

*Herpetological  
Review*

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## HERPETOLOGICAL REVIEW

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

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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 2001 in the Society for the Study of Amphibians and Reptiles are as follows: Individual membership US\$50; Student membership \$30; Family membership \$60. Institutional subscription \$95. \$16 of the amount of a membership pays for a subscription to *Herpetological Review* for one year. \$21 of the amount of a membership pays for a subscription to *Journal of Herpetology* for one year. Remaining funds help support Society activities. Additional fee for air mail postage outside USA \$35 for one year. Institutional subscriptions for *Herpetological Review* are \$70 and individual subscriptions may be purchased for \$30. 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*. Subscription to the *Catalogue of American Amphibians and Reptiles*: Individuals \$20; Institutions \$25.

Payment must be made in USA funds, payable to "SSAR," or by International Money Order, or with VISA or MasterCard (account number and expiration date must be provided). Payment should be sent to: Robert D. Aldridge, SSAR Treasurer, Department of Biology, Saint Louis University, St. Louis, Missouri 63103, USA. Fax: (314) 977-3658; e-mail: ssar@slu.edu.

### Future Annual Meetings

2002 — Crown Center Hotel, Kansas City, Missouri, USA. 3–8 July 2002 (with ASIH, HL)



## About Our Cover: *Phyllomedusa camba*



The hylid frog genus *Phyllomedusa* ranges from Costa Rica to Argentina, and contains a number of large, colorful species, including *P. camba*, the Lowland Monkey Frog. Although only recently described as a "new" species (De la Riva 1999. *Revista Española Herpetología* 13:123–131), herpetologists have long known of this frog. Cannatella (1983. *Proceedings of the Biological Society of Washington* 96[1]:59–66) recognized that at

least two species were represented within the geographically variable and widely distributed *P. boliviana*, and other workers have reported additional observations for this species under the names *P. boliviana* or *P. sp.*

This new species is relatively common and widespread. It occurs in the southwestern Amazon Basin, from southeastern Peru and western Brazil to eastern Bolivia, with a straightline distance of ca. 1200 km between endpoints. Although the ranges of *P. camba* and *P. boliviana* are mostly parapatric, examples of microsympatry are known in some parts of the Bolivian lowlands.

*Phyllomedusa camba* is an inhabitant of primary and secondary rainforests, spending much of its time above ground, both in low vegetation and in the canopy. Exclusively nocturnal, calling and breeding activity start with the first heavy rains and extend from November to March. Sexual dimorphism is evident with females reaching a snout–vent length of 84 mm, while males may reach 70 mm SVL. Eggs are deposited within folded leaves overhanging pools. Tadpoles are undescribed for this species.

The specimen on our cover was collected in May 1989 from rainforest habitat near Tarapoto, Peru, by Anthony Wisnieski for the National Aquarium in Baltimore, where it was photographed by **Will Brown**. This animal differs in some respects from other individuals of *P. camba*, notably in eye color, but is tentatively allocated to this species. Brown used a Nikon N70 with a 105mm macro lens and dual SB23 strobes, recording the image on Fuji Velvia film. After a brief period of working with wolves and big cats, Brown joined the staff of the National Aquarium as a herpetologist. Currently, he is affiliated with University of Virginia's Biology Department, where he conducts research on amphibian reproductive biology and genetics.

Separation and imaging of Brown's photograph is the work of **Jim Bridges** of Herpeto, Inc., Hollywood, Florida.

## Joseph B. Slowinski (1962–2001)

Joseph Slowinski, Curator of Herpetology at the California Academy of Sciences, died on 12 September 2001 in Myanmar after being bitten by a Multi-Banded Krait (*Bungarus multicinctus*). A full obituary will be published in *Copeia* 2002(1). Meanwhile, a tribute to Joe appears at the following website: [http://www.doctorbugs.com/Joseph\\_Slowinski.html](http://www.doctorbugs.com/Joseph_Slowinski.html).

## SSAR BUSINESS

### New Officers for SSAR

In recent years, the duties of Treasurer (an elected office) and Publications Secretary (an appointed office) have been handled together by Robert Aldridge (with the able assistance of his wife, Linda). Aldridge is "retiring" from these positions and the operations are once again being divided. SSAR is grateful to Bob and Linda Aldridge for their many years of outstanding service to the herpetological community.

Effective 1 October 2001, Breck Bartholomew took over as SSAR Publications Secretary. The new address for SSAR Publications is:

*Breck Bartholomew*  
SSAR Publications Secretary  
P.O. Box 58517, Salt Lake City, Utah 84158, USA  
e-mail: [ssar@herplit.com](mailto:ssar@herplit.com)  
Phone/fax: 801/453-0489

Effective 1 January 2002, the new Treasurer will be Theodora Pinou. Her contact information is:

*Theodora Pinou*  
SSAR Treasurer  
Department of Ecology & Evolutionary Biology  
Osborn Memorial Labs, Yale University  
165 Prospect Street, New Haven, Connecticut 06520-8106, USA  
e-mail: [theodora.pinou@yale.edu](mailto:theodora.pinou@yale.edu)  
tel. 203/432-5028; fax 203/432-5176

Previously, the Treasurer's Office handled membership transactions. In an effort to streamline this important societal function, a new membership office has been established. Matters concerning new memberships, renewals, or address changes should be communicated to:

*Donald Schmitt*  
Director, SSAR Membership Office  
P.O. Box 253, Marceline, Missouri 64658, USA  
e-mail: [ssar@memsys.com](mailto:ssar@memsys.com)  
tel./fax: 606/256-3252

### Seibert Award Winners for 2001 Announced

The tenth annual Seibert Awards were presented at the 44th Annual Meeting of the SSAR in Indianapolis, 27–31 July 2001. These awards are named in honor of Henri C. Seibert, an early and tireless supporter of SSAR (having served as an officer for over 20 years). In recognition of outstanding student presentations at the annual meetings. Awardees received a check for US \$200 and a book from Academic Press. The winners:

Systematics: **Emily Moriarty**, Section of Integrative Biology, University of Texas at Austin, "Phylogenetic relationships of North American chorus frogs (*Pseudacris*)."

Physiology/Morphology: **Travis LaDuc**, Department of Integra-

tive Biology, University of Texas at Austin, "Effects of body size on the predatory strike of the western diamondback rattlesnake."

Ecology/Evolution: **Daniel Warner**, Department of Biology, Virginia Polytechnic and State University, "Phenotypes and survival of hatchling lizards."

Conservation: **John Marshall**, Department of Biology, Indiana-Purdue University, "Movements and macrohabitat selection in fen wetlands by the eastern massasauga rattlesnake."

The judges also acknowledged additional outstanding presentations as Honorable Mention recipients:

Systematics: **Si-Min Lin**, National Taiwan Normal University, "Molecular phylogeny and biogeography of the grass lizards, genus *Takydromus* (Reptilia: Lacertidae), of eastern Asia."

Ecology/Evolution: **Jason Kolbe**, Washington University, "Nest-site selection in natural and disturbed habitats: adaptive or an ecological trap?"

Ecology/Evolution: **Vanessa Quinn**, Indiana State University, "Male-male competition and female choice: consequences of the loss of a male signaling trait."

Conservation: **Kristie Gianopoulos**, University of South Florida, "Response of the threatened sand skink (*Neoseps reynoldsi*) to controlled burning and clear-cutting in Florida scrub habitat."

The judges were Marion Preest, chair (The Claremont Colleges), Steve Adolph (Harvey Mudd College), Robin Andrews (Virginia Polytechnic and State University), David Chiszar (University of Colorado), Lisa Hazard (UCLA), Diana Hews (Indiana State University), Meredith Mahoney (AMNH), Kirsten Nicholson (Washington University), Ann Paterson (Williams Baptist College), and Chuck Peterson (Idaho State University).

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### SSAR Henri Seibert Award for 2002

The Henri Seibert Award was initiated in 1992 to provide recognition for the best student papers given at the annual meeting of the SSAR. To be eligible, the presented paper must be the results of research conducted by the presenter. The research must have been done while the student was in either an undergraduate or graduate degree program. The presentations will be judged by the SSAR student prize committee. One Seibert Prize of US \$200 may be given in each of the following four categories: Conservation, Ecology/Evolution, Physiology/Morphology, and Systematics. Consult *Herpetological Review* 28(4): 175 for recommendations to students entering the Henri Seibert competition. Students entering the competition must be members of SSAR. Students can win the Henri Seibert competition only once. Please indicate the category to which you are submitting your abstract on the abstract form in the Call for Papers.

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### SSAR Student Awards Fundraiser: 2001 Results and Call for 2002 Donations

We are disappointed to announce that NO travel grants were awarded for the 2001 Indianapolis SSAR/HL meeting, because we received NO applications. The money raised will be rolled

over to the Brazil meeting in 2003.

We thank all who donated items to the 2001 silent auction at Indianapolis: Mike Cardwell, Harold Dundee, Harry Greene, Julian Lee, Jacqueline Grant, Joseph Mendelson III, Bob Reed, Harold Cogger, Rick Shine, Karen Lips, Roger Birkhead, Arthur Echternacht, Auburn Herpetological Society, Paul Gritis, Peter Meylan, Chuck Crumly, Kraig Adler, Nicole Sloan, Ricardo Javier Torres Cervantes, Scott Boback, Breck Bartholomew, Norm Scott, Alan Savitzky, Barbara Savitzky, Katy Kyle, Jennifer Ferri, and to any we may have missed. The Seventh Annual Frameable Art Silent Auction at Indianapolis raised \$1495.00 for future student travel awards. On behalf of the SSAR, thanks to all who helped, including Matt Williams and Matt Greene, Auburn University, Henry Mushinsky, and the University Place Conference Center and Hotel. Special thanks for a job well done to the SSAR STAC Chairman, Scott Boback.

The SSAR STAC announces the Eighth Annual Frameable Art Silent Auction to be held at the 2002 SSAR meeting at Kansas City. Preferred donations include herp-related photos, line drawings, prints, paintings, plates, engravings, or anything frameable, if not already framed. If you are interested in donating an item (tax deductible for U.S. residents), please contact: *Glen Lubcke and John Campbell, Biology Department, California State University, Chico, California 95929, USA; e-mail: gmlubcke@pacbell.net; tel. 530-898-6303.*

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### SSAR Student Travel Awards Call for Applications

Awards of US \$200 each are available. An applicant for a travel award must be a student and a member of SSAR, must not have previously received a travel award from SSAR, and must be the first author (or co-author, see below) of a paper or poster to be presented. An applicant must include in the application package: 1) a letter signed by his/her major advisor or department chair that states: he/she is not completely funded for travel from another source; 2) an official copy of the poster or paper abstract to be presented; 3) a self-addressed, stamped envelope.

If the research is co-authored, the applicant must also include a letter from his/her advisor stating that the work was primarily the product of the applicant. All qualified applicants will be pooled and awardees will be drawn at random. Students from the local meeting site and current members of the SSAR Student Travel Awards Committee are excluded from applying for a travel award.

APPLICATIONS MUST BE POSTMARKED BY 15 MAY 2002. Award recipients will be notified by 1 June 2002 and award checks will be disbursed at the meeting. Direct requests for information to: *Glen Lubcke or John Campbell, Biology Department, California State University, Chico, California 95929, USA; e-mail: gmlubcke@pacbell.net or tel. 530-898-6303.*

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### Help Us Send You Undergrad Students

SSAR gets many requests from USA high school students regarding colleges offering coursework in herpetology as part of a biology-related degree. Many times, students are interested in remaining within their home state for undergrad degree work.



If you teach classes, and/or offer undergrads participation in research in herpetology, please e-mail the following to George Pisani (gpisani@ku.edu):

*Institution name and address AND home page URL*  
*YOUR name and contact info (e-mail, home page, postal address, phone/FAX)*  
*Your research interests*  
*Your class offerings*

We'll try to match these with the interests sent by prospective students. While thus far we have not had such inquiries from outside the USA, we'll gladly incorporate ALL such info into the database in order to assist any who inquire.

## 2001 Annual Meeting: Indianapolis

The 44<sup>th</sup> annual meeting of SSAR took place from 27 to 31 July 2001 in Indianapolis, Indiana. This year's meeting was held jointly with The Herpetologists' League and was hosted by Henry Mushinsky and Indiana University-Purdue University Indianapolis (IUPUI). All meeting activities were conducted at the IUPUI University Place Conference Center and Hotel, an impressive and comfortable conference facility. More than 300 presentations, about two-thirds of them oral, were scheduled for twenty sessions held throughout the four days of formal meetings. Two symposia provided focused topical presentations. On Sunday, 29 July, "Herpetological Research in Zoos: The Academic Connection" was coordinated by Hugh Quinn and John Groves. This symposium was dedicated to the memory of the late Sherman A. Minton, Jr., and acknowledges the contributions Minton made to zoological park research on amphibians and reptiles, incorporating a collection of 20 talks from members of the academic and zoological park communities. "Amphibian Population Declines" addressed that topic in a two-day symposium (30–31 July) examining numerous issues related to amphibian population concerns. This symposium was organized by David Green and Karen Lips, supported by SSAR and The Herpetologists' League, and brought together experts in many areas to discuss research findings and conservation recommendations in a series of 32 presentations.

### Social Programs

A variety of social events served as lively diversions from the daily scientific presentations. Friday, 27 July 2001, was a day reserved for the board meetings of the two societies. Friday evening marked the return of the SSAR President's Travelogue to the annual meeting. Slide presentations featuring regional amphibians, reptiles, and the people who study them were laced with humorous commentary. Presenters included Patricia Burrowes (Peurto Rico), Tim Halliday (South Africa), John Wilkinson (provided a world-wide herpetological perspective), Ross Alford (Australia), Hinrich Kaiser (Caribbean Islands), and Mike Lannoo (who proved beyond a shadow of a doubt that there are no amphibians or reptiles in Antarctica). Slide presentations were followed by a cash-bar social at the University Place Sports Bar, allowing attendees the opportunity to socialize at their leisure. The Opening Plenary Session, the morning of 28 July, opened with an introduction by Local Committee Chair Henry Mushinsky. David L. Stocum, Dean of the School of Science at IUPUI, greeted meeting attendees. To

open the meeting, Kraig Adler and David Hardy made comments honoring the late Sherman A. Minton, M.D., a long-time supporter of SSAR and Indianapolis resident. The Herpetologists' League Distinguished Herpetologist Lecture was given by Bill Branch, Curator of Herpetology at the Port Elizabeth Museum, who spoke on "Herps and Hopes: Africa in a New Millennium." Following the Opening Plenary session, most attendees gathered in the courtyard of the University Place Conference Center and Hotel to pose and squint for the meeting photograph. This year's photo was included in the conference registration fee and attendants had the opportunity to pick up their prints during the latter half of the meeting.

On Saturday and Sunday, 28–29 July, meeting attendees had the opportunity to view and photograph an impressive assemblage of amphibians and reptiles native to Indiana. The live exhibit was organized by Daryl Karns and Dennis Brown of the Hoosier Herpetological Society and marked a welcome return of this popular aspect to the annual event. Also during these two days, SSAR sponsored the Silent Auction to raise funds to benefit student travel expenses. Scott Boback supervised and coordinated this successful activity that saw active bidding on numerous items of herpetological art, literature, and culture. Saturday evening culminated with an "Icebreaker" in the University Place Ballroom. Drinks, snacks, and light appetizers provided the catalyst for this social gathering. Sunday morning, early risers enjoyed a bird watching opportunity to Eagle Creek Park guided by Greg Watkins-Colwell. During the afternoon of 29 July, the release of a new two-volume SSAR publication resulted in much excitement and attention. The launching of the 2<sup>nd</sup> edition of "The Hylid Frogs of Middle America" by William E. Duellman, with many new watercolor renderings by David Dennis, saw the author and artist signing copies of this revised and updated herpetological classic. Additionally, original David Dennis artwork from the publication was available.

The evening of 29 July saw participants gathering under tents and on the lawn adjacent to the University Place Conference Cen-



A highlight of this year's meeting was the unveiling of William Duellman's *Hylid Frogs of Middle America*. A book signing took place, with author and illustrator (David Dennis) on hand to inscribe books. Shown here, from left to right, are David Dennis, Bill Duellman, Ronald Javitch (benefactor of this revised edition), and Kraig Adler (editor).



Bill Duellman was kept busy signing copies of his new book.

ter and Hotel for the Annual Barbecue. A variety of picnic side dishes complemented fried chicken and barbecued ribs. Following the meal, the annual meeting Auction was cosponsored by SSAR and HL with proceeds from the event being split between the two societies. David Morafka and John Moriarty conducted the auction with assistance provided by Ken Dodd, Julian Lee, and Craig Nelson. Active bidding on a variety of herpetological items carried activities well into the evening and provided significant financial support for this year's meeting.

Monday, 30 July, saw the return of the SSAR Herpetological Quiz compiled and organized by Marty Crump and Julian Lee. Monday evening provided meeting participants with the opportunity to view the latest versions of the David Dennis and Eric Juterbock slide presentations of regionally distinct herpetofauna, coupled with a historically oriented slide show by Dennis, Juterbock, and Kraig Adler. Always a visual and auditory treat, this year's installments pleased a packed crowd in the conference center auditorium.

### Business Meeting and Board Meeting Summary

Society President David Green called the Annual SSAR Business Meeting to order at 1820 h in Room 118 of the IUPUI University Place Conference Center and Hotel on Monday, 30 July 2001. The Business meeting was well attended, with approximately 50 Society members present. The SSAR Board meeting was held on Friday 27 July 2001 at the Conference Center.

President Green summarized reports to the SSAR Board of Directors by focusing on several key issues. Concerning efforts to reach the international herpetological community through involvement with SSAR. To that end, membership brochures have been produced in Spanish, Portuguese, and French. A German version of the brochure is in the works. Regarding personnel changes within the Society, the pending resignation of Robert Aldridge from the Treasurer's position necessitated finding worthy candidates to this important Board seat. To aid in the search process, President Green appointed Julian Lee to head an effort to identify candidates. President Green proposed the possibility of splitting the duties of the Treasurer into two positions: A) the traditional financial tasks of

the Treasurer and B) a Membership Secretary to coordinate membership efforts. President Green appointed Karen Lips to head up a nominating committee to seek candidates for the 2001 elections and appointed Julian Lee to do the same for 2002. During his first year in office, President Green (with Board approval) also appointed the following individuals to positions within the Society: Brian Miller—Caudata Section Editor for the *Catalogue of American Amphibians and Reptiles*; Breck Bartholomew—to take the post of Publications Secretary as of 1 October 2001 (to replace the outgoing Robert Aldridge). Green also announced that Steve Corn has requested a replacement editor be sought for *Herpetological Conservation*. All outgoing editors and officers were thanked for their thoughtful service to the Society.

The Board considered electronic publishing options for SSAR and joined with the HL Board in a special joint Board meeting session to hear representatives from Allen Press and Blackwell Science explain the options and answer questions. Acknowledging that electronic publishing, in some format, is an eventuality for the Society, the SSAR Board felt strongly that we should move the Society forward—electronically publishing its journal while also continuing to produce a paper version. As there are many pros and cons to be addressed with electronic publishing, including issues of generating revenues and organizational management, the Board did not debate at this time precisely how SSAR will embrace this technology. Instead, a joint Task Force with members of The Herpetologists' League, who are facing similar decisions, has been struck with a report on options expected next year.

Society Treasurer Robert Aldridge reported that SSAR remains financially viable with total assets of \$219,000 in restricted accounts. Aldridge reported that the sale of SSAR publications totaled nearly \$69,000. The appointment of Breck Bartholomew as Publications Secretary was announced and Breck noted that his responsibilities in this Society position would be separate and distinct from his personal enterprise as a book dealer. Bob reports that SSAR membership continues to remain stable, at 2384 for FY 2001.

*Journal of Herpetology* Editor Brian K. Sullivan (*in absentia*) submitted a report indicating a number of personnel changes. The addition of Jean Bann, as Copy Editor, to the *Journal* staff has helped in formatting electronic versions of submissions to Allen Press. Additional changes in the editorial staff include Stephen Busack, as Associate Editor (replacing the outgoing Aaron Bauer), and John Wiens (Editorial Board). Brian reported that submissions to the *Journal* were up slightly in 2000 from the previous year at 262. Of these submissions, 90 were accepted, representing a 34% acceptance rate. Submissions as of June 2001 were running 20% higher than a comparable date in recent years, and could reach record levels. Sullivan reported that publication lag times of 9–12 months could be expected for accepted manuscripts, noting that decreasing that time could incur significant costs for the Society. Sullivan endorsed several recommendations made by the Publications Task Force that had been chaired by William Cooper: 1) Changing the *Journal of Herpetology* to a glossy paper stock; 2) Increasing the font size of the *Journal* from its current 9 pt (for Article text) and 8 pt (for citations and Shorter Communications) to 10/9 pt (for text and citations in Articles) and 9 pt (for Short Communications). Sullivan estimated that increasing font size represents a potential increase in page numbers that would result in



added publication costs; and 3) Implementing the addition of abstracts to Shorter Communications. The Board approved the idea of adding abstracts to Shorter Communications and of moving to glossy paper as it would represent a minimal increase in cost to the Society for the increased "professional" appearance of the publication. However, the Board believed that more information was needed before deciding on the issue of increased font size for the *Journal of Herpetology*.

*Herpetological Review* Editor Robert Hansen reported personnel changes including the addition of Eli Greenbaum and Omar Torres as Section Editors (Current Research), and Chris Sheil as Index Editor (a new *HR* position). *Herp Review* seems to be able to maintain its current, expanded production size—272 pages in four issues for Volume 31—a 6% increase from Volume 30. Bob reported that the addition of a new Herpetological History section to *HR* has seen several submissions. Hansen noted that submissions can expect a lag time from acceptance to publication of 3 months (for geographic distribution notes) to 6–9 months (for articles and natural history notes). Bob also said that efforts to electronically index *HR* articles are being developed.

Robert Powell, Editor of the *Catalogue of American Amphibians and Reptiles (CAAR)*, submitted a report on the status of this publication effort. Bob reported that the 2000 contributions to *CAAR* consisted of 20 accounts (Nos. 701–720; 7 salamander, 1 frog, 8 lizard, and 4 snake accounts), for a total of 80 printed pages. Color plates were included in 16 of the accounts. Bob expects the completion of 20 accounts for 2001 (with 17 of these having color photographs), has plans for another 20 accounts for 2002, and would like to see this number maintained annually, as long as sufficient number of individuals submit species accounts. Digital technology continues to be used to archive *CAAR* accounts on CD-ROM.

Kraig Adler (Editor), submitted reports on the activities of two Society publication series, *Contributions to Herpetology* and *Facsimile Reprints in Herpetology*. Recent publications include "Herpetofauna of New Caledonia and Surrounding Islands," by Aaron Bauer and Ross Sadler (November 2000), "Herpetological Illustrations from the Spencer Research Library, University of Kansas," compiled by Sally Haines (December 2000), and "Hylid Frogs of Middle America," by William E. Duellman with new illustrations by David Dennis (July 2001 – see comments above). Upcoming and newly completed offerings include several significant publications. "Amphibians of Honduras," by James R. McCranie and Larry David Wilson is due in December 2001 and will feature accounts on 116 species from this significant Central American region. "Reptile Fauna of Ceylon," by William Ferguson is expected in December 2001. This monographic publication is the first systematic list of Sri Lankan herpetology and is being issued to commemorate the Fourth World Congress of Herpetology (December 2001 in Colombo, Sri Lanka). Also expected in late-2001, or early-2002, is a reprinting of "Anatomy of the Salamander," by Eric T. B. Francis. Originally published in 1934, this work will have a new introduction by James Hanken. Anticipated by mid-2002 is "Herpetology of Cuba," by Thomas Barbour and C. T. Ramsden. This reprint will include new text and additional photographic plates, with an introduction by Blair Hedges expected. Adler reported that three additional projects are in the works and should be published in the next year or two. These include "Field Guide to Amphibians and Reptiles of the West Indies," by



The annual barbecue afforded attendees opportunities for discussions in a more relaxed setting. From left to right, Steve Morey, Roland Knapp, Carlos Davidson, Norm Scott, and Dave Bradford contemplate amphibian declines in the American West.

S. Blair Hedges, "Lizards of Southern Africa," by William Branch and Aaron Bauer, and "Biology of the Reptilia, Volume 20 (Morphology)," edited by Carl Gans and Abbot Gaunt. Also anticipated by the summer of 2002 is a comprehensive index to "Biology of the Reptilia," by Ernie Liner. This will represent Volume 21 in the series and may be available in a searchable CD-ROM format. Adler reported that the transition of his duties as Editor of the *Facsimile Reprints* to Aaron Bauer has already begun, and he has complete faith that the series will be in good hands.

*Herpetological Circulars* Editor John Moriarty reported on the status of three publications in that series. *Herpetological Circular No. 30* – "Amphibian Monitoring in Latin America: A Protocol Manual," by Karen Lips, Bruce Young, Jamie Reaser, and Roberto Ibáñez was expected in August 2001. This contribution is being produced as a bilingual publication (Spanish and English) with production costs being covered by a National Science Foundation grant to the Nature Conservancy. The authors will receive 300 copies for distribution in Latin America. *HC No. 31* – "Conservation Guide to the Eastern Diamondback Rattlesnake," by Walt Timmerman and Marty Martin is planned for 2002. "Herpetological Collecting and Collections Management, revised edition," (*HC No. 32*) by John Simmons will be a revision of *Herp Circular No. 16* and is anticipated for 2002.

Stephen Corn, Editor of *Herpetological Conservation*, reported that progress on Volume 2, "Ecotoxicology of Amphibians and Reptiles," has continued to see difficulties. A proposed Volume 3, "Conservation and Status of Reptiles in Canada," has received solid backing by The Canadian Amphibian and Reptile Conservation Network. The lead editor for the publication is Carolyn Seburn, who has promised reviewed manuscripts, but Corn reports that this volume likely will not be ready until 2002. Other projects are in the planning phase, but will require the direction of another editor as Corn has requested to be relieved of this duty.

Brian Crother (Chair), on behalf of the Standard English and Scientific Names Committee, reported that the completion and publication of *Herp Circular No. 29* was a successful endeavor. The Board recommended that this publication should be recognized as the accepted reference for nomenclature of amphibians and reptiles in North America. President Green stated that this point has been acknowledged by ASIH and HL, and that it had also been accepted by Canadian herpetological organizations.



Fearless Dave Morafka once again demonstrated his willingness to sell just about anything, as evidenced by this attempt to auction old luggage.

Mike Plummer, Chair of the Conservation Committee, reported that the committee continues to focus on informative efforts. To date, 32 of 50 U.S. state agencies have contributed material to the SSAR Conservation Website. Members of the committee include Kurt Buhlmann, Ken Dodd, Mike Dorcas, Lee Fitzgerald, John Jenssen, Andy Price, Steve Sheffield, and Mike Sredl. Other efforts for the year consisted of sending a position letter to the U.S. Fish and Wildlife Service (USFWS) supporting a "Threatened" listing under the Endangered Species Act for the Chiricahua leopard frog, *Rana chiricahuensis*. A second position letter to USFWS was submitted supporting an "Endangered" listing under the ESA for the Mississippi gopher frog, *Rana sevosa*. The committee also endorsed a letter-writing campaign, to Congressmen, supporting the Conservation and Reinvestment Act (CARA) in several states. A letter from the committee to Mr. Abe Blank praised the education and conservation efforts through his El Serpentario y Centro de Educacion Medio Ambiental de La Paz. Mr. Blank's serpentarium was a featured destination during last year's meeting in La Paz, B.C.S., Mexico. Sadly, Mr. Blank was killed in the months following the 2000 meeting, under mysterious circumstances.

Membership Committee Chair Theodora Pinou reported that several initiatives aimed at increasing SSAR membership have been investigated and implemented. Pinou outlined several strategies: 1) Active recruitment at regional and local herpetological meetings. Whenever possible and appropriate, Pinou would like to know about and assist with membership recruiting efforts. Associated with these membership activities, Pinou has worked with other Society members to identify areas that will result in increased foreign membership. Spanish and Portuguese versions of the online membership form are available. Electronic membership capabilities would be of significant benefit, not only to international members, but also to the Society at large. Primary concerns are related to website security and electronic maintenance of memberships. 2) An alternative membership dues structure for international members. The possibility of lowered dues for international members was discussed, but no solid recommendations were made in

the face of increased postal rates and operational costs. 3) Direct solicitation of invitations for membership from individuals identified from the "Combined Directory of Herpetologists" that did not indicate SSAR membership. Pinou reported that it is difficult to gauge the effectiveness of this effort, but stated that 11% of contacted individuals subsequently joined the Society. Future efforts of the Membership Committee will attempt to identify the origin of members' registration to target effective strategies.

Several outstanding student projects received recognition during the past year. Robert Gatten reports that the Kennedy Award Committee selected the best student paper, from 10 eligible contributions published in 2000. The committee selected "Nest site selection, larval hatching, and advertisement calls of *Rana arathooni* from Southwestern Sulawesi (Celebes) Island, Indonesia," by Rafe M. Brown and Djoko T. Iskandar (*Journal of Herpetology* 34:404–413) for this annual award. Bob recognized the efforts of the Kennedy Award Committee in thanking Robin Andrews, Terry Schwaner, Lynnette Sievert, and Sam Sweet for their diligence and service.

Marion Preest announced winning selections in the Seibert Award competition for the 2001 meeting: Emily Moriarty (University of Texas-Austin), Travis LaDuc (University of Texas-Austin), Daniel Warner (Virginia Polytechnic Institute and State University), and John Marshall (Indiana-Purdue University-Fort Wayne) were chosen as the best student presenters in four categories (see below for details on Seibert Award winners).

Several students received support to the SSAR 2001 Meeting through Sherman Minton Student Travel Awards (David Hardy, Chair). These awards provided \$200 to each winner and included the following individuals: Omar Attum (University of Louisville), Philip J. Bergmann (University of Calgary), Angelo Bufalino (Saint Louis University), Amanda Crnkovic (Louisiana State University—Shreveport), Caren S. Goldberg (University of Arizona), Sarah M. Holt (University of Guelph), Ulrich Kuch (University of Frankfurt), Richard M. Lehtinen (University of Michigan), Owen M. Lockhart (Indiana University of Pennsylvania), Michael N. Marchand (University of New Hampshire), Jason R. Rohr (Binghamton University), Michael J. Rubbo (Pennsylvania State University), Stacy N. Smith (University of Georgia), Rebecca Symula (East Carolina University), Ricardo Torres-Cervantes (Universidad Nacional Autónoma de México), Mark E. Walvoord (University of Oklahoma), and Christopher R. Wilson (Appalachian State University).

Henry Mushinsky presented information on future meeting events. The SSAR Board accepted meeting invitations for the next several years. These meetings will be joint events with the American Society of Ichthyologists and Herpetologists (ASIH) and The Herpetologists' League (HL). ASIH President Al Savitzky provided details for future dates and venues: 2002 – Kansas City, Missouri (3–8 July) to be held at the Westin Crown Centre Hotel; 2003 – Manaus, Brazil (in early June), planned for the Hotel Tropical Manaus along the banks of the Rio Negro; 2004 – Norman, Oklahoma (27 May–2 June); and 2005 – Tampa, Florida (date not set). At the Board meeting, Savitzky showed slides of the facilities in Kansas City and Manaus, and promised a good venue for both destinations. Accommodation packages are being arranged for the Brazil meeting and should represent a good opportunity for international travel. President Green announced that undistrib-



uted funds from SSAR student travel awards for 2001 would go towards offsetting travel costs to the 2003 meeting destination for those student members who apply for support.

Akira Mori summarized the activities of the Task Force for Non-US Members. Together with Karen Lips and Carlos Navas, Mori addressed several areas that the Task Force feels would better serve non-US members in the Society and help make SSAR a more internationally inviting organization. He summarized the ways in which SSAR may increase its international appeal with the following suggestions: 1) include more non-US reviewers and editors for Society publications; 2) create guidelines for editors of manuscripts submitted from non-English speaking authors that would result in positive comments; 3) expand the international scope of topical coverage in *Herp Review*; 4) hold the annual meeting at locations outside the United States; 5) create mirror, alternative-language websites for the Society homepage; 6) reduce the dues rate to non-US members to make it more financially attainable; and 7) advertise (in *Herp Review*) the willingness to embrace non-US member opinions. Speaking on behalf of SSAR editors, Bob Hansen stated that publication editors and reviewers already address grammatical and vocabulary concerns in a constructive fashion during the review process when dealing with manuscripts submitted from authors where English is a second language. Kraig Adler said US members should take an active role in reaching out to the international herpetological community. He encouraged US members to subsidize or sponsor non-US membership in SSAR. President Green asked all members working internationally to try and promote SSAR and increase international involvement of the Society.

George Pisani, SSAR Webmaster, reported that the SSAR website (<http://www.ukans.edu/~ssar/SSAR.html>) continues to see a lot of "hits" in terms of web visitation. Attempts to bring alternate language versions of the website are complicated and cumbersome, but progressing slowly—a Portuguese version is in the offing. President Green and members of the Board feel that the webpage should be enhanced to increase the delivery of the Society's mission and information. There was much discussion about online publication issues and how this may be linked to an expanded website for the Society. These and other approaches are being explored. President Green stated that a strong webpage would help to increase international involvement through computer access to the Society.

In other business, Al Savitzky motioned from the floor that SSAR should join the AIBS. After a brief debate by the membership, the motion was approved by a majority of those present.

—Respectfully submitted by John M. Matter, SSAR Secretary

## 2001 Resolutions

### Smithsonian Institution

**WHEREAS**, the National Museum of Natural History, Smithsonian Institution, has played a long and important role in the activities associated with the academic and professional scientific community, and

**WHEREAS**, the collections of the National Museum of Natural

History are the largest in the world, document national and international biodiversity, are studied by hundreds of museum and university scientists every year, both professional and student, either through loans of material or personal visits, are critical to research on systematics and biodiversity studies worldwide, and are crucial to the advancement of science, and

**WHEREAS**, the excellence and diversity of the staff of the National Museum of Natural History, their many significant contributions to the increase and diffusion of knowledge, their critical role in basic research, and their support of scientific research worldwide, that contribute to the advancement of scientific knowledge; therefore,

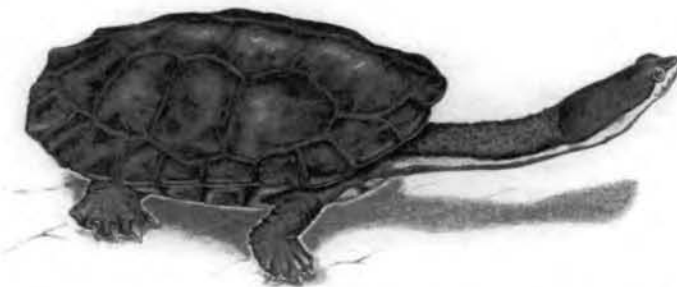
**BE IT RESOLVED** that The Herpetologists' League, at their 49th Annual Meeting, and the Society for the Study of Amphibians and Reptiles, at their 44th Annual Meeting, in Indianapolis, Indiana 27–31 July 2001, urge the Regents of the Smithsonian Institution to review carefully any plans to restructure science at the Smithsonian's National Museum of Natural History, to ensure that the collections continue to be maintained at world-class standards and are made available for study by the international scientific community, and to ensure that the Museum's pivotal role in research in systematics, biogeography, comparative morphology, ecology, and conservation biology in the natural sciences is maintained and supported well into the future.

Adopted by the Society for the Study of Amphibians and Reptiles at its Annual Business Meeting, 30 July 2001.

## Minton Travelling Fellowship Fund Donors

The following individuals, organizations, and institutions contributed to the Sherman A. Minton Travelling Fellowship Fund:

Kraig Adler, Robert Aldridge, Steven Anderson, Bern and Bette Bechtel, Charles Carpenter, Chicago Herpetological Society, Hal Cogger and Tim Cogger, Roger Conant, Carl Gans, J. Whitfield Gibbons, Itzchak Gilboa, Harry Greene, David and Billie Hardy, Hoosier Herpetological Society, John and Sheila Iverson, Daryl Karns and Pam Middleton, Kentucky Reptile Zoo, Bruce Kingsbury, Krieger Publishing Company, Michael Lodato, Madge R. Minton, Paul Moler, Robert Norris, Steve Perrill, Chris Phillips, Alan Resetar, David Sever, Hobart Smith, Margaret Stewart, and Richard Zweifel.



*Hydromedusa tectifera* (South American Snake-necked Turtle). Illustration by Gladys E. Sala.

### Congdon Wins International Award

Justin Congdon, a senior research ecologist with the Savannah River Ecology Laboratory in Aiken, South Carolina (USA), has been awarded the 2000 Longevity Prize by the Fondation IPSEN, a French organization that supports work in the field of longevity. Since 1997 the annual prize has gone to researchers in such fields as biology, genetics, gerontology, demography, and statistics. Congdon is the first ecologist to win the award. Congdon received 100,000 French francs and delivered a lecture based on his work with longevity in Blanding's turtles in July 2001 at the World Congress of Gerontology in Vancouver, Canada.

"It is an honor, and quite a surprise, to be recognized by the Fondation IPSEN and scientists studying aging," said Congdon. "It is not often that a biologist working on a field study of life history evolution gets this kind of recognition, or any kind of recognition for that matter."

Congdon's research on the life histories of turtles is well known to the herpetological community. Over the past 26 years he has followed the lives of about 12,000 *Emydoidea blandingii* at the University of Michigan's E. S. George Reserve. The first 1,000 turtles were marked there between 1953–1957, so he has been able to follow the lives of both young and old individuals. He said, "I think that the demonstration that 60–70-year-old Blanding's turtles have traits that support hypotheses based on evolutionary theory better than those predicted by the senescence theory is what caught the eye of the scientists at the foundation."

SSAR congratulates Congdon for this notable accomplishment.



Savannah River Ecology Laboratory scientist Dr. Justin Congdon (right) receives the 2000 Longevity Prize, given by the Fondation IPSEN, a French organization that supports work in the field of longevity. Shown with him is Yves Christen of IPSEN Foundation. Congdon is the first ecologist to win the award. Congdon is shown at the World Congress of Gerontology in Vancouver where he received 100,000 French francs and delivered a lecture based on his work with longevity in Blanding's turtles.

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### Ohio Department of Natural Resources Honors Conant

The Ohio Department of Natural Resources recently awarded its highest honor to Roger Conant, by inducting him into the ODNR Natural Resources Hall of Fame. Conant spent nine years studying Ohio's herpetofauna during the Great Depression for his book, *The Reptiles of Ohio*, still an essential regional reference. Through his research, writing, and legendary correspondence, he has influenced several generations of herpetologists.

A sample of previous Hall of Fame honorees include the legendary Johnny Appleseed, physician-naturalist Jared P. Kirtland, Ohio-born explorer John Wesley Powell, botanist Lucy Braun, and conservationist/novelist Louis Bromfield.

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### Graduate and Post-Graduate Research Grants

The Biological Research Station of the Edmund Niles Huyck Preserve ([www.huyckpreserve.org](http://www.huyckpreserve.org)) offers grants (max. = \$2500) to support biological research which utilizes the resources of the Preserve. Among the research areas supported are basic and applied ecology, animal behavior, systematics, evolution, and conservation. The 2000-acre Preserve is located on the Helderberg Plateau, 30 miles southwest of Albany, New York. Habitats include northeast hardwood-hemlock forests, conifer plantations, old fields, permanent and intermittent streams, 10 and 100-acre lakes, and several waterfalls. Facilities include a wet and dry lab, library, and houses/cabins for researchers. Deadline = 1 February 2002. Application material: Dr. Richard L. Wyman, Executive Director, E.N. Huyck Preserve and Biological Research Station, P.O. Box 189, Rensselaerville, New York 12147, USA.

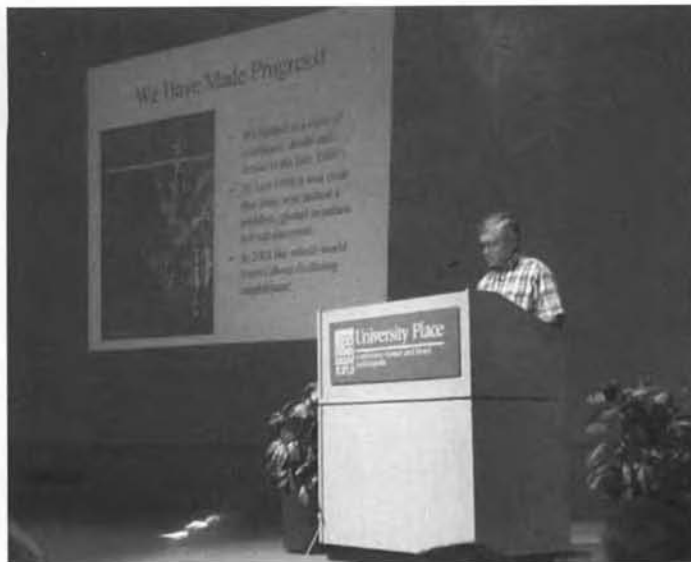
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### Declining Amphibian Populations Task Force

The Declining Amphibian Populations Task Force (DAPTF) has continued its well recognized role in promoting and coordinating international scientific efforts to assess the scope of amphibian declines worldwide and to identify the causes for this decline. DAPTF Seed Grants during 2000–2001 distributed over US \$40,000 to researchers. The number of regional and issue-based working groups continued to grow, and now stands at more than 100. At this last summer's SSAR/HL annual meeting in Indianapolis, Karen Lips (Southern Illinois University) and David Green (McGill University, Canada) organized on behalf of DAPTF a very successful two-day international symposium on amphibian declines. The symposium was extremely well attended and received considerable media attention. A similar symposium will take place at the Fourth World Congress of Herpetology in Sri Lanka in December.

DAPTF efforts for 2002 will maintain all ongoing activities (e.g., *Froglog*, seed grants, working groups), as well as several new initiatives. The latter include DAPTF's participation and assistance with an ambitious Global Amphibian Assessment, which is being spearheaded by the Center for Applied Biodiversity Science at Conservation International.





At the Amphibian Population Declines Symposium in Indianapolis, David Wake reviewed the history of amphibian declines and summarized recent developments and new initiatives.

Pride in DAPTF's continued success is tempered by our growing understanding that the declining amphibian phenomenon is far more pervasive and severe than was appreciated only a few years ago. Yet, these facts only make the work of the Task Force more important. DAPTF's ability to assist scientific studies of declining amphibians and to work with governments and conservation organizations to devise sound strategies for saving natural populations is, to a considerable extent, a direct function of the amount of financial support received. Today, more than ever before, the Task Force depends critically on the donations received from private individuals. Persons or organizations wishing to make a donation to DAPTF should make checks payable to "Brookfield Zoo" and sent to: *DAPTF, Museum of Comparative Zoology, De-*

*partment of Herpetology, 26 Oxford Street, Cambridge, Massachusetts 02138, USA.*

For U.S.-based donors, contributions to DAPTF are fully deductible for federal income tax purposes. Please contact the DAPTF headquarters (e-mail: [Daptf@open.ac.uk](mailto:Daptf@open.ac.uk)) for information regarding payment in other currencies. Additional information about the Declining Amphibian Populations Task Force may be obtained from the DAPTF website: [www.open.ac.uk/daptf/](http://www.open.ac.uk/daptf/).

## MEETINGS

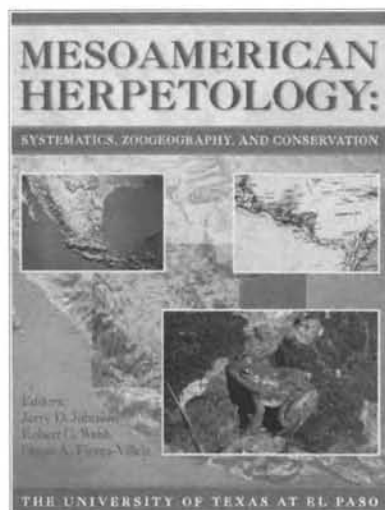
### Meetings Calendar

**21–24 March 2002**—The Desert Tortoise Council 27th Annual Meeting and Symposium, Palm Springs, California, USA. <http://www.deserttortoise.org/>.

**5–7 April 2002**—Current Research on Herpetofauna of the Sonoran Desert II, Tucson, Arizona, USA. <http://tucsonherpsociety.org>.

**18–20 April 2002**—3rd International Symposium on *Emys orbicularis*, Kosice, Slovak Republic. Hosted by Vychodoslovenske Muzeum Kosice in association with Museum fur Tierkunde Dresden and DGHT Rheinbach. Information: Peter Havas, e-mail: [havasp@vakke.slposta.sk](mailto:havasp@vakke.slposta.sk) or [www.cassovia.sk/emys](http://www.cassovia.sk/emys).

**3–8 July 2002**—45th Annual Meeting, Society for the Study of Amphibians and Reptiles, together with The Herpetologists' League and the American Society of Ichthyologists and Herpetologists. Crown Center Hotel, Kansas City, Missouri, USA. Details will be available in the March 2002 issue of *HR* and will be posted on the SSAR web site: [www.ukans.edu/~ssar](http://www.ukans.edu/~ssar).



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### **MESOAMERICAN HERPETOLOGY: Systematics, Zoogeography, and Conservation**

**Jerry D. Johnson, Robert G. Webb, Oscar A. Flores-Villela**  
Editors

**M**ESOAMERICA IS THE LANDMASS CONTAINING MÉXICO AND THE SEVEN COUNTRIES OF CENTRAL America. It has been the object of herpetological investigations for several centuries and continues to attract herpetologists from each of those countries and from foreign researchers as well. The high biotic diversity, including amphibians and reptiles, is well known, and is due to the large assortment of geological features and tropical environments found within the area. New information about various aspects of the herpetofauna continues to be produced and most certainly will be increased in the coming years.

**Mesoamerican Herpetology: Systematics, Zoogeography, and Conservation** is the result of a symposium, sponsored by the Texas Herpetological Society and the University of Texas at El Paso, which was dedicated to increasing our knowledge about the herpetofauna of Mesoamerica. Authors of all 12 included papers are acknowledged experts in the field.

200 pages, 8 x 11 inches, b&w illustrations, maps. US \$28.00 + 4.00 shipping & handling  
Texas residents must add 8.5% sales tax.

# THE ANATOMY OF THE SALAMANDER

by Eric T. B. Francis

*Francis remains the starting place for virtually any rigorous study of salamander comparative or functional anatomy, and is an indispensable reference for studies of urodele developmental anatomy, endocrinology, and physiology.*

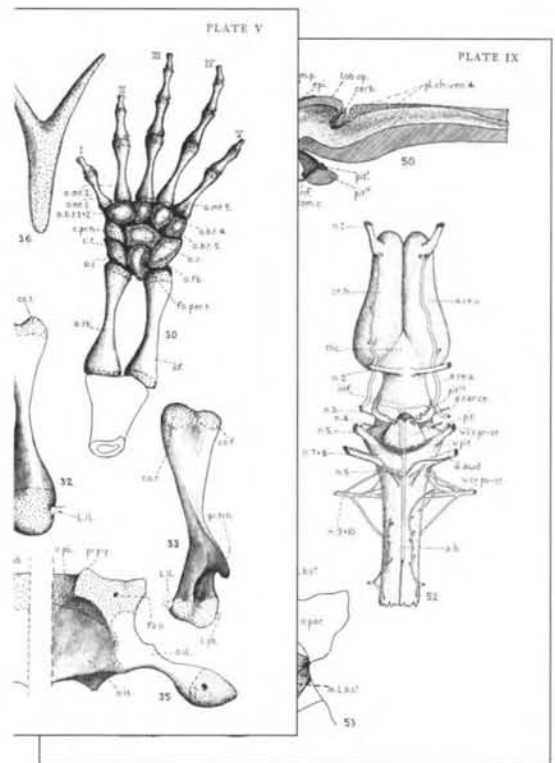
—JAMES HANKEN, from the Foreword

FRANCIS'S *ANATOMY OF THE SALAMANDER*, PUBLISHED IN 1934, REMAINS one of the standard references in the herpetological and anatomical literature. It covers the anatomy of the European fire salamander, *Salamandra salamandra*, in 11 detailed chapters including external features, skeleton, muscles, nervous system, vascular system, urogenital system, ductless glands, and the skin and sense organs. The accounts are extremely thorough. For example, that on cranial nerve V (trigeminal) is six pages long; the branches of the systemic arch take another five pages; and each muscle is described in terms of its anatomy, innervation, synonymy, function, and homology. An added benefit is that Francis lists the relevant literature for each organ system; nearly 850 references are cited. He discusses homologies between structures in *Salamandra* and those in other salamanders and other vertebrates. He also covers the taxonomy, distribution, and life history of the salamanders of the genus *Salamandra*.

James Hanken, a leading vertebrate morphologist at Harvard University, provides an extensive foreword that puts Francis's book in historical context and reviews the relevant current literature. The book is

illustrated with 25 highly detailed plates containing 84 fully labeled figures. There is an extensive index and a long historical introduction that reviews the classical literature on salamander biology beginning in the sixteenth century.

*Specifications:* 465 pages, 7 x 10 inches, 25 plates, colored frontispiece, clothbound. ISBN 0-916984-50-8. To be published February 2002.



# REPTILE FAUNA OF CEYLON

by William Ferguson

THIS BOOKLET, ORIGINALLY PUBLISHED IN 1877, REPRESENTS THE FIRST COMPREHENSIVE AND FULLY ANNOTATED LIST of the herpetofauna of Sri Lanka. It includes 41 species of amphibians and 139 of reptiles. It also gives a list of the Sinhalese common names. Two new and still-recognized species are described in this booklet: a gecko and a colubrid snake. A biography of Ferguson, a British surveyor and amateur naturalist who worked in Sri Lanka during 1839-1887, is added together with a list of his herpetological publications. This reprint is issued to commemorate the Fourth World Congress of Herpetology, to be held in Colombo, Sri Lanka, in December 2001.

*Specifications:* 48 pages, 5.5 x 8.5 inches, cardboard cover. ISBN 0-916984-59-1. To be published December 2001.

## PRICES AND SHIPPING COSTS:

• FRANCIS: Pre-publication to SSAR members US\$50; Institutions, non-members \$60 • *Shipping:* USA address, add \$4; non-USA \$6.  
• FERGUSON: Pre-publication to SSAR members US\$6; Institutions, non-members \$8 • *Shipping:* USA address, add \$3; non-USA \$4.  
**SEND ORDERS TO:** Breck Bartholomew, P.O. Box 58517, Salt Lake City, Utah 84158-0517, USA (telephone and fax: area code 801, 453-0489; e-mail: ssar@herplit.com). Please 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 also be charged to MasterCard or VISA (please provide the account number and card expiration date). SSAR membership information and a complete list of all Society publications can be obtained on request to Mr. Bartholomew.



## 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 wide 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, **Eli Greenbaum** or **Omar Torres-Carvajal**; postal and e-mail addresses may be found on the inside front cover. Comments and suggestions are also welcome.

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

### Systematics of West Indian Toads

The *Bufo peltoccephalus* Group is composed of 11 species of toads that are restricted to the Greater Antilles. A monophyletic origin of the group has been questioned because of disparate morphology, behavior, and ecology of the different species. The authors examined three mitochondrial genes (12S, 16S, and cyt *b*) from 8 West Indian toads and 10 outgroup bufonids to address the monophyly, relationships, and biogeography of the *B. peltoccephalus* Group. Sequence alignment was performed with the CLUSTAL option in Sequence Navigator (version 1.01) and corrected by eye. Phylogenetic analyses were conducted with neighbor-joining by MEGA (version 2.0b2), and with parsimony and maximum-likelihood by PAUP\* (version 4.0b4). All trees supported the monophyly of the *B. peltoccephalus* Group. The data suggest support for a Cuban clade, and the sister-group relationship of *B. guentheri* (Hispaniola) with *B. lemur* (Puerto Rico). A New World origin for the West Indian clade of toads also is suggested by the data. Data from this study and others suggest over-water dispersal of this group, and not a late Cretaceous vicariant event.

PRAMUK, J. B., C. A. HASS, AND S. B. HEDGES. 2001. Molecular phylogeny and biogeography of West Indian Toads (Anura: Bufonidae). *Molecular Phylogenetics and Evolution* 20:294–301.

Correspondence to: Jennifer B. Pramuk, The University of Kansas Natural History Museum & Biodiversity Research Center and Department of Ecology and Evolutionary Biology, 1345 Jayhawk Boulevard, Lawrence, Kansas 66045-7561, USA; e-mail: [pramuk@ku.edu](mailto:pramuk@ku.edu).

### Aging in an Emydid Turtle

The Relative Reproductive Rate Hypothesis contends that older individuals of long-lived species should possess traits that enhance reproductive success. The Senescence Hypothesis suggests that older individuals will experience a decline in reproductive success. The authors studied Blanding's turtle (*Emydoidea blandingii*) to address these hypotheses, and examined whether age and body size contribute to indeterminate growth with associated longevity. Turtles were marked, weighed, measured, and recaptured for years as part of this long-term study. Data on reproduction, nesting, pre-

dition, and mortality were collected as well; statistical analyses included Spearman's Rank Correlation, Wilcoxon tests, and survivorship curves (PROC LIFETEST). Results indicated that the oldest group of turtles had larger clutch sizes, but larger egg size was not associated with any age group. Older females had a significantly higher reproductive frequency than younger females. Older female nests experienced the lowest frequency of predation, but these nests had a higher likelihood of failure attributable to developmental problems. Survivorship did not differ significantly between the sexes, but older individuals survived longer than younger age groups. A strong relationship between body size and age was not found—body size does not appear to be a mechanism for increased reproductive output in older females. Although the data support both hypotheses, the authors contend that the Relative Reproductive Rate Hypothesis is best supported by the results.

CONGDON, J. D., R. D. NAGLE, O. M. KINNEY, AND R. C. VAN LOBEN SELS. 2001. Hypotheses of aging in a long-lived vertebrate, Blanding's turtle (*Emydoidea blandingii*). *Experimental Gerontology* 36:813–827.

Correspondence to: J. D. Congdon, Institute of Ecology, University of Georgia, Athens, Georgia, USA; e-mail: [congdon@srel.edu](mailto:congdon@srel.edu).

### Effects of Agricultural Disturbance on Lizard Diversity

Numerous studies have documented detrimental effects of ecological disturbance on biodiversity. The authors studied the effects of agricultural disturbance on lizard diversity in the Dominican Republic. Twenty-four plots representing 6 habitats ranging in complexity from abandoned pasture to *mogote* top were established in a protected national park. These plots were compared with 9 plots of active, agriculturally-disturbed habitats on the periphery of the park. Glue traps were utilized to capture lizards within the study plots. Species richness was analyzed with rarefaction; richness and evenness were analyzed together with Hulbert's Probability of Interspecific Encounter and the log series index ( $\mu$ ). Species richness was higher inside the park compared to the sites on the periphery of the park; active agricultural habitats exhibited the lowest diversity. The *mogote* sites are identified as the most species-rich habitat.

GLOR, R. E., A. S. FLECKER, M. F. BENARD, AND A. G. POWER. 2001. Lizard diversity and agricultural disturbance in a Caribbean forest landscape. *Biodiversity and Conservation* 10:711–723.

Correspondence to: Richard E. Glor, Department of Biology, Campus Box 1137, Washington University, St. Louis, Missouri 63130-4899, USA; e-mail: [glor@biology.wustl.edu](mailto:glor@biology.wustl.edu).

### Feeding Mechanisms of Gopher and King Snakes

The simple body forms of snakes limit their movements to various axial bends and twists. Recent studies have suggested kinematic similarity between undulations associated with swallowing and lateral locomotion—including the use of the same muscles in some cases. The author examined the activation patterns and kinematics of swallowing in the epaxial muscles of five gopher snakes (*Pituophis melanoleucus*) and one king snake (*Lampropeltis*

*getula*). For experimental trials, snakes were placed in open glass aquaria, offered live mice, and videotaped at 30 frames s<sup>-1</sup>. Measurement TV and Fin software was used to digitize the vertebral midline of the snakes, and calculate bending angles, respectively. Electrodes were surgically implanted into the snakes for electromyographic (EMG) readings; EMG readings were amplified and recorded on FM tape. Plethysmography was used to measure the pressure exerted by snakes on their prey. A multiple regression analysis was used to examine the relationship between muscle activity and vertebral bending. Three distinct stages of swallowing (snout shifting, concertion bending, and ventral flexion) were observed in relation to intraoral transport, and one distinct stage (undulatory bending) was noted for esophageal transport. Peak pressures (0.93–4.8 kPa) were noted at the commencement of a bend after a short hiatus in movement. These results suggest the epaxial muscles are integral lateral flexors to movement that involve large-radius bending, including locomotion and swallowing.

MOON, B. R. 2000. The mechanics of swallowing and the muscular control of diverse behaviours in gopher snakes. *The Journal of Experimental Biology* 203:2589–2601.

Correspondence to: Brad R. Moon, Department of Radiology, Box 357115, University of Washington Medical Center, Seattle, Washington 98195-7115, USA; e-mail: bmoon@u.washington.edu.

## The Hyolingual Apparatus of Chameleons

Since 1733, anatomists and functional morphologists have studied the tongue projection mechanism of chameleons. The authors examined the hyolingual apparatus of seven species of chameleons (*Brookesia armorata*, *B. supraciliaris*, *Chamaeleo calyptrotus*, *C. fischeri*, *C. jacksonii*, *C. oustaleti*, and *C. pardalis*) in order to increase knowledge of the muscles involved in tongue projection. Selected specimens were cleared and stained or sectioned for histological examination. Specific muscles were separated from specimens and stained for examination with a dissecting microscope, polarized light microscope, or scanning electron microscope. A detailed description of the hyoid apparatus, origin and insertion of hyolingual muscles, distribution of motor endplates, and histochemical properties of selected muscles is discussed. A thick connective tissue sheet between the tongue and hyoid apparatus was identified as a potential source of elastic strain energy—this structure may be responsible for tongue recoil. The results of this study suggest that the hyolingual apparatus is more complex than previously assumed in other functional morphology studies of chameleons.

HERREL, A., J. J. MEYERS, K. C. NISHIKAWA, AND F. DE VREE. 2001. Morphology and histochemistry of the hyolingual apparatus in chameleons. *Journal of Morphology* 249:154–170.

Correspondence to: A. Herrel, Biology Department, University of Antwerp, Universiteitsplein 1, B-2610 Antwerp, Belgium; e-mail: aherrel@uia.ua.ac.be.

## Antipredatory Adaptations of *Chamaeleo chamaeleon*

Many species of animals with reduced locomotory abilities use camouflage as the main tactic to avoid predatory attacks. The authors studied the effects of camouflage on escape decisions in the common chameleon, *Chamaeleo chamaeleon* by performing experiments with humans as would-be predators. Effects of background vegetation and individual size of chameleons on the ability of a predator to detect the chameleons were analyzed both in the field and by examination of photographs. Probability of detection was significantly influenced by background and size of chameleons. Based on these results, the authors then analyzed how risk perceived by an individual chameleon influenced its escape decisions. They found that the type of defensive display was different for individuals of different sizes and in different conditions. The results of this study indicate that camouflage has a significant effect on individual escape decisions and that some antipredatory responses are size-dependent.

CUADRADO, M., J. MARTÍN, AND P. LÓPEZ. 2001. Camouflage and escape decisions in the common chameleon *Chamaeleo chamaeleon*. *Biological Journal of the Linnean Society* 72:547–554.

Correspondence to: Mariano Cuadrado, Estación Biológica Doñana-CSIC, Avda. de María Luisa s/n Pabellón del Perú, E-41013 Sevilla, Spain; e-mail: macuagu@cica.es.

## Systematics of Skinks in the Genus *Eumeces*

The scincid genus *Eumeces* is composed of over 50 morphologically and ecologically variable species occurring throughout most of the Holarctic region of the world. The authors conducted a phylogenetic analysis of the genus *Eumeces*, and included the genera *Scincopus* and *Scincus* in their ingroup. Because of the lack of knowledge regarding basal scincid phylogenetic relationships, the authors included nine genera of the family Cordylidae in the outgroup. However, general comparisons were made between the ingroup and other scincid taxa. The phylogenetic analysis was conducted with 16 morphological characters (14 unambiguously polarized), and heuristically analyzed using PAUP\* version 4.0b1. One fully resolved, most parsimonious tree (19 steps) was obtained from the analysis. The analysis indicated: 1) the *Pariocela* species group (39 species) is monophyletic; 2) the *schneiderii* (5 species), *schwartzii* (3 species), and *taeniolatus* (2 species) species groups are more closely related to each other and the *Scincopus* and *Scincus* genera than they are to the *Pariocela* species group; 3) *Scincopus*, *Scincus* and the *schneiderii* and *taeniolatus* species groups form a monophyletic group; 4) the *schneiderii* species group shows several synapomorphies with *Scincopus* and *Scincus*; and 5) *Scincopus* and *Scincus* share a common ancestor. The authors propose a new subfamily (Eumecinae) solely for the genus *Eumeces* (39 species), recognition of the genus *Eurylepis* for the *taeniolatus* species group, the new genus *Mesoscincus* for the *schwartzii* species group, and the new genus *Novoeumeces* for the *schneiderii* species group.

GRIFFITH, H., A. NGO, AND R. W. MURPHY. 2000. A cladistic evaluation of the cosmopolitan genus *Eumeces* Wiegmann (Reptilia, Squamata,



Correspondence to: Robert W. Murphy, Centre for Biodiversity and Conservation Biology, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario M5S 2C6, Canada; e-mail: drbob@rom.on.ca.

## Genetic Divergence of Chinese Giant Salamanders

The Chinese giant salamander (*Andrias davidianus*) is the largest species of amphibian in the world, and it is restricted to mainland China in the Yellow, Yangtze, and Pearl rivers. This species is currently listed under CITES Appendix I because of habitat destruction and human consumption. The authors utilized isozyme electrophoresis (40 loci) and two mt DNA genes (ATPase 6 and *cyt b*) to assess the genetic diversity of 6 populations of salamanders, and to test the null hypothesis that all the populations represent a single species. Results from allozyme data indicated a deficiency in individual heterozygosity, and that *A. davidianus* is not a panmictic species. Genetic divergence levels did not indicate recognition of more than one species, although one population from Huangshan possessed three unique, non-homoplastic synapomorphies (mtDNA) and unique alleles at two loci (isozymes). Lack of geographic correlation is a likely consequence of human relocation of salamanders. The authors suggest a conservation strategy that preserves the maximum amount of genetic diversity.

R. W. MURPHY, J. FU, D. E. UPTON, T. DE LEMAS, AND E. ZHAO. 2000. Genetic variability among endangered Chinese giant salamanders, *Andrias davidianus*. *Molecular Ecology* 9:1539–1547.

Correspondence to: Robert W. Murphy, Centre for Biodiversity and Conservation Biology, Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario M5S 2C6, Canada; e-mail: drbob@rom.on.ca.

## Phylogenetic Relationships of Lissamphibia

The morphological diversity and poor fossil record of living amphibians has complicated efforts to reconstruct the phylogenetic relationships of these animals. Although most modern studies have accepted the monophyly of Lissamphibia (salamanders, caecilians, and frogs), the identification of the sister group and ingroup relationships remains contentious. To address the issue of amphibian monophyly, the authors sequenced the entire mitochondrial genomes of a salamander (*Mertensiella luschani*) and a caecilian (*Typhlonectes natans*); these sequences were compared to the mt genome of the frog *Xenopus laevis* and 9 other tetrapod taxa. Nucleotide sequences were aligned with CLUSTAL X and refined by eye. Maximum parsimony with heuristic searches, neighbor-joining, and maximum likelihood analyses were performed with PAUP\* version 4.0b4a. All three analyses produced the same tree topology, which confirmed the monophyly of Lissamphibia and placed salamanders and frogs in a sister group relationship; this study supports the Batrachia (Caudata+Anura) hypothesis. These results can be utilized in future studies to: 1) examine phylogenetic relationships within salamanders and frogs; 2) compare vertebral development in salamanders and caecilians; and 3) compare brain development and limb morphology in Lissamphibia.

ZARDOYA, R., AND A. MEYER. 2001. On the origin of and phylogenetic relationships among living amphibians. *Proceedings of the National Academy of Sciences* 98:7380–7383.

Correspondence to: Rafael Zardoya, Museo Nacional de Ciencias Naturales, José Gutiérrez Abascal, 2, 28006 Madrid, Spain; e-mail: mcnr154@pinar2.csic.es.

## Tail Loss and Vulnerability of the Skink *Lampropholis guichenoti* to Predation

Tail loss is an effective defense mechanism used by many species of lizards to evade predators. However, tail autotomy may reduce an individual's subsequent fitness and ability to avoid predators. The authors examined how predatory interactions between the common garden skink *Lampropholis guichenoti* and two snake predators are influenced by behavioral shifts induced by tail autotomy of the prey. A series of experiments were performed to estimate nonrandom consumption vs. active selection of tailed and tailless skinks by the diurnal snake *Demansia psammophis* and the nocturnal snake *Rhinoplocephalus nigrescens*. In addition, the differential vulnerability to predation of tailed and tailless lizards was analyzed. The experiments with the diurnal predator resulted in tailless skinks being more susceptible to predation than tailed skinks. In contrast, experiments with the nocturnal predator indicated that skink vulnerability was not affected by tail autotomy. Reduced escape speed of tailless skinks may have increased vulnerability to predation by the diurnal snake, whereas selection of overnight shelters by skinks affected the probability of predation by the nocturnal snake. This study demonstrates that snake-lizard systems are good predator-prey models that can be used in ecological studies.

DOWNES, S., AND R. SHINE. 2001. Why does tail loss increase a lizard's later vulnerability to snake predators? *Ecology* 82(5):1293–1303.

Correspondence to: Sharon Downes, Institute of Nature Conservation, Klinekstraat 25, B-1070 Brussels, Belgium.

## Use of Cover Objects for Sampling Snakes

One of the most effective sampling methods for amphibians and reptiles is the use of artificial cover objects. This method minimizes disturbance of microhabitats and is very useful in ecological studies. The authors tested the effectiveness of three kinds of covers by sampling the secretive snake *Contia tenuis* and three species of *Thamnophis*. Black asphalt, corrugated tin, and plywood were used to build more than 50 cover-stations in the Gulf Islands, British Columbia. Differences in the use of the three cover types were analyzed using contingency tables and the Chi-square test. The snakes used plywood covers less frequently than asphalt and tin covers—probably because the latter two materials heat up rapidly in the sun and become a good source of heat. Artificial cover objects were found to be useful in studying secretive snakes. However, this sampling method might contain biases, such as the sampled individuals not being representative of the population. Thus, potential biases of this method need to be examined in population studies.

ENGELSTOFT, C., AND K. E. OVASKA. 2000. Artificial cover-objects as a method for sampling snakes (*Contia tenuis* and *Thamnophis* spp.) in British Columbia. *Northwestern Naturalist* 81:35–43.

Correspondence to: Christian Engelstoft, Department of Biology, University of Victoria, British Columbia, Canada V8W 3P6 and Alula Biological Consulting, 1967 Nicholas Road, Saanichton, British Columbia, Canada V8M 1X8.

### Lizard Abundance in Guana

Despite the importance of accurate population density estimates in ecology, many studies of lizard abundance are biased because selection of study sites is commonly based on the high density of the species studied. The authors quantified absolute population densities of lizards with four 10 x 10 m forest removal plots in Guana Island, British Virgin Islands. Early successional and mid-successional forests were surveyed, and the results were compared with data of a previous study made in the island of Guam, Mariana Islands. Of the 1401 lizards obtained, 94.5% corresponded to the diurnal gecko *Sphaerodactylus macrolepis*, which was found primarily in leaf litter. With a density of 67,600 ha<sup>-1</sup>, *S. macrolepis* was found to be the densest terrestrial species among non-aggregated vertebrates. Therefore, this lizard represents an excellent model organism for ecological studies in spite of its secretive habits and small size. Lizard assemblages in Guana are similar to those in Guam only in that litter insectivores are the densest species. The main difference between Guam and Guana is that Guana lacks nocturnal species, whereas in Guam nearly half of all terrestrial vertebrate individuals correspond to nocturnal species. This dissimilarity between guild abundances in Guana and Guam contrasts with the significant overlap in assemblage structure between both islands. The authors concluded that some process other than community adaptation significantly influences ecological roles and potential abundances.

RODDA, G. H., G. PERRY, R. J. RONDEAU, AND J. LAZELL. 2001. The densest terrestrial vertebrate. *Journal of Tropical Ecology* 17:331–338.

Correspondence to: Gordon H. Rodda, USGS Midcontinent Ecological Science Center, 4512 McMurry Avenue, Fort Collins, Colorado 80525, USA.

### Dipteran Parasites of Loggerhead and Green Sea Turtle Nests

Larvae of the dipteran families Phoridae and Sarcophagidae have been found in marine turtle nests in many parts of the world. The authors studied dipteran infestation of loggerhead *Caretta caretta* and green sea turtle *Chelonia mydas* nests in northern Cyprus. Dipteran larvae were found and collected during nest excavation in 1996 and 1997, and were identified by keeping some larvae in jars until adult flies emerged. Eleven species of Diptera were found in nests of both turtle species; however, loggerhead nests had more diversity and abundance of dipteran parasites than green turtle nests. By examining developmental periods of three dipteran species, the authors found that larvae developed in loggerhead nests faster than in green turtle nests. The levels of infestation found in northern Cyprus are lower than those of other species of marine

turtles reported from other areas in the world. Although dipteran infestation seems to have no effect on the hatching success of nests, the authors recommend further study given the endangered status of sea turtles in the Mediterranean.

MCGOWAN, A., A. C. BRODERICK, J. DEEMING, B. J. GODLEY, AND E. G. HANCOCK. 2001. Dipteran infestation of loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtle nests in northern Cyprus. *Journal of Natural History* 35:573–581.

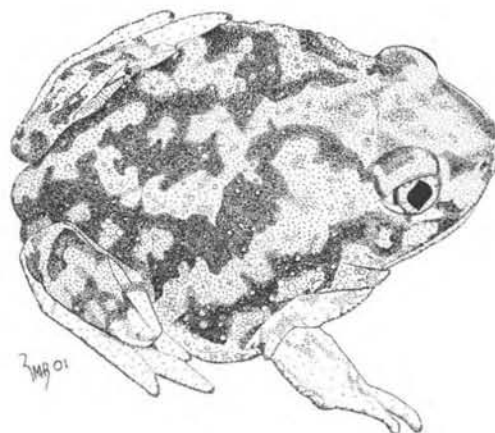
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### Chemical Alarm Cues of the Ravine Salamander *Plethodon richmondi*

Many animals reduce the probability of encountering a predator by adopting avoidance behaviors after detecting the predator through chemical alarm cues. These substances are released upon physical injury by members of the same species or prey guild to communicate the presence of danger. The authors examined the ability of the ravine salamander *Plethodon richmondi* to detect and respond to chemical alarm cues from autotomized tails of conspecifics and of zigzag salamanders (*P. dorsalis*). All individuals were collected in Madison County, Kentucky, and six substrate-choice tests were conducted on consecutive nights. Ravine salamanders detected and avoided chemical cues released from autotomized tails of conspecifics and this response was independent of size and sex. Alarm cues released by zigzag salamanders were not avoided. Thus, ravine salamanders increase their chances of survival by avoiding areas where a conspecific has been injured.

HUCKO, J. A., AND P. V. CUPP. 2001. Avoidance of chemical alarm cues released from autotomized tails of ravine salamanders (*Plethodon richmondi*). *Ethology* 107:315–322.

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*Scaphiopus couchii* (Couch's Spadefoot). USA: Texas: Webb County. Illustration by R. Michael Burger.



## ARTICLES

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### Secondary Sexual Characteristics of the Salamander *Salamandrella keyserlingii*: Throat Coloration

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Assessment of sex is essential to many ecological studies. Among amphibians, sexually dimorphic traits include size, vocalizations, and coloration. Males of many frog species develop pigmented vocal sacs during the breeding season (Duellman and Trueb 1986). In calling males of several hylids (e.g., *Pseudacris crucifer*: W. Duellman, pers. comm.) and the bullfrog *Rana catesbeiana* (Howard 1981), the throats become bright yellow. In the cave frog *Eleutherodactylus cooki*, males with the greatest reproductive success have throats with yellower color than their average ventral coloration (Burrowes 2000). Although yellow throat coloring is unknown in urodeles (but mental glands are sometimes distinguishable in plethodontid salamanders; Houck and Sever 1994), I found white (September–October) and yellow (April–May) pigmented patches in the throat region of adult males of the migratory salamander *Salamandrella keyserlingii* (Hynobiidae). Here I propose how to distinguish sex of this species visually during the terrestrial phase, focusing on seasonal fluctuations of both throat coloration in adult males and development of “ovisacs” (sensu Hasumi 1996b) in adult females. I further present a description of increased head width, tail height, and body mass in aquatic-phase males, similar to those of *Hynobius nigrescens* (Hasumi and Iwasawa 1990).

I studied *S. keyserlingii* inhabiting a wetland in Otanoshike, Kushiro-shi, Hokkaido Prefecture, Japan (43°01'02"N, 144°17'38"E; 4 m elevation). I captured 40 aquatic adults by netting from a fen (oviposition site: Hasumi and Kanda 1998) during the April–May breeding season (1995, examined for 15 days), and 633 terrestrial individuals near the fen during the April–May breeding season (1996–1997, 56 days) and the June–October nonbreeding season (1995–1997, 141 days), using a large grid of 160 pitfall traps within a 100 x 55 m area, composed of forest and marsh. I recorded sex, sexual maturity, age class (i.e., juvenile or adult), and visual characteristics of each individual (see below). I weighed each individual for body mass (M) with a portable beam balance (to within 0.05 g), and measured snout–vent length (SVL, distance from the tip of the snout to the posterior angle of the vent), broadest head width (HW), and maximum tail height (TH) with digital calipers (to within 0.01 mm) by a modification of Wise and Buchanan's (1992) method without using anesthesia. I marked 30 aquatic adults and 516 terrestrial individuals by toe-clipping, and released them either to the fen or near the pitfalls where they were trapped. Subsequently, 105 animals (70 adult males, 30 adult females, 1 unsexed individual, and 4 juveniles)

were recaptured in pitfall traps. In one instance, I found only an adult-size tail (from base to tip) in a pitfall trap; it was classified as an unsexed individual. I compared mean SVL between adult males having brilliant and pale yellow throats during the April–May terrestrial phase, and mean HW, TH, and M between terrestrial- and aquatic-phase males, using the Aspin-Welch test when exhibiting unequal variances (Snedecor and Cochran 1980) or Student's t-test ( $\alpha = 0.05$ , two-tailed).

A tubercle at the anterior angle of the vent (Hasumi et al. 1990; Sato 1943) was never discernible in either sex throughout the year, even during the aquatic phase, and therefore was a poor predictor for distinguishing adult males from others. In contrast, the throat region was a reliable predictor of sex. In adult males, this region assumed a translucent, grayish color from June–August (Table 1). It was translucent white during September and changed into an opaque, white patch during October. This patch turned a brilliant or pale yellow during the terrestrial phase of the April–May breeding season or during breeding immigration. However, some variation in male throat color occurred during this period; when 3 adult males which had a brilliant yellow throat were recaptured during April–May, their throats showed a pale yellow color (dates of capture and recapture, 28 April 1996 and 6 May 1996, 28 April 1996 and 10 May 1996, 30 April 1996 and 22 April 1997). A male's whole body, including this yellow coloring of the throat, became somewhat dusky during the aquatic phase. In terrestrial individuals other than adult males, the throat region took on a translucent, grayish color with or without a pinkish tinge throughout the year.

All size measures differed between males of different phases of the life cycle. First, males with brilliant yellow throats were larger than pale yellow males (SVL: brilliant:  $N = 110$ , mean = 56.65 mm, SD = 4.72, range = 46.21–66.75; pale:  $N = 18$ , mean = 53.46 mm, SD = 4.63, range = 47.18–62.14;  $t = 2.668$ ,  $df = 126$ ,  $P = 0.009$ ). Head width of terrestrial-phase males, including breeding immigrants (HW:  $N = 317$ , mean = 9.23 mm, SD = 0.64, range = 7.46–11.01), was smaller than that of aquatic-phase males ( $N = 39$ , mean = 11.34 mm, SD = 0.85, range = 9.73–13.76;  $t = 15.015$ ,  $df = 43$ ,  $P < 0.001$ ). Similarly, a tailfin never developed in terrestrial-phase males, including breeding immigrants (TH:  $N = 317$ , mean = 7.13 mm, SD = 0.72, range = 5.47–9.24), but was enlarged in aquatic-phase males ( $N = 39$ , mean = 9.41 mm, SD = 0.90, range = 7.49–11.95;  $t = 15.153$ ,  $df = 44$ ,  $P < 0.001$ ). Around the end of each breeding season (mid-May), the tail assumed a fin-like appearance in 9 emigrating males. In early June, after breeding activity ceased, a slightly developed tailfin was found in 6 trapped salamanders (classified as adult males because of an undeveloped tailfin in females). Lastly, adult male body mass differed between the terrestrial phase (M:  $N = 317$ , mean = 4.58 g, SD = 1.06, range = 2.50–8.20) and the aquatic phase ( $N = 39$ , mean = 5.60 g, SD = 0.91, range = 2.50–8.35;  $t = 5.745$ ,  $df = 354$ ,  $P < 0.001$ ).

Ovisac development was a reliable predictor of gravid females. A pair of beige ovisacs were visible through the skin of the ventral side of the torso near the hindlimbs (without holding females up to a light) during September, October, and the April–May breeding season (118 females examined). In general, the ventral region tended to assume a pinkish color in adult females and a dark brown color in adult males throughout the year with the exception of both sexes having an intermediate venter color with or without

many white dots. I verified this propensity during September–May, and applied it to distinguishing sex during June–August.

I identified sex and sexual maturity visually in 476 terrestrial adults (317 males, SVL mean = 57.51 mm, SD = 4.57, range = 46.21–69.49; 159 females, SVL mean = 61.99 mm, SD = 4.75, range = 52.00–72.33) by examining secondary sexual characteristics such as throat coloration, ovisac development, tailfin remaining (during September–May and early June), and venter color (during June–August). However, 5 terrestrial individuals captured from September–May and 19 terrestrial individuals captured from June–August did not show any clear sexually dimorphic trait, and therefore were classified as unsexed individuals (SVL: N = 24, mean = 55.50 mm, SD = 3.76, range = 52.24–66.67). I used SVL to distinguish unsexed individuals (SVL  $\geq$  52.00 mm) from juveniles (SVL < 52.00 mm) by applying the adult female's minimum SVL (52.00 mm; for comparison, the adult male's minimum SVL = 46.21 mm). Additionally, 67 juveniles (SVL: N = 67, mean = 46.60 mm, SD = 3.66, range = 37.43–51.85) and 65 metamorphs (N = 63, mean = 31.18 mm, SD = 3.05, range = 23.11–39.77; measures were not obtained from 2 metamorphs) were captured in pitfall traps.

Little literature exists on seasonal changes in throat coloration in urodeles. My observations on *S. keyserlingii* may be the first to report seasonal color changes in the throat region of urodeles from translucent gray, through opaque white, to brilliant yellow. It is unknown whether the absence of a prior description of this type in *S. keyserlingii* (Borkin 1999; Kuzmin 1999) reflects geographic variation in throat color. The intense yellow coloring of the throat is a striking secondary sexual characteristic in mature males, and may play an important role in sexual selection. Male throat color may be a signal for mate attraction and stimulation (Emlen and Oring 1977; Verrell 1991) or it may be involved in aggressive signalling between breeding males (Halliday and Tejedo 1995), which defend spawn sites on dead leaves of sedges.

In lentic-breeding hynobiids, a tubercle at the anterior angle of the vent is generally seen in breeding males (Sato 1943). Such a tubercle is evident in adult male *H. nigrescens* throughout the year except from May–July when ventral glands are underdeveloped (Hasumi et al. 1990), but is always lacking in adult females (Hasumi 1996a). This structure is a target for androgen (Hasumi et al. 1993), and may control ejaculate expenditure or fertilization duration during scramble competition among males for mates (Hasumi 2001). In contrast, although *S. keyserlingii* appears to have morphological characteristics of lentic-breeding hynobiids (Sato 1943), males lack this tubercle. It is unknown whether this exception reflects differences between genera.

An increased head width is unknown in urodeles other than hynobiids. The male head, body, and tail become swollen and inflated with water during the aquatic phase in *H. nigrescens* (Hasumi and Iwasawa 1990). This was evident in *S. keyserlingii*. Mating

TABLE 1. Seasonal color changes in the throat region in 317 adult males of *Salamandrella keyserlingii* during the terrestrial phase of the April–May breeding season (1996–1997, examined for 56 days) and the June–October nonbreeding season (1995–1997, 141 days).

Time of year	Translucent gray	Translucent white	Opaque white	Pale yellow	Brilliant yellow
April	0	0	0	5	99
May	0	1	1	13	11
June	19	1	0	0	0
July	11	0	0	0	0
August	15	0	0	0	0
September	0	99	16	0	0
October	0	0	23	3	0

ball duration (i.e., fertilization duration) is shorter when males with increased head widths monopolize egg sacs during scramble competition in *H. nigrescens* (Hasumi 1994). Although there is no evidence for this in *S. keyserlingii*, which also forms a mating ball, it is likely that an increased head width in these species is involved in male–male competition for mates.

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## Color Pattern, Predator Avoidance, and Foraging Behavior in the Golden Frog *Colostethus beebei* (Anura: Dendrobatidae)

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Grafen (1991) indicated that animals are elusive prey, efficient foragers, or efficient predators, so they are maximizers of one sort or another. Thus, in this paper I focus on qualitative descriptions of color pattern, predator avoidance and foraging behavior in *Colostethus beebei*, a small, diurnal, presumably nontoxic member of the neotropical poison frog family Dendrobatidae. This species lives and breeds only on the giant terrestrial tank bromeliad, *Brocchinia micrantha*, in Guyana, South America (Bourne et al. 2001). Because *C. beebei* is a small, apparently nontoxic frog, it may be the target of many vertebrate and invertebrate predators. Thus, natural selection should favor the ability to avoid detection and minimize predation. The specific objectives of this observational study were to document: (1) color-pattern polymorphism (the simultaneous occurrence of two or more discrete, genetically-based phenotypes in a population, in which the frequency of the

rarest type is higher than can be maintained by recurrent mutation; Ford 1975), crypsis, and fleeing and hiding behaviors of *C. beebei*; and (2) diet and methods of prey acquisition.

**Materials and Methods.**—I studied an individually marked population of 180 toe-clipped (Hero 1989) *C. beebei* on the tepui *Brocchinia* spp. glades of Kaieteur National Park, Guyana. The study was periodically conducted over 14 visits, of 1 to 7 days, from March 1993 to March 1999 (Bourne et al. 2001). My study site was the 455 m plateau near Kaieteur Falls (05°10'23"N; 59°28'52"W). I used focal animal sampling (Altmann 1974) of 30 randomly selected frogs to observe and record predator avoidance and foraging behaviors, and averaged  $2.4 \pm 0.6$  h on each frog. Randomization was accomplished by placing the identification numbers of each frog in a paper bag and blindly choosing the frogs to be observed on a given day. Observations were initiated at 0530 h and ended at 1800 h, and were sometimes aided by binoculars. I spent over 281 h in these activities. Each of the 180 hand-captured *C. beebei* adults was assigned to one of five color-pattern types. Frogs were compared to color standards of Smithe (1975) between 1000 and 1200 h on cloudless days to subjectively differentiate among polymorphic types. I also used Smithe's (1975) color nomenclature to describe color variation among morphs.

Active antipredator behavior was evaluated primarily by observing and describing the responses of adult and larval *C. beebei* to human approaches and hand captures. Antipredator behavior was also elucidated through fortuitous observations of encounters between *C. beebei* and a colubrid snake, and three incidences of graspid crab attacks on an adult, tadpole, and nonaquatic eggs (Bourne et al. 2001). Death-feigning was observed in *C. beebei* after some frogs were persistently pursued during futile attempts to hide in more than two locations.

Leaf colors (green or brown) associated with the leaf-sitting *C. beebei* morphs (brilliantly colored or brownish) were evaluated by Chi-square tests of independence (Sokal and Rohlf 1995), along two 200-m transects on 16 June 1994 and 25 March 1999. The June transect was adjacent to the falls and was constantly bathed in the falls' mist, and the March transect was to the north of the landing strip and 805 m from the falls (Bourne et al. 2001).

To determine whether these conspicuous, yellow *C. beebei* sitting on green leaves reflected infrared light (700–900 nm; Schwalm et al. 1977), I used a qualitative method of assessment in October 1999. A captive *C. beebei* was photographed on a *Canna glauca* leaf with Kodak Infrared Ektachrome through a Y-2 yellow filter. Furthermore, in March 2000 a brown morph of *C. beebei* was photographed on both brown and green *B. micrantha* leaves. The Y-2 yellow filter excludes blue light, causing a shift in colors such that green objects appear blue, red objects appear green, and infrared reflectance appears red (Mason 1970; Schwalm et al. 1977).

In 1993, I noticed that the base color (the dominant color of the dorsum below the brown stippling) in captive *C. beebei* was fading. To determine whether their fruit fly (*Drosophila melanogaster*) diet supplied enough carotenes, I added 2% paprika to commercial fruit fly medium and subsequently evaluated color changes in the frogs. Six experimental frogs were maintained on fruit flies fed the paprika-enriched medium during their larval development, and six control frogs were fed flies reared on unfortified medium. Color acquisition by experimental frogs was evaluated visually, and control frogs were fed fruit flies maintained on 2% paprika

after 4 mo.

**Results.**—*Colostethus beebei* exhibited color-pattern polymorphism with base colors ranging from spectrum orange, orange yellow, buff-yellow, cream to spectrum yellow (color nomenclature; Smithe 1975). Some individuals were uniformly colored, but many had variable amounts of brown stippled on their dorsal surfaces, whereas others had oblique lateral stripes (*sensu* Edwards 1974) accented by ventral lines of dusky brown running from the posterior nares through the eye to the groin. Most individuals (80% of  $N = 180$  frogs) had distinct oblique lateral stripes extending from the posterior margin of the eye toward the tip of the urostyle that did not dip down to groin (but see Noble 1923). The skin on the dorsum was smooth, somewhat granular on the sides, and smooth ventrally. Rings around the nares were either jet black or dusky brown, and horizontal pupils were set off by gold-colored irises with zero to two black flecks.

I recognized five discrete color patterns in the 180 *C. beebei* examined in this study, of which the first three morphs listed were brilliantly colored (Table 1): (1) spectrum yellow overall with suffuse dusky brown stippling on the dorsum. Bilateral but distinct cream colored oblique lateral stripes outlined ventrally by much narrower dusky brown lines running from the nares to the groin. Twenty-four percent or 43 frogs represented this morph; (2) this morph was similar to the preceding morph, but the base color was spectrum orange to orange yellow, 19% or 35 frogs belong to this morph; (3) 20% or 36 frogs had a cream base color without distinct oblique lateral stripes; (4) buff-yellow base color, distinct oblique lateral stripes, and much dusky brown stippling dorsally just anterior to the vent, and distally on the dorsal surfaces of thighs and shanks (18% or 33 frogs); and (5) 18% or 33 frogs had a base color of spectrum yellow, with heavy even brown stippling on the entire dorsum and flanks, giving the appearance that these individuals were dusky brown. Frogs in this category also had distinct oblique lateral stripes. Although most morphs were conspicuously colored, a crude bioassay, a taste test for the presence of skin alkaloids (Daly et al. 1997), suggested that *C. beebei* was not toxic. However, infrared color photography indicated that this species reflected light in the near-infrared region (700–900 nm), as did the green and brown leaves on which these frogs sat.

Spectrum orange through spectrum yellow morphs with little or no brown stippling, and those with much brown stippling, were territorial on differently colored leaves of *B. micrantha*. Brilliantly colored individuals were more often seen on live, green leaves, while brown stippled frogs were recorded on the lower, dead, brown leaves of bromeliads (June 1994,  $\chi^2 = 59.04$  with Yates correction,  $df = 1$ ,  $P < 0.0001$ ; March 1999,  $\chi^2 = 8.34$  with Yates correction,  $df = 1$ ,  $P = 0.004$ ).

Active antipredator behavior included a high degree of wariness combined with rapid jumping into water at the base of bromeliad leaves. This was followed by complete submersion and wedging between the two leaves forming an axil. *Colostethus beebei* tadpoles also employed wedging behavior when approached by a potential predator. When persistently pursued by humans, 2% ( $N = 180$  frogs) of adult *C. beebei* became limp, but with hind limbs stiffly extended (see Garcia 1999), and floated to the surface motionless. These individuals appeared to be dead. One death-feigning individual remained in this posture for at least 31 min. I fortuitously observed active predation of *C. beebei* on four occa-

sions. The first predation episode consisted of a 1030 mm snout-vent length colubrid snake, *Imantodes cenchoa*, that pursued and caught a wedged adult *C. beebei* in a bromeliad pool. This snake swallowed the frog head-first in 38 sec. The other three predation episodes involved an unidentified species of graspid crab; each crab ate a live adult frog, a live stage 42 tadpole (*sensu* Gosner 1960), and a clutch of four foliar eggs, respectively.

*Colostethus beebei* was primarily a sit-and-wait predator, and foraging was closely linked to calling and sentinel behaviors on all-purpose territories (Bourne et al. 2001). Some food was captured after short distance hopping pursuit of crawling prey such as ants (Formicidae), mites (Acari), and small spiders (Araneae). However, most of the observed feeding events suggested that much of the diet consisted of intercepted emerging imagoes of mosquitoes (*Anopheles* sp., *Culex* sp., *Trichoprosopon* sp., *Wyeomyia* sp.), and midges (Chironomidae) as they left the surface of phytotelmata. Unidentified Drosophilidae flies attracted to nonaquatic clutches of *C. beebei* were also readily eaten.

*Colostethus beebei* apparently owed its brilliant base color to diet-derived carotenes. In captivity the brilliant spectral yellows and oranges faded in a few months. Six experimental frogs, fed fruit flies on a paprika-fortified diet, began regaining bright coloration after 2.5 wk. Six control frogs, maintained on a fruit fly diet without paprika, continued to lose color. Yet, these controls regained bright coloration when fed paprika-fortified fruit flies after 4 mo into the experiment.

**Discussion.**—I found five color-pattern morphs in *C. beebei*, a situation not unlike that for *C. taeniatus* in Ecuador (Edwards 1974), the unrelated *Eleutherodactylus coqui* in Puerto Rico (Pough et al. 1996), as well as 225 other frog species (Hoffman and Blouin 2000). What are the benefits of color polymorphism in prey organisms? Hoffman and Blouin (2000) indicated that the main explanation for the maintenance of color-pattern polymorphisms is direct selection by visually-oriented predators. One plausible hypothesis is that when a visual predator discovers a prey item it may form a search image for that particular color pattern and concentrate on seeking additional prey that look the same (Dawkins 1971; Pietrewicz and Kamil 1977, 1981). Thus, if all members of the population exhibit the same color pattern, then all individuals are at risk of easy detection. Alternatively, the presence of multiple color patterns decreases the chances of detection by a predator using a search image for a single morph. Pietrewicz and Kamil (1977, 1981) tested this hypothesis by randomly projecting a series of polymorphic prey slides to blue jays (*Cyanocitta cristata*). They corroborated the hypothesis because jays encountering polymorphic prey had difficulty forming an effective search image, and so could not easily switch to different prey morphs (Pietrewicz and Kamil 1977, 1981). Thus, polymorphism can reduce the risk of predation on individuals in mixed-morph populations (Pietrewicz and Kamil 1977, 1981), and may similarly benefit the color-based polymorphic *C. beebei*.

In addition to the apparent benefits of reduced predation accruing from color polymorphism, brightly colored *C. beebei* morphs were seen more often on live green leaves, and brown stippled morphs were encountered more often on dead brown leaves. Cryptic animals can minimize chances of detection by selecting appropriate backgrounds. To some extent, concealing coloration (Norris and Lowe 1964), especially of the brown morphs, may have pro-



tected them from high rates of predation, as suggested by experiments conducted by Tordoff (1980) and Morey (1990). Both of these laboratory experiments demonstrated that substrate matching significantly increased the survival of stationary frogs (Tordoff 1980; Morey 1990). It is more difficult to make this argument for the benefits of concealing coloration for yellow morphs of *C. beebei* on green leaves because they seemed conspicuous. However, it cannot be assumed that animals which do not appear cryptic to us are necessarily conspicuous to other animals. For example, snakes and birds, two groups that include frogs in their diets, can detect near-infrared radiation (Bradbury and Vehrencamp 1998). Yellow morphs of *C. beebei* are similar to other species of leaf-sitting *Centrolenella* and *Agalychnis* that reflect near-infrared light, and accrue protection because infrared reflectance from green leaves matches the frogs to the leaves (Schwalm et al. 1977). Even brown *C. beebei* morphs reflected near-infrared light as did their green and brown leaf substrates. Moreover, at this time I cannot rule out a role for minimizing predation due to the effects of mimicry and aposematic coloration of yellow morphs. However, there are no syntopic unpalatable yellow dendrobatids in Kaieteur National Park, except the much larger, terrestrial, and toxic *Dendrobates tinctorius* which has much yellow on its dorsum (Bourne et al. 2001).

In addition to search image disruption accruing from color-pattern polymorphism and crypsis, *C. beebei* relied on rapid jumps combined with either hiding or death-feigning behaviors to minimize predation. The antipredator response of diving-and-wedging in phytotelmata by both adults and tadpoles made it relatively easy for humans to hand capture *C. beebei*. However, as with foliar eggs of other species, those of *C. beebei* were sometimes attacked by larvae of drosophiline (Villa 1980) or phorid flies (Villa and Townsend 1983). Foliar eggs and adults of many species of arboreal frogs are also eaten by grasspider crabs (Hayes 1983; Krügel 1993) and colubrid snakes (Duellman 1958), as I observed for *C. beebei*.

In conclusion, this observational study of color morphs, predator avoidance, and foraging behavior in a bromeliad-specialist dendrobatid frog, *C. beebei*, suggested that it had at least five color morphs. These morphs ranged in color from a brilliant orange to cream, and with varying degrees of brown stippling. The base yellow coloration of *C. beebei* was derived from carotenes that faded in captive frogs. Color was restored to frogs by feeding them insects maintained on carotene-rich fortified commercial medium. Color polymorphism may be adaptive in this frog through disruption of predator search images. In addition to the potential benefits due to the disruption of predator search images, brilliantly colored morphs were found more often on green leaves of *Brocchinia micrantha* bromeliads whereas predominantly brown morphs were found on dead brown, basal leaves. Although brightly colored morphs on green leaves were easily detected by humans, all *C. beebei* morphs, as well as green and brown leaves, reflected near-infrared light when examined by infrared color photography.

TABLE 1. Characteristics used to assign 180 golden frogs, *Colostethus beebei*, to five discrete polymorphic types (color nomenclature from Smithe 1975).

Basic color	(N)	Dusky brown stippling	Oblique lateral stripes
*Spectrum yellow	43	suffuse on dorsum	present and distinct
*Spectrum orange	35	absent	present and distinct
*Cream	36	absent	present and indistinct
Buff-yellow	33	just anterior to vent	present and distinct
Spectrum yellow/Brown	33	heavy on dorsum and flank	present and distinct

\*brilliant morphs

Thus, infrared reflectance may be adaptive because of infrared cryptic coloration. *Colostethus beebei* also relied on vigilance and rapid jumping combined with either hiding behavior or death-feigning to minimize predation. Furthermore, *C. beebei* was an opportunistic sit-and-wait predator whose diet included many small arthropods, but especially mosquitoes and midges.

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related to this approach is that the physiological or behavioral responses of interest are either unaffected or affected in a similar way by time in captivity. However, we argue that time in captivity may be a potentially influential variable, and that the above assumption may be invalid under a variety of circumstances. We support our argument with data on oxygen consumption of hylid frogs in the genus *Scinax* (Duellman and Wiens 1992).

Oxygen consumption relates to energy expenditure and is one of the most informative physiological parameters in herpetology (Pough et al. 1992). The data presented here were obtained in the context of a study of the evolutionary physiology of *Scinax*, and have been used collaterally to examine hypotheses regarding time of captivity. Our research involves routine measures of standard metabolic rate (resting at a given temperature) and during intense forced locomotion. We attempted to test frogs within two weeks of capture, but this was not always possible. Because the time interval preceding metabolic measurements varied, our data allowed for study of the relationship between time in captivity and metabolic rate. Despite some limitations of the data when analyzed in this context, we report conspicuous patterns that illustrate a useful point in the study of amphibians, many of which are very sensitive to physical changes in their milieu.

We report data on males of five *Scinax* species that are common in southeastern Brazil: *Scinax crospedospilus* (mean body mass  $\pm$  SE,  $1.59 \pm 0.028$  g;  $N = 10$ ) is very active and inhabits ponds and lakes in the Atlantic forest or somewhat disturbed habitats; *S. fuscovarius* ( $4.04 \pm 0.096$  g;  $N = 14$ ) is a large and widespread species, and occupies various lentic habitats; *S. perereca* ( $3.01 \pm 0.051$  g;  $N = 16$ ) is found near permanent ponds in open areas or forest borders; *S. g. perpusillus* ( $0.36 \pm 0.010$  g;  $N = 20$ ) reproduces in bromeliads and requires rather well-preserved patches of Atlantic forest; and *S. hiemalis* ( $0.84 \pm 0.008$  g;  $N = 32$ ), which calls mainly in the winter and lives near rivulets that are used for reproduction. In the laboratory, frogs were maintained in individual plastic containers with moist paper towels and artificial vegetation. Photoperiod was 12:12. Diet varied with body size and consisted of crickets, fruit flies, cockroaches, and mealworms.

Metabolic rate was measured between 10 and 30°C using standard techniques (Navas 1996). Standard metabolic rate was measured before 1700 h. Briefly, frogs were placed in humid and aerated chambers, and maintained at the experimental temperature for 2 h. Flow rate was set to maintain pre-experimental oxygen concentration inside chambers at 20.95%. Chambers then were closed for 2 to 6 h, and subsequently re-opened and washed with fresh air. The resulting air mixture was then expressed across a Drierite-Ascarite filter into a Sable Systems PA-1 oxygen analyzer at 130 ml/min, and metabolic rate was calculated from the integrated area under the curve of oxygen concentration versus time (Bartholomew and Lighton 1986) using Datacan 3.0 (Sable Systems). Activity metabolism was measured after 1800 h with a similar approach, but using smaller rotating chambers made out of 50 cc syringes and limiting tests to 3.5 min. Data were log-transformed to improve homoscedasticity and normality.

To isolate effects of time in captivity we used residuals of an ANCOVA in which metabolic rate (ml O<sub>2</sub>/h) was the dependent variable, and mass (g) and temperature (C) were independent variables. We used regression analysis of the residuals to test for an effect of time in captivity. Given the nature of the data, individu-

## Time in Captivity as a Confounding Variable in Herpetological Research: An Example from the Metabolic Physiology of Treefrogs (*Scinax*)

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The study of ectothermic tetrapod physiology and behavior frequently utilizes comparison among related species (Huey 1987). Such research may include the use of animals kept in captivity for variable periods of time; moreover, animal maintenance in the lab may be part of experimental protocols. A common assumption

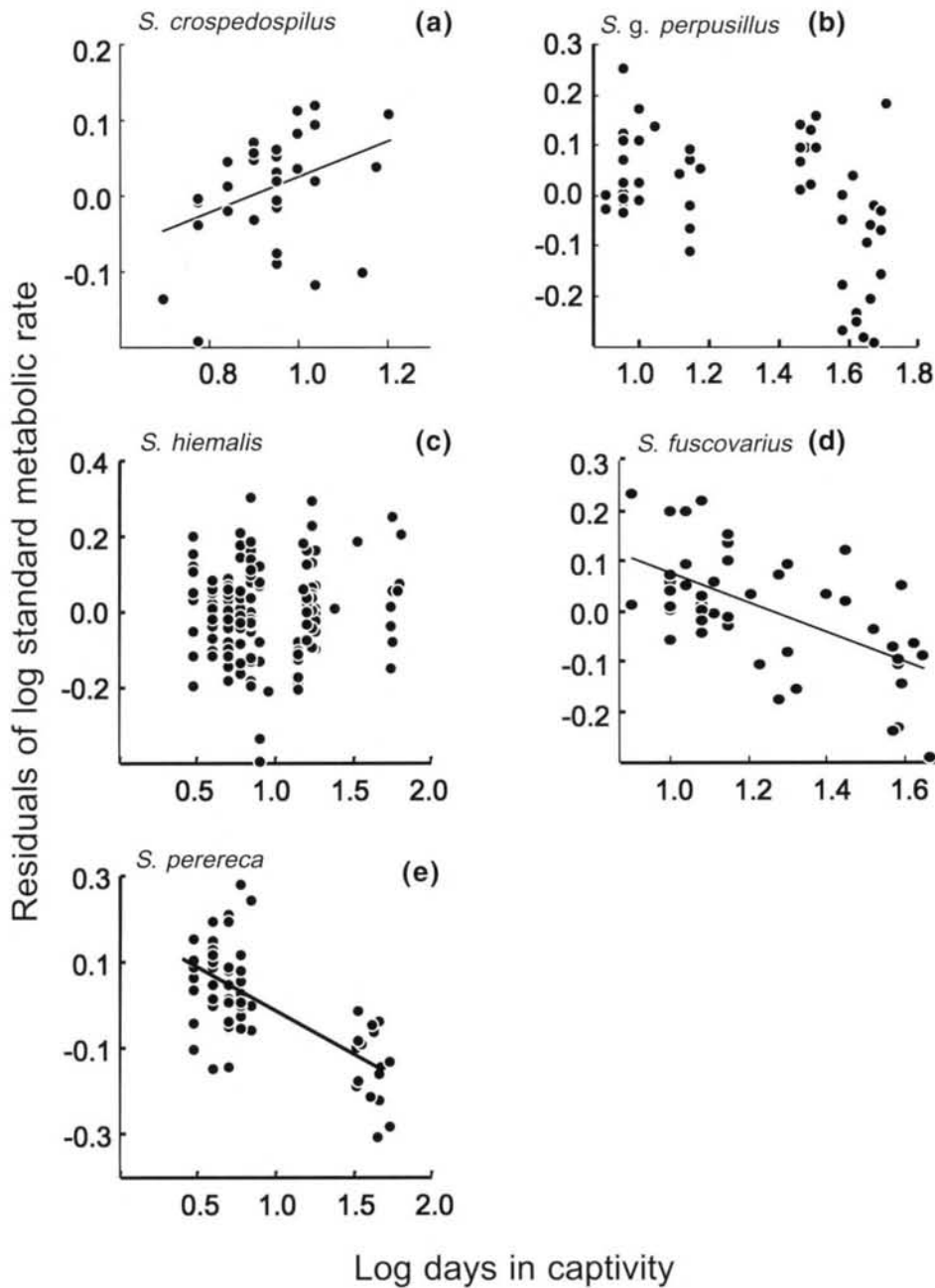


FIG. 1. Residuals of log standard metabolic rate on log body mass and temperature as a function of log-time in captivity in five species of *Scinax*. Regression lines are shown for heuristic purposes and illustrate tendencies of data for which correlation tests are significant. a) *Scinax crospedospilus*,  $r = 0.486$ ,  $P = 0.014$ ; b) *S. g. perpusillus*,  $r = -0.006$ ,  $P = 0.972$ ; c) *S. hiemalis*,  $r = 0.145$ ,  $P = 0.143$ ; d) *S. fuscovarius*,  $r = -0.472$ ,  $P = 0.027$ ; and e) *S. perereca*,  $r = -0.561$ ,  $P = 0.001$ .

als exhibiting outlying metabolic rates and measured over a short time interval had a disproportionate influence on overall tendencies. We evaluated this problem using influence plots (SYSTAT 1992) and deleted from the analysis an individual with a very low standard metabolic rate.

Time in captivity related to very different trends of change in standard metabolic rate among species (Fig. 1a–e). *Scinax crospedospilus* (Fig. 1a) showed an increased standard metabolic rate, *S. g. perpusillus* (Fig. 1b) and *S. hiemalis* (Fig. 1c) showed

no obvious pattern, and *S. fuscovarius* (Fig. 1d) and particularly *S. perereca* (Fig. 1e) exhibited a significant reduction in standard metabolic rate. Similar trends were absent when activity metabolic rate data were analyzed. Accordingly, time in captivity may influence in different manners the metabolic status of even congeneric sympatric species, but we do not know whether the observed changes involve return to, or departure from a normal situation. Simple general explanations, such as seasonal variation or differences in the rate of physical deterioration, do not hold. Metabolic

rate is related to season in some temperate frogs (Rome et al. 1992) and at least one subtropical anuran (Glass et al. 1997). However, *S. hiemalis* remained longest in captivity, was sampled at different times of year, and its rate of metabolism did not change in captivity. Additionally, loss of body mass, which would reflect physical decay, was not reported for any species during standard metabolic rate measures.

In some anuran species, capture and transport to the lab raises plasma corticosterone, and also may reduce circulating sex steroids (Coddington and Cree 1995; Paolucci et al. 1990). Experimental manipulation of these hormones is coupled with changes in energy expenditure in birds (Wikelski et al. 1999) and calling behavior in frogs (Penna et al. 1992). Because of their effects on behavior, plasmatic corticosteroids and sex-hormones may be part of a control mechanism for energy expenditure (Marler and Ryan 1996). It is possible, then, that the patterns reported in our study are related to captivity-induced hormonal and behavioral shifts that vary from species to species. These patterns may be affected by interspecific differences in energetic status at time of capture, and may lead to different metabolic trends according to the intensity of stress responses to changes in surrounding milieu, reduced social stimulation, or others.

Independent of the nature of the metabolic changes observed, the message we convey is that captivity may induce species-specific changes in amphibian physiology and behavior. Accordingly, researchers should not assume homogeneous effects of time of captivity when engaging in interspecific studies. Doing so may add an uncontrolled confounding variable to the study and may lead to equivocal conclusions in diverse research contexts (e.g., Feder et al. 1984). An extreme case may occur when individuals of a given species are more likely to die in captivity than others, so that final samples compared are not random. These considerations may be important for taxa other than amphibians and for within-species studies. Any investigation that relies on sequential data from individuals along a significant period of time may need to consider time in captivity as a possible confounding variable. To address this problem, researchers may maintain a detailed record for individuals (including dates of capture and tests), perform preliminary tests, or use experimental designs that consider time in captivity as a potentially confounding variable (e.g., Zolman 1993).

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## On the Origin of the Common Wall Lizards *Podarcis muralis* (Reptilia: Lacertidae) in Cincinnati, Ohio, USA

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The European common wall lizard (*Podarcis muralis*) was introduced in Cincinnati, Ohio (USA) circa 1950; a population now exists in southeastern urban Cincinnati covering an area of more than 6 km<sup>2</sup> with an expanding tendency. Hedeem and Hedeem (1999) report the present status and the role of railroad tracks in the natural expansion of the population. Because of the ease with which *P. muralis* can be maintained in captivity, they have been introduced



to numerous other parts of the metropolitan area. Some of these subpopulations have persisted. Presently, reproducing subpopulations are found in the Eden Park and Fairview Park areas of the city. J. G. Davis, (Cincinnati Museum of Natural History, pers. comm.) mentions a population on the grounds of the Cincinnati Zoo. Conant and Collins (1998) listed a population in Van Wert County, Ohio, 190 km north of Cincinnati, from which a voucher specimen is available at the University of Kansas Natural History Museum (KU 206727). Recently Davis (pers. comm.) was unable to confirm the continued existence this population. Further, the lizards have been released south of the Ohio River in Kentucky by owners of private gardens (Draud and Ferner 1994). Ferner (pers. comm.) confirms this pattern of colonization south of the Ohio River as a continuing process. However, in other, interior parts of its range, population densities are in decline due to habitat destruction as unmortared stone walls are replaced with concrete walls, refuse piles are removed, and other improvements associated with urbanization are made. The lizards and their varying population density have received attention from the popular press (e.g., Eckberg 1989; Snyder 1993). They have also been the subject of scientific investigations ranging from reproduction to behavior (Brown, Gist, and Taylor 1995; Brown, Taylor, and Gist 1995; Hedeon 1984; Hedeon and Hedeon 1999; Kwiat and Gist 1987; Vagle 1977).

The expansion of *P. muralis* in the New World is of interest to European herpetologists because it is known to be an aggressive species with the potential to influence the range of native herpetofauna. For instance, Henle (in Gruschwitz and Boehme 1986), reports *Podarcis muralis* not tolerating *Podarcis sicula* on walls occupied by *P. muralis*. Although walls are a preferred habitat of *P. sicula*, it retreats to grass-covered areas below the walls whenever *P. muralis* is present. C. Bender (pers. comm.) observed that male *P. muralis* attacked adult sand lizards (*Lacerta agilis*), a European species whose SVL exceeds that of *P. muralis* by 45%.

#### REPORTED HISTORY OF INTRODUCTION OF *PODARCIS MURALIS*

In the local press of Cincinnati, there are several articles from the 1970's to the 1990's providing contradictory information regarding the details of the introduction of the "famous Lazarus lizards" from Switzerland or Italy in the 1940s or 1950s by member(s) of the Lazarus family, a family well-known in Cincinnati. Accounts also vary in the scientific literature. Hedeon (1984) and Hedeon and Hedeon (1999) reported that two *P. muralis* were released by a Cincinnati resident in the backyard of her home in September 1951. Vagle (1977) states the year of introduction as 1948. The animals had been caught during a family visit to Europe in the Lake Como area of northern Italy. Hedeon (1984) found that the climates of Cincinnati and Milan, Italy, only 40 km distant from Lake Como, have almost identical annual temperature and precipitation patterns, and concluded that excellent conditions existed for a rapid settlement of this species. In Europe, *P. muralis* is reported to be the lizard best adapted to live in human settlements (Arnold and Burton 1978).

#### A HITHERTO DISREGARDED DOCUMENT

As a reaction to one of the newspaper articles, a member of the Lazarus family, George Rau, wrote a letter to one of us (DG; letter on file at the Cincinnati Museum of Natural History) on 29 June

1989 in which he stated that, as a child, he was the one who brought approximately ten specimens of *P. muralis* to Cincinnati from Lake Garda in the northern lake section of Italy in 1951 or 1952. As part of a study investigating the status of European lacertids introduced in the USA (Deichsel and Miller 2000), GD gained access to this letter during a recent visit to Cincinnati. A review of the letter prompted an assessment of its contents from the perspective of European herpetology and the writing of the present article. In what follows, we list the key statements in the letter followed by our comments.

Approximately ten specimens of the *P. muralis*, obtained from Lake Garda, Italy were released by George Rau at his parental home on Torrence Court in eastern Cincinnati in September 1951 or 1952. About 1958, he released at the same location another ten lizards with "an absolutely solid blue stomach" obtained from the small island of Vedrá off the southwest coast of Ibiza, Spain. He further states that as a consequence of interbreeding between these two groups, progeny with a series of blue spots on the venters resulted. To support this conclusion, he states that he had never observed lizards with blue spots on the venters prior to releasing the ten specimens from Vedrá.

Despite the passage of time, we attribute a higher credibility to the first person statement of Rau that approximately 10 lizards were released in Cincinnati over second-hand accounts that two lizards were released (Hedeon 1984; Hedeon and Hedeon 1999). The collection site of the first group of lizards in the vicinity of Lake Garda, about 120 km from Milan, Italy, identifies their subspecific status as that of the nominate form, *Podarcis muralis muralis*. Judging from their origin, the second group of lizards released by Rau is *Podarcis pityusensis vedrae*, a cyanistic subspecies of the Ibizan wall lizard (Salvador 1986). The home archipelago of *P. pityusensis* is well separated from the natural range of *P. muralis*. Further, analysis of mitochondrial DNA of *Podarcis* (Harris and Arnold 1999) places these two species in different lineages within the genus. In addition, *P. muralis* does not interbreed with a sister species, *P. sicula*. Thus, the likelihood of Cincinnati *P. muralis* interbreeding with *P. pityusensis* seems remote but could be confirmed by DNA analysis.

It is unlikely that *Podarcis p. vedrae* survived in Cincinnati. This lizard normally lives on two small Mediterranean islands (Vedrá <0.5 km<sup>2</sup>, Vedranell <0.2 km<sup>2</sup>) whose maritime climate differs greatly from Cincinnati's continental climate. Like other subspecies of *P. pityusensis* from small islands, *P. p. vedrae* does not hibernate in the winter and is hence not likely to endure the more severe Cincinnati winters. Dietary factors also may have contributed to their extirpation. Approximately 50% of the diet of a comparable subspecies of *P. pityusensis* is plant material. Salvador (1986) reports that stomachs of *P. p. karlkochi*, a denizen of the neighboring small island of Conillera, contained almost 40% flowers in the month of January. If the diet of *P. p. vedrae* is similar to its con-specifics from small islands, then absence of a continuing plant-based food supply during the winter may have contributed to its demise.

#### A COMMENT ON VENTRAL COLOR POLYMORPHISM

Ventral coloration of *P. muralis* warrants further consideration because it is subject to conspicuous variation, ranging from white, greyish, yellow and orange, to red. Such variation is known even

in small, isolated European populations (Dexel 1986) and is reflected in the Cincinnati population. Brown (pers. comm.) investigated a sample of 77 lizards with 88% white, 7% yellow and 5% red venters, but was unable to correlate ventral color polymorphism of the Cincinnati *Podarcis* with allelic variation at 14 allozyme loci. He attributed the absence of allozyme variation to a founder effect, and the results remain unpublished. It is likely that the blue spots on the belly noted by Rau were actually on the flanks. These spots are particularly pronounced on males, and the intensity of these spots is subject to individual, seasonal, and sexual variation (Gruschwitz and Boehme 1986).

#### CONCLUSION

As the result of a letter written by one of the individuals involved in the introduction of common wall lizards to Cincinnati, Ohio, we believe we have evidence that the Cincinnati population of *P. muralis*, now covering more than 6 km<sup>2</sup>, originated from ten specimens introduced by George Rau approximately fifty years ago. This information may be useful for researchers analyzing genetic variability in this isolate. The introduced lizards originated from Lake Garda, ca. 120 km distant from Milan, Italy. This location identifies the subspecific status as that of the nominate form, *Podarcis muralis muralis*. Another group of lizards introduced by Rau was identified as *P. pityusensis vedrae* and did not survive.

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## The Ornate Box Turtle, *Terrapene ornata*, in Southern Indiana

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The ornate box turtle, *Terrapene ornata*, reaches the eastern limit of its distribution in Indiana, USA (Conant and Collins 1998; Ernst et al. 1994). Here it occurs in two widely separated populations. The larger and better known of these occurs in the sand prairie in the Kankakee Basin in northwestern Indiana (Minton 1972). A single record exists for southern Indiana, from Daviess County, in the southwestern corner of the state, as reported by Minton (1972:168). This specimen was collected on 13 September 1950, "... five miles south of Plainville, Daviess County" (List 1951) and was deposited in the University of Illinois Museum of Natural History collection (UIMNH 18038). Minton accepted this record as valid, presumably because (a) the species had been reported from not too distant colonies to the west in southern Illinois (Smith 1947, 1961); (b) the location was a relatively large area of sand prairie not unlike that in northwestern Indiana where the species is known to occur; and (c) other species of the herpetofauna partial to sand prairies in the Midwest, including those of *Cnemidophorus*, *Ophisaurus*, and *Pituophis*, have been reported from nearby sandy sites proximate to Daviess County (Minton 1972; Minton et al. 1982).

On 13 May 2000, MJL collected a specimen of *Terrapene ornata* in Steele Township, Daviess County, 7 km north of the town of Washington, and about 1 km west of Indiana State Route 57. This turtle, an adult male, was found sliced in two by an agricultural disc at the margin of an area of rank grassland immediately adjacent to a field being prepared for row crops. This specimen represents only the second record of *T. ornata* from southern Indiana, and corroborates List's earlier collection from Daviess County fifty years ago. The specimen has been deposited in the herpetological collection at the University of Michigan Museum of Zoology

(UMMZ 226738).

It is noteworthy that both of the southern Indiana specimens of *T. ornata* came from Steele Township in Daviess County. List's original collection was of a turtle found on Indiana Route 57 (J. C. List, pers. comm.), while the most recent specimen was collected about 1 km west of Indiana Route 57. When plotted on a DeLorme topographic map (Indiana 1998:49, 56), the two collection stations nearly overlie each other, and we surmise that the two specimens were part of the same relict population. This portion of Daviess County consists mainly of gently rolling to flat plains, with sandy soils. There is intensive agriculture, with melon production, orchards, and various row crops. The area from which both specimens of *T. ornata* were collected is a small zone of some fairly well-developed dune topography, where current land use includes pasture in small tracts, perhaps only a few hectares each. The persistence of *T. ornata* at this site over the last half century is remarkable. Other species collected or observed by the authors at the site where *T. ornata* was taken include the following: *Bufo fowleri*, *Hyla versicolor* complex, *Pseudacris crucifer*, *Pseudacris triseriata*, *Scaphiopus holbrookii*, *Rana clamitans* and *Rana utricularia*, *Eumeces fasciatus*, *Coluber constrictor*, *Elaphe obsoleta*, *Heterodon platirhinos*, *Lampropeltis calligaster*, and *Thamnophis sirtalis*.

The Indiana Department of Natural Resources (IC 14-22-34 and Rule 312 IAC9-5-4) lists *Terrapene ornata* as endangered within the state. While not officially listed as endangered or threatened in adjoining Illinois, populations there are apparently now much reduced. Smith (1961) once observed that "... the species is common in many parts of Illinois." However, Phillips et al. (1999:162), commenting on its population status forty years later, concluded that *T. ornata* was "uncommon to rare in much of its range in Illinois."

A small tract from the area where *T. ornata* was most recently collected in Daviess County was acquired in 1999 by the Indiana Department of Natural Resources for the establishment of a nature preserve by the Division of Nature Preserves (L. Casebere, pers. comm.). The recent discovery of *Terrapene ornata*, a state endangered species, will enhance the value of this site in affording some protection for at least one of the state's rarest vertebrates.

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## TECHNIQUES

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### The Benefits of Transparency: Candling as a Simple Method for Determining Sex in Red-Backed Salamanders (*Plethodon cinereus*)

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Gender-specific studies require an accurate technique for sexing individuals. Research on the red-backed salamander (*Plethodon cinereus*) has included many studies that may have gender-biased results, including homing abilities (e.g., Kleeberger and Werner 1982), territorial and agonistic behavior (e.g., Jaeger 1984; Jaeger et al. 1986), and reproduction (e.g., Saylor 1966). Some recent studies have focused on interactions between males and females (e.g., Guffey et al. 1998; Gillette et al. 2000). Sexing adult salamanders using external characteristics is relatively simple when the animals are in courtship condition. Males have mental glands (visible as a whitish area on the chin), square snouts (due to enlarged premaxillary teeth), and a whitish, slightly enlarged region immediately lateral to the cloaca. Females, however, have rounded snouts, lack mental glands, and have no whitish region around the cloaca. The eggs of gravid females are easily visible through the abdominal wall once they reach a diameter of approximately 2 mm. External morphology, however, is not reliable when males are not in breeding condition, and it cannot be used on sexually immature animals.

Sexing animals by invasive internal inspection (e.g., Jaeger et al. 1982) has obvious drawbacks for behavioral or field ecological studies. Quinn and Graves (1999) suggested using the distance between nares at the tip of the snout (inter-nares distance: IND) to sex red-backed salamanders because it is sexually dimorphic and does not change with breeding condition. In the sample examined by Quinn and Graves, however, there was small (0.03 mm) overlap between sexes in the IND; six of the 95 salamanders identified



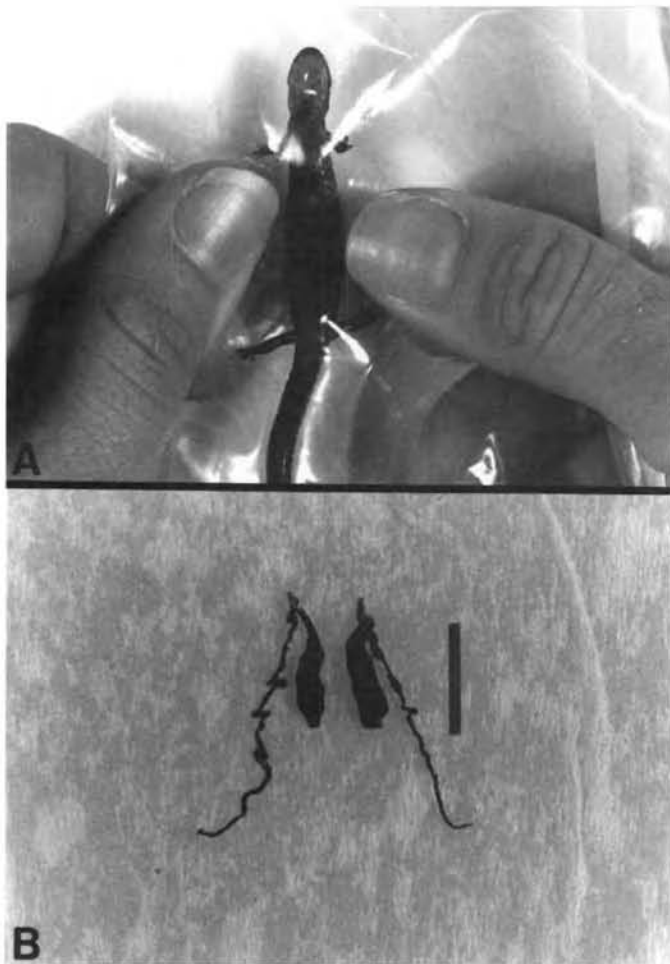


FIG. 1A. Correct position of a salamander to be candled. Thumbs and index fingers should grip the clear plastic bag on either side of the abdomen and gently flatten the animal. B. Testes and vas deferens from a salamander as they appear in an intact animal. Scale bar = 5 mm.

fell into the range of overlap. This suggests that there is a 6.3% chance of making erroneous sex determinations if they are based solely on IND. Furthermore, measuring the IND on a non-anesthetized, live salamander may be difficult. We present here an unambiguous, quick, and non-lethal method for sexing red-backed salamanders by a process generally known as candling.

Candling red-backed salamanders can be used as a reliable means of determining sex because internal organs, particularly the testes (in males), eggs (in females), and intestines, are easily visible through the abdominal wall in a slightly compressed animal that is illuminated from behind. Because candling renders the animal effectively transparent, dissection is unnecessary. We have used this technique for over three years, during which time we have accurately determined the sex of 3000 red-backed salamanders, both in the forest and in the laboratory.

To sex a salamander, we first place it in a small, clear plastic bag. We then manipulate the salamander until its abdomen faces toward us and grip the bag between thumbs and index fingers on either side of the lower abdomen. Next, we gently flatten the animal by stretching the plastic between our fingers (Fig. 1A). This restricts the movements of the animal and compresses it so that light may pass through the abdomen. Stretching the bag immobi-

lizes the animal and increases visibility of its internal anatomy, but too much pressure can cause serious internal damage. Finally, we hold the animal up to a light (e.g., the sun, a flashlight, a standard electric light, or even an overcast sky) so that the light shines through the animal and we can view its internal anatomy through its abdomen. With some manipulation, it is easy to determine in adults (>35 mm snout-vent length (SVL)) whether testes are present or absent; if absent, the animal is female. In gravid females, eggs (as small as 1 mm) appear as whitish circles along either side of the abdomen. Females may have 1–16 eggs, with the average being 7–8 (Sayler 1966). Occasionally, transparency may be greatly reduced by large quantities of material in the gut. In such cases, the animal can be held in a laboratory for a few days until its gut has cleared.

Testes and vas deferens that have been removed from a red-backed salamander illustrate their relative positions to each other (Fig. 1B). The vas deferens is a convoluted tube originating at the anterior tip of the testes, curving posteriorly, and ending at the cloaca, where the sperm are delivered. Although the vasa are not easily distinguishable from the testes while within an intact salamander, they are sometimes visible. Within the body cavity, testes are positioned side-by-side, but their general appearance may vary. However, testes are always in pairs, and are the only paired, black structures in the lower abdomen. Fecal matter, if present, appears as a single black pellet in the lower abdomen and, unlike testes, will break into small pieces if manipulated. If the animal is not aligned so that it is straight from snout to cloaca as it is held in the bag, the testes may not be lateral to each other (i.e., one may be more anterior than the other). However, with gentle manipulation, it is possible to bring both testes back to their normal positions.

The testes of most adult males are obvious and are typically black, large, and slightly pointed on both ends (Fig. 2A). In some

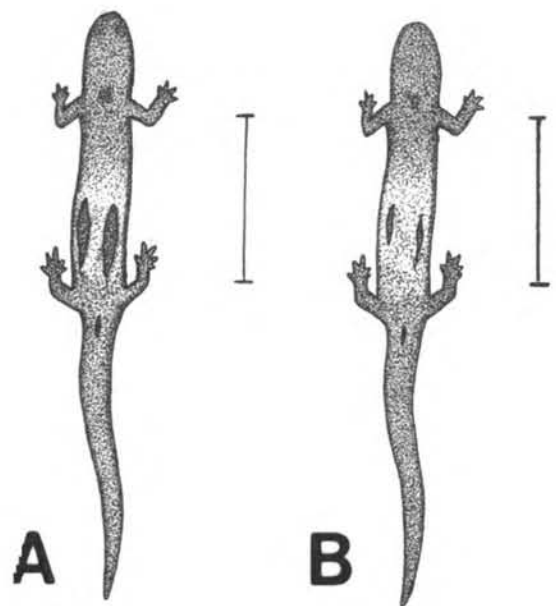


FIG. 2. Relative position and size of testes in red-backed salamanders. A. Most adult males have large, easily detected testes. B. Some testes may be shorter and narrower than others. Scale bars = 20 mm.

adult males, however, often including those held in the laboratory for extended periods of time, testes are relatively short and narrow (Fig. 2B). Testes of immature males (generally < 35 mm SVL) can be more difficult to detect but are identifiable with practice. Such testes have reduced amounts of pigmentation and thus appear gray, with the amount of pigmentation increasing as the animal matures. The testes of immature males are also proportionally much narrower and shorter than those of adult males. We have identified testes in males less than one year old and as small as 22 mm SVL. Ultimately, the appearance of testes represents a continuum, and some may be intermediate to those described in this manuscript.

This technique should prove effective for many researchers requiring a quick, reliable, non-lethal method for sexing red-backed salamanders. In addition, although the specific details concerning male internal morphology may not be applicable in all other salamanders, candling may prove to be especially useful for researchers who wish to sex other species, especially light-bellied plethodontids. With practice, accurate sex determination using this method can take just a few seconds per animal. This simple technique may not only encourage more studies that examine behavioral and ecological differences between male and female red-backed salamanders, but may also spur new research on other species of salamanders.

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## Durability of Silt-Fencing for Drift-Fence Arrays at a Tropical Site

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In 1997, we began to inventory and monitor amphibians and reptiles at the Chatthin Wildlife Sanctuary in north-central Myanmar. One objective was to obtain seasonal activity patterns and abundance estimates of the sanctuary's herpetofauna. Drift-fence arrays seemed a likely method to obtain some of these data.

Aluminum flashing is widely used in the United States for drift-fences (e.g., Corn, 1994). Such material is unavailable or prohibitively expensive in developing nations. It also is costly to transport, i.e., excess baggage charges. Searching for a substitute, one of us (GRZ) read Enge's discussion (1997) and recommendation of silt fencing, and decided to use it, at least for the first year, in the Chatthin herpetofauna monitoring project. Although not avail-



FIG. 1. A local pottery water pot used as pitfall traps for the drift-fence arrays. These containers hold approximately 3.5 liters of water and are about 25 cm high and 30 cm in diameter.

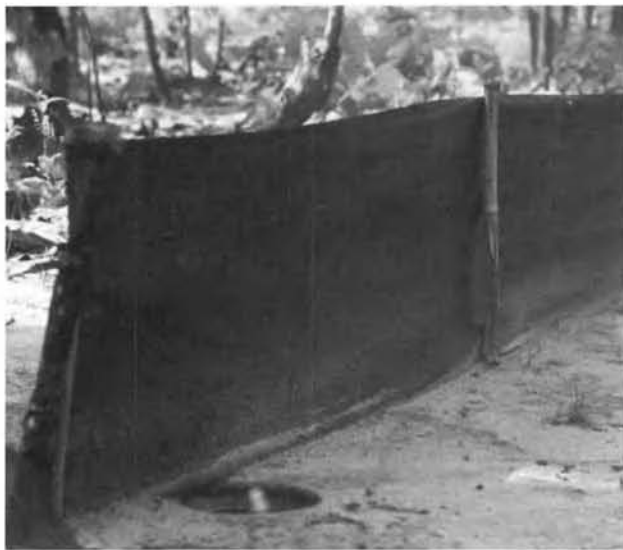


FIG. 2. One arm of the upland array, photographed 6 May 2000, 33 months following fence installation.

able in Myanmar, 100 ft rolls are easily transported in luggage and inexpensive to purchase stateside.

The question of durability remained a major concern. We can now report its high durability and recommend its use. We erected three Y-arrays in early August 1997. The arrays used the local pottery water containers (Fig. 1) as pitfall traps and stakes from locally cut saplings. We stapled the silt fencing to the stakes. As of 6 May 2000, the drift fences are in good condition (Fig. 2) and will remain in operation for one more field season. Each array was placed in a different microhabitat within the dipterocarp forest of the Sanctuary. Canopy cover at the three sites range from approximately 50 to 80%, so the fencing is exposed to some sunlight each day. Temperatures range from daily highs of 45° to 46°C in the premonsoon season to nocturnal lows of 5° to 6°C in midwinter. All sites experience sheet flooding during the heavy rains of the monsoon, one site even in moderate rains. In spite of the range of weather conditions, the silt fencing has not torn or frayed and has not been damaged by large animals.

The arrays have proved a valuable sampling tool, especially for inventorying frogs and lizards and monitoring seasonal movement of these animals. From the beginning, we placed funnel traps, constructed of window screen, at the end of each arm of the array. These traps captured a variety of the larger snake species. The funnel and pitfall traps are opened at the beginning of each month for seven days and checked twice each day, about one hour after sunrise and one hour before sunset. The pitfall pottery usually must be bailed out each morning and evening during the monsoon. When not in use, the pitfalls are covered by a board held in place by a brick; the funnel traps are flattened and stood upright.

Our success recommends silt-fencing drift fences for field studies at other tropical sites.

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## The Visible Implant Elastomer Marking Technique in Use for Small Reptiles

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Mark and recapture studies are used widely in ecology to facilitate the collection of demographic information. Mark and recapture studies of amphibians and reptiles have employed several marking techniques, such as toe clipping (Clarke 1972; Donnelly et al. 1994), scale clipping (Blanchard and Finster 1933; Brown and Parker 1976), shell notching (Cagle 1939), subcutaneous dye injecting (Donnelly et al. 1994), external skin dyeing (Brown 1997), external fluorescent skin dusting (Nishikawa and Service 1988), tattooing (Joly and Miaud 1989–1990), branding (Clark 1971; Sutton 1996), and internal and external tags such as Passive Integrated Transponders (PIT tags) (Jemison et al. 1995; Prentice et al. 1990) and coded wire tags (Beukers et al. 1995; Hale and Gray 1998; Maynard et al. 1996). Often, body size or anatomical features of the study organism limit the choice of marking techniques. For example, toe clipping is practical only for organisms with several digits and dye injection for organisms that have sufficiently translucent skin. The options are especially limited for marking small species.

We have been involved in a relatively long-term mark and recapture study of the federally threatened sand skink, *Neoseps reynoldsi* Stejneger, in which we have monitored the persistence of individuals on research sites. The sand skink is a small, slender, fossorial lizard with maximum snout–vent length of about 68 mm and a maximum total mass of about 3 g (Conant and Collins 1991). The sand skink has four reduced limbs, with only one toe per front limb and two toes per hind limb. The sand skink's small size, fossorial habits, and limb reduction render most marking techniques virtually useless. PIT tags are too large to implant safely, toe clip-



ping yields only a few unique marks, and external paint marks rub off in the abrasive sand through which the sand skink travels.

The only marking technique that has been used with some success on the sand skink is branding (Hill 1999; Sutton 1996). In 1995, when we began our research on the sand skink, we judged branding to be the best available marking technique. Branding was judged to be more useful than other techniques because brands could be very small and would not rub off. We discovered that branding was not useful for relatively long-term studies, however. Brands became difficult to read over time because of shedding and growth (Hill 1999; Sutton 1996), and remained readable for six months or less in fast growing juveniles (Sutton 1996). We required an alternative marking technique for our relatively long-term study, and we selected the injectable Visible Implant Elastomer (VIE) marking technique. Here, we explain the use of the VIE technique to mark the sand skink, and compare safety, reliability, ease of use, and cost of the VIE technique to the branding technique that we employed previously.

VIE, a fluorescent marking material, was developed by Northwest Marine Technology, Inc. for marking juvenile migratory fish for later identification. VIE also has been used for marking other aquatic or partially aquatic organisms, such as juvenile crustaceans and larval and adult anurans (Table 1). The marking technique involves mixing a liquid elastomer with a curing agent, placing it in a syringe, and injecting a small amount (approximately 1  $\mu$ l) of the mixture subcutaneously. The mixture hardens within a few hours into a flexible mark. Often, the mark can be recognized with the unaided eye or, if necessary, through polarized glasses under black light. At present, the elastomer is available in four different fluorescent colors, green, orange, pink, and yellow. By using multiple positions on the body and different color combinations, it is possible to mark hundreds of individuals uniquely.

We needed to ensure that the VIE marking technique was effective and innocuous before applying it to the rare sand skink. We used the common ground skink, *Scincella lateralis* Say, a species similar in body size to the sand skink, to examine survival, behavior, and mark visibility. Six individuals were marked and maintained in the laboratory for six weeks. All individuals survived the procedure and retained readable marks for the six-week period. No change in behavior or locomotory ability was observed. Although the marks were seen more easily through the light ventral skin, marks also could be seen through the more darkly pigmented



FIG. 1. Diagram of marking locations on the sand skink.

dorsal skin when illuminated by black light.

Following successful preliminary testing of the VIE marking technique, we began marking individuals of the sand skink in 1998. Each captured individual was cooled until it no longer exhibited a righting response and then injected with the elastomer at fixed positions on the body. We chose six separate fixed positions on the ventral side of the sand skink for marking, but limited the number of marks on an individual to three (Figure 1). We have used the VIE marking technique on more than 250 individuals over three years (1998–2000).

We examined our ability to identify recaptured individuals and, when present, the extent of mark migration. We found after one year that the pink elastomer appeared yellowish to the unaided eye on 3 of the 28 recaptured individuals (10.7%) that had been marked with the pink elastomer. The same problem was noted in two earlier studies with other organisms (Godin et al. 1996; Willis and Babcock 1998). We could easily distinguish the pink color with a black light, however. Although we found that some individuals experienced minor mark migration from the exact injection point after one year, it did not reduce our ability to identify them. We suspect the mark migration was caused by growth of the individuals, because most individuals that experienced mark migration were juveniles or small adults when marked. We found after two years that most marked individuals still were readily identifiable. We recaptured 13 individuals that had been marked for two years and the marks of 12 of these individuals were readable. Obvious mark migration occurred in six of the 13 individuals, but in only one case did migration render the marks unreadable, because the marks had broken apart and dispersed widely. We suggest that mark migration is more likely to occur the longer an individual is marked. If care is taken to separate marks widely, misidentification because of mark migration can be minimized.

Because we used branding in previous mark and recapture studies of the sand skink, we compared safety, reliability, ease of use, and cost of the branding and VIE techniques. We judged safety by the apparent effect of the techniques on health and survival of marked individuals. We judged reliability by our ability to recognize recaptured individuals. We judged ease of use by the time it took us to train others to use the techniques.

The VIE technique appeared to be at least as safe a technique as branding. We observed no increase in mortality or weight loss when we began using the VIE technique. The VIE technique makes infection less likely than branding, is less invasive, and allows for quicker healing. Branding leaves a relatively large wound and even carries a risk of burning through the body wall. Despite the relative safety of the VIE technique, care still needs to be employed in using it. Inserting needles to inject the elastomer raises the possibility of introducing and/or transferring infection. To avoid this possibility, we suggest wiping needles with alcohol or changing needles before new individuals are marked. We observed no signs of infection of recaptured sand skinks marked with the VIE technique.

The VIE technique appeared to be a more reliable technique than branding. We judged relative reliability first by comparing recapture frequencies in years (1995–1997) when branding was used as the marking technique and in years (1998–2000) when VIE was used. If the two techniques were equally reliable, then using the same capture regime would yield equal recapture fre-

TABLE 1. Comparison of previous studies that have used the Visible Implant Elastomer (VIE) marking technique.

Study	Species	Size range of marked individuals	Maximum length of study	Percentage mark retention	Changes in survival	Multiple marks/colors	Mark recognition	Other
Bonneau et al. 1995	bull trout ( <i>Salvelinus confluentus</i> ); cutthroat trout ( <i>Oncorhynchus clarki</i> )	bull trout: <100 to >400 mm; cutthroat trout: <200 to >200 mm	4 months	2 months 100% 4 months 98.8%	not measured	yes/?	not measured	
Dewey and Zigler 1996	bluegill ( <i>Lepomis macrochirus</i> )	juveniles 34–55 m; adults 73–133 mm	6 months	99% in lab	“no effect”	yes/yes	“good field recognition 98%”	No growth effect (p>.05)
Haines and Modde 1996	Colorado squawfish ( <i>Ptychocheilus lucius</i> )	average 48.9 mm	142 days	85%	No different than other tested techniques (no p value given)	no/no	some problems noted after 142 days	No difference in predation (p = .20) between marking techniques
Uglem et al. 1996	Lobster ( <i>Homarus gammarus</i> )	20–24 mm carapace length	16 weeks	100%	92%	yes/yes		little tag migration
Godin et al. 1996	Shrimp ( <i>Penaeus vannamei</i> )	juvenile = 1.63 g; adult = 38.22 g	10–14 weeks	juvenile 100, 99.9%; adults 100%	juvenile 90.5%, 93%; adults 92.6%	no/yes		differences in tag color recognition
Fredrick 1997	7 species of reef fish	8–55 mm	lab 76 days; field 130 days	lab 100%; field: 2 individuals observed last day	not measured	no/yes	some recognition problems	
Haines et al. 1998	razorback suckers ( <i>Xyrauchen texanus</i> ) Colorado squawfish ( <i>Ptychocheilus lucius</i> )	<i>X. texanus</i> = 127 mm; <i>P. lucius</i> = 150 mm	15 months			yes/yes	<i>X. texanus</i> 74%; <i>P. lucius</i> 60% after 11 months	did not believe this technique was suitable for their species in excess of 1 year

TABLE 1. Continued.

Willis & Babcock 1998	snapper ( <i>Pagrus auratus</i> )		2 weeks	93%	100%	no/yes	difference between color recognition
Linnane & Mercer 1998	lobster ( <i>Homarus gammarus</i> )		3 molts	1.5 months old 100%; 7 months old 100%	1.5 months old 68%; 7 months old 97%		some tag migration
Hale & Gray 1998	brown trout ( <i>Salmo trutta</i> ) and rainbow trout ( <i>Oncorhynchus mykiss</i> )	<i>S. trutta</i> (142–254 mm); <i>O. mykiss</i> (80–314 mm)	24–30 days	94–99%	not measured	yes/yes	
Bailey et al. 1998	salmon ( <i>Oncorhynchus kisutch</i> )	mean length 108 mm	7 months	73%	not measured		
Anholt et al. 1998	Larval anurans ( <i>Rana lessonae</i> & <i>R. esculenta</i> )	≥ 8 mm	5 weeks maximum	85%	100%	yes/yes	no difference in predation (two separate tests; $p = 0.65$ , $p = 0.4$ )
Malone et al. 1999	<i>Coryphopterus nicholsii</i> <i>Lythrypnus dalli</i>	<i>C. nicholsii</i> 30–40 mm; <i>L. dalli</i> 20–30 mm	short lab predation test	not tested	not measured	no/no	no difference in survival to predation ( $p = .836$ , $p = .20$ )
Nauwelaerts et al. 2000	Adult anuran <i>Rana esculenta</i>		8 months in lab	100%	not measured	yes/yes	some marks decreased in size as much as 20%



quencies, as long as the probability of recapturing a marked individual did not change. For the population we studied, trapping devices (drift fence-pitfall trap arrays) and trapping effort (number of trap-days) remained the same in all years, and no differences in mean frequency of movements or distance of movements, or in immigration and emigration rates, were detected between any pair of years (Penney unpubl.). Recapture frequency of individuals marked with the VIE technique was about twice (30% vs. 17%) that of individuals marked by branding (log likelihood ratios with William's correction to G-tests,  $p < 0.001$ ). Another, stronger, measure of relative reliability is the relative likelihood of identifying marked individuals. Of the recaptured individuals, researchers were unsure of the identity of 18% of branded individuals (Hill, unpubl.), but unsure of the identity of only 1% of individuals marked with the VIE technique. Both measures of relative reliability indicate that the VIE technique facilitated better recognition of recaptured individuals than branding. This difference probably arose because brands tend to become less recognizable with time (Sutton 1996).

The VIE technique clearly was easier to master than branding. Learning how to inject the elastomer correctly took less time than learning how to brand individuals correctly, and it caused less harm to individuals in the process. Branding was difficult to master, and individuals may have been injured while researchers learned the technique (Sutton, pers. comm.). Neither technique could be used very easily in the field because they both required ice to immobilize individuals.

The startup cost for branding was less than that for the VIE technique. The hand held cauterizers used for branding cost about \$10 each, but a starter VIE kit costs from \$425 to \$1000. Individual cauterizing units could be used to mark 25–35 individuals before they had to be disposed of (Sutton, pers. comm.), but the \$1000 starter VIE kit could be used to mark at least a few thousand individuals. The costs per individual for branding and the VIE technique would be comparable (about \$0.40 per individual) if 2000 individuals were marked with the VIE starter kit. The minimum amount of elastomer that must be mixed is more than could be used for marking only a few individuals even when the minimum amount recommended by Northwest Marine Technologies is halved. For this reason, we suggest that the VIE technique probably is cost prohibitive for marking only a few individuals at a time. We were able to keep the elastomer in a liquid state on ice or in a freezer for approximately one week, however, although it sometimes hardened beyond usefulness, and others have stored it in the freezer for two to three weeks (Nauwelaerts et al. 2000).

Our results extend the usefulness of the VIE technique beyond apparent limits. Previously, the VIE technique was thought not to be useful for experiments that extended more than one year (e.g., Haines et al. 1998). Our results suggest that the VIE technique can be reliable for at least two years in some organisms. Previously, the VIE technique has been used, as far as we know, only for aquatic and partially aquatic species. Although the VIE technique has been used to mark the terrestrial phase of anurans (Nauwelaerts et al. 2000), our results demonstrate that use of the technique can be extended to completely terrestrial species.

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## HERPETOLOGICAL HISTORY

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### The Writings of Sherman Bishop: Part II. Conservation

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The end of the twentieth century was met with a flurry of activity to address issues of amphibian and reptile declines. Herpetologists and conservationists concerned by the growing reports of species losses formed organizations such as the Declining Amphibian Population Task Force (DAPTF) and Partnership in Amphibian and Reptile Conservation (PARC). While these efforts have led to many studies, status assessments, and advances in species conservation, concern over the loss of habitat for amphibians and reptiles and abuses faced by individual species are not new endeavors. Origins of herpetofauna conservation can be traced to an earlier period. One prominent voice in the attempt to raise awareness of this often-maligned group of organisms was Sherman C. Bishop (1887–1951). Bishop was a prominent herpetologist and naturalist working primarily in New York State during the first half of the twentieth century. Bishop's principal legacy lies in his contributions to the knowledge of the life history and developmental biology of salamanders (Grobman 1952; Hunsinger 2000). What has been overlooked in discussions of Bishop was his passion for species and habitat conservation.

Sherman Bishop addressed issues of conservation in publica-

tions, lectures, and personal letters. He also worked very hard to try to educate and raise awareness and interest in the natural history of amphibians and reptiles, particularly salamanders. From his lecture notes on salamanders, Bishop stated in the introduction,

“Among all the little creatures of the woods and streams none have been so neglected as the salamanders and none are of greater interest. And there still remains the opportunity for those who have the interest and persistence, to make valuable contributions to our knowledge of the group.”

Bishop's interests in education and public awareness are exemplified in one of his favorite stories which concerned the mythology that surrounded the Mudpuppy (*Necturus maculosus*), a species that Bishop researched extensively (Bishop 1926). In lectures he relayed the following account:

“The first salamander I wish to talk about... is the Mudpuppy or water-dog. It should be known as the newspaperman's perennial [sic] friend, for it provides a news item at least once a year in all parts of the range of the animal. This is always the 'strange animal unknown to science' notwithstanding it was first described in 1799 and given a name in scientific literature as early as 1818.



FIG. 1. Bishop's library stamp, drawn by friend Hugh P. Crisp. This depicts Bishop's array of interests including scientific literature, amphibians, reptiles, fish, spiders, and his boyhood home in the Finger Lakes Region of New York. (Courtesy of Beth Bishop Flory)

Once while I was at the State Museum in Albany, a reporter for one of the local papers brought to me a living Mudpuppy taken that day in the nearby Hudson. Here I thought, is a reporter that wishes some information and may be expected to tell the truth when he knows it. So I took the time to tell him all about the animal, where they live, what they eat and something about their nearest relatives. Among other things, I told him that their nearest relatives were found in some of the caves of Europe. I looked in the paper the next day and here again was the old story about the 'strange animal unknown to science,' a fish with four legs and with its ear split into three parts and believed by zoologists at the State Museum to be of European origin having reached the Hudson by way of an underground channel from Bavaria."

Bishop lectured on salamanders throughout the northeastern United States during the 1930s and 1940s. In a letter to long-time colleague W. P. Alexander at the Buffalo Museum of Science, dated 19 May 1937, Bishop wrote:

"I will be glad to talk on salamanders. I have given this same lecture in Boston and at fair Harvard where it was received with acclaim at the Boston Society of Natural History and with sadness at Harvard. At the last named institution, my talk revealed to one of the graduate students that he had written a doctor's dissertation dealing with one species of salamanders which he had misidentified and confused with another."

Cornell professor and lifetime friend Albert H. Wright undoubtedly influenced Bishop's interest in conservation. As an undergraduate, Bishop traveled to the Okefenokee Swamp in 1912 with Wright and co-authored his first paper (1915) on the snakes of the region. Wright is credited with helping to preserve the Okefenokee Swamp. Wright's influence is seen in Bishop's first publication on salamanders. In his lengthy account of the four-toed salamander (*Hemidactylium scutatum*), Bishop (1919) cited Wright (1918), who stated, "The four-toed salamander... is vanishing with the drying up or draining of sphagnum bogs and feather bed swamps." Bishop continued the discussion of habitat alteration by stating, "It is certain that the final conversion of sphagnum areas will mark the extirpation of the species in such localities." It is worth noting that Wright (1918) was writing about the decline of habitat of the Bog Turtle (*Clemmys muhlenbergii*), a species that is currently one of the most imperiled turtles in the northeastern United States. The expanding use of gasoline-powered engines in the early 1900s must have rapidly accelerated the rate of wetland dredging and filling as backhoes and bulldozers were able to make the efforts of men much easier. This obviously did not go unnoticed by Bishop and Wright.

In *The Amphibians and Reptiles of Allegany State Park* (Bishop 1927), Bishop again struck a conservationist tone. In the introduction he stated, "The amphibians are timid and inoffensive. Some, as the toad, are beneficial because of the noxious insects, slugs, etc., that they destroy."

Bishop (1927) also tempered some of the common misconceptions about the impact of nongame species on game species that has been prevalent in state management agencies. He wrote, "A few, the Water snake and Garter snake among them, are harmful when under certain conditions they kill too many valuable food fishes and toads." Bishop's comments were quite benign when compared to those of his colleague Elon H. Eaton. Eaton (1928) wrote, "I believe the water snake should be destroyed by all sportsmen whenever they have the opportunity." Bishop and Eaton were

more than just casual acquaintances. They went on collecting trips for Timber Rattlesnakes (*Crotalus horridus*) together in 1925 (NYSM 2623, 2627), and worked summers on the New York State Watershed Surveys conducted by the Conservation Department. Eaton also authored the text *Birds of New York* (Eaton 1910, 1914), published by the State Museum just preceding Bishop's tenure as Zoologist. Despite their close professional relationship, their attitudes towards reptiles could not have been farther apart. Eaton (1928) also wrote:

"The softshell turtle (*Amyda spinifera*) which inhabits Keuka, Seneca, and Cayuga is a predacious species which frequently feeds on fish. The same is true of the generally distributed snapping turtle."

The account also included a photograph of a snapping turtle with an inscription similar to a federal warrant, stating "Soft shell (sic) turtle (*Amyda spinifera*), enemy of shallow water fish." Although the photo was incorrectly identified, the view towards these species could not be mistaken.

The plight of the Timber Rattlesnake (*C. horridus*) was also of concern to Bishop in his accounts of the herpetofauna of Allegany State Park. It is evident from his remarks that he was fully aware of the dangers that a population faced when confronted with increased human activity. Bishop (1927) wrote in the introduction:

"The Timber Rattlesnake is found in numbers in several restricted areas in the park and surrounding reservation. Confined, as they are, to the out-of-the-way places where they are not likely to be encountered by the camper and tourist, they may be expected to persist for years as one of the most striking and interesting animals of the region."

Bishop reinforces this sentiment in the species accounts, stating:

"The Timber Rattlesnake has never been found in any section of the park set aside for the use of campers and tourists. It is therefore not likely to be encountered and can not be regarded as a source of danger to those visiting the region."

In the description of the regions of the park, Bishop again returned to the theme of human pressure on rattlesnakes by writing:

"Limestone Hollow is locally celebrated because of the work of 'Rattlesnake Pete' of Rochester who secured many specimens from the region."

It is hard to determine if it was Bishop's quest for scientific accuracy (an attribute that was evident in all his work and the review of his work by others) or his naiveté of the extent of the pressures this species faced, but his detailed description of the den areas may have hastened the decline of rattlesnakes in the park. In describing the area of Peters Run he wrote:

"The cracks and cavities in this conglomerate ledge are noted among the inhabitants of the region as being the denning up place for the Timber Rattlesnake. Peters Run is one of the few localities where rattlesnakes occur in numbers within the park area."

Thirty years later, rattlesnakes were rarely seen in the park. Stewart (1961) wrote about her 1957 field work, "Most of the 'snake stories' that the natives tell of seeing rattlers in the park are from years ago; few people have seen a live rattler in recent years, except near the den sites." Recent work indicates that the species is extirpated from the park and surrounding area.

Bishop was decades ahead of the rest of the northeast in attempts to educate the public and conserve the Timber Rattlesnake.



Many counties of New York State offered bounties on rattlesnakes for many decades after Bishop's account. In the 1940s, the State Conservation Department attempted an experimental eradication program for rattlesnakes in Essex County that involved using dynamite to blast the main den areas (Stechert, in Brown 1993). A high school science textbook in use in New York State (Wood and Carpenter 1938) in the decade following Bishop's remarks stated, "Rattlesnakes, copperheads, and cobras are the worst enemies of man." It was thirty years between Bishop's writings and the next published account expressing concern about the plight of the Timber Rattlesnake in New York (Wright and Wright 1957). It was not until 1984 that the state protected rattlesnakes from the type of extirpation feared by Bishop, long after it had disappeared from Allegany State Park.

Bishop's strongest statements about habitat alteration during his work in Allegany State Park did not appear in his publication, but rather in a letter written to Charles Adams, Director of the New York State Museum. On 18 August 1926 Bishop wrote from his camp:

"Some fine collecting places have been destroyed in the process of 'improving' the park and among them one of the two known streams for the Red Salamander. It seems to me that conditions might be improved at the park if someone would direct the efforts of the laborers engaged in clearing certain areas for the use of campers."

The Red Salamander (*Pseudotriton ruber*) was taken in the area Bishop referred to on 3 August 1922 (NYSM 3205). Recent attempts to find *P. ruber* in the Park have failed (unpubl. data).

Bishop also acknowledged the decline of the Box Turtle (*Terrapene carolina*) in the greater Albany, New York area. In response to a letter received at the State Museum inquiring about a turtle that had been seen in Victory Mills, New York, Bishop wrote on 13 July 1928:

"Judging from your interesting account, I believe the turtle you have found is a Box-turtle. Formerly the Box-turtle was common at Albany but the frequent burning over of the sand plains has probably wiped it out."

Fire was a natural occurrence in the Albany Pine Bush prior to European settlement and fire suppression. Although it is hard to tell what role these changes played, if any, in the decline of the Box Turtle, we must recognize Bishop as one of the earliest herpetologists to address the decline of this overharvested species. Bishop (1923a) noted this decline in his accounts on the herpetology of Albany County a few years earlier.

Bishop left the State Museum in August 1928 to take a position at the University of Rochester. His concern for habitat alteration continued to grow during this period. His harshest comments on this topic are found in a letter to Charles Adams dated 12 June 1929. Bishop wrote:

"The Mendon Ponds area is being developed for park and picnic purpose. I was sorry to see that wide boulevards are being constructed all through the place so that auto tourists will be able to get in and pick all the curious flowers."

A Bog Turtle from Mendon Ponds on 26 June 1931 (NYSM 2220) was placed in the collection of the now defunct University of Rochester Museum of Natural History. This is the only report of their occurrence in the park.

In the same letter to Adams, Bishop continued, "Bergen Swamp, which I visited for the first time last week, is a remarkable place and should be preserved just as it is. I wish you could stop off long enough some time to visit the place with me." Bishop would spend the rest of his life working to ensure the preservation of Bergen Swamp as an active member of the Rochester Academy of Sciences (RAS), for which he served as the president in 1946–1947, and the Bergen Swamp Preservation Society, which formed in 1912. Bergen Swamp is one of only two localities of the Massasauga Rattlesnake (*Sistrurus catenatus*) in the state and supported a population of Bog Turtles during Bishop's life. At the time of Bishop's death it was written in the Museum Service Bulletin (1951) that, "He had been one of the most active supporters of the Rochester Academy of Science and the Bergen Swamp Preservation Society." Bishop was appointed Fellow of the Rochester Museum of Arts and Sciences in 1946 "for his attainments as a scholar, and for his contributions to this community in promoting a broader appreciation of the place of science in life." Bishop's strong interest in conservation was a perfect match for RAS, as its members were instrumental in helping to establish the Everglades National Park as well.

Bishop was a man of many talents and interests. It would be incorrect to categorize him only as a herpetologist, considering that he authored or co-authored more than 100 papers on spiders (Adler 1989) and spent seven summers working on the watershed surveys of New York State documenting fish distribution (see Fig. 1). Due to his diverse, yet accurate, knowledge of the natural world, Bishop has deservedly been called a field naturalist (Adler 1989). His concern for species preservation outside of herpetology was voiced just as strongly. A paper entitled "More Bird Protection Needed" (Bishop 1923b) states in part:

"An additional large number hunted in and out of season, killing nongame birds and game birds greatly in excess of the legal limit. This is the wholesale drain on the wild life of a limited region; if the record is extended to cover the country, the result is appalling."

In fixing the limits of the reproductive capacity of birds Nature did not take into consideration the automatic shot gun or the ability of man to construct nets and snares."

Still, Bishop's most vocal efforts centered on the effect of habitat destruction on salamanders, a group of organisms he spent his life studying. Bishop (1941) wrote in the introduction to *The Salamanders of New York*:

"If any justification is needed for the publication of the detailed records accompanying the accounts of the species, it is to be found in the rapidly changing conditions which, in various parts of the state, have brought about the extermination of certain species over wide areas. These changes may be expected to continue and exert an ever-increasing pressure as swamps and marshes are drained, and land cleared."

Bishop was no clairvoyant, yet his prediction of salamander declines in regions of New York are being realized. Recent attempts to locate Mudpuppies in Salmon and Black Creeks (Monroe County) were unsuccessful (T. W. Hunsinger and W. L. Hallahan, unpubl. data, 2000 survey). Bishop (1941) cites many specimens from these localities spanning a decade.

Bishop again took the role of advocate for the study of the natural history of salamanders in the preface to his major work, *Hand-*

book of Salamanders (Bishop 1943). The first lines of the text are an invitation to advance the scientific knowledge of the group. In it he writes:

"It is hoped that this handbook may be of help to the growing number of persons interested in salamanders and perhaps lead some of them to more detailed studies of many of the forms than I have been able to make."

Sherman Bishop was a rare combination of dedicated scientist with an insatiable thirst for an understanding of the natural world and advocate for species and habitat conservation at a time when few people were thinking about, let alone advancing, the issue. He took full advantage of every opportunity to try to educate others and share his enthusiasm for amphibians and reptiles with any audience. After his death it was written in the Museum Service Bulletin (1951), "With all that he was a very human person who liked outdoor life, and shared his enthusiasm with all who came in contact with him, giving encouragement to the student and amateur alike."

Perhaps the passing of Sherman Bishop was best expressed in a letter from D. L. Gamble of Ward's Natural Science Establishment to Karl P. Schmidt concerning the shipment of Bishop's specimen collection from Rochester to the Chicago Natural History Museum (Field Museum of Natural History) dated 2 October 1951. Gamble wrote, "I miss Sherm Bishop very much. I talked with him just a week or so before his death. His death was a great loss to zoology and we can ill-afford to lose men of his calibre (sic)." Indeed, Bishop's death silenced a passionate voice for the advancement of knowledge and conservation for this group of "neglected" animals, as Bishop frequently referred to them.

*Acknowledgments.*—I thank Kraig Adler, Robert Daniels, Beth Bishop Flory, Bill Hallahan, Alan Resetar, and Roy McCaig (RAS) for their assistance in researching this paper. Robert Daniels and Kimberley Corwin Hunsinger reviewed drafts of the manuscript and provided insightful comments. This is contribution number 826 of the New York State Museum and Science Service, the last in the series.

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## HERPETOLOGICAL HUSBANDRY

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### Multiple Generations, Multiple Clutches, and Early Maturity in Four Species of Monitor Lizards (*Varanidae*) Bred in Captivity

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We report on the successful reproduction of four species of monitor lizard (*Varanus glauerti*, *V. kingorum*, *V. pilbarensis*, and *V. caudolineatus*) maintained by the senior author. All are currently assigned to the subgenus *Odatria* (King and Green 1999). There are no previous literature reports of captive breeding of these species. All species are housed under the same conditions. The animals are kept in pairs or trios in enclosures approximately 130 x 60 x 80 cm (L x W x H), with 30-cm deep substrate (loam and grit), and stacked boards to provide hiding places. Water is added to the substrate in sufficient quantities to ensure that the lower levels are always moist. Temperatures in the enclosures range between 28°C and 66°C, maintained 24 hours a day. Heat is provided by spotlights and heating mats. The animals are fed crickets of various sizes dusted with a 3:1 by volume mix of Rep-Cal® and Herptivite® and small mice. Food is provided generously.

Initial copulations are observed more or less continuously over three to five days. Prior to production of subsequent clutches the

mating period is shorter (about 24 h). Throughout the mating period the pair stay in close contact. Eggs are buried in the substrate, usually at night (despite the 24 h light cycle). They are removed immediately and incubated in a 1:1 mixture by weight of perlite and water. Initially clutches were incubated at a constant 30.6°C. Under these conditions eggs of all species hatched after 90–100 days (exceptionally 65–110 days). Subsequently, incubation temperatures were allowed to fluctuate between 28.5°C and 32.5°C. Incubation times for individual species under these conditions are given below.

*Varanus kingorum* has been maintained since 1993. During this time six generations of captive animals have been produced. Clutch size is typically two but as many as six eggs have been laid. Up to 14 clutches of eggs have been produced by a single female in as many months. Incubation takes 65–80 days under the conditions described above. Hatchlings have a total length of about 15 cm. Both sexes become sexually mature at four months of age. Males are removed from enclosures after egg laying to allow females to regain condition.

Since 1996 *V. glauerti* have produced a total of five generations of captive bred animals. Females produce up to 68 fertile eggs in eight clutches over eight months; eggs hatch after 90–110 days. Average clutch size is nine with a maximum of 12 eggs. Hatchlings measure approximately 18 cm total length and can reach maturity at around seven months of age. Males are separated from females after egg laying.

Since 1997 three generations of *V. pilbarensis* have been produced. Clutch size averages four eggs, with a maximum of six. Up to six clutches are produced per year, usually laid two weeks apart over 2–3 months followed by a pause of nine months. Eggs typically hatch after 80 days, sometimes as quickly as 65 days. Hatchlings measure approximately 13 cm total length and can reach sexual maturity as early as eight months of age. It has not been necessary to separate sexes after egg laying because females regain condition rapidly.

Three generations of *V. caudolineatus* have been produced since 1997. Typically 5–6 clutches of eggs are produced over four months, followed by an eight month pause. Clutch sizes of 2–3 eggs are common, however a maximum of five eggs have been laid. The eggs hatch between 65 and 80 days and reach sexual maturity at the age of five months. It has not been necessary to separate sexes after egg laying.

Although multiple clutches have been recorded many times in captive monitor lizards (Card 1994; Horn and Visser 1990, 1997; Vincent and Wilson 1999) and occasionally in wild populations (Shine et al. 1996), the numbers of clutches reported here are much higher than those previously reported for any captive monitor lizard. Similarly, the ages at maturity reported here are much lower than those in the literature. The results suggest that, given conditions of almost unlimited access to food and heat, these lizards are capable of much higher rates of growth and reproduction than had been previously supposed. They further suggest a capacity for rates of metabolism that are at present undocumented.

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## NATURAL HISTORY NOTES

Instructions for contributors to Natural History Notes appear in Volume 32, Number 1 (March 2001). Submissions should be directed to one of the section editors (contact information located on inside front cover of this issue), as follows: amphibians (Painter); lizards, amphisbaenians, crocodylians, *Sphenodon* (Hayes); snakes and turtles (Butterfield).

### CAUDATA

**BATRACHOSEPS STEBBINSI** (Tehachapi Slender Salamander). **ATTEMPTED PREDATION.** Examples of predation are known for only a few species of *Batrachoseps*, and none has been reported for *B. stebbinsi*, a species with a very restricted distribution in the Tehachapi Mountains of south-central California, USA (Hansen and Wake, *in press*. In M. J. Lannoo [ed.], *Status and Conservation of U.S. Amphibians.* University of California Press, Berkeley).

On 18 March 2000, two of us (TB, SW) observed a female *Diadophis punctatus* (190 mm SVL) attempting to constrict an adult *B. stebbinsi* (54 mm SVL). Both were located beneath small rocks at the base of a north-facing talus slope. The snake had seized the salamander just anterior to the hind limbs and was attempting to encircle the salamander's body with coils, but with little success. The snake appeared rather thin, perhaps having recently emerged from winter dormancy. After a ca. 15 minute struggle, the salamander dislodged the snake by dragging it down among smaller rock fragments and escaped. This observation was made at 1400 h at an air temperature of 20°C within Caliente Canyon, Kern County, California.

Ringneck snakes readily consume *Batrachoseps* in captivity (Hubbard 1903. *Univ. California Publ. Zool.* 1:157–170; RWH, pers. obs.). As the distribution of *D. punctatus* overlaps the ranges of most species of *Batrachoseps*, several authors (e.g., Stebbins 1954. *Univ. California Publ. Zool.* 54:47–124) have suggested that ringneck snakes likely are natural predators.

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**EURYCEA LONGICAUDA LONGICAUDA** (Long-Tailed Salamander). **PREDATION.** Little is known about predation pressures faced by long-tailed salamanders. On 17 Sept 2000, we col-