Missouri Herpetological Association

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MISSOURI HERPETOLOGICAL ASSOCIATION NEWSLETTER NO. 27

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NATURAL HISTORY NOTES

Cover: Black Kingsnake (*Lampropeltis nigra*). Gravid female from Scott County, MO. See related article on page 18. Photograph by Brian S. Edmond.

INTRODUCTION

The Twenty-seventh Annual Meeting of the **Missouri Herpetological Association** was held 27-28 September 2014 at **Bull Shoals Field Station**, Taney County, Missouri. This organization is designed to provide herpetologists in Missouri and surrounding states with an opportunity to meet and exchange ideas regarding current efforts in research and other professional activities. High on the list of priorities is to provide students, involved in research at either the graduate or undergraduate level, (1) the chance to interact with senior herpetologists, and (2) an outlet to present, in a semi-formal setting, the results of their labors.

This newsletter is the result of a decision made at the inaugural meeting to provide a means of publicly acknowledging papers presented at this and subsequent annual meetings. Further, the newsletter will inform the herpetological community of new distribution records of Missouri's herpetofauna, additions to the bibliography dealing with the state herpetofauna and provide an outlet for the publication of short notes dealing with the natural history of Missouri amphibians and reptiles.

ANNOUNCEMENTS

28th Annual Meeting of the Missouri Herpetological Association

The Twenty-eighth Annual Meeting of the Missouri Herpetological Association will be held 19-20 September 2015. Next year we will return to the **Reis Biological Station**, in Crawford County, near Steelville, Missouri. A "call for papers" and registration materials will be sent electronically in mid-July. For additional information, please check the official MHA site or contact **Jeff Briggler** at:

Missouri Department of Conservation
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Jefferson City, MO 65102-0180
(573) 751-4115
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MHA on the Net

The Association has an official site on the internet at http://mha.moherp.org/. Here, you will find information on meetings and copies of past newsletters. The Missouri Herpetological Atlas Project and the most recent edition of the Atlas can be accessed at http://atlas.moherp.org/.

Abstracts of Papers Presented at the 27th Annual Meeting of the Missouri Herpetological Association

Bull Shoals Field Station
27-28 September 2014

RESPONSE TO PREDATORY THREAT BY DIFFERENT SEX CLASSES OF OKLAHOMA SALAMANDERS, *Eurycea tynerensis*

Lauren Rudolph and Alicia Mathis
Department of Biology, Missouri State University, Springfield, MO

The threat-sensitive predator avoidance hypothesis states that prey animals vary the intensity of antipredator behavior relative to the level of threat posed. As a result, the ability to accurately assess the level of risk should be adaptive. Chemical cues have been found to be a primary mode of predator detection for aquatic amphibians. We tested the ability of Oklahoma salamanders (*Eurycea tynerensis*) to assess the density and proximity of predatory sculpin (*Cottus hypselurus*) using chemical cues alone. Salamanders were exposed to either a blank control or one of two threat treatments that kept overall cue concentration constant but changed the volume of cue provided by each predator. One treatment simulated high predator density and distant proximity ("many/far"). The other simulated low predator density but close proximity ("few/near"). Preliminary results indicate behavioral differences among sex classes of salamanders. In the absence of threat, gravid females are more active than non-gravid females, and males tend to show intermediate activity. None of the sex classes show strong differences between the two threat treatments. However, in comparison to the controls, males tend to respond to threat by increasing activity whereas females tend to respond by decreasing activity. This project is ongoing.

RESPONSE TO CHEMICAL ALARM CUES OF OKLAHOMA SALAMANDER BY SYMPATRIC AND ALLOPATRIC RAINBOW DARTERS

Kelsey Anderson, Alicia Mathis and Benjamin Dalton
Department of Biology, Missouri State University, Springfield, MO

In aquatic environments with limited visibility, detection of predators via chemical cues may provide a selective advantage. Many aquatic species produce chemical alarm cues that warn nearby conspecifics of danger, and closely-related species frequently respond to each other's alarm cues. However, species in distant taxa could also benefit by responding to each other's alarm cues if they share the same predators.

Rainbow Darters (*Etheostoma caeruleum*) are benthic fish native to fast-flowing Ozark streams. In some populations, their range overlaps with paedomorphic Oklahoma Salamanders (*Eurycea tynerensis*), which occupies a similar habitat and is vulnerable to the same predators, such as Ozark Sculpin (*Cottus hypselurus*) and other predatory stream fish. We tested the responses of *E. caeruleum* from two different populations, one sympatric and one allopatric with *E. tynerensis*, to chemical cues prepared from salamander skin (an alarm cue), a control of salamander muscle and bone, or blank water control. Darters from the sympatric population exhibited anti-predator responses when exposed to alarm cues from salamander skin, but not to salamander muscle or the water blank. Darters from the allopatric population did not exhibit anti-predator responses to any of the treatments. Therefore, darters can develop responses to the alarm cues of sympatric species occupying the same prey guild even when the other species is phylogenetically distant.

HONEST SIGNALING IN AGGRESSIVE CONTESTS BETWEEN OZARK ZIGZAG SALAMANDERS (*Plethodon angusticlavius*)

Rachel Bortosky and Alicia Mathis
Department of Biology, Missouri State University, Springfield, MO

Communication of information concerning the sender's quality or intentions is essential for maintaining territories, courtship, and mating. For signals to be favored by natural selection, they must benefit both the sender and the receiver. A dishonest signal that provides misleading information about quality or intent should therefore be selected against. Honest signals prevent cheating because they are constrained by factors such as the energetic costs of the signal. I tested the hypothesis that "All Trunk Raised" (ATR), a behavior that occurs in territorial contests in terrestrial salamanders, is an honest indicator of aggressive intent. In staged contests between pairs of Ozark zigzag salamanders (*Plethodon angusticlavius*), individuals that performed bites spent more time exhibiting ATR prior to biting than individuals that did not bite. In addition, I examined whether ATR is an energetically costly behavior. In trials where the diet of the intruder was manipulated, high-quality intruders tended to perform more ATR than low-quality intruders. In metabolic rate trials, individuals that performed more ATR produced more CO_2. These results support the hypothesis that ATR is an honest indicator of aggressive intent in this species.

SPERMATOGENIC CYCLE DIFFERENCES FROM TWO DIFFERENT POPULATIONS OF *Eurycea longicauda*

Dustin S. Siegel, Sam Alvino and Brittney Cathcart
Department of Biology, Southeast Missouri State University, Cape Girardeau, MO

Historical literature provides data outlining the spermatogenic cycle of 24 species of plethodontid salamanders from North America. All but three studies reveal a picture of

spermatogenesis that could be considered stereotypical in plethodontid salamanders. The stereotypical cycle is delineated by major meiotic divisions of spermatogenesis occurring as early as late spring, summer, and, at the latest, early fall. This is observed histologically by the presence of secondary spermatocytes and spermatids filling testicular lobules during these months. Following meiosis, secondary sexual characteristics hypertrophy, and mating occurs in the fall, winter, and/or spring. Thus, two major events of male salamander reproductive biology are asynchronous; i.e., mating/secondary sexual characteristic hypertrophy occurs subsequent to sperm production with little to no overlap. In three separate studies on *Eurycea longicauda melanopleura*, *E. multiplicata*, and *Pseudotriton ruber*, meiotic events of spermatogenesis occur in late fall, winter, and early spring, concordant with secondary sexual characteristic hypertrophy. Thus, it appears that in at least three taxa of plethodontid salamanders, mating and secondary sexual characteristic hypertrophy are synchronous with sperm production. Two of these taxa were studied in northwest Arkansas (*E. l. melanopleura* and *E. multiplicata*), whereas the other (*P. ruber*) was studied in eastern Pennsylvania. Variation from the stereotypical spermatogenic cycle of plethodontid salamanders may result from local ecological pressures or temporal variation, as we provide data from *E. l. longicauda* from southwest Illinois that indicate *E. longicauda* follows the stereotypical North American plethodontid reproductive cycle. Furthermore, historical literature on *P. ruber* from the southern Appalachians was also congruent with the stereotypical plethodontid reproductive cycle.

BIOTIC AND ABIOTIC INFLUENCES ON LARVAL SALAMANDER ABUNDANCE, OCCUPANCY AND BODY SIZE

Thomas L. Anderson, Brittany H. Ousterhout, William E. Peterman, Dana L. Drake, Jacob Burkart, Freya Rowland, Lori S. Eggert, and Raymond D. Semlitsch
Division of Biological Sciences, University of Missouri, Columbia, MO

We present the results of a three-year study of salamander population dynamics across a large landscape of ponds at Fort Leonard Wood, MO. Approximately 200 ponds were surveyed during the egg, larvae and metamorphic stages for Ringed (*Ambystoma annulatum*), Marbled (*A. opacum*) and Spotted Salamanders (*A. maculatum*). We used a combination of survey techniques including quadrat, visual encounter, minnow traps and dip net sweeps. In general, we found that pond habitat traits best predicted the density of larvae but body size was best predicted by larval salamander density. All three focal species showed increased larval densities when ponds were surrounded by higher amounts of forested habitat, and decreased density and occupancy when fish were present. Spotted Salamander occupancy and larval density also increased in ponds with greater canopy closure. Pond clustering was positively correlated with the occupancy and larval density of Ringed Salamanders, the density of Marbled Salamanders, and the probability of colonization by Ringed Salamanders. Ponds with a longer hydroperiod were more likely to be occupied by and had higher larval densities of Ringed Salamanders. The body size of larvae of both Ringed and Spotted Salamanders was negatively correlated with Marbled Salamander density. No measured factors predicted

Marbled Salamander body size. We did not observe any interactions between habitat variables and larval densities as predictors of either larval size or density. Overall, consideration of both habitat features as well as biotic factors are critical to determining local and regional persistence of species, and that improved understanding of species-specific responses to different factors will contribute to developing effective management plans.

NATURAL HISTORY AND CONSERVATION OF SALAMANDERS IN CENTRAL PANAMA

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Amphibians are experiencing extensive declines worldwide, with Neotropical species deemed the most affected. A high diversity of the world's amphibian fauna exist in Latin America, and many species, especially salamanders and caecilians, are data deficient. The goal of this study was to learn about the natural history of salamanders in central Panama to aid in their conservation. We conducted 105 visual encounter surveys at night along a 237m paved trail in a park managed by the Panamanian National Environmental Authority. We used program PRESENCE to compare detectability models, and a PCA analysis to evaluate habitat selection. Salamander diets were also analyzed based from stomach flushes in the field. We captured 123 individuals over 3 field seasons, representing at least five species and two genera (*Bolitoglossa, Oedipina*). Temperature, season, and precipitation had the largest impact on detection rates, with the majority of captures occurring in the wet season of 2013. *Bolitoglossa* were captured along the entire trail but were more clustered than assumed by random chance. A PCA analysis incorporating 24 physical characteristics of the site was unable to explain why certain areas were preferred. Diets contained invertebrates of the family Formicidae, order Coleoptera, and sub-classes Collembola and Acari.

VIDEO ANALYSIS OF NEST-GUARDING BEHAVIOR OF A MALE OZARK HELLBENDER

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In light of the recent decline in populations of both subspecies of Hellbenders (Eastern: *Cryptobranchus alleganiensis alleganiensis,* Ozark*: C. alleganiensis bishopi)*, the Missouri Department of Conservation (MDC) has increased population recovery efforts. In the wild, lack of juvenile recruitment into existing populations is a key factor in the decline, yet the cause of this lack is unknown. To gain additional information concerning activities at nests of hellbenders, MDC biologists collected continuous video footage from a naturally-occurring nest of a single male Ozark Hellbender in the North

Fork of the White River during the 2008 breeding season. We observed the video tape and recorded variables that included behavior of the hellbender (presence/absence at nest entrance; tail-fanning, rocking), occurrence of potential prey, and occurrence of potential predators. Although we are still in the early stages of development, the preliminary analysis indicates that the male hellbender spent approximately 54% of the footage visible at the nest entrance and rarely left the nest unguarded. Rocking and tail-fanning behavior occurred on most days with no apparent changes in frequency over the course of the season. Centrarchids were the most common fish that occurred in the vicinity of the nest.

SUCCESS OF AMPHIBIAN REPRODUCTION IN MAN-MADE VERNAL POOLS

Brock Couch, Jessica Sunderland, Derek Arbuckle, Dawn M. Drake, and Mark S. Mills
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Amphibian populations are declining worldwide because of various factors such as habitat destruction and disease. Creating new habitat and/or rehabilitating damaged or lost habitat has become an important tool used to restore amphibian populations. For our study, we were working in Mark Twain National Forest to determine if amphibians will use man-made vernal pools. To identify the species using each pond, we used calling surveys and collected tadpoles or larvae using traps and dip nets. We found that a variety of different amphibian species used the vernal pools: including, *Lithobates clamitans*; *Lithobates sphenocephalus; Anaxyrus americanus*; *Anaxyrus fowleri*; *Acris blanchardi*; *Pseudacris crucifer*; *Ambystoma maculatum;* and *Ambystoma opacum*. From this data, we further wanted to determine which man-made vernal pools would be most suitable for amphibian reproduction using GIS (ESRI ArcGIS). To this end, we correlated various habitat types or categories to species richness as well as the presence of individual species.

PHYSIOLOGICAL AND FITNESS CONSEQUENCES OF EMBRYONIC REARING ENVIRONMENT AMONG POPULATIONS OF POST-METAMORPHIC WOOD FROGS, *Lithobates sylvaticus*.

Timothy A. Clay[1], Matthew E. Gifford[1] and William E. Peterman[2]
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[2]Illinois Natural History Survey, Champaign, IL

Early ontogenetic stages can have lasting effects on future stages. It is important to quantify the magnitude and nature of carry-over effects within a species before making broad generalizations among species. We examined how experimental pond drying affected post-metamorphic morphology, physiology, and performance in wood frogs, *Lithobates sylvaticus*. In addition, we tested if populations differed in their response to pond drying. Initial mass, limb-length, snout-vent length, and resting metabolic rate were measured on newly metamorphed frogs. Juveniles were then reared with ad-libitum food for 7 weeks to measure growth rate. Larval treatment induced differences in limb length with individuals in the drying treatment having longer limbs upon completion of metamorphosis. Postmetamorphic frogs differed by population in initial mass, snout-vent length, jumping performance, swimming performance, resting metabolic rate, and growth rate. Our study suggests that population, and not larval conditions, has a greater influence on the post-metamorphic phenotype and performance. Furthermore, despite population level differences, our study suggests that populations respond similarly to larval rearing conditions.

REINTRODUCTION ECOLOGY OF ALLIGATOR SNAPPING TURTLES (*Macrochelys temminckii*) ON THE KANSAS/OKLAHOMA BORDER

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Although alligator snapping turtles historically occurred in the Caney River in northern Oklahoma and southern Kansas, there have been no records since the 1940s. A targeted survey in the 1990s failed to detect any specimens, suggesting that alligator snapping turtles were extirpated from the river. As a result, reintroduction of the alligator snapping turtle to the Caney River and Pond Creek (a tributary of the river) began in 2008. Results of the release have been monitored annually using mark-recapture surveys. In 2014, we trapped 52 alligator snapping turtles 67 times. We identified each specimen by an implanted PIT tag, and we collected morphometric data. All other species of turtles caught in the traps were marked and measured, as well. Growth rates of released alligator snapping turtles were calculated by comparing data from the same individuals captured in previous years. The largest individual that we caught was a male/female weighing 8000 kg (carapace length = 39.5 cm). This turtle exceeds the minimum size at sexual maturity for the species, which suggests that natural recruitment could already be occurring.

REINTRODUCTION PROGRAM EVALUATED USING ACTIVITY PATTERNS AND HOME RANGE SIZE OF HEAD-STARTED *Terrapene ornata*

Eric R. Sievers[1], Charlie R. Tucker[1], Jeramie T. Strickland[2], David K. Delaney[3], and Day B. Ligon[1]
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[3]*US Army CERL, Champaign, IL*

A reintroduction program was initiated to return state-threatened ornate box turtles (*Terrapene ornata*) to tracts of remnant prairie in Illinois. This program uses eggs collected from a nearby donor population that are head-started for ten months before release. Seventeen head-started turtles were released in June 2013, and were divided among three experimental treatments including: 1) five turtles released at the donor site, 2) six turtles placed inside a 7.5-ha soft-release enclosure at the reintroduction site, and 3) six turtles placed outside the enclosure at the reintroduction site. We used radio telemetry to examine the merits of soft-releasing head-started turtles in an enclosure by comparing average home range size and the activity patterns among the three treatments. Home range size varied greatly among individuals, but core activity centers were located near woody cover, indicating the importance of refuges as a key habitat component at reintroduction sites. Activity patterns were affected by weather, time, and season.

UNDERWATER AND UNDETECTED: AQUATIC RESPIRATORY CAPACITY OF A SECRETIVE AQUATIC TURTLE

Carolyn Kupec and Day B. Ligon
Department of Biology, Missouri State University, Springfield, MO

Aquatic turtles vary widely in their capacity to remain submerged in water for extended periods. Ecologically, remaining below the water's surface can have great benefits to individuals by prolonging foraging bouts and reducing the likelihood of detection by predators. However, prolonged submersion presents obvious physiological challenges for a group that classically relies on aerial respiration across pulmonary surfaces to support metabolic demands for gas exchange. Two options for metabolically supporting long diving bouts include, 1) relying on anaerobic metabolic pathways to supplement or supplant aerobic metabolism, and 2) engaging in aquatic gas exchange across non-traditional respiratory surfaces, including skin, oral and buccal surfaces, and cloacal bursae. In general, ecology tends to trump phylogeny in predicting species' capacity for aquatic respiration; therefore, highly aquatic species that are seemingly ill-suited for aquatic respiration warrant extra scrutiny. One such species is the Alligator Snapping Turtle (*Macrochelys temminckii*), a secretive denizen of rivers, oxbows and swamps in the southeastern United States. Although the species possesses cloacal bursae (whose function in this species is presently unknown), its large size dictates that it have a relatively low surface area-to-volume ratio thereby limiting the degree to which cutaneous respiration could replace pulmonary respiration as a means of supporting metabolic demands. Therefore, we measured oxygen consumption in air as a means of estimating whole-animal metabolic rate. We then measured oxygen consumption in water to determine what fraction of their metabolism could be supported by non-pulmonary means. Additionally, we conducted both aerial and aquatic gas exchange measurements across a range of size classes (all juveniles) and temperatures to determine whether there was a threshold below which metabolic demands could be wholly supported via aquatic respiration. Contrary to what we predicted based on the species' ecology, we found that even juvenile Alligator Snapping Turtles—individuals whose small size results a relatively high surface area-to-volume ratio—had very low capacity for aquatic respiration. Therefore, extended submersion bouts by this species are likely supported anaerobically.

GOOD VIBRATIONS: A NOVEL METHOD FOR SEXING CHELONIANS

Donald T. McKnight, Hunter J. Howell, Ethan C. Hollender, and Day B. Ligon
Department of Biology, Missouri State University, Springfield, MO

The ability to accurately determine the sex of individuals is important for research and conservation efforts. While most species of turtle exhibit secondary sexual dimorphisms that can be used to reliably infer sex, there are some species that are very difficult to sex, and even within many dimorphic species, it is not uncommon to encounter individuals that appear to exhibit both male and female secondary sex characteristics. Therefore, we tested the method of using a vibrator to stimulate male turtles to evert their phalluses. We tested this method on males of four species with known sexual dimorphisms: western chicken turtles (*Deirochelys reticularia miaria*; N = 17), Mississippi mud turtles (*Kinosternon subrubrum hippocrepis*; N = 10), common musk turtles (*Sternotherus odoratus*; N = 9), and spiny softshell turtles (*Apalone spinifera*; N = 14). The method was successful for 64.7% of *D. r. miaria*, 80% of *K. s. hippocrepis*, 55.6% of *S. odoratus*, and 100% of *A. spinifera*. Despite the low success rates in some species, we believe that this method will be useful for researchers working with some species that are difficult to sex.

DIET COMPOSITION OF THE RAZOR-BACKED MUSK TURTLE

Joshua R. Harmon, Donald T. McKnight, and Day B. Ligon
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The razor-backed musk turtle (*Sternotherus carinatus*) is a medium-sized kinosternid that typically inhabits deep waters in rivers, oxbows, and swamps, and typically prefers waterways with soft substrate. Although the species has been described as both omnivorous and as preferring mollusks, the species' diet is little-studied. We sampled *S. carinatus* at two locations in southeastern Oklahoma and held individuals for 48 hours to collect fecal samples. Samples were initially stored in ethanol and then analyzed by visual examination in the laboratory. Diets differed between locations. We confirmed that animals in our populations were indeed omnivorous, consuming aquatic and terrestrial insects, crayfish, and plants. Catbrier (*Smilax* sp.) vegetation and seeds dominated most samples; at one of our study sites catbrier seeds were found in nearly all samples. Although our sample size is limited, diet composition appeared to be influenced by resource abundance and time of year.

THE CORTICOSTERONE STRESS RESPONSE OF THE OUACHITA MAP TURTLE AND THE EFFECTS OF TRAPPING ON CORTICOSTERONE CONCENTRATIONS IN THE RED-EARED SLIDER TURTLE

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The sensitivity of the hypothalamo-pituitary-adrenal (HPA) axis can be quantifiably measured through concentrations of plasma corticosterone. Initial samples were acquired from Ouachita map turtles (*Graptemys ouachitensis*) within ten minutes (time 0) of hoop net disturbance. Stress-induced samples were acquired 30 minutes after initial net disturbance (time 30). Preliminary results of the corticosterone stress response show a significant increase in corticosterone (time 0: $\mu = 0.47$ ng/ml ± 0.077 SE; time 30: $\mu = 2.07$ ng/ml ± 0.289 SE; $p < 0.0001$) when exposed to acute handling stress. There was no sex difference in the corticosterone stress response, nor did body condition affect baseline corticosterone. Additionally, certain trapping techniques have often been assumed to increase baseline corticosterone in freshwater turtles. For birds and mammals, trapping techniques cause increases in corticosterone due to trap restraint (i.e., mist net, Sherman live trap), making acquisition of accurate baseline corticosterone difficult. In the red-eared slider (*Trachemys scripta*), we found that 26 to 30 hour trap residency corticosterone (time 0: $\mu = 0.66$ ng/ml ± 0.17 SE) and laboratory residency corticosterone (time 0: $\mu = 0.57$ ng/ml ± 0.16 SE) were not significantly different from initial capture baseline corticosterone (time 0: $\mu = 0.41$ ng/ml ± 0.10 SE; $p = 0.95$). These two studies show that the Ouachita map turtle exhibits a distinct corticosterone stress response whose magnitude was significantly lower than the corticosterone stress response of red-eared sliders and yellow-blotched map turtles. And the results of our trapping study reveal that trap and laboratory residency does not affect the baseline corticosterone in red-eared slider turtles, indicating that these techniques are not chronically stressful to this freshwater turtle.

COMPARISON OF REPRODUCTION IN FOUR POPULATIONS OF THE DIAMOND-BACKED WATERSNAKE (*Nerodia rhombifer*) DIFFERING IN PREY SIZE

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Many environmental factors cause variation life-history traits. Prey size is of particular interest as it characterizes the energetic content available to individuals within populations. As prey size varies among populations, allocation strategies to the various components of the life-history budget should differ because the energetic constraints have shifted. Within the life-history budget, variation in reproduction is important to examine as is it influences fitness, is energetically costly to females, and is often difficult to examine in many taxa. In order to investigate the influence of prey size on patterns of reproduction, we examined four populations of diamond-backed watersnake (*Nerodia*

rhombifer). Populations are located on fish farms in close proximity to each other in Lonoke County, Arkansas. Two populations raised large-bodied fish species, and two raised small-bodied prey. From 2012 to 2014 we collected reproductive data on more than 30 wild-captured females from each of these populations. Here we describe the patterns of reproduction and compare each population to examine differences in their reproductive strategies. We suggest prey size strongly influences many characteristics of reproduction including offspring size, litter size, and timing of reproduction.

OSTEOLOGICAL PREDICTORS OF GAPE CIRCUMFERENCE IN DIAMONDBACK WATER SNAKES (*Nerodia rhombifer*)

Ian Clifton and Matthew Gifford
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Organisms are exposed to different environmental pressures based on the locations they inhabit. This variation in exposure to environmental factors may lead to variation in morphological characters. Diamondback water snakes (*Nerodia rhombifer*) are common in many habitats and provide an excellent system to study this variation. As gape-limited predators, the maximum size of prey a snake can consume is defined by how wide it can open its mouth and throat. To account for this limitation, macrostomatan snakes have a highly kinetic skull that is composed of many different loosely connected bones. With all these different bones contributing to the entire skull it is likely that some components contribute more to the maximum gape than other parts. Snakes from populations exposed to different prey sizes might be expected to vary in gape size and the bones that significantly contribute to gape. We found that the mandible contributes significantly to maximum gape and both gape size and mandible length differ among populations exposed to different prey sizes.

DO MUSK GLAND SECRETIONS FUNCTION AS ALARM CUES IN SNAKES?

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The malodorous musk secretions produced by cloacal glands of snakes that are captured by predators have commonly been assumed to be an antipredatory adaptation. Support for this antipredatory function has been derived from experimental results suggesting that musk secretions are distasteful to some snake predators. A second hypothesis for musk gland secretions is that they act as an alarm substance, although support for this idea is largely derived from anecdotal reports. We tested cottonmouth snakes (*Agkistrodon piscivorus*) for evidence of an alarm response when subjected to conspecific musk gland secretions in separate experiments that evaluated changes in metabolic rate and also in behavioral response variables. We found no evidence of differences among musk and control treatments in metabolic trials, but this result was confounded by significant litter and order effects. In contrast, snakes exhibited significantly increased antipredatory behaviors, including greater latencies to complete a feeding task, tongue flick rates, and time spent immobile, in musk secretion treatments compared to controls. These behavioral results are consistent with alarm responses in many other taxa and provide, to our knowledge, the first experimental behavioral evidence for an alarm substance function for snake musk.

NATURAL HISTORY NOTES

NEW HERPETOLOGICAL DISTRIBUTION RECORDS FOR MISSOURI IN 2014

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The following list represents new county records accumulated or brought to our attention since the publication of Daniel and Edmond (2014a). Publication of these records extends our knowledge of the amphibians and reptiles native to Missouri. In addition, recipients of this list have the opportunity to update checklists and distribution maps. Finally, the publication of this list allows us to acknowledge the contributions of the many individuals who have provided information or specimens.

The records listed below represent the first reported occurrence of the species within a given county and are based on catalogued voucher specimens or photographs deposited in a public institution. Distribution records are presented in the standardized format of Collins (1989): common and scientific name, county, specific locality (unless withheld for species of special concern), legal description of locality, date of collection, collector(s), institution and catalogue number where the specimen is deposited.

Specimens reported in this note have been deposited in the Dean E. Metter Memorial Collection, University of Missouri, Columbia, MO. Unless otherwise indicated, all distribution records are documented by post-metamorphic/hatchling fluid preserved specimens.

We would like to extend our appreciation to M. Bower, A. Braun, C. Chambers, M. Jeppson, A. Nicholson, J. Severson, and M. Tovar for contributing photographs that were used in this note.

AMPHIBIA: CAUDATA (SALAMANDERS)

SPOTTED SALAMANDER
Ambystoma maculatum
Franklin Co.: Long Ridge Conservation Area (T41N R2W Sec. 20); 9 April 2014; R. Daniel (digital image, UMC 2567P).

TIGER SALAMANDER
Ambystoma tigrinum
Pulaski Co.: MO 133, 1.82 air km W Swedeborg (T37N R13W Sec. 27); 11 March 2014; M. Jeppson (digital image, UMC 2723P).

CENTRAL NEWT
Notophthalmus viridescens
Franklin Co.: Long Ridge Conservation Area (T41N R2W Sec. 20); 9 April 2014; R. Daniel (digital image, UMC 2570P).

Polk Co.: 4.76 air km NE Morrisville (T32N R22W Sec. 18); 9 August 2014; A. Nicholson (digital image, UMC 2725P).

AMPHIBIA: ANURA (FROGS AND TOADS)

AMERICAN TOAD
Anaxyrus americanus
Dallas Co.: Lead Mines Conservation Area (T36N R18W Sec. 26); 26 April 2014; R. Daniel, B. Edmond, C. Cannon (UMC 8878).

COPE'S GRAY TREEFROG
Hyla chrysoscelis
Caldwell Co.: Bonanza Conservation Area (T56N R27W Sec. 32); 11 June 2014; R. Daniel, C. Gerhardt (digital image, UMC 2610P).

GREEN TREEFROG
Hyla cinerea
Carter Co.: Current River, Van Buren (T27N R1W Sec. 24); 17 June 2014; J. Briggler, K. Irwin, M. Wanner (digital image, UMC 2707P).

PLAINS LEOPARD FROG
Lithobates blairi
Pettis Co.: Rt. NN, 0.75km E Dunksburg (T47N R23W Sec. 6); 9 August 2014; R. Daniel (digital image, UMC 2619P).

REPTILIA: SQUAMATA (LIZARDS)

COAL SKINK
Plestiodon anthracinus
Benton Co.: Big Buffalo Creek Conservation Area (T41N R20W Sec. 1); 18 April 2014; J. Briggler, L. Rizzo, J. Willard, B. Stephens (digital image, UMC 2708P).

FIVE-LINED SKINK
Plestiodon fasciatus
Ste. Genevieve Co.: Horton Farm Conservation Area (T37N R7E Sec. 33); 3 May 2014; A. Braun (digital image, UMC 2598P) (Braun and Bueltmann, 2014b)

LITTLE BROWN SKINK
Scincella lateralis
Pettis Co.: Lookout Rd., 0.4 km SE Muddy Creek (T47N R20W Sec. 25/36); 20 September 2014; R. Daniel (digital image, UMC 2627P).

REPTILIA: SQUAMATA (SNAKES)

COPPERHEAD
Agkistrodon contortrix
Polk Co.: MO 123 (T33N R24W Sec. 34); 12 October 2014; B. Edmond, C. Chiu (digital image, UMC 2665P).

ROUGH EARTH SNAKE
Haldea striatula
Washington Co.: Washington State Park (T39N R3E Sec. 27); 3 May 2014; B. Edmond, J. Edmond (digital image, UMC 2651P).

BLACK KINGSNAKE
Lampropeltis nigra
Mississippi Co.: Delaney Lake Conservation Area (T27N R15E Sec. 30); 21 May 2011; R. Daniel, B. Edmond (digital image, UMC 2040P).
Scott Co.: General Watkins Conservation Area (T28N R13E Sec. 27); 21 May 2011; R. Daniel, B. Edmond (digital image, UMC 2038P) (Daniel and Edmond 2014b).

EASTERN MILKSNAKE
Lampropeltis triangulum
St. Francois Co.: Terre Du Lac (T37N R4E Sec. 19); 19 May 2014; J. Severson (digital image, UMC 2592P).

EASTERN FOXSNAKE
Pantherophis vulpinus
Pike Co.: Location withheld; 26 June 2008; C. Chambers (digital image, UMC 2749P).

BROWN SNAKE
Storeria dekayi
Platte Co.: Tiffany Springs Park (T51N R34W Sec. 4); 16 October 2014; M. Tovar (digital image, UMC 2718P).

REPTILIA: TESTUDINES (TURTLES)

SMOOTH SOFTSHELL
Apalone mutica
Pike Co.: Mississippi River, Clarksville (T53N R1E Sec. 16); 4 July 2014; B. Edmond, M. Bowe (digital image, UMC 2682P).

SNAPPING TURTLE
Chelydra serpentina
Wright Co.: MO 5, 0.49 km W Jct. Co. Rd. 257 (T30N R15W Sec. 36); 25 May 2014; R. Daniel, G. Dryden (digital image, UMC 2585P).

ALLIGATOR SNAPPING TURTLE
Macrochelys temminckii
Madison Co.: St. Francis River (T32N T5E Sec. withheld); 20 June 2014; T. Priday (digital image, UMC 2630P).

THREE-TOED BOX TURTLE
Terrapene carolina
Platte Co.: Parkville (T51N R34W Sec. 27); 8 July 2011; M. Tovar (digital image, UMC 2713P).

RED-EARED SLIDER
Trachemys scripta
Ste. Genevieve Co.: MO 32 Jct. Glassey Ln. (T37N R7E Sec. 33); 27 April 2014; A. Braun, A. Bueltmann (digital image, UMC 2601P) (Braun and Bueltmann 2014a).

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A NEW KINGSNAKE FOR MISSOURI AND SOME COMMENTS ON THE BIOGEOGRAPHY OF SOUTHEAST MISSOURI

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Pyron and Burbrink (2009) demonstrated the existence of five distinct lineages in the common kingsnake, *Lampropeltis getula*, and recognized each as a species. Based on their analysis, the Mississippi River was a presumed barrier to gene flow in this species complex. They assigned Missouri animals to *L. holbrooki*, the Speckled Kingsnake. All animals immediately east of the Mississippi River in Illinois, Kentucky, and Tennessee were assigned to *L. nigra*, the Black Kingsnake.

However, the matter is complicated since the position of the Mississippi and Ohio Rivers in present day Missouri, Illinois, Arkansas, and Mississippi has shifted considerably and often suddenly throughout the Pleistocene in response to the effects of glaciation. While the Mississippi River is undoubtedly a formidable barrier for some species of amphibians and reptiles, the river itself has changed course so much in recent geological time that its present day channel, used in delineating state boundaries, is not a reliable indicator of its long-term effects as an allopatric speciation mechanism.

In May 2011, the authors collected two Black Kingsnakes (*L. nigra*) in southeast Missouri, one salvaged in Mississippi Co, MO (UMC 2040P) and another taken alive in Scott Co MO (UMC 2038P). Both animals were suspected Black Kingsnakes based on coloration and pattern. The Scott Co, MO specimen was later verified using the same mtDNA techniques employed by Pyron and Burbrink. This specimen was reported as the first documented occurrence of the species in the state (Daniel and Edmond 2014). Both specimens were reported as new county records (see p. 17, this issue).

Prior to the Pleistocene (2mya), the Mississippi River flowed directly south and east of the Ozark Plateau and at different times followed a course through the present day Saint Francis and Cache River channels in Missouri and Arkansas, joining its current course near present day Helena, AR. At the same time, the Ohio River more or less followed its current path to the ancient coastal plain and at different times occupied the present day Mississippi River and Yazoo River channels along the eastern portion of the Delta region in the state of Mississippi. The two major rivers followed separate courses during much of the Pleistocene and at one point, joined as far south as present day Vicksburg, MS.

At the time, the geologic formation now known as Crowley's Ridge was a long, thin upland ridge continuous with the Shawnee Hills in southern Illinois. The ridge separated the ancient Mississippi and Ohio rivers, much like the smaller-scale "backbones" that can be found separating some streams in the Ozarks and elsewhere.

Due to the spring and summer glacial melt runoff from the Missouri, Mississippi, and Ohio watersheds during the four major glaciations of the Pleistocene, a massive amount of floodwater was directed through the Mississippi River valley. The ancient coastal plain occupied by the river in southeast Missouri had an extremely low gradient and poor drainage (as the area does today). At times, the floodwater was sufficient to fill the existing river valley and force its way through low-lying areas of Crowley's Ridge. Over many years and several flood events, the Mississippi eventually abandoned its old course for a more direct route to the Ohio River at Thebes Gap, just south of present day Cape Girardeau. Monopoly Lake and the surrounding swamps at Mingo National Wildlife Refuge are remnants of the ancient Mississippi River channel. This complex and slow process is explained in a detailed, but accessible narrative in Hawker (1992), and described in more detail in Blum *et al*. (2000), Saucier (1994), and Fisk (1944).

Today, Crowley's Ridge is a prominent feature in the otherwise flat alluvial plain landscape of southeast Missouri and eastern Arkansas. Including the Benton Hills region south of Cape Girardeau, the ridge extends more than 200 miles between Scott City, MO and Helena, AR. Parts of the ridge were completely obliterated during Pleistocene flooding events, giving the present effect of a series of elongate islands in the floodplain. The ridge varies in width from nearly 15 miles in Stoddard Co, MO to less than a mile in several places in Missouri and Arkansas. Elevation is typically 100 - 250 feet above the surrounding floodplain, with the eastern side of the ridge generally higher in elevation.

Although the ridge has a core of bedrock, it is overlain with alluvial gravels and sands and capped with moderately deep loess (Nigh and Schroeder 2002).

Another discontinuity along the Mississippi River that deserves mention is Fountain Bluff in Illinois. This "lost hill" in the Mississippi River valley was on the western side of the river prior to the Pleistocene. It was cutoff from the Ozarks when the Illinoian ice sheet (150 kya) blocked the river's preferred channel along the present day Big Muddy River, forcing it through a new channel. Although the Mississippi probably used both the new and old channels after the glaciers receded, it eventually adopted its present course (Willman and Frye 1980).

The Mississippi River valley appears to serve as a gene flow barrier within several wide-ranging eastern species, including *Sceloporus undulatus* (Leache and Reeder 2002), *Carphophis amoenus* (Clark 1968), and *Pantherophis obsoletus* (Burbrink *et al*. 2000). In Missouri, this distribution pattern has also been observed in vascular plants, with several eastern species known from the state only at stations along Crowley's Ridge (Steyermark 1963). At least two additional eastern species of amphibians and reptiles unknown in Missouri, the Spotted Dusky Salamander (*Desmognathus conanti*) and the Eastern Wormsnake (*Carphophis amoenus*), are documented from Arkansas along Crowley's Ridge (Trauth *et al*. 2004). Neither of these species is found in large floodplain habitats and was likely stranded during the Pleistocene when the Mississippi River shifted channels. Other upland species unknown to Missouri, such as the Northern Slimy Salamander (*Plethodon glutinosus*) and the Northern Zigzag Salamander (*P. dorsalis*), common in the area immediately across the Mississippi River in Illinois from which Crowley's Ridge is derived, might also be found in this region.

Because of the history of the lower Mississippi River and existing biological evidence, one could expect Crowley's Ridge to harbor eastern representatives of species complexes isolated by the Mississippi River instead of the western counterparts found in other regions of Missouri and Arkansas. Likewise, species found on Fountain Bluff could be the same as those from the nearby Missouri Ozarks rather than species found elsewhere in Illinois. For species found in both upland and alluvial habitats, the situation could potentially be much more complex with no obvious barriers preventing gene flow or hybridization between closely related species. As more genetic work is done on widely distributed eastern species in North America, it would behoove investigators to obtain specimens from Crowley's Ridge, Fountain Bluff, southeast Missouri, eastern Arkansas, the Delta region of Mississippi, and other points along the valley subjected to recent geologic changes. Because many of the resulting new species tend to be morphologically cryptic, inclusion of such specimens in analyses would clarify the role of big rivers in gene flow as well as satisfy the curiosity and conservation needs of biologists along the Mississippi River valley.

Acknowledgements

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ADDITIONS TO THE BIBLIOGRAPHY OF REFERENCES ON THE HERPETOFAUNA OF MISSOURI

Compiled by
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Division of Biological Sciences, University of Missouri, Columbia, MO 65211

The following is a list of references dealing with the biology of amphibians and reptiles from Missouri that have been brought to the attention of the author since the publication of Daniel (2013). Readers are requested to notify the author of any additional references that should be included in future compilations.

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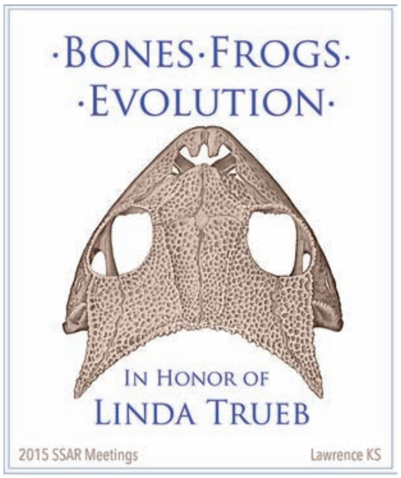
Second Update

UNIVERSITY OF KANSAS MEETING IN 2015

Society for the Study of Amphibians and Reptiles

co-sponsored by Partners in Amphibian and Reptile Conservation (PARC)

together with the herpetological societies of Kansas, Missouri, and Arkansas, the Center for North American Herpetology, *and the* International Society for the History and Bibliography of Herpetology



Symposium
Bones, Frogs, & Evolution
Organized by David Blackburn, Anne Maglia, and David Cannatella

This event, kept strictly confidential until now, will celebrate the exceptionally productive career of Linda Trueb, Curator Emerita, KU Herpetology Division. The contributions of Trueb's students, spanning 40 years of scholarship, will include oral presentations from many of her highly successful doctoral mentees. Invited participants include Ana Baez, David Blackburn, David Cannatella, Luis Coloma, Helio da Silva, Eli Greenbaum, Anne Maglia, Dave McLeod, Greg Pregill, Chris Sheil, Erik Wild, and William Duellman.

PROJECTED COSTS FOR 2015

- *Registration fees (member rates):*
  - Students . . . . US $150
  - Regular $295
  - Seniors, retired / over 70 . . . . . . $150
- *Dorm room rates (on campus, linens included):*
  - Dual-occupancy rooms or suites, per day . . . . starting at $35
  - Single-occupancy rooms or suites, per day . . . . starting at $55

There are many motels and a major hotel at the edge of campus. Motels allow more persons per room, at lower per-person costs than for the on-campus dorms (as low as $25/person). Full details will be supplied in the formal *Announcement and Registration Information* that will be posted in Spring 2015.

SSAR will hold its 2015 meeting on the beautiful campus of the University of Kansas, one of America's major research universities and a world center for research and graduate education in herpetology. This will be held from **Thursday, July 30 through Monday, August 3.** All scientific sessions will be held in the Kansas Union, which is adjacent to the Museum of Natural History. The intimate campus setting will facilitate personal and friendly interactions while moderating fees for registration and lodging (see projected rates below).

This special event will include oral and poster presentations, silent and live auctions, vendor displays, student social, symposia, and special lectures provided by David Hillis (Keynote) and Miguel Vences (President's Travelogue). SSAR will resurrect popular activities from the past, including:

- Redesigned audiovisual shows arranged by David Dennis and Eric Juterbock.
- Reception honoring distinguished senior herpetologists designed so that students can interact personally with luminaries in the field.
- Herpetological Quiz, arranged by the graduate students at UT Arlington and KU, with prizes for winners.
- Live Kansas amphibians and reptiles (organized by KHS), with photographic set-ups for use by delegates.
- Tours of Fitch Reserve, site of Henry Fitch's classic long-term snake ecology work.
- Tours of the herpetological research laboratories and Biodiversity Institute.

The plenary session, keynote addresses, regular oral and poster presentations, PARC workshops, the ISHBH special session, symposia, and Seibert student award competition will all be held in the Kansas Union (*above*), a modern facility equipped with multiple restaurants, coffee shops, bowling alley, lounge, ballroom, and break-out conference rooms.

PHOTO BY TOM KENNEDY

Symposium
Frontiers in Integrative Organismal Biology: Herpetological Horizons
Organized by Rich Glor and Rafe Brown

This event will bring together a group of exceptionally research-active herpetologists working at the forefront of evolution-related fields, using amphibians and reptiles as study systems. Topics include speciation, adaptive radiation, convergence, phenotypic evolution, and the evolution of development—all through the lens of genomic approaches to understanding evolution of amphibians and reptiles. Participants include Frank Burbrink, Todd Castoe, Ben Evans, Matt Fujita, Luke Harmon, Ryan Kerney Adam Leaché, Emily Lemmon, Jim McGuire, Rachael Mueller, Robert Thompson, and John Wiens. Summary by David Wake.

Comfortable, air-conditioned, and affordable dorm rooms located 5–15 minutes walk from the meeting venue, will be a welcomed feature of these attendee-friendly meetings. Single, dual, and four-person occupancy suites are available. Amenities include kitchen, laundry, parking, private bath, social room, etc. Naismith Residence Hall allows alcoholic beverages in rooms.

PHOTO BY DAVID M. DENNIS

Society for the Study of Amphibians & Reptiles

58th Annual Meeting • July 30–August 2, 2015 • University of Kansas

KU

AWARDS FOR STUDENT* ATTENDANCE AT SSAR MEETING UNIVERSITY OF KANSAS, 2015

The *Carl Gans Collections and Charitable Fund* (hereafter the "Gans Fund") is pleased to announce that it will support two kinds of awards to students*—both graduate and undergraduate, but not postdoctoral—who are attending the SSAR meeting at the University of Kansas next summer (July 30 to August 3, 2015; visit SSAR for more information). There will be 20 awards covering the full student registration fee of US$150 and limited funds to support student travel expenses. Both awards are *open to all students regardless of nationality*. **The deadline for receipt of applications for both awards is February 15, 2015.**

To be eligible, applicants (1) must certify their student status with a separate message from their professor; (2) must list the herpetological society or societies to which they belong*; (3) must be presenting papers (oral or poster) at the meeting; and (4) the paper's subject area must be within the broad spectrum of research conducted by Professor Gans on the biology of amphibians and reptiles (especially morphology, systematics, faunistics, behavior, physiology, and evolution). Applicants must provide a paragraph (no more than 300 words) describing the work to be presented at the meeting, to enable the selection process. *Award announcements will be made about March 15, 2015*, allowing all applicants to know their status before meeting registrations begin.

- **REGISTRATION AWARDS.** Selections will be made by SSAR. The application, research paper description, and certifications should be sent by email to: Dr. Marion Preest, SSAR Secretary, at mpreest@kecksci.claremont.edu (if by air mail, to her at: Joint Science Department, The Claremont Colleges, Claremont, CA 91711, USA). The award funds will be sent by SSAR directly to the University of Kansas, which will receive a list of the successful applicants.
- **TRAVEL AWARDS:** Selections will be made by the Gans Fund, on the recommendation of its Scientific Advisory Board (visit CarlGans for list of board members). The maximum award for applicants from the USA and Canada is US$500; for all other countries $1000. The application, research paper description, and certifications should be sent to the Gans Fund; application details may be found at: http://www.carlgans.org. Submissions will be made via the web. Applicants should detail their expected expenses for the meeting including the travel costs; be sure to indicate the amount you are requesting from the Gans Fund and the amounts received (or applied for) from other sources. The award funds will be distributed by SSAR directly to the successful applicants. Further details may be obtained from the Gans Fund at the on-line address given above.

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* For this meeting of SSAR, the meeting organizers have defined "student" as all student members of SSAR, HL, and ASIH, as well as student members of all national and international herpetological societies, who will be allowed to register at the "student member" rate of US$150.