IRCF

REPTILES & AMPHIBIANS

CONSERVATION AND NATURAL HISTORY

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SPECIAL ISSUE, PART III:
A Tribute to Henry S. Fitch

JOSEPH SAGE

An Eastern Massasauga rattlesnake (*Sistrurus catenatus catenatus*) education and outreach initiative in Michigan seeks to provide accurate and consistent information pertaining to rattlesnakes and provide people with knowledge and skills to make informed decisions about how to safely co-exist with rattlesnakes. See article on p. 130.

MIGUEL A. LANDESTOY T.

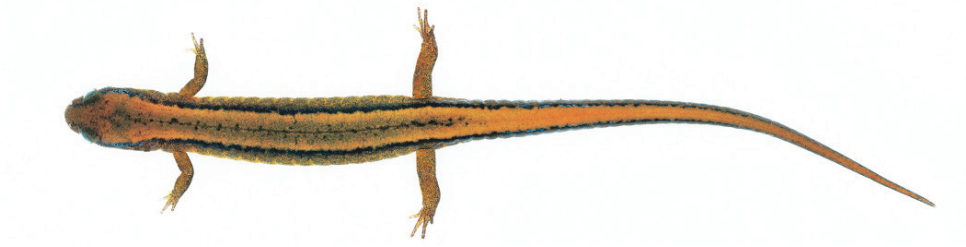
The Smooth-scaled Worm Lizard (*Gymnophthalmus underwoodi*), which is widely distributed throughout northeastern South America and in the southern Lesser Antilles, has been reported for the first time from the Dominican Republic (Hispaniola) in the Greater Antilles. See article on p. 180.

KENNETH L. KRYSKO

African Five-lined Skinks (*Trachylepis quinquetaeniata*) are established in Port St. Lucie, St. Lucie County, Florida. The subadult male (left) is losing the juvenile pattern, whereas adult females (right) maintain the juvenile pattern throughout life. See article on p. 183.

DIRK J. STEVENSON

Eastern Indigo Snakes (*Drymarchon couperi*) are rarely encountered in the wild. A long-term mark-recapture study in southern Georgia, much like those conducted in eastern Kansas by Henry Fitch, seeks to enhance our understanding of this charismatic snake. See article on p. 146.



BRANDON BALLENGÉE AND STANLEY K. SESSIONS

This is a digital scan of a live Northern Two-lined Salamander (*Eurycea bislineata*). See article on p. 153.

Front Cover: John Binns

The Honduran Paleate Spiny-tailed Iguana (*Ctenosaura melanosterna*) has a distribution restricted to the Valle del Aguán and the Cayos Cochinos off the coast of Honduras. Along with the other members of the *C. palearis* clade, it has been listed in CITES Appendix II. See article on developing conservation strategies in Central America on p. 136.

Back Cover: Alejandro Sánchez Muñoz

Three amphibians were included in the list of the world's 100 worst invasive species. The Coqui (*Eleutherodactylus coqui*) is an icon in Puerto Rico, where it is endemic and where this photograph was taken, but it poses a serious threat to endemic arthropods and insectivorous birds in Hawai'i, where it was introduced with decorative plants. See Newsbrief on p. 187.

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CONSERVATION AND NATURAL HISTORY

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AARON FORTIN

Michigan is home to the greatest number of remaining Eastern Massasauga rattlesnake (*Sistrurus catenatus catenatus*) populations in the United States. With support and cooperation of the public, it can serve as a model for how people can safely co-exist with rattlesnakes.

Michigan's Eastern Massasauga Rattlesnake Outreach Initiative: Rattlin' an Image

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The Eastern Massasauga rattlesnake (*Sistrurus catenatus catenatus*) is one of North America's smallest rattlesnakes, measuring, on average, less than two feet in length (Ernst and Ernst 2003). Its cryptic coloring and defensive stance of "sitting tight" make this animal difficult to detect, even by trained technicians (Black and Parent 1999).

The range of the Eastern Massasauga rattlesnake extends from southern Ontario and central New York west to Iowa and eastern Missouri (Ernst and Ernst 2003). Michigan is believed to be central in the range of this animal and currently provides its last stronghold in terms of known populations.

The conservation plight of this animal was already apparent in the mid-1990s, and a status assessment of the species was published by the United States Fish & Wildlife Service (USFWS) (Szymanski 1998). Reported threats to the snake included habitat loss and degradation and human persecution (Szymanski 1998), and the snake was granted "candidate" status by the USFWS in 1999.

History of the Outreach Initiative

In 2001, Michigan began the process of entering into a Candidate Conservation Agreement with Assurances (CCAA) with the USFWS to enable continued management of habitat for Eastern Massasaugas, in spite of some incidental take in the process. As a part of the CCAA, the Michigan Department of Natural Resources and Environment (MDNRE) and Michigan Natural Features Inventory (MNFI) applied for funds from the USFWS to enter into educational outreach as a part of their efforts to address current conservation threats to the species in Michigan as reported by Legge (1996). Unfortunately, the educational outreach portion of the CCAA proposal was not funded through USFWS and so other potential funding was sought.

In 2002, one of the authors (Christoffel) entered into a graduate degree program at Michigan State University (MSU) with the intent of studying the human dimensions of snake conservation and management. She met with MDNRE and MNFI personnel prior to arrival on campus to

KILE KUCHER

Eastern Massasauga rattlesnakes (*Sistrurus catenatus catenatus*) are among the smallest North American rattlesnakes.

discuss opportunities to work together on testing the efficacy of educational outreach for conservation of Eastern Massasaugas.

In 2003, we applied for and received funding through the U.S. Environmental Protection Agency's (EPA) Environmental Education Grants program to develop and implement an educational outreach initiative featuring Eastern Massasaugas in southeastern Michigan. This area is one in which a number of Eastern Massasauga populations have been documented, human population pressures have been increasing, and human-snake conflicts are likely. A second application was made and funded by the U.S. EPA in 2007 to expand our efforts to southwestern Michigan, another area with a number of Eastern Massasauga populations that has been experiencing rapid human population growth.

The goals of the project were fourfold: (1) Develop and initiate an Eastern Massasauga education and outreach initiative in Michigan modeled after similar efforts in Ontario, (2) provide accurate and consistent information pertaining to Eastern Massasaugas, (3) provide people with knowledge and skills to make informed decisions about how to safely coexist with Eastern Massasaugas, and (4) identify and develop strategies or mechanisms for sustaining Eastern Massasauga education and outreach for the long-term.

Six objectives were identified for our project: (1) Assess public attitudes toward the Eastern Massasauga and snakes in general, (2) develop and/or revise educational materials about Eastern Massasaugas and snakes in general, (3) develop a local resource network to deal with human-snake conflicts, (4) develop and conduct educational workshops, (5) promote balanced media coverage of the Eastern Massasauga and snakes, and (6) evaluate the effectiveness of our efforts.

We identified several target audiences for our efforts: Natural resource managers, naturalists, outdoor writers, landowners living in rattlesnake habitat, wildlife damage operators and animal control personnel, educators and schoolchildren, future "snake responders," veterinarians, local hospitals and health departments, and utility workers.

We used an approach modeled after an existing and successful program in Ontario that was developed and conducted by the Toronto Zoo and the Canadian Eastern Massasauga Rattlesnake Recovery Team. This approach consisted of workshops featuring a talk and PowerPoint presentation given by two of the authors (Christoffel and Lee) and Andy Snider (then Curator of Reptiles at the Detroit Zoo), an essential member of our team. The workshop consisted of several components, including a discussion of the value of snakes, the natural history of snakes in Michigan, identification of the Eastern Massasauga and five of its mimics or look-alikes, the ecology and conservation status of the Eastern Massasauga, threats to this species, and research and conservation efforts focused on Eastern Massasaugas in Michigan. Participants were given the opportunity to view an Eastern Massasauga and its mimics or look-alikes in tanks during the program. The look-alike snakes were handled during the program by one of the presenters who "modeled" a safe interaction between a human and snake. The latter half of the program dealt with human-snake interactions and included a discussion of how to encourage or discourage snakes from living on your property, the use of snake deterrents, how to avoid and treat Eastern Massasauga bites, and, for professional audiences, how to communicate with the public about rattlesnakes. At the end of the workshop, audiences were given a demonstration on how to safely move an Eastern Massasauga from an area if absolutely necessary. The presenters stressed the importance of leaving the snake alone to leave or move along on its own whenever possible.

YU MAN LEE

U.S. Environmental Protection Agency (EPA) Environmental Education Grants funded the development and implementation of an educational outreach initiative featuring Eastern Massasauga Rattlesnakes in southeastern Michigan.

A list of workshop venues and target audiences was compiled by one of the authors (Hyde) to guide our efforts, make efficient use of resources, and ensure that we reached the audiences most likely to benefit from the programs. In addition, we wanted to minimize travel distances for audiences while attempting to reach as many people throughout the study area as possible.

To design our workshops, we began by attending an Eastern Massasauga workshop held by the Toronto Zoo and led by Bob Johnson and Andrew Lentini. The script and accompanying PowerPoint presentation we developed for use in Michigan were based on the Toronto material as well as workshop materials used by one of the authors (Christoffel) in Wisconsin that featured the Timber Rattlesnake (*Crotalus horridus horridus*). One of the authors (Christoffel) designed pre-program, post-program, and long-term assessment instruments or surveys to measure gains in knowledge and changes in attitude that occurred as a result of attending a workshop.

In 2004 and 2005, we conducted 23 workshops that were attended by >700 people. This included nine natural resource professional and naturalist audiences, and 14 workshops for private landowners and the general public, including a workshop for about 270 sixth-grade students and their teachers and chaperones. In 2008 and 2009, we held 19 workshops in southwestern and southeastern Michigan that were attended by >700 participants. These included six workshops specifically for naturalists, natural resource, and other professional personnel, one workshop for medical professionals, nine workshops for private landowners and the general public, and three workshops for combined natural resource professionals and the general public. Natural resource and other professionals that attended the Eastern Massasauga workshops in 2008 and 2009 represented more than 30 different public or private agencies and organizations.

We reviewed existing education and outreach materials about Eastern Massasaugas and their management to identify materials that we could use in their current form or that could be revised for use in Michigan, and materials we would need to develop. New educational materials produced by our team included a "Snakes of Michigan" identifier, an Eastern Massasauga rattlesnake fact sheet, guidelines for interpreting venomous reptiles to the public, a listing of Eastern Massasauga rattlesnake contacts and information resources, and a PowerPoint presentation and accompanying script for use by natural resource professionals and naturalists.

The Ontario team, particularly Bob Johnson and Andrew Lentini, were incredibly supportive of our efforts and provided us with many materials that we were able to adapt for use in Michigan including a "dogs and snakebite" fact sheet. Andy Snider of the Detroit Zoo orchestrated the transformation of an existing poster from Ontario for its use with Michigan audiences. A Michigan Eastern Massasauga rattlesnake web site (http://web4.msue.msu.edu/mnfi/emr) has been developed. It was modeled after the Canadian Eastern Massasauga Rattlesnake Recovery Team's site (http://www.massasauga.ca). A snakebite prevention and treatment fact sheet was assembled from Minnesota, Wisconsin, and Ontario materials. We obtained permission from Bob Hay, retired herpetologist from the Wisconsin Department of Natural Resources, to take a Wisconsin brochure

YU MAN LEE

The volunteer snake responder network in Michigan consists of trained professionals and citizen volunteers who deal with human-snake reports and conflicts in local communities.

about how to live with snakes and adapt it for use in Michigan. Funding was obtained to reprint the USFWS brochure, "Live and Let Live," featuring the Eastern Massasauga. A MNFI species abstract, Detroit Zoo brochure, and MI DNRE information card about the Eastern Massasauga also were distributed.

Because not all target audiences were able to attend the workshops, especially law enforcement personnel, we initiated production of an Eastern Massasauga training DVD that individuals can view at their convenience. Funding for production of this DVD was granted by the John Ball Zoological Society in 2008 and the Michigan Society of Herpetologists in 2009. We have been working with Steven Evans of MSU's College of Agriculture and Natural Resources (CANR) Communications Office to produce the DVD. The DVD will be available in autumn of 2010 through MNFI, and will be distributed to project partners and priority target audiences whom we were unable to reach through our workshops.

Efforts to develop and maintain a corps of volunteer snake responders to deal with human-snake reports and conflicts in local communities were initiated in 2004. This effort was modeled after volunteer snake responder programs in Minnesota and Wisconsin. We developed a second training module for individuals who had attended one of our workshops and were interested in helping us in our snake conservation and management efforts. Andy Snider of the Detroit Zoo had a great deal of experience in dealing with phone calls from angry or frightened people who wanted someone to come out and remove what they believed to be rattlesnakes on their properties. He was able to guide us in deciding what specific questions to ask of callers to determine whether an on-site visit was needed. He emphasized the need to calm excited callers in order to obtain useful information.

The volunteer snake responder network in Michigan consists of trained professionals and citizen volunteers who are coordinated regionally and statewide. In 2006, we had trained 13 volunteers and identified another 20 potential volunteers. In 2009, we held two volunteer training workshops and were able to train an additional 17 individuals and identify another 75 potential volunteers. The MNFI currently serves as the statewide coordinator of the volunteer network in collaboration with the MI DNRE, and the Binder Park Zoo and Detroit Zoo currently serve as the regional coordinators. An Eastern Massasauga response protocol was developed to guide regional network coordinators and volunteer snake responders.

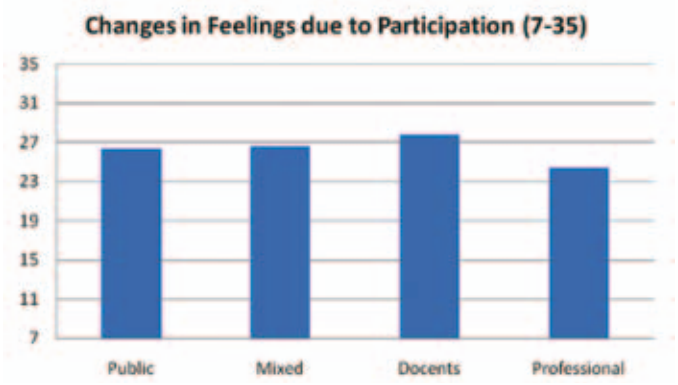
We identified outdoor writers in Michigan with whom we could collaborate on feature stories about Eastern Massasaugas. We wrote or cowrote several articles with information on the identification, natural history, management, and conservation of Eastern Massasaugas and other Michigan snakes. Among these was a special issue of the Toronto Zoo's "Rattlesnake Tales" newsletter highlighting Eastern Massasauga research, outreach, and conservation efforts in Michigan.

Our assessment of the Eastern Massasauga workshops demonstrated that participants increased their knowledge and had more favorable attitudes toward snakes after attending our programs. We also found out that fear levels did not change, although our participants generally demonstrated a healthy respect for the animal and thus would not put themselves in situations where they were likely to be bitten (i.e., handling an Eastern Massasauga Rattlesnake or trying to kill such a snake).

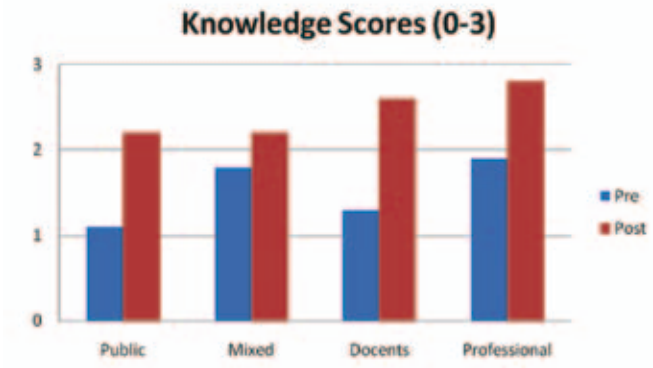
Future of the Outreach Initiative

The future of Michigan's Eastern Massasauga Rattlesnake Outreach Initiative includes several more areas of emphasis. We would like to see our efforts eventually expand statewide because the Eastern Massasauga has been documented throughout Michigan's Lower Peninsula.

The youth of Michigan is one important group with whom we have had limited interactions. The future and the fate of the Eastern Massasauga lies with decision makers that will emerge from this group. We are working toward the development and distribution of an Eastern Massasauga educational traveling trunk and curriculum that can be used in primary and middle schools.



Average scores regarding how participation in a snake workshop had changed the feelings of four audience types toward snakes. Scores ranged from 7–35, with 7 indicating that participation had greatly decreased positive feelings and greatly increased negative feelings toward snakes, 21 indicating no change in feelings toward snakes due to participation in a workshop, and 35 indicating that participation had greatly increased positive feelings and greatly decreased negative feelings toward snakes.



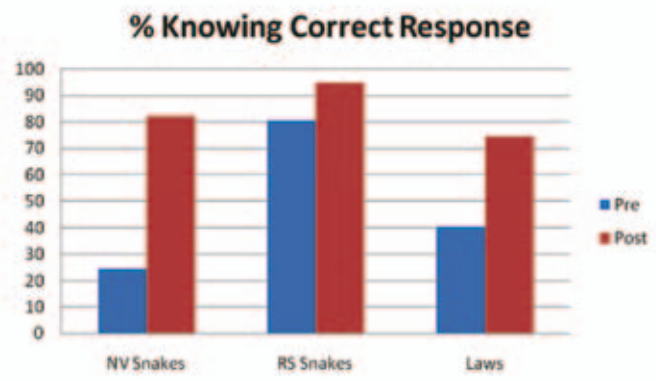
Average knowledge scores for four audience types who attended a series of snake workshops presented in southwestern Michigan in 2008. Pre-workshop scores for each audience type included: Public = 1.1, Mixed = 1.8, Docents = 1.3, and Professionals = 1.9. Post-workshop scores and net gain in knowledge scores for each audience type included: Public = 2.2 (a 1.1 point gain); Mixed = 2.2 (a 0.4 point gain); Docents = 2.6 (a 1.3 point gain), and Professionals = 2.8 (a 0.9 point gain).

Because of the role they play in the management of Eastern Massasaugas and public perceptions of rattlesnakes, we continue our efforts to work with veterinarians, county health departments, and law enforcement personnel. Accurate information regarding bites to humans, pets, or livestock in Michigan and the outcomes of bites when they do occur is rarely available. Such information is crucial to efforts to conserve and manage Eastern Massasaugas. We are planning to write additional articles for use in local newspapers, which feature snakes and information on how to keep pets, livestock, and people safe in Eastern Massasauga habitat. Other articles, such as how to manage habitat for Eastern Massasaugas, also are in development.

We must increase the geographic scope and number of volunteers in local communities to respond to human-snake conflicts. Such volunteers are a vital part of conservation efforts geared toward Eastern Massasaugas in Michigan. Volunteers are able to respond more quickly and are more likely to be trusted by their neighbors than an "expert" who drives from a centralized city.

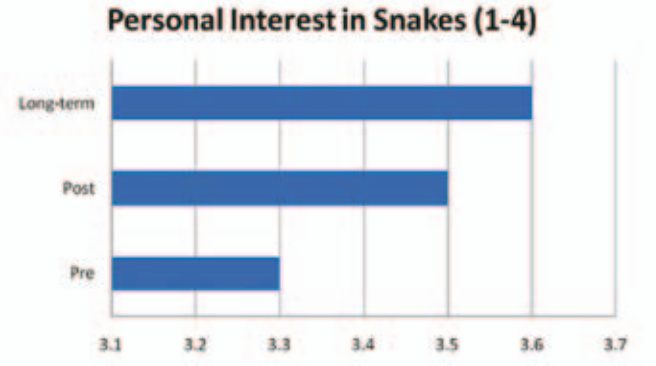
Many individuals who recreate in Michigan are unaware of the presence of Eastern Massasaugas and may not behave appropriately when visiting rattlesnake habitat. Eastern Massasauga outreach materials have been developed, distributed, and installed in several state parks. We have initiated work with the MI DNRE to develop a traveling informational display on the Eastern Massasauga and other rare herpetofauna in Michigan that can be loaned out and displayed at sites where Eastern Massasaugas are found and other public places.

We feel very fortunate to have had the opportunity to embark on this adventure and we learned many important lessons along the way. We learned the joy of modifying existing materials and programs, rather than creating materials from scratch. We learned that it is very helpful to be flexible in terms of planning workshops and operating within the time constraints of various organizations. Most of the workshops that we held for professional audiences were incorporated into existing training days or events. As we have proceeded with this project, we have identified additional target audiences for our efforts. We have learned that adequate time and money are never available — but that somehow we can pull off the

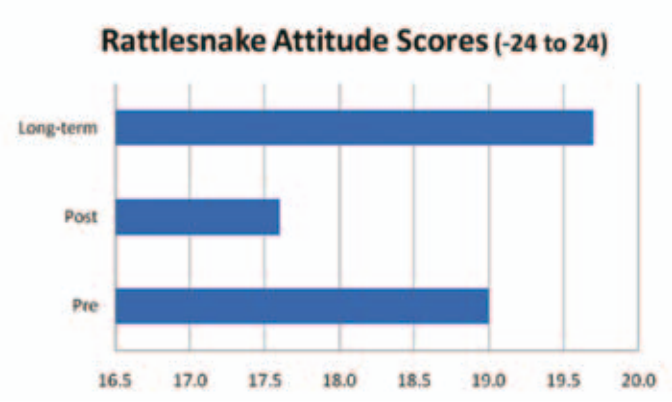


Percentage of participants attending a series of snake workshops held in southwestern Michigan in 2008 who knew: (a) The approximate number of non-venomous (NV) snake species that are found in Michigan, (b) the exact number of rattlesnake (RS) species that reside in Michigan, and (c) laws exist that protect snakes in Michigan.

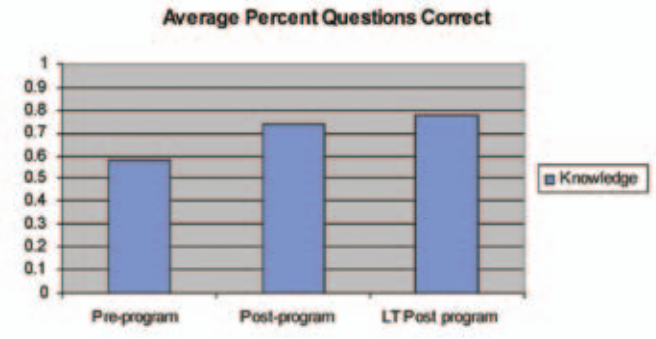
Average personal risk ratings due to rattlesnakes for audiences who attended a series of snake workshops held in southwestern Michigan in 2008. Responses included: I am at great risk (1), I am at some risk (2), I am at slight risk (3), and I am at no risk (4).



Mean interest in snakes as reported by participants in a series of snake workshops held in southwestern Michigan in 2008. Responses included: Very disinterested (1), Somewhat disinterested (2), Somewhat interested (3), and Very interested (4).

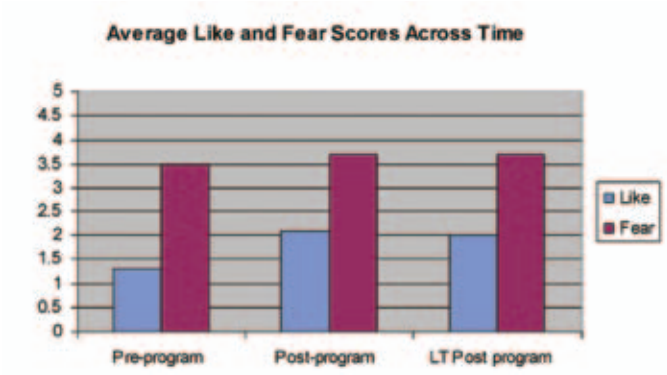


Pre-workshop, post-workshop, and long-term questionnaire "rattlesnake attitude" scores for participants at a series of snake workshops held in southwestern Michigan in 2008.

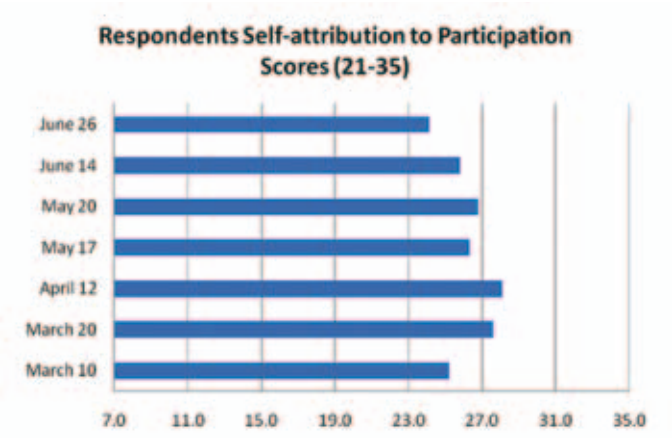


Mean percentage of knowledge questions answered correctly by participants at Eastern Massasauga workshops in 2004 and 2005 at three time intervals (pre-program, immediately post-program, and 6–8 months after attending program).

Average and mode scores for changes in feelings toward snakes, as assessed by participants at a series of snake workshops held in southwestern Michigan in 2008. Responses were scored with a 1 (a respondent's feeling about an item had become much more negative), a 2 (a respondent's feeling had become somewhat more negative), 3 (a respondent's feeling had not been affected), 4 (a respondent's feeling had become somewhat more positive), and 5 (a respondent's feeling had become much more positive).



Average fear and "like" levels toward snakes of participants at Eastern Massasauga workshops held in Michigan in 2004 and 2005 at three time intervals (pre-program, immediately post-program, and 6–8 months after attending program). Fear levels increased from 5 (I feel no fear at all) to 0 (I could not be in the room if a television program featured this animal) and "like" levels increased from 0 (the only good snake is a dead one) to 5 (this is one of my favorite animals and I'd do whatever I can for it).



Respondents' average self-assessment score of how participation in a snake workshop held in southwestern Michigan in 2008 had affected their feelings toward snakes. Scores ranged from 7–35, with a score of 7–13 indicating that their feelings had become more negative, a score of 14–20 indicating a somewhat negative change, a score of 21 indicating that their feelings had not changed due to attendance at a workshop, a score of 22–29 indicating that their feelings were somewhat more positive since attending the workshop, and a score of 30–35 indicating that a respondent's feelings had become much more positive since attending the workshop.

seemingly impossible. Finally, we have realized that educational outreach initiatives are very long-term efforts and that partners are critical to the success of such programs.

Acknowledgements

Funding for this project and associated outreach materials was provided by the U.S. Environmental Protection Agency's Environmental Education Grants Program, John Ball Zoo, Michigan Society of Herpetologists, Detroit Zoo, Oak County Parks, and the U.S. Fish and Wildlife Service. Key partners on this project have included Andy Snider (Fresno Chaffee Zoo, formerly Detroit Zoo), Bob Johnson and Andrew Lentini (Toronto Zoo), Bruce Kingsbury (Indiana-Purdue University at Ft. Wayne [IPFW]), Joe Sage (Florida Fish and Wildlife Conservation Commission, formerly IPFW), Lori Sargent and Tom Goniea (MI DNRE), Chris Gertiser and Lisa Duke (Binder Park Zoo), Jeff Jundt (Detroit Zoo), and Steve Evans (MSU CANR Communications). Additional partners include Michigan Department of Natural Resources and Environment, Wisconsin DNR, Huron-Clinton Metroparks Authority (Kensington and Indian Springs Metroparks), Love Creek Nature Center, Nature Discovery, Binder Park Zoo, Detroit Zoo, John Ball Zoo, Pierce Cedar Creek Institute, Kalamazoo Nature Center, Edward Lowe Foundation, Sarett Nature Center, Howard Christensen Nature Center, Wolf Lake Fish Hatchery, Gerald E. Eddy Discovery Center, Calvin College Bunker Interpretive Center, Dahlem Environmental Education Center, Matthei Botanical Garden, Michigan Poison Control Center, Barry and Cass County Conservation Districts, and The Stewardship Network. We are grateful to the many, many other individuals who are not listed but were incredibly helpful to us in our efforts.

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ANDREA MARTÍNEZ

The Utila Iguana (*Ctenosaura bakeri*) is endemic to Utila, one of the Honduran Bay Islands.

CITES Appendix II Listing for the *Ctenosaura palearis* Clade: Developing Conservation Policies in Central America

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In June 2006, Stesha A. Pasachnik, Daniel Ariano, and Paola Cotí traveled to the Motagua Valley, Guatemala to collect data pertaining to conservation-based ecological and genetic studies of *Ctenosaura palearis*. Given the nature of the research, collecting data from all areas where this species occurs was imperative. Although successful in encountering individuals in the majority of the range, reality intruded when we got to the westernmost part of the species' distribution. Despite records for this species in this area, no individuals were encountered. Interviews with locals led to the discovery that "foreigners" had been periodically visiting this area over the last five years for the purpose of purchasing *C. palearis* for the international pet trade. Furthermore, villagers indicated that approximately 200 individuals are taken every time these foreigners visit. Follow up visits by P. Cotí and D. Ariano generated identical results, leading to the conclusion that one of the main causes of this extirpation is exploitation (Cotí and Ariano 2008), which was confirmed as illegal by the Guatemalan government.

Given this information, an agreement was made between Zootropic (D. Ariano) and the National Council of Protected Areas (CONAP) to investigate the possibility of listing this species in the appendices of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). Simultaneously, S.A. Pasachnik and the Iguana Research and Breeding Station (IRBS) were in the process of organizing the annual meeting of the IUCN (International Union for Conservation of Nature) Iguana Specialist Group, which was to be held on Utila, Bay Islands, Honduras. At that meeting, discussions of trade in various species of ctenosaurs led the members to agree that the threat of exploitation demanded further investigation.

JOHN BINNS

The Honduran Paleate Spiny-tailed Iguana (*Ctenosaura melanosterna*) has a distribution restricted to the Valle del Aguán and the Cayos Cochinos off the coast of Honduras.

Although many species of ctenosaurs are threatened with extinction, are listed on the IUCN Red List, and the live animal trade is implicated in many of those assessments, no ctenosaurs were listed in any of the CITES Appendices. In early 2009, in order to address this discrepancy, we began the process of developing a proposal for listing the entire genus or selected species. The first months were spent collecting data to determine the historical and current degree of trade involving ctenosaurs. We concluded that the species most threatened by the live-animal trade and for which we could generate enough data to develop a CITES listing proposal were the four species of the *Ctenosaura palearis* clade: *Ctenosaura palearis* (endemic to the Valle del Motagua, Guatemala), *C. melanosterna* (endemic to the Valle del Aguán and Cayos Cochinos, Honduras), *C. bakeri* (endemic to the island of Utila, Honduras), and *C. oedirhina* (endemic to the island of Roatán, Honduras). All members of this group are listed as Critically Endangered on the IUCN Red List, are severely threatened by international trade, and are easily differentiated from other species in the genus by the presence of a dewlap, a lateral dentary flange, frontal-parietal skull rugosities, a snout that slopes steeply downward (flat), and a maximum adult size of 31 cm.

Ctenosaura palearis occurs in less than 930 km² of the Motagua Valley in Guatemala. The total population is estimated to be approximately 2,000 mature individuals, distributed over 10–15 subpopulations, and is thought to be in decline. The main threats include habitat loss and collection for the international pet trade. Extirpation of some populations (Morazán, El Progreso) within the historic range has occurred as a direct consequence of the pet trade (Cotí and Ariano 2008). Illegal traders usually catch 50–60 individuals per month. Internet and market surveys have shown that individuals are sold in Greece, Germany, and the USA at an average price of US$ 25. All *Ctenosaura palearis* sales outside Guatemala are illegal, as governmental authorities in Guatemala to date have issued no export permits for this species.

Ctenosaura melanosterna is known only from a portion (1,316 km²) of the Rio Aguán Valley in northern Honduras and two islands within the Cayos Cochinos Archipelago (2.2 km²) off the Caribbean coast of Honduras. Genetic data demonstrate that two evolutionarily significant units exist within the species, thus the island and mainland populations are ecologically and genetically distinct and should be managed as such (Pasachnik, unpubl. data). The main threats to the species are habitat loss and over-harvesting of both adults and eggs for human consumption and adults for the international pet trade. The exact number of individuals being exported is difficult to determine because declaration of the species name is not necessary for importation into most nations and the exportation from Honduras is illegal and undocumented. Most animals are imported into the USA or Europe. The cost of an individual in the Valle del Aguán is US$ 1–30 depending on size and sex. Although all populations are currently threatened, those in the Rio Aguán Valley are in greatest need of immediate attention.

Ctenosaura bakeri is endemic to the island of Utila, Honduras. The estimated range occurs within mangrove and beachfront habitats that are currently being developed by the tourist industry. Genetic data indicate that this is a panmictic population (Pasachnik, unpubl. data). The population is declining as a consequence of habitat loss and fragmentation, overharvesting for human consumption, pollution, and invasive species. Illegal exportation for the pet trade has not yet been documented for this species, but is thought to be occurring. Hybridization with a sympatric congener is not a threat at this time, but as habitat destruction increases, the possibility of outbreeding depression, due to mating with *C. similis*, might also increase (Pasachnik et al. 2009).

Ctenosaura oedirhina is endemic to the island of Roatán and various satellite islands in Honduras. Total population size is not known, but fewer than 2,500 mature individuals are thought to remain. Genetic data suggest that geographic variation is present across the island (Pasachnik, unpubl. data). This species is threatened primarily with habitat destruction and modification associated with the tourist industry. Small-scale hunting for food and the eradication of individuals due to the perception that they are pests is also occurring. Illegal exportation for the pet trade has not yet been documented, but is thought to be occurring. A widely distributed congener (*C. similis*) has recently been introduced onto a small satellite island less than 50 m from Roatán (Pasachnik, pers. obs.). This invasive species could easily disperse to Roatán and threaten *C. oedirhina* through competition and hybridization.

To begin the listing process, we held various meetings with local scientific and administrative authorities in Guatemala and Honduras to sensitize them to the status of these species and the threats they face, and to discuss the importance of a CITES proposal for these species. These meetings then allowed us to determine the degree of in-country support that was present for listing these species under the various appendices. From this, we determined that a proposal focusing on listing these four species under

STESHA PASACHNIK

The Roatán Spiny-tailed Iguana (*Ctenosaura oedirhina*) occurs only on the Honduran Bay Island of Roatán.

DANIEL ARIANO

The Guatemalan Spiny-tailed Iguana (*Ctenosaura palearis*) is endemic to the Valle del Motagua, Guatemala.

CITES Appendix II was most appropriate. On 3 August 2009, a validation meeting was held in Tegucigalpa, Honduras with the necessary government counterparts. The final proposal was completed on 5 August 2009 and was sent from the governments of Guatemala and Honduras to the CITES secretariat on 10 August 2009. Due to the political situation in Honduras at the time, two separate proposals were submitted, one from Honduras and one from Guatemala. The Guatemalan proposal listed only *C. palearis*, suggesting that CITES Appendix II criteria Resolution Conf. 9.24, annex 2 a, criteria A and B, were met. The Honduran proposal suggested that the remaining three species within the clade be listed under Appendix II due to look-a-like status with *C. palearis*.

On 21 March 2010, the two proposals were brought before the CITES delegates in Doha, Qatar. D. Ariano attended the meeting as a delegate from Guatemala and S.A. Pasachnik represented the International Iguana Foundation. First, Guatemala introduced proposal 12 to list *Ctenosaura palearis* under Appendix II. The delegates drew attention to its fragmented and continually declining habitat, small population size, and exploitation, noting the export of 240 individuals in 2008, which accounted for 10% of the total adult population. The proposal was met with a recommendation for support and was accepted by consensus. Next, Honduras presented proposal 11 to include *Ctenosaura bakeri*, *C. oedirhina*, and *C. melanosterna* under Appendix II. They noted that *C. melanosterna* qualified in terms of biological criteria and was harvested from the wild for the international pet trade, and that the other two species were included in the proposal based on their similarity to *C. melanosterna*. This proposal also was met with support from all who spoke except the International Animal Trade Organization, which recommended Appendix-III listing, based mainly on information concerning the population size of *C. bakeri* as estimated by Gutsche and Streich (2009). Given that no delegates agreed with this organization, proposal 11 also was accepted by consensus.

Both D. Ariano and S.A. Pasachnik plan to continue to aid in the protection of these species. D. Ariano and Zootropic will develop a semi-captive breeding conservation program for *C. palearis* and also will develop a national conservation plan for this species within Guatemala. S.A. Pasachnik will continue to work with the three Honduran species throughout the next year as she pursues a post-doctoral appointment focusing on *C. oedirhina*; she also will continue to work closely with *C. melanosterna* and *C. bakeri* as a member of the Fundación Islas de la Bahía. Both S.A. Pasachnik and D. Ariano intend to continue the development of CITES capacity-building efforts in Guatemala and Honduras now that these listing proposals have been accepted.

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LILI ELIAS

Vegetation of the forest of Laguna Maxbal.

Amphibian Diversity in Laguna Maxbal, Guatemala: An Ecotone to Conserve

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Photographs by the senior author except where noted.

The Department of Huehuetenango in Guatemala has been identified as an area with high endemism among its insect and amphibian populations at elevations of 900–2400 m above sea level (Stuart 1943, Schuster et al. 2000, Schuster and Cano 2005, Campbell and Vannini 1998). However, given the levels of biodiversity and endemism (Jolón-Morales 2007), conservation efforts in the department have been limited, especially in the northern region, which has been identified as one of the major gaps in the Guatemalan System of Protected Areas (SIGAP from its Spanish acronym).

In 2008, the NGO FUNDAECO initiated a project to establish a system of protected areas in the northern region of Huehuetenango. To this end, the project is building a social and institutional base to support local conservation by identifying and prioritizing sites with high biodiversity in relation to their social, political, and institutional feasibility.

In August and October 2008, we conducted inventories of biological diversity in Laguna Maxbal, located in northern Huehuetenango in the town of Barillas. This lake is of karst origin, fed by an underground spring,

Laguna Maxbal, Barillas, Huehuetenango.

JEAN-LUC BETOULLE

A Long-limbed Salamander (*Nyctanolis pernix*) captured in the forest near Laguna Maxbal.

Table 1. Amphibian species identified in the forest near San José Maxbal and San Ángel.

Species (N)	Elevation (masl)	Microhabitat
Bolitoglossa occidentalis (1)	1443	10 cm above the ground on a seedling
Bolitoglossa rufescens (29)	1740–1780	0.2–1.0 m above the ground on palm leaves or shrubs
Bolitoglossa cuchumatana (3)	1730	1 m above the ground on palm leaves
Nyctanolis pernix (1)	1443	1.5 m above the ground on a tree covered with moss
Bradytriton silus (2)	1725	1 m above the ground on the leaf of a seedling
Craugastor xucanebi (5)	1230–1515	0.1–2.0 m above the ground on tree trunks covered with moss
Craugastor chac (1)	1276	In leaf litter
Incilius valliceps (7)	1360–1535	Among litter and stones
Incilius macrocristatus (1)	1344	In leaf litter
Prectohyla matudai (2)	1460	Along stream banks on rotting logs
Lithobates berlandieri (13)	1240–1400	Along banks of the lagoon and pools in the stream
Agalychnis moreletii (1)	1550	0.5 m above the water on a seedling leaf
Ptychohyla sp. (1)	1550	2 m above a pool in a shrub

and lacks any surface inlet or outlet. Local people use the relatively small, exceptionally beautiful lake for recreation, but tourists seldom visit.

Two communities inhabited by people of the Kanjobal ethnic group are situated along the southwestern side of Laguna Maxbal. San José Maxbal (1200–1500 m asl; UTM 0680644 N, 1765346 W) and San Ángel to the east (1500–1800 m asl; UTM 0674986 N, 1766636 W) are surrounded by well-preserved forest that forms a transition zone (or ecotone) between tropical lowland forest and high-elevation cloud forest. The composition and richness of both amphibian and bird populations are remarkable. For example, we observed species such as the Resplendent Quetzal (*Pharomachrus mocinno*) and Highland Guan (*Penelopina nigra*), both typical of cloud forests, as well as the Black-faced Grosbeak

Critically endangered Morelet's Treefrog (*Agalychnis moreletii*) from the community of San Ángel at 1500 m above sea level.

Stream Frogs (*Ptychohyla* sp.) range from southern Mexico through Central America.

View of the forest in the community of San Ángel.

(*Caryothraustes poliogaster*) and the Plain Xenops (*Xenops minutus*), which usually are found in tropical lowland forest.

Amphibian diversity

Thirteen species were identified (Table 1): *Bolitoglossa occidentalis*, the Northern Banana Salamander (*Bolitoglossa rufescens*), *Bolitoglossa cuchumatana*, the Long-limbed Salamander (*Nyctanolis pernix*), the Finca Chiblac Salamander (*Bradytriton silus*), *Craugastor xucanebi, Craugastor chac*, the Gulf Coast Toad (*Incilius valliceps*), *Incilius macrocristatus, Prectohyla matudai*, the Rio Grande Leopard Frog (*Lithobates berlandieri*), Morelet's Treefrog (*Agalychnis moreletii*), and Stream Frogs (*Ptychohyla* sp.). Of particular significance is the presence of *Bradytriton silus*, which is endemic to northwestern Guatemala. This species was described in 1983 and the first specimens were collected in already disturbed areas (Elias and Wake 1984). During our sampling, we found two individuals at 1,745 m asl in the primary forest characteristic of this area.

Another interesting find was that of a single *Nyctanolis pernix* in San José Maxbal. This rare species is threatened by habitat destruction, and was previously known from only four localities of pine-oak cloud forest at 1200–1610 m asl (Elias and Wake 1983; Cárlos Vásquez, pers. comm. 2009).[1] This individual was found one night during heavy rain 1.5 m high on a tree covered with moss.

The amphibian assemblage from the vicinity of Laguna Maxbal includes endemic species with restricted habitat as well as common species with extended distributions. Of the 13 species identified, six are considered Threatened according to the IUCN Red List (IUCN 2010). *Bradytriton silus* and *Agalychnis moreletii* are listed as Critically Endangered (CR), *Nyctanolis pernix* as Endangered (EN), and *Plectrohyla matudai*, *Craugastor xucanebi*, and *Incilius macrocristatus* as Vulnerable (VU).

Based solely on the amphibian diversity found during sampling at Maxbal, the preservation of the forest is of considerable importance. Although we assigned this region a high conservation priority because it is still well preserved and integrated, the integrity of this forest region nevertheless faces threats that include changing land use patterns, deforestation, and the construction of roads. The first steps necessary for protecting the biodiversity of Laguna Maxbal will be the continuation of current biological surveys and the promotion of partnerships between local communities and environmental institutions that can lead to the establishment of a protected area system.

[1] At the northeastern extreme of the Sierra de los Cuchumatanes (Finca Chiblac, Barillas, Guatemala); near Laguna Montebello in northern Chiapas, México; in Alta Verapaz and in the Sierra de las Minas above Purulhá, Guatemala.

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Nectarivory in Puerto Rican Emerald Anoles (*Anolis evermanni*)

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Photographs by the author.

On 11 June and 31 July 2010, I observed three Puerto Rican Emerald Anoles (*Anolis evermanni*) licking nectar from the flowers of a Camasey Almendre (*Mecranium latifolium*) at the entrance to the Tradewinds National Recreation Trail, in El Yunque National Forest in Río Grande, Puerto Rico (elevation ca. 670 m above sea level). On both occasions, anoles were on the same plant and were observed about midmorning after a short rainfall.

Although this is the first report of nectarivory in *A. evermanni*, lapping nectar is not uncommon in West Indian anoles. *Anolis allisoni* laps nectar from Manila Palms (*Veitchia merillii*) in Cuba (Valido 2006). K.B. Sandved (in Losos and de Queiroz 1997) observed *A. grahami* of Jamaica licking a flower, presumably for its nectar. *Anolis conspersus* engaged in floral and possibly extrafloral nectarivory of the orchid *Schomburgkia thomsoniana* var. *thomsoniana* (Echternacht and Gerber 2000). *Anolis stratulus* of the Puerto Rico Bank is known to sip nectar on the shrub *Pedilanthus tithymaloides* (Perry and Lazell 1997), the stipitate glands of *Inga versa* (Mimosoideae; Rios-López 2004), and of *Anthurium* sp., orchids, and banana (*Musa*) plants (A.J. Sánchez Muñoz in Henderson and Powell 2009). *Anolis pulchellus*, also from the Puerto Rico Bank, engages in extrafloral nectarivory on *Leucaena leucocephala* (Leguminosae; Perry and Lazell 2006). The Lesser Antillean species, *A. bimaculatus*, *A. gingivinus*, *A. pogus*, and *A. sabanus* will lap nectar (Powell et al. 2005), as does Guadeloupean *A. marmoratus* (Breuil 2002b) and Barbadian *A. extremus* (Fläschendräger and Wijffels 2009). *Anolis aeneus* and *A. richardii* from the Grenada Bank engage in nectarivory and might be pollinators of *Charianthus grenadensis* and *Marcgravia umbellata*, respectively (Timmermann et al. 2008).

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A young naturalist with a seven-foot male Eastern Indigo Snake from southern Georgia.

DEDICATION

Emulating the Father of Snake Ecology

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Photographs by the author.

As a high school senior from southern Illinois, I obtained a copy of Henry Fitch's classic *Autecology of the Copperhead*. Stunned and excited to find so much life history information about one of my favorite snakes, I devoured the book. Fitch's Copperhead book was foremost among the works that stoked my early naturalist fires and always stayed close — even riding in the glove box of my late 1970s VW Beetle on herping sojourns to remote bluffs and swamps in southern Illinois.

For the past 15 years, I've studied one of North America's most impressive serpents — the Eastern Indigo Snake (*Drymarchon couperi*) — focusing on long-term mark-recapture efforts similar to Dr. Fitch's work in eastern Kansas. Attired in an old ball cap and charcoal-stained (from a recent prescribed fire) snake boots, jumbo pillowcases looped in my belt, I like to think of myself as a bit like Dr. Fitch as I embark on a long sandhill hike to search for indigos basking at tortoise burrows. Anticipating a 3-hour walk, I travel light, carrying a compass, mirror, thermometer (for cloacal and environmental temperatures), small field notebook, and some ribbons of flagging tape. The persistent and indefatigable snake-hunter (i.e., Fitch-like!) who visits many dozens — or hundreds — of burrows on a mild winter day will sometimes be rewarded with the sight of a bluish-black, large-scaled coil partly concealed by a Saw Palmetto frond or clump of Golden Wiregrass.

What can long-term field studies tell us about the ecology of snakes, a notably slippery and difficult group? As Dr. Fitch's excellent work demonstrated, they offer a glimpse into the lives of individuals. Our mark-recapture research has provided novel and interesting data relating to Eastern Indigo Snake survival, size, growth rates, and site fidelity. From many

An adult female Eastern Indigo Snake from southern Georgia.

recaptures of individuals marked in previous years, we determined that smaller snakes grow fast, reaching 1.2–1.5 m by their second winter, and attaining sexual maturity in 2–3 years. In undisturbed landscapes far from roads, Eastern Indigos commonly live 8 to >12 years.

The author with three adult Eastern Indigo Snakes found on the same day at one of his south Georgia study sites.

As part of this mark-recapture population monitoring effort, Eastern Indigo Snakes are sexed, measured, weighed, and uniquely marked with PIT tags.

When I processed adult indigos for the first time I was nervous; they are, after all, federally protected under the Endangered Species Act, an imperiled animal that occurs in low numbers even where common. I was shaking the first few times I plunged the 12-gauge needle to insert a PIT tag under the skin of a pregnant female, clipped ventral scales for a genetic study, or struggled with a recalcitrant snake that just did not want to be enclosed in a pillowcase for weighing. "Hang in there, man, you can do this," I would think to myself, remembering that Dr. Fitch had painstakingly scale-clipped thousands and thousands of small delicate snakes (shoot, many thousands of Ringnecks [*Diadophis punctatus*] alone!).

Dr. Fitch's singular energy, dedication, focus, and the veritable mountain of valuable natural history data that he contributed have been and always will be a source of inspiration for me and countless others. I return frequently to southern Illinois, typically timing my trips with the spring bloom of wildflowers and the April emergence of serpents. As I bound upslope toward a stony glade sprinkled with new color, nosing for serpents and lizards under and among the lichen-marked stones, I am always thinking of him.

Adult Eastern Diamondback Rattlesnakes (*Crotalus adamanteus*), like Eastern Indigo Snakes, frequently seek shelter in Gopher Tortoise burrows during the winter.

The venerable Gopher Tortoise is the primary host for the largest tick in North America, the Gopher Tortoise Tick (*Amblyomma tuberculatum*).

Sex Ratios in Samples from Eight Snake Populations in Sand Prairies in South-Central Kansas

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Photographs by the author.

Sex ratios are important parameters of population structure, and may also provide information on differential behavior, activity, or habitat selection by the sexes. Sample sex ratios may be affected by many factors, including the method of capturing the animals, seasons, weather patterns, foraging behavior, and reproductive status (Parker and Plummer 1987). This report discusses sex ratios in samples collected in a study of natural snake populations, using live traps and mark-recapture methods to investigate population parameters.

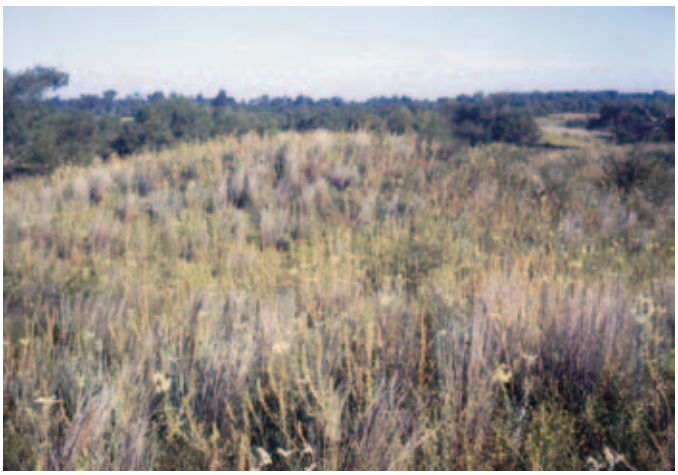
Methods

Three study sites in western Harvey County, south-central Kansas, were used in this study. In 1959–1963, trapping was conducted on a 50-acre study site in the southwestern part of Harvey County West Park. In 1960–1963, a second 50-acre study site was used in the northeastern part of the Graber Pasture that was less than one mile northwest of the initial study site. In 1966–1974, the 80-acre Sand Prairie Natural History Reservation, which adjoins Graber Pasture to the north, was used. These are all hum-

One end of a trapping station with funnel trap fitted under end of the metal drift fence.

Large wetland on Sand Prairie Natural History Reservation, Harvey County, Kansas. In some years it is completely dry.

Low grassland on Sand Prairie Natural History Reservation, Harvey County, Kansas.



Upland on Sand Prairie Natural History Reservation, Harvey County, Kansas.

Table 1. Primary sex ratios in populations of five species of snakes in Harvey County, Kansas. Two asterisks (**) after the chi-square value indicate a significant difference at the 1% level.

Species	N	♂ per 100 ♀	χ^2
A. Neonates trapped in Fall			
Yellowbelly Racer	85	81	0.753
Bullsnake	247	104	0.065
Eastern Hognose Snake	73	128	0.877
B. Neonates in litters born in captivity			
Red-sided Garter Snake	538	126	6.916**
Plains Garter Snake	870	98	0.093

Table 2. Sex ratios in samples trapped from snake populations in Harvey County, Kansas, in the period May through October in the 14 years 1959–63 and 1966–74. Two asterisks (**) after the chi-square value indicate a significant difference at the 1% level and three asterisks (***) at 0.1% level.

Species	N	♂ per 100 ♀	χ^2
Red-sided Garter Snake	2288	120	18.368***
Plains Garter Snake	2209	133	43.504***
Yellowbelly Racer	1086	143	33.592***
Bullsnake	721	125	8.876**
Plains Hognose Snake	520	127	7.156**
Eastern Hognose Snake	228	165	13.268***
Kansas Glossy Snake	81	212	9.679**
Prairie Kingsnake	100	127	1.210

Table 3. Sex ratios in samples trapped from snake populations in Harvey County, Kansas, in May and June in the 14 years 1959–63 and 1966–74. Two asterisks (**) after the chi-square value indicate a significant difference at the 1% level and three asterisks (***) at 0.1% level.

Species	N	♂ per 100 ♀	χ^2
Red-sided Garter Snake	753	137	17.870***
Plains Garter Snake	841	211	107.015***
Yellowbelly Racer	455	242	77.679***
Bullsnake	255	186	22.651***
Plains Hognose Snake	256	158	12.691***
Eastern Hognose Snake	81	200	8.346**
Kansas Glossy Snake	48	500	20.021***
Prairie Kingsnake	44	175	2.750

Table 4. Sex ratios in samples trapped from snake populations in Harvey County, Kansas, in July and August in the 14 years 1959–63 and 1966–74. None of the differences were significant at the 5% level.

Species	N	♂ per 100 ♀	χ^2
Red-sided Garter Snake	612	106	0.472
Plains Garter Snake	891	104	0.287
Yellowbelly Racer	273	95	0.132
Bullsnake	135	85	0.741
Plains Hognose Snake	179	86	0.944
Eastern Hognose Snake	54	100	0.000
Kansas Glossy Snake	22	100	0.000
Prairie Kingsnake	39	77	0.410

Table 5. Sex ratios in samples of snakes at least one year old trapped from populations in Harvey County, Kansas, in September and October in the 14 years 1959–63 and 1966–74. One asterisk (*) after the chi-square value indicates a significant difference at the 5% level and two asterisks (**) at the 1% level.

Species	N	♂per100♀	χ^2
Red-sided Garter Snake	923	117	5.309*
Plains Garter Snake	477	97	0.075
Yellowbelly Racer	264	111	0.640
Bullsnake	48	118	0.188
Plains Hognose Snake	72	188	6.125*
Eastern Hognose Snake	35	289	7.314**
Kansas Glossy Snake	11	57	0.364
Prairie Kingsnake	16	220	1.562

Table 6. Sex ratios in samples of Garter Snakes trapped in May and June in A. years of high frog populations following at least one year of low frog populations (1961, 1969, 1973), B. years of high frog populations following a year of high frog populations (1962, 1974), and C. years of low to moderate frog populations (1959–1960, 1963, 1966–1968, 1970–1972). One asterisk (*) after the chi-square value indicates a significant difference at the 5% level and three asterisks (***) at the 0.1% level.

Year	N	♂per100♀	χ^2
Plains Garter Snake			
A. 61,69,73	280	344	83.604***
B. 62,74	206	199	21.791***
C. 59–60,63,66–68,70–72	355	155	16.270***
Red-sided Garter Snake			
A. 61,69,73	241	177	18.075***
B. 62,74	174	142	4.833*
C. 59–60,63,66–68,70–72	338	112	1.183

mocky shrubby grasslands on fine sand. Because surface drainage is poorly developed and the subsoil is relatively impervious, small temporary or semi-permanent ponds and marshes are present in many of the swales between dunes for short periods or whole seasons.

Each year, live-trapping of snakes was conducted using traps with funnel entrances (modified from those described in Fitch 1951) fitted on each end of low drift fences. Samples of eight species of snakes were large enough to provide information on sex ratios: Plains Garter Snake (*Thamnophis radix*), Red-sided Garter Snake (*T. sirtalis parietalis*), Yellowbelly Racer (*Coluber constrictor flaviventris*), Bullsnake (*Pituophis catenifer sayi*), Plains Hognose Snake (*Heterodon n. nasicus*), Eastern Hognose Snake (*H. plati-*

Sex ratios of Eastern Hognose Snakes (*Heterodon platirhinos*) captured in July/August did not differ significantly from a 1:1 ratio, but those taken in May/June and September/October were male-biased.

The male-biased sex ratios in fall samples for Plains Hognose Snakes (*Heterodon n. nasicus*) suggest a resurgence of mating activity in the autumn.

rhinos), Kansas Glossy Snake (*Arizona e. elegans*), and Prairie Kingsnake (*Lampropeltis c. calligaster*). The sex of snakes was determined by probing for the hemipenial sacs and later confirmed by the tail length as a percentage of snout-vent length (SVL). In tabulating the sex of captured snakes, only the first capture of an individual in a year was included. The null hypothesis of an equal sex ratio was tested by chi-square tests with Yates correction. For all results, one asterisk after the chi-square value indicates a significant difference at the 5% level, two asterisks at the 1% level, and three asterisks at 0.1% level.

Female Garter Snakes that were obviously gravid when captured were kept in cages until the litters were born. In this way, 32 litters of Red-sided Garter Snakes and 59 litters of Plains Garter Snakes were obtained and the neonates were sexed by probing for hemipenial sacs with a small probe. Relative tail length varies little between the two sexes at this age. The term neonate is used in this paper for young snakes in autumn from birth or hatching to first dormancy. For additional information on the methods used in this study, see Platt (1969, 1984).

Results

Primary Sex Ratios.—Samples of neonate Yellowbelly Racers, Bullsnakes, and Eastern Hognose Snakes trapped in the fall had sex ratios that did not differ significantly from 1:1 (Table 1). Although the sample of Racers was moderately female-biased and of Eastern Hognose Snakes was moderately male-biased, the samples were too small to detect a statistically significant imbalance. Few neonate Glossy Snakes or Kingsnakes were caught and neonate Garter Snakes and Plains Hognose Snakes were too small to be caught in the funnel traps. However, 538 neonate Red-sided Garter Snakes and 870 neonate Plains Garter Snakes born in captivity provided information on the primary sex ratios in these two species (Table 1). The sample of Red-sided Garter Snakes had a moderately but significantly male-biased sex ratio. Eight Red-sided Garter Snake litters consisted of 67–82% males, whereas only two litters were female-biased to that degree. If those 10 litters are omitted, the sex ratio in the remaining litters is 107 males per 100 females. The sex ratio of Plains Garter Snakes did not significantly differ from equality.

Secondary Sex Ratios.— The total samples (excluding neonates) of each of the eight species of snakes trapped on the study sites from May–October in the 14 years were moderately to strongly male-biased (Table 2). The deviations from an equal sex ratio were significant, except for the Prairie Kingsnakes, in which the sample was small and only moderately male-biased.

The sex ratios varied in samples taken at different seasons. The samples from May and June were more strongly male-biased than the total sample (Table 3). In each species, the sample from May was more strongly male-biased than the sample from June, except for the Eastern Hognose Snake, in which the sex ratio of the sample from May was 1.81:1 and from June was 2.27:1. The sex ratios of the May/June samples were significantly different from equality in all species except the Prairie Kingsnake, for which, however, the May sample did differ significantly from equality. The sex ratios in samples taken from all eight species in July and August did not differ significantly from equality (Table 4). The sex ratios in samples of Yellowbelly Racers, Bullsnakes, Plains Hognose Snakes, and Prairie Kingsnakes were slightly to moderately female-biased, but the differences were not significant.

The sex ratios in samples of Red-sided Garter Snakes, Plains Hognose Snakes, and Eastern Hognose Snakes that were at least one year old when captured in September and October were significantly male-biased. However, the sex ratios in similar samples of Plains Garter Snakes, Yellowbellied Racers, Bullsnakes, Kansas Glossy Snakes, and Prairie Kingsnakes did not differ significantly from equality (Table 5). The sex ratios of Racers were slightly male-biased and those of Plains Garter Snakes were slightly female-biased.

Yearly samples of Garter Snakes were large enough to detect significant differences in sex ratios. These differences may be related to the abundance of the snake's primary prey item, the Plains Leopard Frog (*Lithobates blairi*). Frog populations varied greatly, being almost nonexistent in those years when the wetlands were dry for most of the season and very large in

Samples of neonate Yellowbelly Racers (*Coluber constrictor flaviventris*) trapped in the fall had a sex ratio that was moderately female-biased, but did not differ significantly from 1:1.

Primary sex ratios in samples of Bullsnakes (*Pituophis catenifer sayi*) from Harvey County, Kansas, did not differ significantly from 1:1.

years when they were flooded all season. Table 6 shows pooled samples of Garter Snakes from May and June in years with similar frog abundance. All three pooled samples of the Plains Garter Snake were significantly male-biased, but the excess of males was greatest in those years with good flooding following one or more years with very low frog populations. The sex ratio in the pooled sample from those years was significantly different from the other two pooled samples (chi-squares: A to B, 14.169***; A to C, 32.376***; B to C, 2.691). The Red-sided Garter Snake had a similar pattern but less extreme, and only the two pooled samples from years with high frog populations have a significantly male-biased sex ratio. The sex ratio in the pooled sample from those years with good flooding following one or more years with very low frog populations was significantly different from years with low to moderate frog populations (chi-squares: A to B, 1.798; A to C, 10.834***; B to C, 2.082).

Discussion

Most published primary sex ratios from snake populations do not differ significantly from 1:1 (Parker and Plummer 1987). Primary sex ratios in samples of Plains Garter Snakes, Bullsnakes, Yellowbelly Racers, and Eastern Hognose Snakes from Harvey County, Kansas, did not differ significantly from 1:1. A sample of 96 hatchling Bullsnakes from eight clutches of eggs laid by females from Nebraska had a male-biased sex ratio of 2:1 (Gutzke et al. 1985), but Iverson (1990) reported a primary sex ratio that did not differ from equality for Bullsnakes from the same study area.

The primary sex ratio of Red-sided Garter Snakes in our study was 1.26:1 and differed significantly from 1:1. In a sample of 514 neonates of the Red-sided Garter Snake born in captivity to females from a population in northeastern Kansas, the sex ratio was even more skewed at 1.66:1 (Fitch 1999). Carpenter (1952) reported a primary sex ratio of 1.06:1 for another subspecies of this Garter Snake in Michigan. In my study, the male-biased sex ratio was primarily due to eight litters that consisted of two-thirds or more males. Dunlap and Lang (1990) reported from a study of another subspecies in Minnesota that male-biased litters were produced by larger females, but this was not true in my study. The eight extremely male-biased litters in this study came from females averaging 645 mm SVL and the other 24 females contributing litters averaged 676 mm SVL.

Secondary sex ratios in the samples of older snakes caught in the funnel traps were moderately to greatly male-biased. Males can invest more resources in activity than females, because females invest more in the production and development of eggs. If males are more active, this can result in male-biased sex ratios in samples from funnel traps on drift fences. These traps intercept moving snakes, and individuals that are more active and move around more have a greater probability of being caught. The seasonal changes in sex ratio in samples from the three study sites in this study are consistent with increased male activity during the mating season in spring and early summer and essentially equal activity later in the summer; this has been reported by many authors (e.g., Parker and Plummer 1987, Iverson 1990). The male-biased sex ratios in autumn samples for the Red-sided Garter Snake and the two Hognose Snake species suggest a resurgence of mating activity for these species in the autumn. Fitch (1965) reported evidence of autumn mating of Red-sided Garter Snakes and Platt (1969) reported similar evidence for the Eastern Hognose Snake. The sex ratio for the sample of Racers from autumn was not significantly different from 1:1, and Fitch (1963) concluded that Racers probably did not copulate during that season.

Most Garter Snakes leave the study sites in Harvey County during seasons when the wetlands are dry, but come back in large numbers in years when the wetlands are flooded and the frog populations surge. The extreme male bias of May/June samples of Plains Garter Snakes in wet years that follow dry years, and to a lesser degree in samples of Red-sided Garter Snakes (see Table 6), is consistent with greater movement by males that results in their return to this favorable habitat before most females and even before the great increase in frog populations that occurs in July with the metamorphosis of young.

The sex ratios of the May/June samples were significantly different from equality in all species except the Prairie Kingsnake (*Lampropeltis c. calligaster*), for which, however, the May sample did differ significantly from equality.

Although rarely encountered in nature, an albino Kansas Glossy Snake (*Arizona e. elegans*) was collected during sampling in Harvey County, Kansas. Note the sharp contrast when compared with a normally pigmented individual.

Yearly samples of Red-sided Garter Snakes (*Thamnophis sirtalis parietalis*) were large enough to detect significant differences in sex ratios. These differences may be related to the abundance of the snake's primary prey, the Plains Leopard Frog (*Lithobates blairi*).

Secondary sex ratios in samples of snakes must be interpreted with caution because they can be influenced by many factors that differentially affect the two sexes, and changes in actual population structure may be a minor factor. Sex ratios in samples have been shown to change rapidly when differential sexual behavior is affected. Shine et al. (2006) found significant daily variation in sex ratios of samples of Garter Snakes as they emerged from hibernation. These variations were related to time in season and daily maximum and minimum temperatures. In my study, greater activity by males in the spring and, in some species, in the autumn searching for mates and/or favorable habitat are probably the most important factors in the male-biased secondary sex ratios of these eight species of snakes.

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Salamander Sci-Art

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All scanned images by the authors.

"Salamander" is the common name for amphibians with tails, and (with the exception of the Sirenidae) four legs of about equal size. They include all the members of the order Caudata, comprising nine families and over 500 species. The name "salamander" is derived from an old Arab/Persian word meaning "lives in fire," stemming from the belief that the salamander was born in fire or could walk through fire without being harmed (Khanna and Yadav 1998). This myth might have originated from the bright skin colors that resemble flames in some salamanders, perhaps from the burning taste one might feel while trying to eat such a creature, or observations of salamanders emerging from logs thrown onto a fire.

Salamanders of the northeastern United States and southeastern Canada are an ecologically interesting group. Their habitats include eastern mesophytic forests and periglacial features, such as woodland pool depressions, rocky wooded hillsides, outcrops, talus, and ravines (Petranka 1998). Included among northeastern species are enigmatic permanently aquatic forms that include Hellbenders (*Cryptobranchus alleganiensis*) and the mys-

terious Mudpuppy (*Necturus maculosus*). Also, almost every pond is inhabited by Red-spotted Eastern Newts (*Notophthalmus viridescens*).

We have been monitoring high-diversity amphibian sites over the past three decades, focusing on two main issues: Declining amphibian populations and developmental deformities among wild stocks. We have scouted over a hundred amphibian breeding pools and habitats across New York, Pennsylvania, New England, and Quebec, sampling populations, documenting species, wetlands, and woodlands from March through November for well over a decade. We then selected a "top-ten list" to revisit repeatedly to monitor water levels and catch per unit time effort as recorded on data sheets, field notebooks, and spreadsheets using two basic surveying methods: Timed searches per person hour as well as area searches of a specific habitat type. The "good news" is that many of the remaining habitats we selected had relatively dense, healthy populations. The "bad news" is that many previously recorded salamander sites no longer exist or the habitat is degraded or severely changed. The bottom line is that fewer wild salamanders are around now than were historically and fewer habitats persist to sustain these great creatures.

A percentage of individuals from all populations showed signs of trauma such as injury, infection, or fungal growth. Occasional missing limbs and other injuries can be survivable and partial regeneration can create permanent deformities (Ballengée and Sessions 2009). Long-term surveys and further studies are still needed to understand the normal background rate of deformities, injuries, and disease (Sessions and Ballengée 2010). Our current biological research will continue as long as necessary.

In an effort to inspire people to become aware of these vulnerable creatures and to better appreciate their intrinsic value, we have been incorporating art in our research. "Sci-Art" is the scientific pursuit of knowledge combined with the desire for the understanding inherent in art. Art and biology always have attempted to describe the world around us. From Neolithic cave renderings to Greek zoological accounts to E.O. Wilson's modern concept of Biophilia, humankind's desire to interpret the natural world has never ceased — and emerging technologies are expanding our ability to

Supernumerary digits in a Northern Dusky Salamander (*Desmognathus fuscus*) collected in Allegheny County, New York in 2001.

Spotted Salamander (*Ambystoma maculatum*) at 72 hours.

Northern Slimy Salamander (*Plethodon glutinosus*).

Red efts are the intermediate terrestrial stage of development in Eastern Newts (*Notophthalmus viridescens*). Both larvae and adults are aquatic.

Northern Red Salamander (*Pseudotriton ruber ruber*).

Marbled Salamander (*Ambystoma opacum*).

comprehend the diversity of life on our planet, from the microscopic to the colossal. Art can be an effective tool to "frame" current ecological issues and bring them to public mind (Lippard 2007).

The accompanying images depict a variety of species and individual life history stages, including egg, larva, and adult. Each animal was gently examined for any scars or regeneration from injuries, fungi, ectoparasites, edema, and visible signs of infection. Most looked healthy and strong with good muscle tone and body weight. We also looked for asymmetries of the right and left eyes, mouthparts, limbs, digits, etc. Anuran larvae were staged according to Gosner's stages of embryological development (Gosner 1960). The animals then were gently placed alive onto the glass bed of a scanner for digital recording at 1,200–8,000 dpi. This is approximately 25 times the output of a typical home or office scanner. The appeal of the process is the incredible detail that can be recorded into a digital file. These files can then be used to generate both scientific research images as well as fine art prints.

Salamanders are beautiful and intriguing animals that have persisted through millions of years of evolution, withstanding past extinction events. They are now being subjected to the "anthropocene" period of human-wrought habitat destruction resulting from bulldozing, paving roads, building dams across rivers, draining wetlands, introduding invasive species, and other afflictions. We are working to increase public awareness of salamanders and their habitats in the hopes of reducing detrimental human impacts. We hope that these images will inspire people to appreciate not only the scientific and ecological significance of salamanders but also their aesthetic value in terms of beauty and form. Our main conceptual mission is to increase public awareness and understanding of biological phenomena and environmental concerns while challenging people both aesthetically and intellectually.

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Evidence of a Contact Zone for Mudpuppies (*Necturus* sp.) in the Lower Mississippi River Basin

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The Mudpuppy, *Necturus maculosus*, is frequently recognized as having two subspecies, *Necturus m. maculosus* and *N. m. louisianensis* (e.g., Crother et al. 2008). Originally described as distinct species (Viosca 1937, Cagle 1954) due to their allopatric distributions and distinct morphological features, the two forms are distinguished primarily based on the presence/absence of midventral spots (Powell et al. 1998). Disagreement over the taxonomic status of these forms continues.

While sampling for fishes in the lower White River in Arkansas with trotlines baited with worms (long lines with hooks suspended at intervals), we collected 12 *Necturus* sp. in late January 1999. Further examination revealed eight *Necturus maculosus* and four (based on the absence of midventral spots) *N. louisianensis*. The latter is the only form recorded in Arkansas (Trauth et al. 2004).

Specimens (ten males and two females) ranged in size from 221–226 mm total length (TL). The salamanders were collected in 7.9–10.7 m of water with a substrate of rip-rap (boulder-sized rocks used for bank stabilization) and articulating concrete mats (ACM) at a water temperature of 9 °C. The rocky substrate may act as a refuge. The identity of the Mudpuppies was verified by Dr. Stan Trauth. Preserved specimens were deposited in the Herpetology Collection at Arkansas State University and represent new county records for Desha County, Arkansas (ASUMZ 31398–31409).

Catching Mudpuppies on baited hooks has been reported by many authors (e.g., Brimley 1920, Cagle 1957, Shoop and Gunning 1967). In Louisiana, Cagle (1957) used a variety of hooks and lines but found setlines were satisfactory in catching adult *Necturus*. Shoop and Gunning (1967), while studying seasonal activity of *Necturus*, used liver as bait for their hook-and-line sets but found electrical shocking to be more effective. In addition, several of these authors (Cagle 1957, Shoop and Gunning 1967) reported catching a fair number of *Necturus* around logjams or structure.

Over a ten-year span of seasonal sampling of the Lower Mississippi River for Pallid Sturgeon (*Scaphirhynchus albus*) using trotlines baited with worms, we have captured only three additional *Necturus*. The lack of *Necturus* in our samples could be due to our sampling efforts and the targeted habitats. The majority of our samples were taken in the main

William E. Lancaster, commercial fisherman, with a *Necturus* hooked on a trotline in the lower White River in Arkansas.

Ventral view of *Necturus maculosus* collected on a trotline in the Mississippi River near Cairo, Illinois.

Ventral view of *Necturus maculosus* collected on a trotline in Claiborne County, Mississippi.

A series of Mudpuppies collected on trotlines in the Lower White River of Arkansas. Patterns of midventral pigmentation suggest the occurrence of two different species.

channel over sand and gravel, and generally not over substrates of rip-rap or ACM. Of these three specimens, only one was retained as a museum voucher. The voucher specimen was a female *N. maculosus* measuring 265 mm TL. That specimen was collected in mid-January 2002 with a water temperature of 5.9 °C over rip-rap in 7 m of water. It represented a new county record for Claiborne County, Mississippi and was deposited in the Herpetological Collection at the Mississippi Museum of Natural Science in Jackson (MMNS 16712). Of the remaining two specimens, one was measured, photographed, and released; the remaining specimen was retained live for educational purposes. The photographed Mudpuppy was *N. maculosus* and measured 320 mm TL. It was collected in the Mississippi River near the Hwy-60 bridge in Cairo, Illinois on 17 December 2004 in 16.1 m of water with a water temperature of 5.2 °C.

Examination of additional *Necturus* specimens housed at the Mississippi Museum of Natural Science revealed that both species occurred sympatricaly in the Yazoo River of Mississippi and in a tributary of the Tennessee River prior to the construction of the Tennessee-Tombigbee Waterway. Further taxonomic studies, including genetic assessments, are needed to elucidate the taxonomic status of these elusive salamanders.

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Sixty-hook trotline baited with worms in a jump box prior to being set.

Distribution and Habitat Use by the Critically Endangered Stout Iguana (*Cyclura pinguis*) on Guana Island, British Virgin Islands

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The Stout Iguana (*Cyclura pinguis*, Fig. 1) is a large lizard endemic to the Greater Puerto Rico Bank (Lazell 2002, Lazell 2005). It is one of the largest species in the genus, and, like all congeners, is imperiled. *Cyclura pinguis* is listed as Critically Endangered by the International Union for Conservation of Nature (IUCN 2004) and as Endangered by the U.S. Fish and Wildlife Service (USFWS 1999). For at least several hundred years, these lizards have presumably been confined to the 4,000-ha island of Anegada in the British Virgin Islands, where they currently face many threats, including non-native mammals. For example, introduced ungulates, such as sheep, compete directly for resources. By the early 1990s, only an estimated 164 individuals remained on Anegada (Mitchell 1999). Because of the continued decline of the iguana population on Anegada, eight individuals were introduced to Guana Island, British Virgin Islands between 1984 and 1986 (Goodyear and Lazell 1994), with subsequent introductions to Necker and Norman islands. All three of these islands have the advantage of being privately owned, thus restricting human access, and harbor few introduced mammals (Perry and Gerber 2006). The most recent population estimates for the islands are 250 individuals on Anegada (Gerber 2004), 130 on Guana Island, and 30 on Necker Island (Perry and Mitchell 2003).

WESLEY ANDERSON

Fig. 1. Stout Iguanas have been very successful at establishing themselves on Guana. The hundreds of iguanas living on the island are all descended from just eight individuals released in the 1980s.


SARAH WULFF

Fig. 2. Although translocated from the flat, sandy island of Anegada, the population on Guana appears to be thriving in an area with considerably more topographic relief.

Despite substantial conservation concerns, little is known about the natural history of this species (but see Goodyear and Lazell 1994, Mitchell 1999, Levering and Perry 2003, Perry and Mitchell 2003, Lazell 2005, Perry et al. 2007). Because habitat use has never been studied in the Guana population, we sought to determine age-class specific habitat use on the island. As Guana Island differs markedly from Anegada Island in both geologic substrate and topography (Fig. 2), these results could have important habitat management implications. A second objective was to examine the distribution of iguanas on Guana Island. Over 15 years ago, Goodyear and Lazell (1994) noted that the distribution of iguanas on Guana appeared patchy, with no individuals observed in the northeastern or southern sections of the island.

Methods

In 2009, every marked trail on the island was surveyed by a group of two to three people, and most trails were revisited at least once and up to three times on separate occasions (Fig. 3). Because we could not determine if we were observing new or previously sighted individuals, we recorded all locations if an iguana had not been observed in the immediate vicinity within the past two hours. Once an iguana was observed, we recorded the time of day, percent cloud cover, location on the island relative to trails and/or landmarks, and general habitat at the spot of initial observation. Location coordinates (UTM, NAD83) were recorded using a geographic positioning system (Garmin International, Inc., Olathe, Kansas), and the lizard was categorized as an adult, yearling, or hatchling based on size. Once the iguana moved from the initial point of observation, we recorded air temperature with a mercury thermometer at 5 cm above the ground. We then positioned a 3-sided ½ m x ½ m quadrat at the original location and oriented it toward the north (Fig. 4). We took photographs of both the quadrat (ground cover) and the canopy cover above the quadrat with a digital camera (Canon, USA, Inc., Lake Success, New York) held 1 m above the ground. Both ground and canopy cover pictures were analyzed using SamplePoint, version 1.48 to determine percent composition of cover types. We categorized ground cover types as herbaceous vegetation, woody vegetation, litter, bare ground (including rocks < 2.5 cm in diameter), rock (> 2.5 cm in diameter), man-


SARAH WULFF

Fig. 3. Whereas many iguanas along the trails would flee at the approach of people, individuals living in close proximity to humans on Guana Island were readily visible during the surveys.

ROBERT POWELL

Despite substantial conservation concerns, little is known about the natural history of the Stout Iguana (*Cyclura pinguis*). This individual sought a shady retreat from the early afternoon heat on Guana Island (British Virgin Islands).


WESLEY ANDERSON

Fig. 4. A quadrat was placed at the site where an iguana was encountered and a photograph was taken. Photographs were later analyzed with computer software to determine percentage of ground cover types.


JENNY STROVAS

Fig. 5. Hatchling iguanas were generally captured using a noose.


SARAH WULFF

Fig. 6. Once an iguana was captured by researchers, length and weight measurements were taken and habitat variables measured.

made, or unknown (ground cover we could not identify from our photographs). Canopy was classified as either vegetative cover or sky. A random direction was selected and the quadrat was repositioned 5 m from the original location along that azimuth in order to establish random locations to compare with encounter locations. Ground cover and canopy cover photographs were then taken in the same fashion as before. Differential use of cover types between both age classes and between encounter and random locations were analyzed using a chi-square analysis in Tadpole, version 2.

We recorded slope and aspect at each location. Aspect was divided into five ordinal categories: 315–44°, 45–134°, 135–224°, 225–314°, and flat. Finally, a designation of developed (if location was in close proximity to man-made structures) or undeveloped was assigned to each location.

We attempted to capture hatchling and yearling iguanas with nooses (Figs. 5 & 6). Captured hatchlings were weighed to the nearest gram, snout-vent length (SVL) and tail lengths were measured, individuals were marked with a unique number using white correction fluid for identification purposes (Fig. 7), and were released at the site of capture. Repeated observations of these individuals were recorded as re-sightings and habitat measurements were taken at these new locations and at associated random points.

Locations of iguanas observed by other researchers not directly involved with the project were marked with flagging by the observer. The primary investigators later visited these locations and recorded the same environmental measurements excluding temperature, percent cloud cover, and time of day (if not recorded during initial sighting). Additionally, for distribution analysis only, we used location data for both adult and hatchling iguanas recorded by researchers in 2004–2008.

General slope, aspect, and elevation for each location were compared to data collected at random points in 2008 during an ecological study of the island. Random habitat data points were collected along transects adjacent to trails throughout the island. Those data are representative of habitats in which we could have encountered iguanas during our surveys. A one-way ANOVA was used to compare general slope and elevation among adult iguana locations, hatchling iguana locations, and random sites. Least


SARAH WULFF

Fig. 7. Hatchling iguanas were temporarily marked with white correction fluid by researchers to aid in identification if they were encountered again. Here, iguana no. 11 basks on a stone wall.

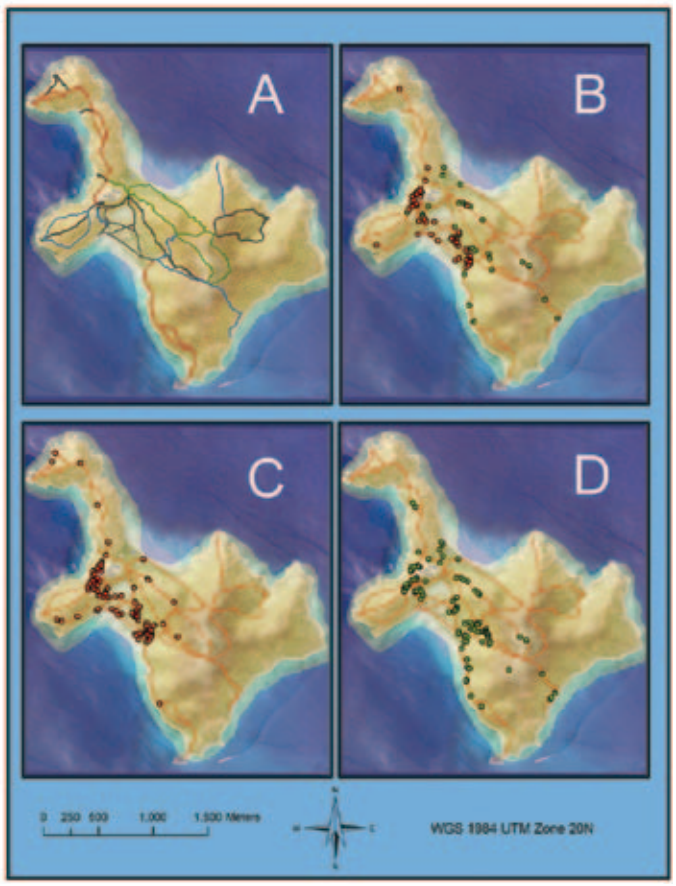

Fig. 8. Sampling effort and distribution of iguanas on Guana Island, BVI: (A) 2009 sampling effort based on number of times each trail was sampled (once-black, twice-blue, three times-green, four times-red); (B) 2009 iguana locations based on sampling effort from map A (green-adult and red-hatchling); (C) 2004–2009 locations of hatchling iguanas; (D) 2004–2009 locations of adult iguanas.

Significant Difference (LSD) post hoc tests were performed to evaluate pair-wise differences. Differences between general aspect among adult iguanas, hatchling iguanas, and random locations were compared using a chi-square test. The general aspect of the location at which an iguana was encountered was compared to time of day using a chi-square test. Time of day was classified into four categories: Early morning (beginning of surveys to 1000 h), late morning (1001–1200 h), early afternoon (1201–1400 h), and late afternoon (1401 to end of surveys). Finally, differences between iguana age class (adult or hatchling) and use of developed areas was analyzed using a chi-square test. Iguana locations within close proximity to human structures were categorized as "developed," whereas locations on or adjacent to trails were assumed to be representative of natural habitat across the island and were classified as "trails." All tests were performed within SPSS (SPSS Inc., Chicago, Illinois) with an alpha level of 0.05.

All UTM coordinate locations were mapped and analyzed in ArcGIS 9.3 (ESRI, Redlands, California). UTM coordinates were added and created into a shape file for adult iguanas, hatchling iguanas, and trails. Trails were categorized into classes based on numbers of surveys we conducted during 2009 to denote sampling effort. These shapefiles were then overlaid on a digital elevation model (DEM) and hillshade raster file to produce an elevational gradient map. Overall iguana distribution, elevational distribution, and age class distribution can be extrapolated from these maps.

Results

In 2009, we recorded 96 iguana sightings (43 adults, 52 hatchlings, 1 yearling). Sampling efforts are illustrated in Fig. 8, Map A, and iguana locations are illustrated in Fig. 8, Map B. All iguana sightings from 2004–2009 (N = 285: 123 adults, 160 hatchlings, 2 yearlings) are illustrated in Fig. 8, Maps C and D.

The majority of hatchling sightings (75%) occurred in developed areas, whereas the majority of adult sightings (51%) occurred on or near trails throughout the island (Maps C & D). Hatchlings represented 65% of the sightings in developed areas; however, adults represented 63% of the sightings on trails. Sightings of age class and location on the island differed significantly. No iguanas of either age class were observed on the eastern half of the island. This appeared to correspond strongly with feral sheep spoor, such as tracks, scat, and evidence of foraging on vegetation (Fig. 9).

Microhabitat characteristics and canopy cover for random versus iguana sightings are summarized in Table 1. Hatchlings were most frequently found in areas of bare ground (30.8%) with 55% cover, whereas adults were most frequently found in areas of leaf litter (54.7%) with 80% cover. When age classes were pooled, the difference between iguana and random sites for microhabitat or cover were not significant (Table 1). However, we did find a significant difference between adult and hatchling sightings for both microhabitat and canopy cover.

Slope, elevation, and aspect data are summarized in Table 2. Adults were generally encountered on steeper slopes and at higher elevations than hatchling iguanas. Random points along trails often had steeper slopes and higher elevations than both adult and hatchling iguana locations.

Fig. 9. Most groundcover and low-hanging vegetation on the eastern half of Guana Island has been consumed by feral sheep. Feral sheep compete directly with Stout Iguanas for food, and their presence may account for the lack of iguanas on this part of the island.

Fig. 10. Iguanas found on northern, eastern, southern, western, or flat aspects of Guana Island, BVI during 2009 sampling.

Table 1. The mean percentage of microhabitat characteristics or canopy cover (± 1 standard deviation) for random and all iguana locations in 2009 on Guana Island, BVI. Iguana locations then were divided into adult and hatchling categories. Differences between both adult and hatchling microhabitat and canopy cover use were statistically significant at $p < 0.005$.

	Herbaceous	Woody	Litter	Bare	Rock	Manmade	Unknown	Cover	Open
Random	10.1 ± 21.2	4.2 ± 9.0	44.6 ± 30.2	16.7 ± 25.5	14.3 ± 19.3	9.8 ± 28.5	0.5 ± 1.6	71.0 ± 32.2	29.0 ± 32.2
All Iguanas	9.7 ± 20.0	4.4 ± 7.9	41.3 ± 31.9	23.7 ± 30.8	13.7 ± 19.2	7.1 ± 24.2	0.1 + 0.5	66.3 ± 30.9	33.7 ± 30.9
Hatchlings	13.8 ± 24.0	4.4 ± 8.3	29.6 ± 27.8	30.8 ± 34.5	13.2 ± 20.4	8.3 ± 26.2	0.1 ± 0.5	55.4 ± 34.2	44.6 ± 34.2
Adults	4.2 ± 11.7	4.3 ± 7.1	54.7 ± 32.0	15.8 ± 24.5	14.9 ± 18.2	5.9 ± 22.5	0.2 ± 0.6	78.9 ± 20.6	21.1 ± 20.6

Table 2. The average slope and elevation (± 1 standard deviation) for each location class, and percentage of locations within each aspect category in 2009 on Guana Island, BVI. Differences among adult, hatchling, and random locations for both slope and elevation were significant at $p < 0.001$. Significant differences at $p < 0.001$ were detected when comparing adult and random aspect as well as hatchling and random aspect, but no significant difference existed between adult and hatchling aspect.

	Slope (degrees)	Elevation (m)	Aspect (% of occurrences)				
			North	East	South	West	Flat
Adult	20 ± 11 (0–38)	51 ± 52.6 (5–223)	16.3	16.3	20.9	37.2	9.3
Hatchling	12 ± 12.0 (0–38)	31 ± 20.9 (7–80)	25.0	7.7	25.0	30.8	11.5
Random	34 ± 14.3 (2–80)	92 ± 62.4 (3–245)	32.6	23.8	22.1	21.0	0.5

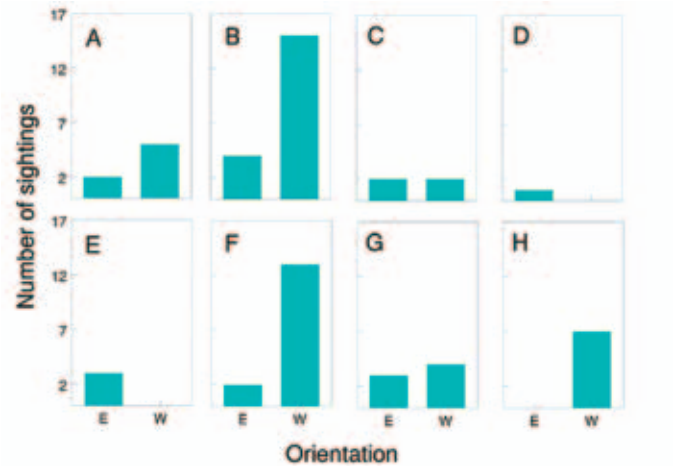

Fig. 11. Hatchling or adult iguanas found on eastern or western aspects according to time of day on Guana Island, BVI during 2009 sampling: (A) Hatchlings – early morning (before 1000 h); (B) Hatchlings – late morning (1001–1200 h); (C) Hatchlings – early afternoon (1201–1400 h); (D) Hatchlings – late afternoon (after 1401 h) (E) Adults – early morning; (F) Adults – late morning; (G) Adults – early afternoon; (H) Adults – late afternoon.

Significant differences existed in general slope and elevation among adult iguanas, hatchling iguanas, and random sites. A significant difference also was detected among adult iguanas, hatchling iguanas, and random sites when comparing general aspect. We found significant differences in aspect between hatchling and random sites and between adult and random sites, but not between hatchling and adult sites. Figure 10 illustrates the relationships between the number of iguanas encountered and aspect.

The number of iguanas sighted on easterly or westerly aspects in relation to time of day is illustrated in Fig. 11. The majority of iguana sightings (49%) occurred during late morning, and 44% of those iguanas were found on slopes facing southwest to northwest (225–314°).

Discussion

The Stout Iguana has become successfully established on Guana Island since the translocation of eight individuals 25 years ago (Goodyear and Lazell 1994). Continued successful reproduction is evident in the numerous hatchlings encountered by researchers each year.

The distribution of iguanas throughout the island does not seem to be uniform. Iguanas appear to be in high densities on the western half of the island, particularly around developed areas, whereas they appear to be largely absent from eastern sections of the island.

Distribution also varied between adults and hatchlings. Hatchlings were typically in developed areas, whereas adults were found along both trails and in developed areas (Fig. 12). Some additional differences in habitat characteristics can likely be explained by preferred nesting locations. Stout Iguanas preferentially nest in sandy locations (Perry et al. 2007). Unlike Anegada, which is a low-lying island composed of limestone and sand, Guana is formed of igneous rock hills (to 246 m; Goodyear and Lazell 1994). Therefore, many

Fig. 12. Both adult and hatchling iguanas were frequently encountered in areas with noticeable human activity or influence.


GRANT SORENSON

Fig. 13. Stout Iguanas prefer to nest in sandy substrate. Beaches provide some of the best nesting habitat on Guana.


ROBERT POWELL

Fig. 14. Hatchling iguanas often remain near beaches; this unmarked individual thermoregulated by shuttling back and forth between sun and shade.

of the sandy areas suitable for nesting are along the beaches (Fig. 13). As iguanas on Guana are likely hatching near sea level, they may not have had enough time to disperse from their natal beaches to the higher elevations within the confines of the sampling periods (Fig. 14). This might explain the differences in elevations at which hatchlings and adults are encountered. Similarly, the areas nearest the beaches are generally flat, which might explain the differences between slopes at which age classes were encountered.

Differences in percentage canopy cover use between age classes may be a function of physiological constraints related to size. Smaller iguanas have a much higher surface area-to-volume ratio, and thus have less thermal inertia (Bell 1980). We suspect that the percentage canopy cover utilized by hatchlings is lower because of their need to actively thermoregulate more frequently. It might also explain why hatchlings were found more often in developed areas and the lowland flats. These areas appeared to be generally more open, whereas the trails are generally forested.

Finally, we believe that the feral sheep population is having a direct impact on this species. Although sheep eradication efforts have been in place since the 1980s and numbers have been reduced, reproduction still occurs. Sheep may outcompete iguanas by consuming much of the desirable understory vegetation within 2 m of ground level (Goodyear and Lazell 1994). Although not within the scope of this study, an apparent correlation between the presence of sheep — whether direct sightings of individuals or indirect evidence, such as tracks and scat — and the absence of iguanas was evident. Mitchell (1999) found that on Anegada, where feral livestock also is a problem, iguanas have altered their diets to include greater amounts of less palatable or even toxic leaves avoided by livestock. On Guana Island, iguanas may simply avoid areas overbrowsed by sheep, possibly explaining why none are encountered on the eastern side of the island.

Overall, the outlook for this species on Guana Island appears favorable. Not only has the species become established over the past 25 years, it seems to be flourishing. Still, long-term persistence of this population will depend on sound management strategies. These strategies should consider the fact that hatchlings and adults do differ in numerous habitat requirements. Removal of the feral sheep from the island would almost certainly be beneficial for iguanas. As protection for the Stout Iguana continues to be a contentious subject on the island of Anegada (Mitchell 2000, Perry and Gerber 2006), Guana Island currently represents this species' best chance for continued survival.

Acknowledgements

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Three Color Variants in the Malabar Pit Viper (*Trimeresurus malabaricus*)

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Photographs by the senior author.

The Western Ghats of India and nearby Sri Lanka are a global hotspot of biodiversity (Brooks et al. 2007). The Malabar Pit Viper (*Trimeresurus malabaricus*) is endemic to the higher elevations of the southern Western Ghats in southwestern India. This pit viper appears to be very secretive and is known to occur only near forest streams in the mountains (Smith 1943). The tropical rainforests of the Western Ghats, with an annual average rainfall >550 cm (220 in), currently provide ideal habitats, but are rapidly being degraded. This snake is typically green with a black pattern, especially on the tail. Although it is venomous, the Malabar Pit Viper is not considered lethal, probably because the venom lacks the enzyme hyaluronidase (Gowda et al. 2006). Other than some taxonomic and phylogenetic work (Malhotra and Thorpe 2004, Uetz and Hallermann 2009), little is known about this species, including its natural history.

Map of southern India showing the Western Ghats and the study area in the Bisale Forests.

Many snakes are variable in color and pattern, and such color morphs are popular with captive breeders. For example, Russell's Vipers (*Daboia russelii*) in southern India may be either melanistic or albinistic (Thorpe et al.

Habitat in the study area consists of tropical rainforest.

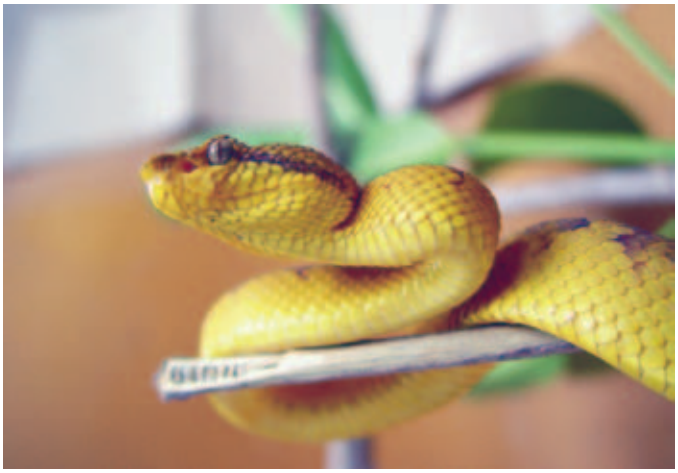
The most common color morph of the Malabar Pit Viper (*Trimeresurus malabaricus*) showing the distinct tail pattern.

2007). However, color variants of Indian pit vipers are poorly documented. Here we report three color variations in sympatric Malabar Pit Vipers.

During the period 1999–2005, we observed 126 individuals of *T. malabaricus* to examine morphological variation and record natural history data. The study area, Bisale Forests (12º15'N, 75º33'E; elevation 800–1,000 m above sea level), is located along the western slopes of the Western Ghats near the borders of Dhakshina Kannada and Hassan districts in the southern state of Karnataka. The snake's habitat in this area is threatened by the proposed Gundia Dam project, which would inundate large areas of the forest and dramatically modify surrounding areas. We observed three distinct color morphs in the same geographic area. The first is the common form with a light green ground color and distinct dark markings. The second variant has only a faint pattern on a red ground color and the third has a bright yellow ground color with a faint but clearly discernible pattern. Tail markings are distinct in all variations, with the clear dark pattern probably used to lure prey.

These snakes employ an ambush prey-procuring strategy, which suggests that variations in color and pattern might facilitate crypsis. However, other than the pattern in the common morph serving to break up the snake's outline, we observed no correlations between snake color and background color or pattern, which was generally green (foliage) and occasionally black (snakes lying on rotting logs).

Markings on the red color morph of the Malabar Pit Viper are very indistinct.



The yellow variant of the Malabar Pit Viper has a faint but clearly discernable pattern.

The distinct tail pattern is conserved in the yellow color variant.

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Notes on Reproduction in the Brownback Salamander (*Eurycea aquatica*)

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Photographs by the senior author.

Life history data often are lacking for species with an uncertain taxonomic status. As phylogenetic analyses improve and our understanding of species boundaries become more refined, ecological information should likewise keep pace. Here, we report information on the timing of reproduction, clutch size, and nest attendance for the Brownback Salamander (*Eurycea aquatica*), a species recently documented to be a separate lineage after a long, controversial systematic history. We confirm that this species has the largest clutch size of any lineage within the *Eurycea bislineata* complex, and suggest that male and male-female nest attendance is not uncommon in this species. We suggest that, in addition to the genetic divergence documented between *E. aquatica* and other members of the *E. bislineata* complex, ecological differences also are present and possibly are influenced by the unique springs inhabited by Brownback Salamanders.

Reporting detailed natural history information for amphibian and reptilian species is necessary for their conservation, and for analyses that describe evolutionary and ecological patterns. For some taxa, this information is currently unavailable due to their recent recognition as distinct species (e.g., cryptic species, newly described taxa) or due to controversy regarding their status as a separate evolutionary lineage. An example is the Brownback Salamander (*Eurycea aquatica*), a plethodontid salamander with a long, turbulent taxonomic history that has recently been confirmed as a monophyletic lineage distinct from nearby populations of its congener, the Southern Two-lined Salamander (*Eurycea cirrigera*; Kozak et al. 2006, Timpe et al. 2009). Previous contributions to this salamander's reproductive biology have been complicated by the uncertain taxonomic status of this species, the presence of putative "intermediates" between *E. aquatica* and *E. cirrigera*, and the subjective categorization of individuals for analysis (Jones 1980). Here, we compile information on the timing of reproduction, clutch number, nesting sites, and nest attendance in this species that was obtained coincident with collections for the morphological and phylogenetic analyses by Timpe et al. (2009). We therefore had an *a priori* method for categorizing individuals as belonging to either species. This also allowed us to reconsider potential intermediates mentioned by other authors, and we report possible explanations for the morphological confu-

Large adult male *Eurycea aquatica*.

Spring habitat of *Eurycea aquatica*; Sander's Spring, St. Clair County, Alabama. The wellhouse is in background; note the extensive growth of Watercress (*Nasturtium officinale*) and the overturned potted plant in foreground.

Nest of *Eurycea aquatica* found under a potted plant at Sander's Spring.

sion between *E. cirrigera* and *E. aquatica*, which may have hampered earlier efforts to characterize the Brownback Salamander's life history.

Materials and Methods

Brownback Salamanders are locally abundant and inhabit springs throughout the limestone regions of northern Alabama and Georgia (Jones 1980). We sampled populations that had previously been studied by Jones (1980), and located and collected salamanders by turning cover objects in and around the springs. Tail tissue and/or whole individuals were collected for the morphological and phylogenetic analyses of Timpe et al. (2009). When clutches were found, the object covering the eggs was noted, photographs were taken of each clutch, and the number of eggs per clutch was determined from the photos. Each nest was categorized as being attended by either a male, a female, both a male and female, or no adult. Males of this species can easily be distinguished from females based on the presence of a grossly enlarged head and small but distinct cirri (Jones 1980, Timpe et al. 2009). In March 2009, we marked artificial cover objects (plastic pots for plants) at a spring site (Sander's Spring, St. Clair County, Alabama) that had previously been productive for finding clutches. At this spring, the landowner uses the spring water for potted aquatic plants, and the spring contains dozens of these pots. When found under these artificial cover objects, salamanders were photographed with or without eggs. To suggest the degree of parental care, we returned to this site three days later, re-photographed each salamander, and identified salamanders by pattern matching (e.g., Forester 1977, Bailey et al. 2004) to confirm their ongoing attendance of the egg clutch.

In addition, we examined nests for each of three divergent clades identified by Timpe et al. (2009) in their phylogenetic analysis of *E. aquatica* (e.g., those found in the Coosa Valley, Birmingham-Big Canoe Valley, and Cumberland Plateau, respectively), and compared mean clutch sizes for nests from each of these clades using ANOVA. This analysis was conducted using JMP 8.0.1 software with $\alpha = 0.05$.

Results

Previous to the nesting period, gravid females and males in breeding condition (i.e., with enlarged heads and small but distinct cirri) were located under rocks in springs and small streams in limestone regions of northern Alabama and Georgia. Males and females were observed in springs as early as 3 January. One male in breeding condition was found crossing a road on a rainy night on 10 January 2008. Forty-one nests were located during February–March 2007–2009. The earliest recorded nests were found on 2 February, and the latest nests were observed on 16 March. In April and subsequent months, adult *E. aquatica* were less frequently observed along the edges of springs, and no nests were located. Twenty-four nests were under rocks (mostly in springs or spring runs), one under a log, and 15 under artificial cover objects (e.g., plastic pots for plants). Twenty-five nests were found with females in attendance, five with males in attendance, seven with both a male and female in attendance, and three had no adult presence/attendance. One nest was found with an adult in attendance that escaped before it could be sexed. The mean clutch size of *E. aquatica* (based upon eggs counted in nests) was 65.93 (N = 41; range 31–138). Mean clutch sizes for each of the three clades recovered within *E. aquatica* (Timpe et al. 2009) differed significantly ($F_{2, 39} = 7.51$; $p = 0.002$), with 26 nests from the Coosa Valley exhibiting a higher clutch size (mean 72.6 ± 24.4 SD) relative to those in the Birmingham-Big Canoe Valley (N = 5, mean 44.0 ± 9.8 SD) or Cumberland Plateau (N = 10, mean 52.4 ± 9.9 SD; Tukey-Kramer post hoc test; $p = 0.01$).

The artificial cover objects at Sanders Spring contained six nests on 3 March 2009, and seven nests on 7 March 2009. On 7 March 2009,

two nests attended by females on 3 March were still attended by the same individuals. Two nests attended by females were still attended by the same females and were joined by males. One male remained with the nest he had attended, and one nest was abandoned by a male. One male replaced another male under a pot, was joined by a female, and their cover object contained a newly laid egg clutch. One male without eggs remained alone under a pot, and one male switched from one pot to another; each of these males had no eggs. Finally, a new pair arrived under a pot. No eggs were present at that time.

Discussion

The average clutch size of *Eurycea aquatica* is larger when compared to those of other members of the *E. bislineata* complex, and the mean we report in this study is larger than any population mentioned by Petranka (1998), Pauley and Watson (2005), or Sever (2005a, b) in their synopses of the complex. Although some of the larger nests we found could have been the result of communal nests (Sever 2005a), eggs in all large nests appeared to be of the exact same developmental stage, and cover objects often were found with two discrete nests with eggs in different stages of development (N = 4 observations). Similar to other plethodontid salamanders, differences in clutch size between each of the three divergent clades of *E. aquatica* recovered by Timpe et al. (2009) may be explained by variation in adult body sizes of these salamanders (Tilley 1968).

Reproductive information was used as one of many characters to distinguish *E. aquatica* from its relatives in the type description of this species (Rose and Bush 1964). Rose and Bush (1964) also reported that clutch size (based upon number of enlarged eggs counted in gravid females) was quite large in *E. aquatica*, attributing this difference to the productive habitat of the limestone springs they inhabit. Jones (1980) also provided data on Brownback Salamander clutch size; however, in his analysis, salamanders were subjectively assigned to species based on uncertain morphological characters. Previous considerations of Brownback Salamanders have referred to "intermediate" forms between *E. aquatica* and nearby populations of *E. bislineata* (= *E. cirrigera*), and the presence of these problematic individuals contributed to the controversial assignment of this species as a spring "ecotype" of *E. cirrigera* (Folkerts 1971, Mount 1975, Jones 1980, Petranka 1998). Because these "intermediates" were included in Jones' (1980) analysis, which species was involved is uncertain, and the reproductive information included is consequently of tenuous value.

We encountered individuals that we believe, based on coloration and patterning, would have been considered "intermediates" by previous authors, including a gravid female (AUM 37688) collected about 0.25 km from the closest spring (Sander's Spring) harboring *E. aquatica*. This individual had yellow dorsal coloration, and otherwise was morphologically consistent with *E. aquatica*. Other salamanders collected from this site and other springs were dark brown when collected and later became considerably lighter in captivity, exhibiting a more yellow color with less distinctive brown dorsolateral stripes. The above individuals shared identical mitochondrial haplotypes to other *E. aquatica* (Timpe et al. 2009). One individual obviously assignable to *E. cirrigera* was eventually collected at this site (AUM 37836; 1 February 2009), and was confirmed to be *E. cirrigera* genetically (E.K. Timpe, unpubl. data). Thus, although these species are broadly sympatric throughout the karst regions of Alabama and Georgia, the Sander's Spring site is currently the only known locality where these

Example of an individual *Eurycea aquatica* (AUM 37688) that could be confused for an *E. aquatica* x *E. cirrigera* "intermediate." Note the yellow dorsal coloration and the lack of an enlarged head (this individual is female). The dark sides also are considerably lighter than in most individuals.

Comparison between an adult male *E. cirrigera* (left) and an adult male *E. aquatica* (right). These salamanders were collected on the same day ~5 km apart in Murray County, Georgia.

salamanders have been confirmed to occur syntopically. No evidence is suggestive of mitochondrial or nuclear gene exchange between these species at this site. We believe that "intermediates" noted by other authors were considered so for three reasons: (1) Female *E. aquatica* and *E. cirrigera* are very similar morphologically, (2) dorsal coloration is variable in *E. aquatica*, with some individuals occasionally exhibiting yellow coloration, and (3) male *E. aquatica* may appear more similar to *E. cirrigera* during the non-breeding season if their head size is less pronounced during this time. Otherwise, adult males of these species are unmistakably different morphologically.

Because the reproductive information we present here is based upon known populations of *E. aquatica*, these are the first data known explicitly for this species. We confirm the large clutch size (compared to other members of the *E. bislineata* complex) suggested by Rose and Bush (1964). In addition, we provide information about the location and microhabitat of several nests and information about the nesting period. Perhaps our most interesting finding is the possibility of biparental care in this species. Most reports of egg attendance in *Eurycea* have been of individual females attending nests (Wells 2007). Seven nests were attended by a male and female, five were attended by males, and 25 nests were attended by females. Interestingly, of four nests reported for the sister taxon of *E. aquatica*, the Junaluska Salamander (*E. junaluska*; Kozak et al. 2007, Timpe et al. 2009), one was attended by a male and female and two were attended by females (Bruce 1982). Although further study is needed, this suggests that these closely related salamanders might share similar reproductive strategies. An alternative explanation is that these species breed immediately prior to oviposition, and males remain with the females shortly before and/or after breeding and then disperse. This would also be an interesting characteristic for these species, since, in most plethodontids, breeding and oviposition are temporally dissociated (Wells 2007). If this is the case, we witnessed many pairs that were in the process of breeding or about to breed. However, the number of male-only nests and our observation that females already present on nests were later joined by males suggest that male parental care and biparental care may be involved.

Interestingly, few studies have examined long-term nest attendance/fidelity in salamanders (Wells 2007). Our small experiment confirmed that many individuals found on nests were found with them after three days, suggesting that these individuals were not simply there immediately after oviposition. Follow-up studies should be performed to confirm that the individuals present with the eggs are the actual parents of the offspring, and if these individuals remain with the eggs throughout their development. This study also confirms that, in addition to the morphological and genetic differences reported by Timpe et al. (2009), disparate life history strategies are present between this species and other members of the *Eurycea bislineata* complex. As proposed by Rose and Bush (1964), these differences appear to be associated with the unique spring habitat occupied by *E. aquatica*. Future research should be directed toward comparisons between this salamander and its congeners and the extent to which their habitat and/or mating systems determine these differences.

Acknowledgements

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Perch Height Differences among Female *Anolis polylepis* Exhibiting Dorsal Pattern Polymorphism

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Female-limited dorsal pattern variation within a species has been of interest to naturalists for years, and has been observed in animals ranging from spiders, damselflies, and dragonflies to frogs and lizards. Protection against predation by birds has been offered as a preliminary explanation for the evolution of these patterns, especially from birds that have acute color vision and which preferentially prey on females because they are less agile and more nutritious (Stamps and Gon 1983).

Fig. 1. Male *Anolis polylepis* with dewlap extended (right) and female *A. polylepis* (above) with the "diamond stripe" (ds) dorsal pattern (see text). Copyright © David Laurencio 2010. Used with permission.

Female-limited dorsal pattern variation is observed in many anoline lizards (Savage 2002, Losos 2009). In anoles, multiple dorsal patterns occur in females throughout a population, and these dorsal patterns are heritable (Calsbeek et al. 2008) and relatively fixed throughout a female's life (although the intensity of the pattern can change depending on light availability, humidity, and temperature; pers. obs.). Savage (2002) described some recurring dorsal pattern phenotypes seen widely in species of Costa Rican anoles.

Female *Anolis polylepis* from Las Cruces Biological Station in Costa Rica show a number of dorsal patterns. As part of a demographic study of *A. polylepis*, I captured and recaptured females that possessed different dorsal patterns and measured perch heights and other ecological variables to determine if females with different dorsal patterns differ in microhabitat use.

Study Site and Methods

During the dry season of 2003, I performed a capture-mark-recapture study of juvenile and adult *Anolis polylepis* (Fig. 1) in a 10,000-m^2 plot of primary forest within the boundaries of the Las Cruces Biological Station. The Station is located at an elevation of 1,200 m above sea level in San Vito, Coto Brus County, Puntarenas Province, in southern Costa Rica (8°47'7''N, 82°57'32''W). This mid-elevation site is comprised of more than 300 ha of Premontane Wet Forest habitat according to the Holdridge classification system.

I superimposed a Cartesian coordinate system over the plot and every five meters placed a survey flag that contained the Cartesian coordinates. I performed standardized searches for lizards on this plot by entering the plot from the same point during every search (the southeastern side) and slowly walking a zigzag pattern from one end to the other end of the plot. I continually searched the plot for lizards in this way from 0800–1130 h. When a lizard was observed during a standard plot search, I noted its location with respect to the nearest flag, and recorded whether the lizard was perched on the ground versus a trunk or branch of a tree. I measured the height of the perch and the diameter at breast height (DBH) of the tree on which the lizard was perched with a hand-held 5-m tape measure. I then captured the lizard (by hand or with a noose) and brought it back to the Las Cruces lab, where I measured its snout-to-vent length (SVL) in millimeters, mass in grams, and, if the lizard was a female, I noted if she was gravid (i.e., had a shelled egg in the right or left oviduct) or had yolking follicles. I collected data for 19 days from 3–24 March. I estimated home range sizes for females using the methods of Jennrich and Turner (1969).

Three dorsal patterns were common among female *A. polylepis*. I described and drew them in detail in my field notes (Fig. 2), and they appeared to be intermediate phenotypes of that described for female Costa Rican anoles by Savage (2002). I defined the three common dorsal patterns as: (a) Diamond stripe (or "ds"), which consists of black diamonds, and is the dorsal pattern labeled "b" in Savage (2002); (b) checkered stripe (or "cs"), which consists of a white and black hyphen- or dash-like pattern, and appears to be a variation of dorsal pattern "e" in Savage (2002), with a black dash overlying the white stripe; and (c) white stripe (or "ws"), which consists of a bright white stripe bordered by black stripes, and is the dorsal pattern labeled "e" in Savage (2002).

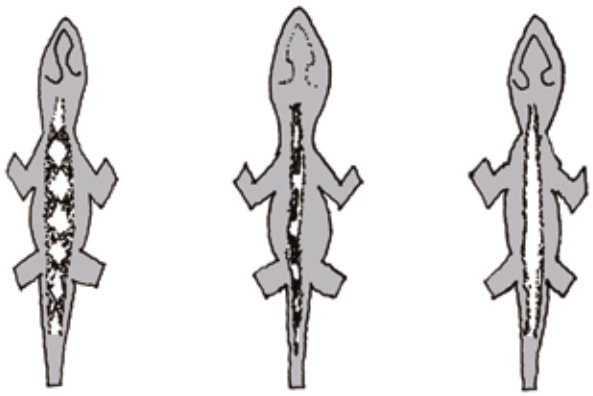

Fig. 2. Dorsal patterns observed in female *Anolis polylepis* in primary forests near Las Cruces Biological Station: ds = diamond stripe, cs = checkered stripe, ws = white stripe.

To determine whether females with the three dorsal patterns differed in mass, SVL, perch height, DBH, and home range size, I performed one-way ANOVAs for each variable, with dorsal pattern type as the independent variable. To determine whether females with the three dorsal stripe patterns differed in being gravid or not or in the number of home range overlaps with other males and females, I used chi-square tests for each variable, with dorsal pattern type as the independent variable.

Results

Females of the three differing dorsal patterns did not differ in mass, SVL, DBH, home range size, gravidity status, or number of overlapping home ranges with male or females (Table 1). However, a dorsal pattern-specific difference in perch heights was evident. Females with the ds pattern perched the lowest, females with the cs pattern perched at intermediate heights, and females with the ws pattern perched the highest (Fig. 3).

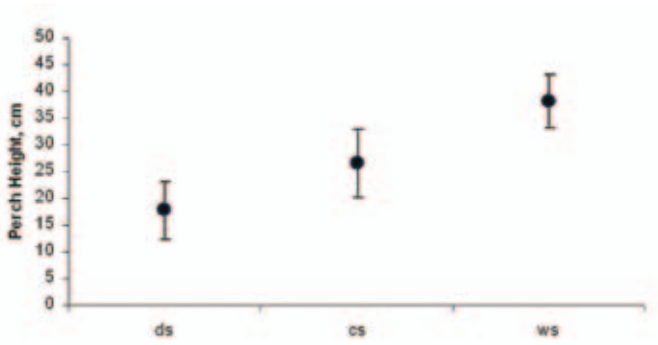

Fig. 3. Perch height differences among female *Anolis polylepis* with differing dorsal patterns at Las Cruces Biological Station. ds = diamond stripe, cs = checkered stripe, and ws = white stripe. Bars represent one standard error. One-way ANOVA showed these differences to be statistically significant at $p \leq 0.05$).

Discussion

These data suggest that females that possess different dorsal patterns differ in perch height in *Anolis polylepis* at Las Cruces Biological Station. Furthermore, these females do not appear to differ according to other common ecologically relevant variables that were measured.

Avian predation has been hypothesized to be the key selective force responsible for the evolution of these dorsal polymorphisms in most species (Stamps and Gon 1983). That avian predation has an influence on population density (Andrews and Rand 1982), community structure (Adolph and Roughgarden 1983), and habitat choice (Wunderle 1981) in anoles has been recognized for years. Recently, Calsbeek et al. (2009) studied female-specific dorsal pattern polymorphism in Caribbean island populations of the closely related *Anolis sagrei*, and found that predation on particular patterns was frequency dependent and acted as a significant selective agent maintaining the frequency of pattern variants in the population. Unfortunately, the study did not attempt to study perch height differences in dorsal pattern variation. The authors speculated that particular dorsal patterns appear differentially conspicuous to predators in certain microhabitat conditions. Interestingly, the dorsal pattern variations observed in *A. sagrei* are different in shape and design than those in *A. polylepis*.

Table 1. Results of separate one-way ANOVAs and Chi-square analyses testing dorsal pattern differences in ecologically relevant dependent variables among female *Anolis polylepis*. Dorsal pattern type was the independent variable. Female dorsal patterns commonly observed at Las Cruces Biological Station were "ds" (diamond stripe), "cs" (checkered stripe) and "ws" (white stripe). N refers to number of individual females repeatedly observed with a particular dorsal pattern, and the number in parentheses refers to the total number of sightings for the particular dorsal pattern sighting. DBH = tree trunk diameter at breast height. An asterisk (*) marks results significant at $p \leq 0.05$.

Dependent variable	**F**	**df**	**P**	**N (ds)**	**N (ds)**	**N (ws)**
Mass	0.500	14	0.613	6 (26)	3 (20)	6 (21)
SVL	1.431	14	0.259	6 (26)	3 (20)	6 (21)
Perch height	3.955	14	0.039*	6 (26)	3 (20)	6 (21)
DBH	0.200	14	0.821	6 (26)	3 (20)	6 (21)
Home range	0.714	14	0.502	6 (26)	3 (20)	6 (21)
	χ^2	**df**	**P**	**N (ds)**	**N (cs)**	**N (ws)**
gravid / not-gravid	4.611	14	0.330	6 (26)	3 (20)	6 (21)
# Male HR overlap	5.220	14	0.516	6 (26)	3 (20)	6 (21)
# Female HR overlap	5.882	14	0.443	6 (26)	3 (20)	6 (21)

The data I present here are consistent with an avian predation explanation — if the different dorsal patterns could be shown to be differentially conspicuous to avian predators in different microhabitats, and if different dorsal patterns experience differential mortality as a result of this conspicuousness. Future research on female dorsal patterns in anoles should therefore focus on the ecological significance of the female dorsal patterns with respect to avian visual systems.

Acknowledgements

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COMMENTARY

Amphibians and Reptiles are Wild Animals

In his commentary, "Domestic Reptiles and Amphibians?" (*R&A* 16(3):190–194), Al Winstel ended by proclaiming: "… some herps deserve to be admitted to the ranks of the domestic!" Such a pronouncement implies that the title "domestic" is somehow honorific and desirable to reptiles and amphibians. It is not.

A close look at the situations in which most captive reptiles and amphibians find themselves demonstrates that, rather than striving to achieve an extolled status, they are suffering in great numbers, languishing under improper care, and often treated as mere objects or "collections" for the gratification of their human keepers. Colorado Reptile Humane Society (CRHS) does not support the captive breeding of reptiles and amphibians for such purposes and implores all herpetoculturists to think carefully about breeding decisions and the plight of captive reptiles and amphibians. Indeed, the human need to own something that looks "pretty" is insufficient justification to bring so many living creatures into suffering.

While it is true that some reptiles and amphibians are capable of being socialized and becoming tolerant of their human caretakers, this does not mean they are "happy" to do so, as Winstel implies. Indeed, even the best captive situation offers a marked reduction in habitat area, stimulation, seasonal variation, and food availability from a wild habitat. Regardless of their color variation (of which a great, beautiful abundance exists in nature — see box turtles or the *Ensatina* salamanders of California!), captive-bred reptiles and amphibians are wild animals and should be treated as such. Engaging in irresponsible breeding and further exacerbating the overabundance of reptiles and amphibians in captivity, simply for the pleasure of ownership, is irresponsible and shows a lack of respect for these lovely animals as living creatures. Is this not the same mentality that brought us the spectacle of the cross-eyed "white tigers?"

Additionally, the continued breeding of reptiles and amphibians for the pet trade and personal ownership is rapidly becoming a major ethical, safety, and economic issue across the country. In the first 10 months of 2009, CRHS accepted over 300 reptiles and amphibians from owner surrenders and found stray animals. We are one organization that serves a portion of a single state; given the paucity of such organizations across the country and the inundation with unwanted animals of those that do exist, this amounts to nothing short of a crisis for captive reptiles and amphibians. Additionally, accidentally or intentionally released captive animals are causing massive damage to ecosystems across the country, from Snapping Turtles in California to Green Iguanas and Burmese Pythons in Florida. While a single creamsicle-colored Corn Snake escaping from an owner's cage isn't going to destroy an ecosystem, thousands of breeders engaging in reckless and thoughtless experiments can lead to disastrous cumulative effects.

We at CRHS do not wish to condemn herpetocultural enthusiasts who have found a love for these oft-maligned creatures. We do, however, beseech all would-be reptile or amphibian breeders to consider the implications of their actions. Until every animal has a home, it is unconscionable to continue adding animals to captivity when plenty are simply waiting to find permanent caretakers or euthanized for want of space in already-crowded shelters. Additionally, relishing the possibilities of "creating" new color patterns on a whim both objectifies the individual animal and diminishes the wondrous variety of still-wild creatures. Before breeding, please consider the greater context of your actions.

CAROLE SAUCIER

Captive breeding has "created" many new color patterns in species such as the Bearded Dragon (*Pogona vitticeps*). The individual on the left is "Hypo Orange"; the one on the right is a "Hypo Orange Leatherback." The authors suggest that relishing the "creation" of such "morphs" objectifies the animal and diminishes the wondrous variety of individuals in nature.

An adolescent Common Snapping Turtle (*Chelydra serpentina*), unhappy to be removed from his ditch.

TRAVELOGUE

An Inadvertent Travelogue: Daniel Island, South Carolina

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Photographs by the author except where noted.

"He chased me a couple hundred feet up the creek, that's what then." The snapping turtle paused for effect. "But I escaped — lost him in a muddy cloud near the fall-down tree. I watched him walk away, stooping, in the direction we came."

They were incredulous, this odd collection of compatriots — snapping turtles, mud turtles, and one crayfish (admitted only after a protracted argument regarding the dorsal segment of his crustacean exoskeleton being called a "carapace"). They'd heard rumors of such encounters with these bipedal beasts, but never firsthand. There were vague legends of turtles disappearing for soup or to live out a few short months trapped in a class cage in a boy's bedroom. But never this. Never an escape.

Although I know Common Snapping Turtles (*Chelydra serpentina*) lack a social structure, let alone the power of vocalization, I couldn't resist imaging today's meeting projected with human musings. In this setting, such anthropomorphizing seems almost appropriate: I waded through the mucky waters of this ditch, forested on either side for a mere 100 feet or so, to the echoing songs of cardinals and titmice punctuated by the sharp *ping* of golf balls being whacked. Daniel Island, South Carolina, is no nature preserve. After falling out of the hands of a wealthy family who used the land for occasional sport hunting and cattle grazing, the island became a quick magnet for developers. It is now home to two golf courses, professional tennis tournaments, and the concomitant array of multi-million-dollar homes. As an outgrowth of the City of Charleston, the human population continues to increase exponentially, now at about 7,000 inhabitants. Here for a week to visit family, I could not resist a muddy exploration of this narrow remnant of what this place used to be — wooded and wild.

WILLIAM SLATER

The author holds an adult Yellowbelly Slider (*Trachemys s. scripta*) with a beautifully textured carapace.

The psychedelic markings of a juvenile Yellowbelly Slider (*Trachemys s. scripta*).

My encounter was with a smallish snapping turtle, let's call him an adolescent (which might at least partially explain the bravado with which he relayed his tale), meandering in the mire just off a golf-cart bridge. I saw him, paused a moment to measure the situation, then grabbed firmly (although not without some trepidation) at the rear of the carapace. I set him on the bank to take some photos and admire him closely, as much as one can admire a fellow creature intent on one's demise (or, more accurately, who saw my demise as the surest path to his own safety). In his version of events, it was his own reaction that produced a quick release, the clawing and sudden snapping, the dramatic pauses with mouth fully agape, daring me to try again. I replaced him in the small brook, much more clumsily than I intended as his rear legs slapped forcefully at the moment

of release, plopping him into the leafy shallows. He then moved fluidly and intentionally upstream, a walking-in-water that lacked the usual implied laboriousness of locomotion in reduced gravity. The sepia tones of the setting were most appropriate for an animal unchanged for some 60 million years, framing him somewhere amongst the ancients, frozen in some past that no longer exists but still haunts us.

Next day, I returned to this spot and ventured farther down-creek (or, more aptly, down-ditch) and chanced upon two Eastern Mud Turtles (*Kinosternon subrubrum*), one basking on the grassy bank and the other just a few inches away, submerged in the tannin-brown water. This pair was much more tolerant of my investigations and photographs than their predecessor; I fancied that word had spread quickly amongst their contingent that I was not to be feared. The mud turtles' survival technique was the antithesis of the snapper's, but no less effective. They tucked in their heads and held steady. Their patience exists on a scale in time with geologic movements and the slow turning of years, not the rush of our harried lives.

This marked the third turtle species I'd seen in the vicinity of my parents-in-law's house during our short visit. The remaining species is, of course, the ubiquitous Yellowbelly Slider (*Trachemys s. scripta*), found basking, often in large numbers, on the tidy shores and drainage pipes of every water hazard and decorative pond. With such a hearty tolerance for sculpted landscapes and close quarters with both humans and conspecifics, these are the suburbanites of the turtle world. Several juveniles made themselves readily available for quick capture, photographing, and release.

A basking juvenile Yellowbelly Slider (*Trachemys s. scripta*), enjoying both the sunshine and a prime view of the golf course.

A Common Mud Turtle (*Kinosternon subrubrum*) basks on the leafy bank.

Natural selection has blessed them with a carapace as psychedelic as any 1960s rock poster, yellows and greens swirling in patterns at once nebulous and repetitive. They grow less ostentatious with age, as do we all — the algae-black adults drift wearily in the middle of ponds, watching us watch them from the safety of distance.

Now this could go one of two ways. On the one hand, these shelled reptiles are to be extolled for their plodding tenaciousness, their ability to survive and possibly even thrive (at least in the case of the sliders) in such a manicured environment. These are tough beasts; they have lived unfathomably long, and, most likely, will continue to do so well after the heyday of humans. We should revere such endurance. And yet, although this may even be true, such perspective lets us off too easy. It's a lesson in compla-

The author holds two juvenile Yellowbelly Sliders (*Trachemys s. scripta*) recently caught in a golf-course pond.

Just some of the ubiquitous Yellowbelly Sliders (*Trachemys s. scripta*) basking on a drainage outlet.

An adolescent Common Snapping Turtle (*Chelydra serpentina*) showing his ferocity in an attempt to ward off the author; he was successful.

cency to believe that our most egregious habitat alterations leave the turtles intact. Perhaps this meager corridor of forest is too small for a proper home range and nesting, perhaps fragmentation prevents gene flow, perhaps the pesticides will catch up with even the sliders eventually. Maybe these are walking ghosts, the last vestiges of what was once, not at all long ago, a truly impressive showing. But this condemning perspective, also perhaps true, does not lead us to answers. A slider prefers a golf course to a mall parking lot, no doubt.

I prefer the lesson of simultaneous reverence and caution. Moralizing, even when warranted, seldom creates solutions. There is great joy at finding such survivors — they are doubtless that — in such close quarters to our homes and businesses. There is no harm in wonder at the quotidian. It is this wonder that sparks imagination, and imagination is the impetus for preservation. The snapper, the slider, and the mud turtle are not exceptional in the sense of being rare or exotic; rather, if it is not oxymoronic, they are exceptional in their abundance. As three of the most common turtles in North America, the expanded range of this assemblage now covers the better part of the continent as well as a spattering of colonies around the globe. To protect the imperiled, it may be of great benefit to study the flourishing — or, at the very least, admire their staying power.

Our brave snapper and his cohort would agree. Could these turtles organize and petition, as I dream they could on this breezy spring afternoon, they would implore us to be mindful, to watch our steps, to know that they, too, are here.

INTRODUCED SPECIES

Hemidactylus frenatus and *Gymnophthalmus underwoodi* in the Dominican Republic

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During recent herpetological surveys of the Dominican Republic, we collected the first known specimens of two species on Hispaniola: *Hemidactylus frenatus*, which is native to southeastern Asia and which has an almost circumtropical distribution, but has not been recorded previously from anywhere in the West Indies; and *Gymnophthalmus underwoodi*, a parthenogenetic native of northeastern South America that is being discovered on an increasing number of Lesser Antillean islands (Henderson and Powell 2009), but was not previously known from the Greater Antilles.

Several species in the genus *Hemidactylus* (including *H. frenatus*) are included among the most successfully colonizing species of amphibians or reptiles (Bomford et al., 2009). Several African and Asian species have become established in the Western Hemisphere (*H. angulatus*, *H. frenatus, H. garnotii, H. mabouia, H. platyurus,* and *H. turcicus*), with most or all benefiting from human mediation. *Hemidactylus angulatus* (West Indian populations were formerly assigned to *H. haitianus*; Weiss and Hedges 2007) and *H. mabouia* are widely distributed in the Greater Antilles, and *H. turcicus* occurs locally on Cuba (Henderson and Powell 2009). In August 2008, one of us (JN) collected a subadult male *H. frenatus* (Fig. 1) from beneath the exfoliating bark of a fence post at Balneario La Zurga (an oasis along highway 46 between the towns of Jimaní and Duvergé in Independencia Province, Dominican Republic). That lizard was taken during the morning hours, and no others were observed. We have been unable to survey the area at night, although the senior author conducted an extensive nocturnal survey in La Descubierta (ca. 10 km northeast of Jimaní) in 2009. The only geckos observed were *Aristelliger expectatus*, *H. angulatus*, *H. mabouia*, and *Sphaerodactylus elegans*.

Figure 1. Dorsal and ventral views of a *Hemidactylus frenatus* collected in the Dominican Republic. Note the lightly tuberculate dorsal surface, light stripe on the rostrum, and subdigital lamellae that reach the palm on the fourth digit. Photographs courtesy of Jonathan Woodward and The Museum of Comparative Zoology.

The occurrence of *H. frenatus* at a rather isolated site in the xeric western Dominican Republic is puzzling, as this species is typically associated with warm mesic or edificarian habitats. Illegal Chinese immigrants often cross the Haitian border into the Dominican Republic in this area, and this record might be related to such activities. The failure of the species to spread farther could be limited by the oppressively xeric conditions of the Valle de Neiba. However, a general attitude of indifference by herpetologists to invasive species of *Hemidactylus*, as well as difficulty distinguishing between species of *Hemidactylus*, might have caused *H. frenatus* to go undetected. Careful surveys of the gecko fauna throughout the Dominican Republic should be conducted in order to clarify the status and monitor the potential spread of this highly invasive species.

Gymnophthalmus underwoodi is widely distributed throughout northeastern South America and in the southern Lesser Antilles (Williamson and Powell 2004). Some insular populations may have been founded by ancestors that arrived by natural over-water dispersal, but many are undoubtedly human-mediated (Powell et al. 2011). In September 2009, one of us (ML) collected an individual in leaf litter surrounding the research station at the Punta Cana Resort in La Altagracia Province (Fig. 2). Further searches produced an additional specimen and two other lizards, which we failed to secure. We initially were puzzled by the occurrence of this species in a formerly remote area of the country, but we soon realized that these animals were taken in an exotic fruit-tree garden established by the resort decades ago. These small, parthenogenetic lizards were almost certainly introduced as stowaways in tree containers. Leaf litter surveys of surrounding regions (Boca de Yuma, Bávaro, Bayahibe, and Isla Saona) have not revealed any additional *Gymnophthalmus*. Other lizards collected in proximity of the *Gymnophthalmus* consisted of *Aristelliger lar*, *Celestus* sp., *Hemidactylus angulatus*, and *Sphaerodactylus savagei*.

The voucher specimen of *H. frenatus* is in the Museum of Comparative Zoology (MCZ-R-186874). The specimens of *G. underwoodi* have been assigned numbers from the Richard E. Glor field series (Glor 6813 & 6845). Jimmy McGuire and Tony Gamble confirmed the identity of the *H. frenatus* from photographs, and the identity of the *G. underwoodi* was confirmed from photographs by Robert Powell. We thank Jonathan Woodward who provided photographs of the *H. frenatus* specimen.

Figure 2. *Gymnophthalmus underwoodi* from the Dominican Republic: A. Dorsum with pattern and coloration typical of this species; B. Venter showing enlarged, imbricate scales.

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Amphisbaena fuliginosa (Reptilia: Squamata: Amphisbaenidae) in the Lesser Antilles

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Seventeen species of amphisbaenians representing two families (Cadeidae and Amphisbaenidae) and two genera (*Cadea* and *Amphisbaena*) are known from the West Indies, with a distribution restricted to Cuba, Hispaniola, and the Puerto Rico Bank (Henderson and Powell 2009). No species are known to occur in the Lesser Antilles. Here we report on two specimens of *Amphisbaena fuliginosa* collected in the Lesser Antilles: One from St. Lucia and the other from Grenada. *Amphisbaena fuliginosa* is a South American species with its origin in Amazonia (Vanzolini 2002). Both specimens are in the museum collection at the University of the West Indies (UWITT) in St. Augustine, Trinidad. Both compare closely with published descriptions of *A. fuliginosa* in overall external morphology (Hoogmoed 1973, Murphy 1997, Vanzolini 2002; Table 1).

The St. Lucia specimen (UWITT 2010.12.24) was collected at Barre de L'isle on 4 April 1994 by Christopher K. Starr. The Barre de L'isle area is forested and mountainous. A discussion with the collector suggested that it was not taken in an area disturbed by humans, although hotels and human modified habitats are within 4 km of the Forest Reserve.

The Grenada specimen (UWITT 2010.12.28) was collected by Garth Underwood. The jar with the specimen contained a slip of paper with a hand-written "Grenada 4-4." This number was also associated with a jar containing specimens of *Anolis aeneus* and *A. richardii* that had been collected by Underwood between 12 and 22 December 1961 at localities from throughout the island and from near sea level to more than 500 m above sea level; therefore, we have no specific locality data for the *A. fuliginosa*. That Underwood did not mention this specimen in his 1962 publication or the supplement that was published in 1964 is puzzling. Perhaps he considered the specimen a "vagrant" and not worthy of mention, but that seems unlikely. Why did he not consider it an addition to the Grenada herpe-

tofauna, which was then poorly known? Alternatively, the specimen was mislabeled and was not found on Grenada.

Given that no other specimens are known, that both islands have been intensely collected by herpetologists during the past 50 years, and that this is a relatively common, geographically widespread squamate on Trinidad and mainland South America, the presence of *A. fuliginosa* in the Lesser Antilles is best explained by human transport.

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Amphisbaena fuliginosa. **A.** UWITT 2010.12.24 from Barre de L'isle, St. Lucia. **B**. UWITT 2010.12.28 from Grenada. **C.** Individual from The Cocal on Trinidad's eastern coast.

Table 1. A comparison of specimens of *Amphisbaena fuliginosa* from Grenada and St. Lucia with those from Trinidad. The range includes published data taken from the literature.

Location	Grenada	St. Lucia	Trinidad	Range
	(N = 1)	(N = 1)	(N = 12)	—
Total length (mm)	395	290	179–395	174–425
Tail (mm)	51	35	33–66	33–66
Tail/SVL	0.15	0.14	0.13–0.17	0.11–0.17
Body annuli	199	199	195–210	186–212
Tail annuli	21	26	21–28	21–28
Pre-anal pores	6	9	6–11	6–11
Number of supralabials	3/3	3/2	nd	2–3
Number of infralabials	6/3	3/2	nd	3–6
Supralabials contact ocular	y	n	y/n	both
Supralabials contact prefrontal	y	n	y/n	both
Tail constriction	y	y	y	

The African Five-lined Skink, *Trachylepis quinquetaeniata* (Lichtenstein 1823): A New Established Species in Florida

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Photographs by the senior author.

From 2–4 April 2010, KLK and SAJ took six students from their University of Florida's Invasion Ecology of Amphibians and Reptiles class on a field trip to southern Florida. On 4 April 2010 at 1145–1230 h, under mostly sunny skies, 25 °C, 57% humidity, and 12 mph ESE winds, we visited a warehouse district across the street from where a reptile dealer was formerly in business in Port St. Lucie, St. Lucie County, Florida. We surveyed a 4-block area from a vacant lot at N 27.29225° W -80.36766° (datum WGS84) to the north, SW Sea Holly Terrace to the south, SW Biltmore Street to the east, and SW South Macedo Boulevard to the west. On 20 June 2010 from 1045–1130 h, under mostly sunny skies, 32 °C, 66% humidity, and 10.4 mph E winds, KLK, JPB, and CAS revisited this site. Specimens were collected opportunistically by hand and deposited in the Florida Museum of Natural History (FLMNH), University of Florida (UF) collection.

We discovered a previously undocumented introduced lizard species, identified as the African Five-lined Skink, *Trachylepis quinquetaeniata* (Lichtenstein 1823). Digital images of our live and preserved specimens, along with additional images of live animals that were not collected, were sent to colleagues who confirmed our identification (W. Böhme and A.M. Bauer, pers. comm.).

During our initial 45-min daytime survey on 4 April 2010, we recorded 46 different juveniles and adults, suggesting reproduction and a well-established population. Lizards were readily observed basking on concrete slabs and curbs, in asphalt parking lots, along buildings, and at the bases of trees, but we also found individuals under concrete slabs and wooden boards. When pursued, most of the lizards ran swiftly under debris or escaped into holes in the sides of buildings. One individual climbed >4.5

An adult male African Five-lined Skink basking on a concrete slab in Port St. Lucie, St. Lucie County, Florida. This individual was not collected.

The presence of neonate African Five-lined Skinks, such as this individual (UF 157937), provides strong evidence of reproduction by the population in Port St. Lucie, St. Lucie County, Florida.

Adult male (left) and female (right) African Five-lined Skinks basking on an asphalt parking lot in Port St. Lucie, St. Lucie County, Florida. These individuals were not collected.

m up a tree. We successfully captured only 5 (9.2%) of the individuals observed. Although our second survey lasted as long as our initial survey, nearly the entire time was dedicated to capturing at least one neonate to provide evidence of reproduction. Voucher specimens include UF 157446–50 and UF 157936–7.

Trachylepis quinquetaeniata has a wide native distribution in eastern, central, and western Africa, from Kenya through the arid sub-Saharan belt west to Senegal (Spawls et al. 2002), and has at least one non-indigenous population in Egypt (Kraus 2009). This species is diurnal and found in rocky and grassland habitats, on trees, in holes, as well as on man-made objects (i.e., houses and bridges), at elevations of 200–1,600 m (Spawls et al. 2002).

The mode of introduction for *Trachylepis quinquetaeniata* in Florida is via the pet trade. In April 2005, JPB visited the former pet dealer's warehouse (directly across the street from our study site) while it was still in business. He observed 6–7 dead skinks on the ground that appeared to have been thrown out the back door. This is nothing novel, as many non-indigenous herpetofaunal species have been illegally introduced in Florida by dealers simply dumping sick or unwanted animals (e.g., King and Krakauer 1966). Because *Trachylepis quinquetaeniata* is non-indigenous to Florida and still highly localized, we suggest that eradication efforts should be attempted immediately before this population expands.

Acknowledgments

We thank Wolfgang Böhme, Aaron M. Bauer, and Louis A. Somma for assistance in both species identification and obtaining relevant literature; Kevin M. Enge for glue-trap information; Louis A. Somma, Gad Perry, Robert Powell, Robert N. Reed, and an anonymous reviewer for helpful comments on this manuscript; and Picklé Barrél and K-merica for logistical support.

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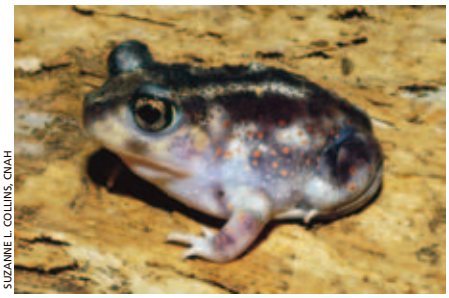
Subadult male (UF 157447) African Five-lined Skink, *Trachylepis quinquetaeniata*, from Port St. Lucie, St. Lucie County, Florida.

CONSERVATION RESEARCH REPORTS

Wild Pigs and Herpetofaunas

Herpetofaunal populations are decreasing worldwide, and the range of wild pigs (*Sus scrofa*) is expanding. Depredation of threatened reptilian and amphibian populations by wild pigs could be substantial. By understanding depredation characteristics and rates, more resources can be directed toward controlling populations of wild pigs coincident with threatened or endangered herpetofaunal populations. From April 2005 to March 2006, **Jolley et al.** (2010. *Journal of Mammalogy* 91:519–524) used firearms to collect wild pigs (n = 68) and examined stomach contents for reptiles and amphibians. The authors found 64 individual reptiles and amphibians, composed of five different species that were consumed by wild pigs during an estimated 254 hours of foraging. Primarily arboreal species (e.g., Green Anoles, *Anolis carolinensis*) became more vulnerable to depredation when temperatures were low and they sought thermal shelter. Other species (e.g., Eastern Spadefoot toads, *Scaphiopus holbrookii*) that exhibit mass terrestrial migrations during the breeding season also faced increased vulnerability to depredation by wild pigs. Results suggest that wild pigs are opportunistic consumers that can exploit and potentially have a negative impact on species with particular life history characteristics.



SUZANNE L. COLLINS, CNAH

Species, such as Eastern Spadefoot toads (*Scaphiopus holbrookii*), that exhibit mass terrestrial migrations during the breeding season face increased levels of predation by wild pigs.

Climate Change Implicated in Lizard Extinctions

Many predictions have suggested that climate change will cause species extinctions and distributional shifts in coming decades, but data to validate those predictions are relatively scarce. **Sinervo et al.** (2010. *Science* 328:894–899) compared recent and historical surveys for 48 Mexican lizard species at 200 sites. Since 1975, 12% of local populations have gone extinct. The authors verified physiological models of extinction risk with observed local extinctions and extended projections worldwide. Since 1975, they estimated that 4% of local populations have gone extinct worldwide, but by 2080 local extinctions are projected to reach 39% worldwide, and species extinctions may reach 20%. Global extinction projections were validated with local extinctions observed from 1975 to 2009 for regional biotas on four other continents, suggesting that lizards have already crossed a threshold for extinctions caused by climate change.

FAUSTO MÉNDEZ-DE-LA-CRUZ

The phrynosomatid lizard *Sceloporus serrifer* has been extirpated at several Mexican sites where increased temperatures have been documented.

Climate Change Spells Catastrophe for Blanchard's Cricket Frog

Climate change may be one of the greatest environmental catastrophes encountered by modern human civilization. The potential influence of this global disaster on wildlife populations is subject to question. **McCallum** (2010. *Acta Herpetologica* 5:119–130) interpolated how seasonal variation in weather patterns influences growth and reproduction in Blanchard's Cricket Frogs (*Acris blanchardi*). He then extrapolated the influence of future climate conditions on these life history characteristics using fuzzy regression. Fuzzy regression was an accurate predictor of growth and reproduction based on the climatic conditions present from 1900–2007. It predicted that the climate projections expected for Arkansas by 2100 could reduce total reproductive investment in Blanchard's Cricket Frogs by 33–94%. If these results reflect responses by other poikilotherms, climate change could induce major population declines in many species. Because poikilotherms represent the vast majority of vertebrates and significant ecosystem components, the implementation of strategies to reduce greenhouse gas emissions and circumvent this possible catastrophe is imperative.

SUZANNE L. COLLINS, CNAH

Climate projections for Arkansas by 2100 could reduce total reproductive investment in Blanchard's Cricket Frogs (*Acris blanchardi*) by 33–94%.

Anthropogenic Disturbance Degrades Habitat Quality for Rock-Dwelling Reptiles

Even apparently subtle disturbance to habitat can have severe long-term consequences if that disturbance alters specific microhabitat features upon which animals depend. For example, in southeastern Australia, the endangered Broadhead Snake (*Hoplocephalus bungaroides*) and its prey (Velvet Geckos, *Oedura lesueurii*) shelter in narrow crevices beneath sun-warmed rocks. Humans frequently displace rocks while searching for snakes and lizards, and these reptiles are rarely found under such displaced rocks (even when the rocks superficially appear suitable). **Pike et al.** (2010. *Animal Conservation* 13:411–418) quantified disturbance to rock outcrops and showed that most disturbance was subtle (rocks were typically displaced <30 cm from their original position), but that disturbed rocks harbored fewer reptiles than undisturbed rocks.

PAVEL GERMAN, WILDLIFE IMAGES

Even subtle disturbances to habitat can have severe long-term consequences if that disturbance alters specific microhabitat features, such as narrow crevices beneath sun-warmed rocks used by the endangered Australian Broadhead Snake (*Hoplocephalus bungaroides*).

In a field experiment, the authors replaced half of the rocks back to their original positions to test whether crevice structure and microclimates differed between disturbed and restored rocks. Crevices beneath displaced rocks were larger and cooler than those beneath restored rocks, and precise repositioning of rocks enhanced usage by reptiles. Both crevice size and temperature influence retreat-site selection; hence, minor displacement of overlying rocks reduces habitat quality by modifying critical crevice attributes. The subtlety of this disturbance suggests that even well intentioned researchers could damage habitat during field surveys. Conservation of rock outcrop systems requires efforts to reduce rock disturbance, and the education of those searching for animals beneath rocks about the importance of replacing them properly.

NATURAL HISTORY RESEARCH REPORTS

Are Rattlesnakes Evolving More Toxic Venom?

Recent reports in the lay press have suggested that bites by rattlesnakes in the last several years have been more severe than those in the past. The explanation, often citing physicians, is that rattlesnakes are evolving more toxic venom, perhaps in response to anthropogenic causes. **Hayes and Mackessy** (2010. *Wilderness & Environmental Medicine* 21:35–45) suggested that other explanations are more parsimonious, including factors dependent on the snake and factors associated with the bite victim's response to envenomation. Although bites could become more severe due to an increased proportion of bites from larger or more provoked snakes (i.e., more venom injected), the venom itself evolves much too slowly to explain the severe symptoms occasionally seen. Increased snakebite severity could also result from a number of demographic changes in the victim profile, including age and body size, behavior toward the snake (provocation), anatomical site of bite, clothing, and general health including asthma prevalence and sensitivity to foreign antigens. Clinical management of bites also changes perpetually, rendering comparisons of snakebite severity over time tenuous. Clearly, careful study taking into consideration many factors will be essential to document temporal changes in snakebite severity or venom toxicity. Presently, no published evidence for these changes exists. The sensationalistic coverage of these atypical bites and accompanying speculation is highly misleading and can produce many detrimental results, such as inappropriate fear of the outdoors and snakes, and distraction from proven snakebite management needs, including a consistent supply of antivenom, adequate health care, and training. The authors urged healthcare providers to avoid propagating misinformation about snakes and snakebites.

SUZANNE L. COLLINS, CNAH

No published evidence supports recent reports suggesting that bites by rattlesnakes, such as this Mojave Rattlesnake (*Crotalus scutulatus*), are more severe than in years past.

TROY HIBBITTS, 2007

Juvenile Leopard Tortoises (*Stimochelys pardalis*) favor colors that correspond to feeding preferences of adults in Namibia for plants with reddish-pink or yellow flowers.

Juvenile Leopard Tortoises Like Red

Juvenile Leopard Tortoises (*Stimochelys pardalis*) from Namibia approached the colors red, light green, and olive more frequently than they approached nine other colors in a behavioral experiment. The 44-day study by **Simang et al.** (2010. *Journal of Herpetology* 44:327–331) sought to determine what visual cues are important in foraging Leopard Tortoises and if they engage in color discrimination. Data suggested that a natural preference exists for certain colors and that these correspond well with foraging observations. Free-ranging adult Leopard Tortoises eat considerable amounts of plants with reddish-pink or yellow flowers and reddish-pink stems. The authors noted that other visual cues such as texture, shape, and height might also influence tortoises when selecting food.

NEWSBRIEFS

Turtles Killed "in Millions" by Fishing Gear

Millions of marine turtles have been killed over the past two decades through entrapment in fishing gear, according to a global survey. Described as the first global synthesis of existing data, the study found especially high rates of "bycatch" in the Mediterranean and eastern Pacific. Six of the seven sea turtle types are on the Red List of Threatened Species.

Writing in the journal *Conservation Letters*, researchers advocate much greater use of gear safe for turtles. These include circular hooks rather than the conventional J-shaped hooks on long fishing lines, and hatches that allow the reptiles to escape from trawls.

Turtles must come to the surface to breathe. When they are caught in a net or on a fishing hook, they cannot surface, and drown. Lead researcher Bryan Wallace said the state of the world's turtles was an indicator of the wider health of the oceans. "Sea turtles are sentinel species of how oceans are functioning," he said. "The impacts that human activities have on them give us an idea as to how those same activities are affecting the oceans on which billions of people around the world depend for their own well-being." Dr. Wallace works in the global marine division of Conservation International and at Duke University in the US.

The raw material from the study came from records of bycatch — incidental catches in fishing gear — from different regions of the world. Over the period 1990–2008, records showed that more than 85,000 turtles were snared. However, those records covered a tiny

DOUG PERRINE, SEAPICS.COM

Numbers of adult Leatherbacks (*Dermochelys coriacea*) — the largest species of sea turtle, which grows to more than 2 m in length and is capable of journeys that span entire oceans — are thought to have declined by more than 75% between 1982 and 1996.

proportion of the world's total fishing fleets. "Because the reports we reviewed typically covered less than 1% of all fleets, with little or no information from small-scale fisheries around the world, we conservatively estimate that the true total is probably not in tens of thousands, but in the millions of turtles taken as bycatch in the past two decades," said Dr. Wallace.

Three types of fishing gear are identified in the survey — long-lines, gillnets, and trawls. Modern long-line boats trail strings of hooks that can be 40 km long, usually in search of high-value species such as tuna and marlin. Gillnets are usually stationary, and use mesh of a set size in an attempt to target certain species of fish. The researchers suggest that several areas of the world account for particularly high levels of bycatch — the Mediterranean Sea and the eastern Pacific Ocean for all types of gear, together with trawling operations off the western coast of Africa.

Modifying fishing gear can have a dramatic impact on the size of bycatch. Shrimp trawls fitted with turtle excluder devices (TEDs) catch markedly fewer of the reptiles. A grid prevents anything large from entering the back portion of the net, and a hole above the grid allows accidentally snared animals such as turtles to escape. A number of countries now require that shrimp boats must use nets fitted with TEDs.

The circular long-line hooks also reduce bycatch of birds such as albatrosses. However, some fleets have resisted adopting selective gear because fishermen believe it will reduce their catch. In many parts of the developing world, the gear is not available.

Marine turtles face other significant threats. Debris in the oceans, such as plastic bags, can also cause drowning, while development in coastal regions can affect nesting and reproduction. Some turtles are still targeted for meat, and their shells used for tourist souvenirs. Numbers of adult Leatherbacks — the largest species, growing to more than 2 m long and capable of journeys that span entire oceans — are thought to have declined by more than 75% between 1982 and 1996.

Richard Black
Environment correspondent, BBC News

The Global Invasive Species Database

The Global Invasive Species Database (GISD: www.issg.org/database/), managed and maintained by the IUCN Invasive Species Specialist Group (ISSG: www.issg.org/), was launched in 2001 to profile invasive species that threaten native biodiversity and covers all taxonomic groups from microorganisms to mammals. The comprehensive, peer-reviewed profiles contain information on the ecology and biological traits of invasive species, their distributions both in native and introduced ranges, how they are being managed globally, their effects on biodiversity and ecosystems, reference lists, and names of expert contacts. The GISD currently features profiles of over 675 invasive species, and plans are to increase the database to 1,000 profiles in the near future.

100 of the World's Worst Invasive Species

The Global Invasive Species Database (GISD) features a list of 100 of the world's "worst" invasive alien species (www.issg.org/database/species/search.asp?st=100ss&fr=1&str=&lang=EN). Species were selected for the list according to two criteria: (1) Their serious impact on biological diversity and/or human activities, and (2) their illustration of important issues surrounding biological invasion. To ensure the inclusion of a wide variety of examples, only one species from any genus was selected. Absence from the list does not imply that a species poses a lesser threat. Three species of amphibians and two species of reptiles are included:

Cane Toad (*Rhinella marina*)

Cane Toads were introduced to many countries as biological control agents for various insect pests of sugarcane and other crops. The Cane Toads have proved to be pests themselves. They will feed on almost any terrestrial animal and compete with native amphibians for food and breeding habitats. Their toxic secretions are known to cause illness and death in domestic animals, such as dogs and cats, with which they come into contact, as well as wildlife, such as snakes and lizards. When threatened, they are able to squirt the toxic secretion over a meter, causing extreme pain if rubbed into the eyes. Human fatalities have been recorded following ingestion of the eggs or adults.

Cane Toads (*Rhinella marina*) have been introduced around the world to control various insect pests, primarily of sugarcane — instead, the toads have become pests, feeding on almost any terrestrial animal and competing with native amphibians for food and breeding habitats.

Coqui (*Eleutherodactylus coqui*)

The Coqui is a relatively small tree frog native to Puerto Rico. The frogs are quite adaptable to different ecological zones and elevations. Their loud call is the main reason they are considered a pest. The mating call is the species' namesake, a high-pitched, two-note "co-qui" (ko-kee') that


LORI OBERHOFER, NWRC HAWAII FIELD STATION

Coquis (*Eleutherodactylus coqui*), which are native to Puerto Rico, have a voracious appetite and the concern in Hawai'i, where they have been introduced, is that they might put Hawai'i's endemic insect and spider species at risk and compete with endemic birds and other native fauna that rely on insects for food.

attains nearly 100 decibels at 0.5 m. These frogs have a voracious appetite and the concern in Hawai'i, where they have been introduced, is that *E. coqui* may put Hawai'i's endemic insect and spider species at risk and compete with endemic birds and other native fauna that rely on insects for food.

American Bullfrog (*Lithobates catesbeianus*)
The American Bullfrog is native to North America, but has been introduced to over 40 countries on four continents. Many introductions have been intentional with the purpose of establishing new food sources for human consumption. Other populations have been estab-


S. PRICE, BCFROGWATCH@VICTORIA1.GOV.BC.CA

Introduced American Bullfrogs (*Lithobates catesbeianus*) have displaced native amphibians from large areas of southeastern Vancouver Island in Canada — and might be carriers of the chytrid fungus that is decimating amphibian populations around the world.

lished from unintentional escapes from Bullfrog farms. Consequences of the introduction of non-native amphibians to native herpetofauna can be severe. The American Bullfrog has been held responsible for outbreaks of the chytrid fungus found to be responsible for declining amphibian populations in Central America and elsewhere. They are also important predators and competitors of endangered native amphibians and fish. The control of this invasive in Europe partly relies upon increasing awareness, monitoring, and education about the dangers of releasing pets into the wild. Strict laws are also in place to prevent further introductions. Eradication is achieved largely by physical means that include shooting, spears/gigs, bow and arrow, nets, and traps.

Red-eared Slider (*Trachemys scripta elegans*)
The Red-eared Slider has been the most popular turtle in the pet trade. More than 52 million individuals were exported from the United States to foreign markets between 1989 and 1997. Despite the vast worldwide occurrence of these turtles, little is known of their impact on indigenous ecosystems. Clearly, research and education on the dangers of releasing pet turtles into the wild are needed. Their omnivorous diet and ability to adapt to various habitats give them great potential for impacting indigenous species.


KEVIN ENGE

Red-eared Sliders (*Trachemys scripta elegans*) are the most popular turtles in the pet trade, and more than 52 million individuals were exported from the United States to foreign markets between 1989 and 1997. They can be especially damaging when they hybridize with endemic sliders (such as in the Greater Antilles) or compete with native turtles (such as in peninsular Florida, where this individual was photographed).

Brown Tree Snake (*Boiga irregularis*)
Native island species are predisposed and vulnerable to local extinction by invaders. When the Brown Tree Snake was accidentally introduced to Guam, it caused the local extinction of most of the island's native species of birds and lizards, causing "cascading" ecological effects by removing native pollinators, resulting in the subsequent decline of native plant species. The ecosystem fragility of other Pacific islands to which cargo flows from Guam has made the potential spread of the Brown Tree Snake from Guam a major concern.


GAD PERRY

When Brown Tree Snakes (*Boiga irregularis*) were accidentally introduced to Guam, they caused the local extinction of most of the island's native species of birds and lizards, causing "cascading" ecological effects by removing native pollinators, resulting in the subsequent decline of native plant species.

California Upholds Ban on Non-native Frogs and Turtles

In an effort to reduce the number of invasive species and infectious diseases harming native wildlife, the California Fish & Game Commission voted 3–2 to uphold their recently instated ban on the importation of non-native frogs and turtles for use as food. The ban, intended to reduce the influx of harmful invasive species into the state, drew significant criticism from the San Francisco Chinese community, one of the largest US consumers of frog legs and turtles. This, in turn, prompted a re-consideration hearing in a Sacramento room that was filled to capacity with legislators, businessmen, nonprofit representatives, and other members of the public eager to express their views.

Frog populations worldwide have been declining at unprecedented rates, and nearly one-third of the world's amphibian species are threatened with extinction. Up to 200 amphibian species have completely disappeared in recent years, and California is home to 16 threatened amphibians. The frog-leg trade is responsible for the spread of infectious diseases and invasive species that damage California ecosystems, according to Santa Cruz-based public charity SAVE THE FROGS! (www.savethefrogs.com), which led the campaign to maintain the California


GARY M. FELLERS, USGS

If cultures did not adapt, humans would have long since eaten the California Red-legged Frog (*Rana draytonii*) to extinction.

Fish & Game Commission's April 8th ban. The group's supporters sent nearly 1,200 letters to the California Department of Fish & Game.

SAVE THE FROGS! founder Kerry Kriger testified at the Commission hearing, highlighting the spread of infectious diseases and invasive species that inevitably accompany the frog-leg trade. "Several million Bullfrogs from North America are farmed overseas and imported into California for food each year. A recent study showed that over 60% of these frogs are infected with a deadly chytrid fungus that has decimated frog populations in the Sierra Nevada range." The fungus, which causes a potentially lethal skin disease called chytridiomycosis, has caused the extinction of up to 100 amphibian species worldwide. Furthermore, says Dr. Kriger, "Bullfrogs and turtles regularly escape or are purposely set free into the wild. They establish

populations and damage local ecosystems by eating native frogs and other wildlife."

San Francisco-based legislators Leland Yee, Fiona Ma, and Ted Lieu testified in opposition to the ban, stating that it would damage the economy and that it discriminated against the Chinese community and their 5,000-year-old history of eating frogs and turtles. However, the vast majority of frogs the Chinese-American community is eating are Bullfrogs from North America, which have only a very recent history in Chinese cuisine.

"Cultures necessarily evolve: If they did not, we would have long since eaten the Buffalo and the California Red-Legged Frog to complete extinction, as we did the Passenger Pigeons," said Dr. Kriger. "As Americans, we are fortunate to have many choices of food, and thus it is our responsibility to act wisely and ensure that our culinary decisions are not unduly impacting our natural heritage and the future of our planet."

Americans consume 20% of the world's frog legs, and scientists estimate that over a hundred million frogs are taken out of the wild each year for food. SAVE THE FROGS! recently convinced San Francisco's upscale Restaurant Gary Danko to remove the frog legs from the restaurant's menu. The group, which organizes the annual Save The Frogs Day events, recently held the world's first protests in defense of frog populations — at four east-coast restaurants that refuse to stop serving frog legs.

More information on the frog-leg trade and on the ban can be found at: http://savethefrogs.com/frog-legs and http://bit.ly/ca-frog-legs-ban.

Vipers: New IUCN Specialist Group

Vipers are found on all continents except Australia and Antarctica, including extreme environments such as the Arctic Circle and high elevations in the Andes. The Viperidae have a high proportion of endangered species (~14%) relative to other families of snakes. Although people are fascinated by vipers, they are one of the world's most heavily persecuted groups of wildlife. In addition, vipers are facing a variety of threats including the loss and fragmentation of habitats, global climate change, and collection for the pet trade. The initial objectives of the Viper Specialist Group are to develop a conservation assessment/action plan for vipers and to develop a series of focal initiatives aimed at particular species or regions.

JEFF ETTLING

Darevsky's Viper (*Vipera darevskii*) might be the rarest viper in the world. It has a very small distribution in the Dzhavakhet Mountains in northern Armenia and may possibly occur in adjacent Georgia and Turkey.

Editors' Remarks

The IRCF has a new mailing address! All correspondence should be addressed to:

International Reptile Conservation Foundation
PO Box 90270
Tucson, AZ 85752

Our toll-free number for US residents will remain the same: 1-877-472-3674. Our website can still be accessed at www.IRCF.org and membership inquiries can be sent to info@IRCF.org. Our apologies for the slow response to membership inquiries during the transition; we hope to be caught up will all membership and renewal requests by the time you receive this issue of the journal, the third installment in our year-long tribute to Dr. Henry Fitch.

The Editors of *Reptiles & Amphibians*

STATEMENT OF PURPOSE

The International Reptile Conservation Foundation works to conserve reptiles and amphibians and the natural habitats and ecosystems that support them.

The International Reptile Conservation Foundation, Inc. is a non-profit 501 (c)(3) California corporation.

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The IRCF encourages contribution of articles, letters to the Editor, news items, and announcements for publication in *REPTILES & AMPHIBIANS*. General articles can deal with any aspect of reptilian or amphibian biology, including conservation, behavior, ecology, physiology, systematics, or husbandry. Submission of photographs to accompany articles is encouraged. Guidelines for submissions and figures are at www.ircf.org/about/submissions. Manuscripts may be submitted via e-mail (send to AJ@IRCF.org). Authors of one page or more of print will receive a free copy of the journal in which their contribution appears, and will receive a PDF file of their article for distribution.

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BRANDON BALLENGEE AND STANLEY K. SESSIONS

Hellbender (*Cryptobranchus alleganiensis*). The temporarily anesthetized live salamander was gently placed onto the glass bed of a scanner. The resulting digital files can then be used to generate both scientific research images and fine art prints. See article on p. 153.