Batrachylodes*, endemic to the Solomon Islands, had an origin on Borneo (p. 75)! The rationale for this conclusion is not provided.

Menzies discusses (pp. 42–48) several of the more interesting distributional patterns found within Papuan frogs. This section is useful for giving the novice a feel for some of the ecological and regional subsets of Papuan frogs, although I think it would have been improved if ecological patterns had been distinguished from geographical patterns instead of intermingled. These patterns are illustrated by reference to a few exemplar species instead of a comprehensive treatment or listing of all constituent species. This is fine, but it is hard for me to see why so much discussion was given to the depauperate and poorly known fauna of the Aru Islands (p. 48) while providing only cursory discussion of the far more speciose, endemic, and better-known faunas of the Bismarck and Solomon islands (p. 47) and no discussion of those of Yapen, Biak, D'Entrecasteaux, and Louisiade islands.

To my mind, however, the greatest fault of the book is that it cannot be used in most instances to reliably identify Papuan frogs. Only three complete keys (for 3 spp. of *Lechriodus*, 8 spp. of *Batrachylodes*, 4 spp. of *Choerophryne*) appear in the book, and these (with one minor addition) are cribbed from existing literature. Other published keys requiring no (e.g., *Barygenys*) or little (e.g., *Callulops*) modification are not repeated here. This reflects the author's stated belief (e.g., p. 102) that diagnostic keys are not possible for most of these genera. Instead, Menzies provides a table of assorted attributes on p. 53 that is intended to guide the student toward or away from particular taxa in comparison to a specimen in hand. But this table has errors (Table 1) and the genus *Oxydactyla* is omitted. A few examples of partial keys (typically modified prior keys from the literature) appear in the book but these are of limited use or are utterly misleading. For example, the key to *Platymantis* of New Britain (p. 90) distinguishes among some incredibly different species (e.g., *P. browni* and *P. mamusiorum*) using only trivial morphometric ratios not easily determined in the field and doesn't distinguish among others (e.g., *P. boulengeri*, *P. magnus*) that are separable at a glance. In that same key, diagnostic couplets are incorrect (e.g., *P. rhipiphalcus* lacks longitudinal skin folds but has a diverging fan of such folds, hence its name; *P. akarithymus* and *P. schmidti* have more than two longitudinal skin folds; *P. gilliardi* is equivalent in size to *P. mimicus*, not smaller) or internally inconsistent (e.g., one must

TABLE 1. Corrections to some errors of fact in *The Frogs of New Guinea and the Solomon Islands*.

Page	Correction
24	Most recent El Niño event was in 2002–03, not 1997–98
38	Is only 1 species of Australian *Nyctimystes*, not 3
44	*Litoria pratti* and *Nyctimystes montanus* are also endemic to Bird's Head region
46, 190	*Cophixalus cryptotympanum* restricted to Mt. Dayman area, not widespread, according to Global Amphibian Assessment
46, 155	Range of *Nyctimystes kubori* includes the Owen Stanley Mts.
53	Character 2 should read "S" for *Austrochaperina*, "R" for *Oreophryne*, and "R" for *Xenorhina*
53	Character 12 should read "R" for *Choerophryne* and "+" for *Pherohapsis*
66	Sonnini should be included as author in original citation for *Limnonectes grunniens*
79–80	*Ceratobatrachus* eating *Platymantis* is not an instance of cannibalism
83	There were 55 species of *Platymantis* described by the end of 2005, not 40
85	*Platymantis macrosceles* is not smooth but has scattered pointed warts
86	*Platymantis pelewensis* is not a Philippine species
86	Range of *Platymantis* extends well north of Mindanao
87	Original name for *Platymantis papuensis* was *P. corrugatus papuensis*, not vice versa
88, 91	*Platymantis papuensis* is not known from New Britain
91	Place name is Weitin Valley, not Weitin
92	*Platymantis browni* is known from New Britain, as noted in original description
94	*Platymantis nexipus* lacks longitudinal skin folds
95	Original name is *Platymantis rhipiphalcus*
97	Fingers of *Platymantis acrochordus* are pointed, not just without discs
134	Kraus & Allison (2004b) did not report *Litoria arfakiana* from the D'Entrecasteaux Islands
154, 167	*Nyctimystes semipalmata* is not large and it lacks a heel lappet; the description given under this species is fictional
155	*Nyctimystes kubori* also ranges throughout the Owen Stanley Mts.
174	Not all *Albericus* are brown; some are gray or green
182	*Choerophryne rostellifer* has discs on first fingers
183	Kraus & Allison (2001) did not include the upper Fly R. specimen of *Choerophryne rostellifer* in *C. proboscidea*
185	All species of Menzies' Group 2 have the first finger present, though all have it reduced to some greater or lesser extent
190	Range of *Cophixalus verrucosus* includes Woodlark and Sudest islands
230	Elevational range of *Oxydactyla crassa* extends to 2880 m
236	Type locality for *Barygenys exsul* is Rossel Island, not Sudest Island
246	*Callulops slateri* is known from many more than 6 specimens
253	*Mantophryne infulata* is known from the Finisterre Mts., not the Adelberts
254	*Xenorhina doriae* was changed to *Callulops doriae* in 1988
254	*Pherohapsis menziesi* is known from several more than 7 specimens
265	The call for *Xenobatrachus subcroceus* is C144, not C148

traverse through 6a to get to 9b but the two are contradictory).

The claim that keys cannot be written is, of course, specious but application of this claim seriously undermines the utility of the book. This is worsened by the fact that the sections on "Field recognition" for most species are usually a general color-pattern description that doesn't always focus on diagnostic features, combined with the author's astounding claim (p. 52) that color and pattern are not much help for species identification beyond a few examples. Omission of explicit diagnostic features is widespread in the book and disqualifies it from being viewed as a field guide or from providing much assistance to anyone for identification purposes. I could give many examples where diagnostic, easily discernible features of species and genera go unmentioned, but I will provide only a few to give a flavor of the problem: *Rana jimiensis* is distinguished from *R. arfaki* by relative size of the tympana alone (p. 69), a character not liable to assessment in the field, even though the two may be distinguished at a glance by the broad finger fringes and tuberculate tympana of the former; *Rana kreffti* is easily distinguished by its lateral white stripe from all Papuan congeners but this feature goes unremarked (p. 72); *Litoria impura* is distinguished from *L. thesaurensis* solely on the basis of amount of foot webbing and *L. flavescens* is distinguished from neither, even though all are closely related and unambiguous color-pattern features distinguish each (Menzies and Zug 1979; Kraus and Allison 2004a); *Litoria dorsalis* is not diagnosed from its close relative *L. timida* by its diagnostically different canthus and its size (Tyler and Parker 1972) but is contrasted instead with the "*Litoria dorsalis* complex" which contains only those two species in the Papuan region. Many additional examples exist, and I simply note that it might be possible to get a tentative identification using this book but that the serious student will necessarily require reference to the original literature for verification. So why use the book and add a step?

Identification difficulties are exacerbated by substandard supplementary materials (color plates, range maps) that would normally assist in identification. Several of the color plates are informative and will help in the identification of some species. But many (most?) of these images clearly date back to the 1970s, are of poor or mediocre quality, and do not reflect the standards usual in today's books. Many photos are out of focus, too dark, have the animal partially hidden, appear to be of animals anaesthetized and draped over vegetation, or are not shot in profile. It is hard to imagine what identifying information is intended to be conveyed by Plates 36, 67, 72, 84, 89, 94, 113, 117, 127, 129, 137, 138, 139, or 166, for example. Many other plates are substandard but serviceable; few shine. Plate 154 is almost certainly *Callulops personatus*, not *C. robustus*. Given the wealth of good photographs available from other researchers of this fauna, I find it incredible that Menzies did not attempt to borrow from them so as to improve his photographic coverage.

Almost as important, the range maps in the book are not comprehensive, either in terms of species coverage or in areal coverage for a species. All are unfriendly to use, with several taxa invariably combined into each map and separated only by difficult-to-read symbols in small font. Fortunately, far better and more comprehensive range maps are available on the web at either the Global Amphibian Assessment website (http://www.globalamphibians.org/) or the Papuan Herpetofauna website (http://www.bishopmuseum.org/research/pbs/papuanherps/), so the reader with Internet access will not have to rely on those provided in this book. But that won't help those in the field with a frog in hand. (I must note, though, that in one case [*Litoria timida*] the range given on the GAA website is wrong and Menzies is correct.)

Despite the long list of problems above, I stress that I have by no means attempted an exhaustive search for errors. Most of my attention was focused on the 83 species (out of 331 treated) for which I have direct experience in the field, and I have omitted mention of several other statements, practices, emphases, and omissions in the book liable to disputation from knowledgeable researchers in this field. Hence, this review should not be mistaken as a definitive treatment of this book's errors and questionable claims.

Given this litany of faults, it might be wondered if there are any positive aspects to the book. Indeed there are. First, Menzies' description of the climatic regimes in New Guinea and effects of El Niño events is quite good. His plates illustrating different habitats around the island are uniformly excellent and they nicely capture the impression one has on the ground. This is welcome given the extent to which so many published photos of tropical forests merely illustrate an uninformative swath of dark green; Menzies has admirably avoided that problem. For those having some familiarity with frog-call analysis, the many graphs of spectrograms and waveforms provided in Appendix A will be a welcome addition, especially when taken in concert with verbal descriptions of a call's acoustic impression, available in many of the systematic accounts. Still, it must be noted that some of these spectrograms illustrate nothing more than the sound of rushing water and culling those would have improved this section. Extremely useful for the beginning student will be Menzies' practice of including complete citations for each original description. This will prove an invaluable service considering the inability of the book to serve as a reliable identification guide. Also, some of the color plates are helpful for discriminating among certain difficult-to-identify species (e.g., *Xenobatrachus*), and others (e.g., *Palmatorappia*, *Nyctimystes granti*) usefully illustrate color-pattern polymorphisms not detailed in prior literature.

In my opinion, the most valuable aspect of this book is the ecological information given for many species. Menzies has considerable breadth of experience with these animals in the field and little ecological information has been previously published for this fauna, so provision of so much of it is truly a boon for researchers active in the region. It is this aspect of the book that I think will prove of longest value for future students of this fauna.

Given the nature of the numerous criticisms raised above, it is only fair to point out the utter negligence of the publishers in providing any sort of meaningful editing or external review for this volume. Many of the book's failings could easily have been avoided by doing so. To their credit, the binding of the book does seems sturdy, although I confess that despite many temptations I did not utilize the rigorous testing procedures pioneered by Crombie (1992).

So how to rate this book overall? Its approach to the subject seems decidedly lackadaisical; fact-checking appears scarce; concern for rigor and scholarship is not evident; resort to museum specimens other than those collected by the author appears lacking. I suppose this book could provide some form of service to the novice by comprehensively summarizing the species names and literature sources and by providing some degree of faunal overview, however compromised. But much of the constituent information cannot be accepted at face value, especially for distinguishing among species and understanding the evolutionary processes creating its subject fauna. For these reasons, the book is likely to be of questionable utility to the professional scientist (ecological information excepted) and, worse, is liable to mislead those not well-versed in the subject. The book could have avoided its numerous problems while retaining its useful features if Menzies had chosen to co-author (or at least vet) it with a more meticulous person such as Richard Zweifel (who, in more than 700 pages of contributions to the Papuan frog fauna has made only two important errors, one later corrected by himself). It is a pity that option was eschewed.

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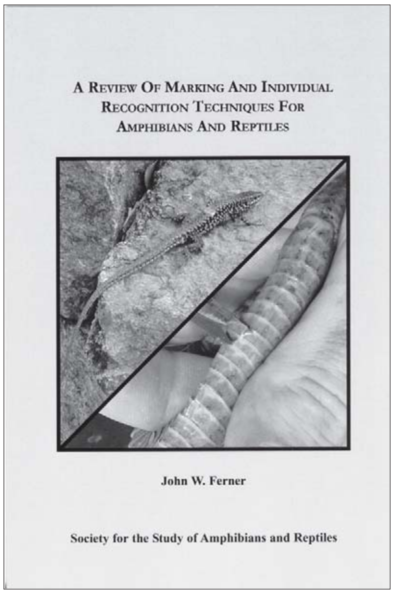
A Review Of Marking And Individual Recognition Techniques For Amphibians And Reptiles

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Society for the Study of Amphibians and Reptiles

Much of organismal biology relies on the ability to identify individual animals. Without it, one cannot calculate home ranges, estimate population size, measure growth rate in the field, or document dispersal patterns. Consequently, many methods books include sections on marking of amphibians or reptiles, including an old mainstay, that of Ferner (1979). This slim circular (42 pages), now out of print, summarized the state of the knowledge at the time, covering major taxonomic groups and methods in a readable and easy-to-follow way. However, as Ferner points out in the preface to the current update, many things have changed in the three decades that have intervened. For one thing, technology has greatly improved, giving us tools such as the Passive Integrated Transponder (PIT) tag. Another major change has been the ascendancy of the animal rights movement and the increased control of animal care and use committees (ACUCs) and veterinarians over herpetological research. In 1979, one decided what was most appropriate and went about doing it. Today, most universities require ACUC approval of herpetological research, even though it is in most cases not actually required by law in the US. One must justify the use of techniques to non-experts and list ACUC permit numbers on papers, if possible (for the SSAR policy see http://www.ssarherps.org/pages/ethics.php). The current circular rather successfully brings this compendium up to date.

The current text is 72 pages long, of which 59 pages are devoted to the methods and the rest to references spanning 1933–2006. Many of them are taken from the pages of *Herpetological Review* but the coverage is quite wide. Besides the various herpetological journals it also includes *Nature*, *Ecology*, a variety of books, and less readily available sources such as *Froglog*, *Missouri Speleology*, and a research publication of the Texas Parks and Wildlife Department. Most of the book is organized by group, with coverage of larval amphibians (pp. 1–3, which include the egg-mass marking method of Regester and Woosley [2005]), frogs and toads (pp. 3–13), salamanders (pp. 14–20), caecilians (seven lines on p. 20), turtles (pp. 20–28), lizards (pp. 29–37), snakes (pp. 37–45), and crocodilians (p. 46). The tuatara, a rather specialized case, does not receive a separate section. Toe clipping, a common method which has become somewhat controversial, receives expanded coverage in relevant sections. Two additional sections follow, one on the use of PIT tags (pp. 47–51) and the other on radio-transmitters (pp. 51–59, also briefly covering the use of GPS-based technology), each internally organized by taxonomic group. Twenty-two helpful illustrations, many of them taken from the previous version, are provided, as is a table listing possible combinations available for toe-clip marking using one of the techniques.

No technique is free of limitations and unintended consequences so, as Ferner emphasizes, it is important to use the correct methods for the species, environment, and study type. Ferner wisely does not attempt to list every study that uses a particular technique, instead focusing on original descriptions of methods and subsequent evaluations of their efficacy, with common techniques receiving broader attention. I paid special attention to the section on lizards, the organisms with which I have the most experience. This section begins with discussion of toe and scale clipping and is updated enough to include recent work by Langkilde and Shine (2006) which suggests that not only does clipping have little impact on stress hormone levels but that methods many favor as more apparently humane, such as PIT tag use, appear more stressful. Methods based on integument pattern, branding and painting, and tagging follow, and recent methods such as implanted elastomers, only recently applied to lizard studies, are included.

Overall, the coverage is good. Common methods are all listed, and methods that are rarely used nowadays, such as the use of radioactive tags, still receive coverage. Ferner spends enough time to familiarize the readers with the basic plusses and minuses, but often avoids detailed descriptions of issues such as surgery for radio-transmitter implantation. Ferner also carefully avoids making strong statements for or against a particular technique, letting readers draw their own conclusions. Although this can be a drawback, the author is clear from the start that "use of very complex techniques … require careful review of the original sources." This seems essential if one is to maintain the compactness of the original work, and references to more detailed work abound.

There are some drawbacks to the work, but they tend to be minor. I found the occasional misspelling ("were" instead of "where" near the bottom of page three, unfortunately a common type of problem in the age of computerized spell-checkers) and awkwardness (an outline of a gecko inserted into a figure illustrating frog markings on page four), but these are few and far between. Some references cited as "in press" in the now defunct Smithsonian Press will likely never see the light of day, an extremely unfortunate situation that is not of Ferner's doing. A reference or technique is sometimes absent or difficult to find. For example, the general reviews of Murray and Fuller (2000) and Beausoleil et al. (2004) are absent, as are some other general references on marking that include herpetological sections. The heat-branding method for iguanas cited by Hayes et al. (2000) is absent in the lizard section, but heat-based branding can be found in the snake section, complete with methodological citation. However, this rarely happens and, when it does, tends to involve a minor variant on a common technique that is listed (freeze-branding does appear in the lizard section). One recent method completely absent is the use of DNA for individual identification. Albeit still infrequent in herpetological studies, DNA is already being used for individual identification in the case of highly endangered and intensely-studied species such as some iguanas (e.g., Hayes et al. 2000). DNA-based individual identification is unlikely to soon become the standard for field studies, but will doubtlessly become more common as the technology improves and costs continue falling. Another absence that, although not crucial, could have helped readers is a summary table quickly listing each method, basic pros and cons, and pages where relevant text is displayed. Finally, my personal preference would have been to arrange things by method first and taxonomy second, as a method applied for one group may well apply to another where it has not yet been tried, and is therefore not currently listed. Doubtlessly, this would have created its own difficulties.

Despite these minor weaknesses, this is a valuable contribution. Ferner's circular is best when used as an initial screening tool for eliminating inappropriate techniques and zeroing in on more likely tools. In the case of low-tech methods such as toe-clipping, one can find everything they need here. For more complex methods, additional reading will definitely be required. Because of this, the booklet is most likely to be of primary use to those starting out in herpetological field research or seeking alternative methods to the ones they are familiar with. However, it also holds an important benefit for the seasoned professional. Having an updated, taxon-specific volume listing methods can be a huge boon in the process of obtaining ACUC approval, since most such committees are geared towards biomedical work and are unfamiliar with appropriate methods for herpetological field studies (Lindzey et al. 2002). One can refer to it as the state-of-the-art in the field, an authoritative source of acceptable methods which goes considerably beyond the less detailed considerations jointly published and occasionally updated by the herpetological associations in the US (http://www.asih.org/files/hacc-final.pdf) and elsewhere (e.g. the Australian position on toe clipping is at http://www.griffith.edu.au/school/asc/ppages/academic/jmhero/ash/pdf/Lizard_Toe_Clip_Position_Statement_1.pdf). Overall, especially given the very reasonable cost of this booklet, this is a contribution every field herpetologist should have access to.

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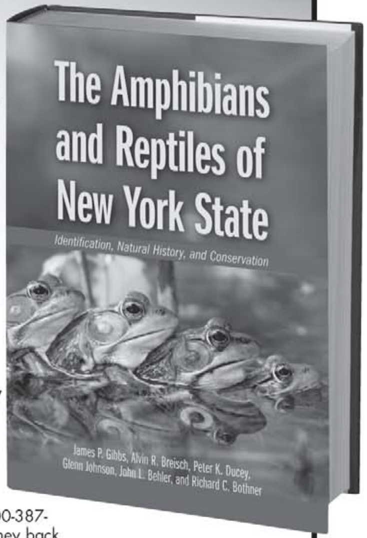

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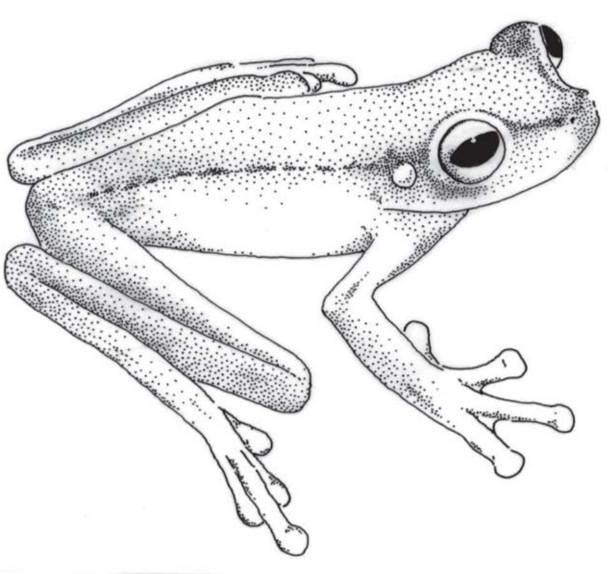

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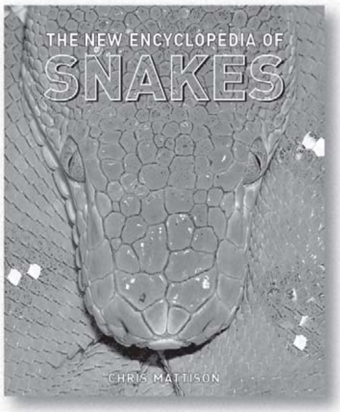

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CRHSD IV
Current Research on
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First Announcement

Current Research on Herpetofauna of the Sonoran Desert IV

April 11–13, 2008
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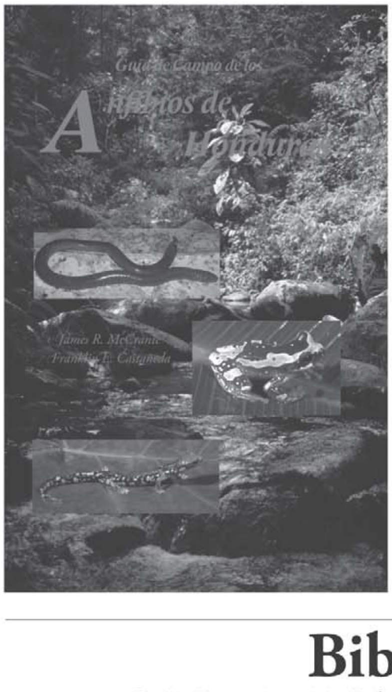
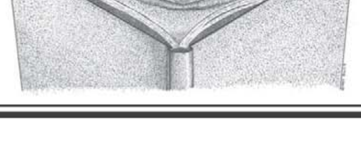
The Tucson Herpetological Society (THS) and co-sponsors are pleased to announce the fourth meeting of *Current Research on Herpetofauna of the Sonoran Desert* (CRHSD). The first CRHSD meeting was held at The Phoenix Zoo April 9–10, 1999. This conference, co-sponsored by the Arizona Game and Fish Department, Arizona State University West, and The Phoenix Zoo, was hugely successful with a number of would-be registrants turned away due to seating limitations. Since then, this event has been held every 3 years and has grown in interest and enthusiasm. The second CRHSD meeting, sponsored by the THS and others, was held in April 2002 in Tucson, and the third meeting was hosted by ASU in Phoenix in April 2005.

The goals of this fourth meeting are two-fold: 1) dissemination of information concerning research on the herpetofauna of the Sonoran Desert (in the states of Arizona, Sonora, and on the Baja California peninsula and gulf islands); and 2) provide opportunities for social interaction and dialogue among meeting participants.

The meeting will begin on Friday evening with an Icebreaker Social Event. Scientific Sessions on Saturday and Sunday will include approximately 30–40 oral presentations as well as poster presentations. Saturday evening will include a Social Hour followed by a Banquet. There will be three invited speakers at the meeting. Harry W. Greene, Professor at Cornell University, will open the Scientific Session on Saturday morning. Cecil Schwalbe, of the U.S. Geological Survey, will be the Banquet speaker on Saturday evening, and Edward O. Moll, Professor Emeritus at Eastern Illinois University and Adjunct Professor at the University of Arizona, will be the featured speaker on Sunday morning.

The CRHSD IV second announcement will be made in the fall and will include registration information, call for papers, and information on accommodations at the Inn Suites Hotel. All information will soon be available on the THS web site (www.tucsonherpsociety.org). We hope you will mark your calendar and plan to attend what will be the continuation of an exciting and informative scientific meeting.





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