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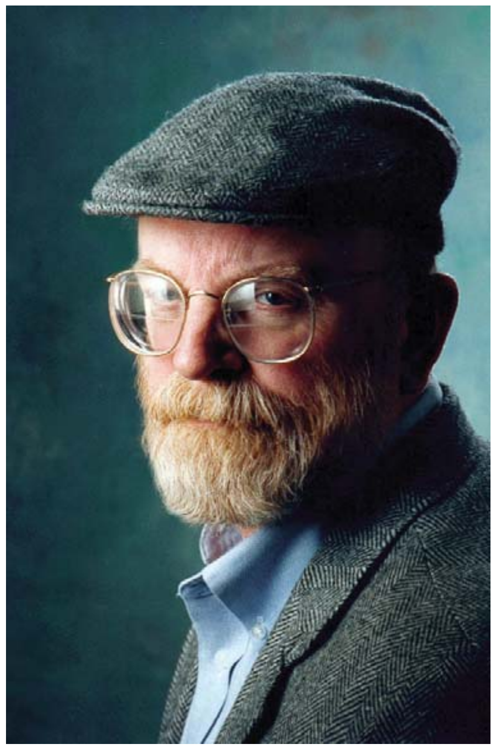

Celebrating the Memory of
Kansas Herpetological Society Founder,
Joseph T. Collins, 1939-2012

Kansas Herpetological Society

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KHS BUSINESS

KHS ANNUAL MEETING INFORMATION

The Kansas Herpetological Society will hold its 39th Annual Meeting on the campus of Fort Hays State University and the Sternberg Museum of Natural History from Friday 2 November through Sunday morning 4 November 2012. Registration will begin at 8:00 am on Saturday and Sunday. Registration is still only $10.00 and the beer is free; gratis non-alcoholic drinks for the younger folks.

The three day meeting will be a tribute to KHS founder Joe Collins. Joe passed away early this year while vacationing in Florida. The meeting is open to everyone and Joe's friends and colleagues are especially encouraged to attend.

A welcoming reception will be held 7pm Friday evening at the Sternberg Museum. Beverages and snacks will be provided. The extensive Joseph T. Collins Memorial Natural History Library, recently moved to the Sternberg Museum, will be dedicated and open to the public. A slide show of Kansas herps and herpetologists featuring Joe Collins will be running during the reception. Please feel free to bring your own contributions or send them to the contact below ahead of time.

Oral presentation sessions will be conducted Saturday morning, Saturday afternoon, and Sunday morning in Albertson Hall on the FHSU main campus.

Dr. Brian I. Crother, Southeastern Louisiana University will give the keynote address "The Bold Hypothesis(es) of Joseph T. Collins" following the banquet on Saturday evening at the Museum. A short awards program will follow and then the always popular KHS auction led by Dan Fogell, Walter Meshaka, and Eric Thiss. Please bring herp related items to donate and help support the KHS.

In conjunction with the meeting, 'Rattlerssss, From Fear to Fascination' featuring all 23 species of US rattlesnakes will be on display at the Sternberg Museum of Natural History.

CALL FOR PAPERS

Those wishing to give an oral presentation please send the following information to the e-mail address provided below. There are 30 presentation slots available so get yours in promptly to reserve a place.

1. Name, mail and e-mail address of presenter
2. Name(s), mail and e-mail address(es) of co-author(s)
3. Title of your presentation

Please allow 15 minutes for presentation and questions. All presenters will receive a confirmation e- mail or phone call that indicates you are scheduled to present a paper. Please bring your presentation on flash drive (memory stick) and/or compact disc. Projectors and computers will be provided. Include any additional equipment request with your submission.

Be sure to note whether your presentation is a candidate for The Collins Award (must be primarily about Kansas herpetofauna) and/or The Toland Award (must be a KHS student member). These will be flagged in the program and on the annual meeting web site.

Any questions can be directed to:
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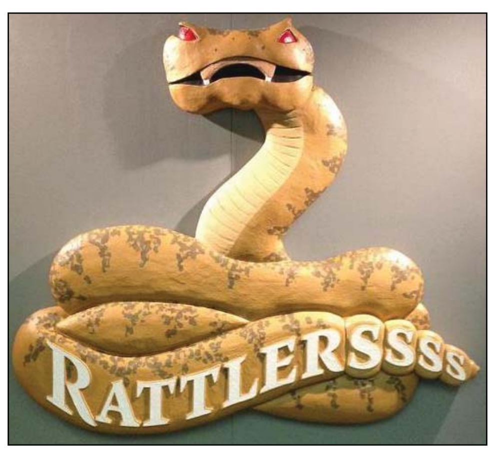

NOTES

SIXTEEN COUNTY RECORDS OF HERPETOFAUNA FROM SOUTH-CENTRAL NEBRASKA

Ballinger et al. (2010) and Fogell (2010) recently updated distributional accounts of herpetofauna in Nebraska, improving our overall understanding of species' ranges since the last comprehensive account published by Lynch (1985). One region of the state still lacking many county records of occurrence is south-central Nebraska. Counties such as Furnas, Gosper, Harlan, Kearney, and Phelps have fewer records of species than many others in Nebraska, including the lack of documentation for some of the more common and widespread species in the state.

Herein, I report on 16 county records of herpetofauna collected from April to October 2011 in south-central Nebraska. Most individuals were collected late in the year while driving roads during unseasonably warm days in the afternoon. For example, daytime high temperatures were 26.7°C (6 October), 26.1°C (15 October), and 27.2°C (24 October) on days I searched for herpetofauna, whereas average temperatures for those days were 20°C, 18.3°C, and 16.1°C, respectively, based on averages from the Kearney Airport, Buffalo County (Wunderground.com). Numbers of snakes observed on 6 October also were likely enhanced by morning rains throughout the region. On 6 October, I estimated that I observed at least 40 snakes on 5 km of paved and gravel roads in Hall County along grasslands and woodlands on lands managed by The Crane Trust south of Alda, Nebraska. On 15 October, I documented 35 snakes representing 5 species and 4 Plains Leopard Frogs (*Lithobates blairi*) on roads while driving 233 km in Franklin, Harlan, Kearney, and Phelps counties. On 24 October, I documented 19 snakes representing 4 species and 1 Woodhouse's Toad (*Anaxyrus woodhousii*) while driving 212 km in Adams, Franklin, Harlan, Kearney, and Phelps counties. An effective strategy to obtain distributional and late-seasonal information on reptiles appears to be to conduct late-seasonal searches on roadways during unseasonably warm days.

For distributional records presented below, voucher specimens were deposited in the herpetology collection at the Sternberg Museum of Natural History (FHSM), Fort Hays State University, Hays, Kansas. Many vouchers also included preserved tissues. All specimens were verified by Curtis J. Schmidt. Coordinates were taken with a hand-held GPS unit using map datum NAD83. Voucher specimens were collected under the authorization of the Nebraska Game and Parks Commission (Scientific and Educational Permit No. 1031). Order of accounts and names (scientific and common) follows Fogell (2010).

Anura-Frogs

PSEUDACRIS MACULATA (Boreal Chorus Frog). USA: NEBRASKA: BUFFALO CO.: 4.1 km S, 0.6 km E Gibbon, Windmill State Recreation Area (40.70985°N, 98.83717°W). 6 April 2011. FHSM 15724-15727, 15841. First county records. Records fill in distributional gap in south-central Nebraska; prior records are known from all surrounding counties including Custer, Hall, Kearney, Phelps, and Sherman (Ballinger et al. 2010, Fogell 2010). Individuals were captured at night in a grassy flooded area surrounded by scattered deciduous trees.

USA: NEBRASKA: GOSPER CO.: 6.5 km S, 0.9 km W Bertrand (40.4667°N, 99.6441°W). 19 June 2011. FHSM 15846-15849. First county records. Records fill in distributional gap in south-central Nebraska between Dawson, Furnas, and Phelps counties (Ballinger et al. 2010, Fogell 2010). Individuals were captured in flooded roadside along the edge of agricultural field with center-pivot irrigation.

USA: NEBRASKA: HARLAN CO.: 6.7 km S, 2.3 km W Atlanta (40.3070°N, 99.4996°W). 19 June 2011. FHSM 15845. First county record via a voucher specimen. Record fills in distributional gap in south-central Nebraska between Franklin, Furnas, and Phelps counties (Ballinger et al. 2010, Fogell 2010, Geluso 2011). Individual was captured in small pool of water along NE Hwy 4 in corner of agricultural field with center-pivot irrigation. Hubbs (2012) recently reported the species from the county via a photographic voucher.

LITHOBATES BLAIRI (Plains Leopard Frog). USA: NEBRASKA: FRANKLIN CO.: 1.1 km N, 6.8 km W Hildreth P.O. (40.3470°N, 99.1234°W). 15 October 2011. FHSM 16151. First county record. Record fills in distributional gap in south-central Nebraska; all surrounding counties contain prior records—Adams, Harlan, Kearney, Phelps, and Webster (Ballinger et al. 2010, Fogell 2010). Individual was captured along roadside in semi-permanent pool of water adjacent to corn fields.

Squamata-Lizards

SCELOPORUS CONSOBRINUS (Prairie Lizard). USA: NEBRASKA: DAWSON CO.: 7.2 km S, 3.9 km E Lexington (40.70993°N, 99.69467°W). 14 July 2011. FHSM 15850. First county record. Individual represents the farthest east that *S. consobrinus* has been documented along the Platte River in south-central Nebraska (Ballinger et al. 2010), along with a record from Gosper County (this study, see next account); distributional records from Buffalo and Hall counties are from sandy habitats south of the South and Middle Loup rivers (Ballinger et at. 2010). Voucher specimen fills in distributional gap in south-central Nebraska between Gosper (this study), Buffalo, Custer, Frontier, and Lincoln counties (Ballinger et al. 2010, Fogell 2010). I captured the individual under a wooden board in an open woodland in the flood plain of Platte River; the soils were sandy.

USA: NEBRASKA: GOSPER CO.: 13.5 km N, 4.4 km E Smithfield (40.6939°N, 99.6899°W). 21 October 2011. FHSM 16158 and 16159. First county records. Specimens represent the farthest east that *S. consobrinus* has been documented along the Platte River in south-central Nebraska (Ballinger et al. 2010), along with the record from Dawson County (this study, see above account). Voucher specimen fills in distributional gap in south-central Nebraska between Dawson (this study), Frontier, and Furnas counties (Ballinger et al. 2010, Fogell 2010). Lizards were captured along a wooded linear strip consisting mainly of Siberian elms (*Ulmus pumila*) on north side of a large canal in flood plain of Platte River.

Figure 1. Milk snake (*Lampropeltis triangulum gentilis*) from Harlan County, Nebraska, 29 April 2011 (FHSM 15844).

Squamata – Snakes

LAMPROPELTIS TRIANGULUM (Milk Snake). USA: NEBRASKA: HARLAN CO.: 5.0 km S, 1.1 km E Republican City (40.05268°N, 99.2079°W; NAD1983). 29 April 2011. FHSM 15844. First county record. Record adds to counties in south-central Nebraska with prior records of occurrence for the species (Ballinger et al. 2010, Fogell 2010). Franklin County is the only adjacent county in Nebraska with a previous record (Ballinger et al. 2010, Fogell 2010), but *L. triangulum* also is known to the south from adjacent Phillips County, Kansas (Collins et al. 2010). Based on location of capture and coloration (Figure 1), the individual is best referred to as *L. t. gentilis* of the three subspecies in the state (Ballinger et al. 2010). The individual was captured under discarded concrete block on small hill surrounded by grasses and scattered trees.

LIOCHLOROPHIS VERNALIS (Smooth Green Snake). USA: NEBRASKA: PHELPS CO.: 17.6 km N, 0.4 km W Funk P.O., Funk-Odessa Road (40.6215°N, 99.2560°W). 15 October 2011. FHSM 16152. First county record. Most counties with records of occurrence for *L. vernalis* are from central and south-central Nebraska (Geluso and Wright 2009, Fogell 2010, Ballinger et al. 2010). Adjacent counties with records of occurrence include Franklin and Kearney counties (Ballinger et al. 2010, Fogell 2010). The individual was found dead on a road adjacent to rolling hills with sandy soils that have been mostly converted to agricultural fields with center-pivot irrigation. This site is best described as an upland grassland; however, Ballinger et al. (2010) and Fogell (2010) state that this species inhabits mesic and wet prairies, meadows, and wet grasslands. This individual might have been moving to a hibernaculum. Triangular-shaped corners of fields with pivots might represent refugia for this species and sand-loving species in the area. Fogell (2010) reports that Smooth Green Snakes are active from mid-April to September. This specimen represents the latest seasonal date of aboveground activity for *L. vernalis* in Nebraska.

DIADOPHIS PUNCTATUS (Ringneck Snake). USA: NEBRASKA: ADAMS CO.: 0.1 km N, 3.1 km W Holstein (40.4663°N, 98.6890°W). 4 October 2011. FHSM 16148. First county record. This record fills in a distributional gap in south-central Nebraska between Buffalo, Hamilton, and Webster counties (Ballinger et al. 2010, Fogell 2010, Bridger and Geluso In review). The individual was captured along a dirt road in an upland grassland with sandy soils.

USA: NEBRASKA: PHELPS CO.: 13.4 km N, 0.4 km W Funk P.O., Funk-Odessa Road (40.5835°N, 99.2555°W). 15 October 2011. FHSM 16152. First county record. This record fills in distributional gap in south-central Nebraska between Harlan (Fogell and Taggart 2010), Dawson, and Buffalo counties (Ballinger et al. 2010, Fogell 2010). The individual was found dead on a road in area mostly converted to agricultural fields with center-pivot irrigation.

STORERIA DEKAYI (Brown Snake). USA: NEBRASKA: ADAMS CO.: 6.3 km S, 2.0 km W Holstein (40.4082°N, 98.6747°W). 24 October 2011. FHSM 16162. First county record. This individual represents the most westward record of *S. dekayi* in Nebraska, extending its distribution 50 km northwest of a record from southeastern Webster County (5.5 mi S, 6 mi E Red Cloud; University of Nebraska State Museum #15014; Ballinger et al. 2010); Ballinger et al. (2010) reported that a locality record from Lincoln County potentially is in error. Individual was found dead on a road in area with a patchwork of upland grasslands and agricultural fields with center-pivot irrigation.

STORERIA OCCIPITOMACULATA (Redbelly Snake). USA: NEBRASKA: KEARNEY CO.: 19.4 km N, 0.2 km E Axtell (40.6549°N, 99.1245°W). 24 October 2011. FHSM 16161. First county record. This specimen adds to those counties with known occurrences in the Big Bend Reach of the central Platte River for this disjunct population of *S. occipitomaculata* in Nebraska (Ballinger et al. 2010, Fogell 2010). Individual was found dead on a road that bordered a wooded area along the Platte River on one side and an agricultural field on the other side. This appears the latest seasonal observation for this species in Nebraska based on specimens housed at the University of Nebraska State Museum.

THAMNOPHIS RADIX (Plains Garter Snake). USA: NEBRASKA: HARLAN CO.: 2.9 km N, 7.6 km E Ragan (40.3364°N, 99.2015°W). 24 October 2011. FHSM 16164 and 16165. First county records. These specimens represent documentation from one of the last counties without records for *T. radix* in south-central Nebraska (Ballinger et al. 2010, Fogell 2010, Lingenfelter et al. in review). This species is known from all surrounding counties except for Furnas County (Ballinger et al. 2010, Fogell 2010, Lingenfelter et al. in review). Individuals were found dead on a road in an area with many agricultural fields.

THAMNOPHIS SIRTALIS (Common Garter Snake). USA: NEBRASKA: PHELPS CO.: 5.0 km S, 4.5 km E Odessa (40.6565°N, 99.2037°W) and 5.0 km S, 3.7 km E Odessa (40.6568°N, 99.2129°W). 6 October 2011. FHSM 16149 and 16150. First county records. These specimens fill in a distributional gap in south-central Nebraska between Buffalo, Dawson, Gosper, Harlan, and Kearney counties (Ballinger et al. 2010, Fogell 2010, this study). Individuals were found dead on road in agricultural area near woodlands in flood plain of Platte River.

USA: NEBRASKA: FURNAS CO.: 0.8 km S, 3.7 km E Edison P.O., Hwy 136 (40.2708°N, 99.7328°W). 15 October 2011. FHSM 16154. First county record. Record fills in distributional gap in south-central Nebraska between Frontier, Gosper, Harlan, and Red Willow counties (Ballinger et al. 2010, Fogell 2010, this study). Snake was found dead on roadway in agricultural area near a farmstead in the flood plain of Republican River.

USA: NEBRASKA: GOSPER CO.: 13.5 km N, 4.4 km E Smithfield (40.6940°N, 99.6898°W). 21 October 2011. FHSM 16160. First county record. Record fills in distributional gap in south-central Nebraska between Dawson, Frontier, Furnas, and Phelps counties (Ballinger et al. 2010, Fogell 2010, this study). Snake was captured under log along wooded linear strip consisting mainly of Siberian elms (*Ulmus pumila*) on north side of a large canal in the flood plain of Platte River.

I thank Mark Peyton (Central Nebraska Public Power and Irrigation District) for access to Jeffrey Island in Dawson and Gosper counties.

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STORERIA OCCIPITOMACULATA (RED-BELLIED SNAKE). BEHAVIOR: LIP-CURLING.

Lip-curling defensive behavior, is well documented in this species (doAmaral, J.Â P. S. 1999. Lip-curling in redbelly snakes (*Storeria occipitomaculata*): functional morphology and ecological significance. J. Zool., Lond. (248):289-293.). Lip-curling has not been observed in Kansas (Taggart et al. Kansas Herpetofaunal Atlas (http://webcat.fhsu.edu/ksfauna/herps/index.asp last accessed 0900, 18 May 2012).

In the course of our field study of this species in Kansas we have observed the behavior several times, performed by different animals—all of them female. On 17 May 2012 we captured and examined a gravid female, in Franklin Co., KS, and photographically documented the behavior (Figs. 1, 2). In all respects the display corresponds to doAmaral's illustrations.

We thank Kansas Department of Wildlife, Parks and Tourism for ongoing support of this project (KAN0067608), and the staff of Timber Lakes Camp for access to restricted areas.

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ADULT BODY SIZE AND CLUTCH CHARACTERISTICS OF THE SPRING PEEPER, *PSEUDACRIS CRUCIFER* (WIED-NEUWIED, 1838), FROM A SINGLE SITE IN SOUTH-CENTRAL PENNSYLVANIA

The Spring Peeper, *Pseudacris crucifer* (Wied-Neuwied, 1838), is a geographically widespread inhabitant of eastern North America, including Pennsylvania (Hulse et al., 2001; Conant and Collins, 1991; Butterfield et al., 2005; Meshaka and Collins, 2010). This species is considered common and relatively abundant throughout Pennsylvania; however, little specific data about its life history are available in the state. (Hulse et al., 2001; Steele et al. 2010). As part of an ongoing long-term study assessing the herpetofauna of south central Pennsylvania, we focused on a single breeding site.

The Spring Peeper is a locally abundant frog at Letterkenny Army Depot (LEAD) in Chambersburg, Cumberland County, Pennsylvania (Delis et al., 2010), and its chorus aggregations have been heard beginning in late February or March (PRD and WEM, pers. obs.). Data on fecundity and clutch characteristics of this species do not exist for LEAD or Pennsylvania generally (Hulse et al., 2001). Here, we provide clutch characteristics of this species hand-collected from a single site at LEAD on the night of 17 March 2011 and the early morning hours of 18 March 2011. Individuals were fixed in formalin and later preserved in 70% ETOH. All specimens were deposited in the Section of Zoology and Botany of the State Museum of Pennsylvania, Harrisburg. Sexually mature males were recognized by the presence of a vocal sac and their calling. Females were considered gravid by the presence of polarized ova. Body size was measured to 0.1 mm snout-vent length (SVL) with the use of calipers. Clutch size was estimated by a count of all eggs found in each female. The diameter of 10 ova from each clutch was measured to the nearest 0.1 mm with the use of an ocular micrometer. Means are followed by ± 1 standard deviations. We used t-tests and correlation coefficients to determine statistical differences. Statistical significance was recognized at $p < 0.05$.

The mean body size of males (mean = 24.5 ± 1.2 mm SVL; range= 22.3-26.7; n = 15) was significantly different ($t = -7.380$; $df = 24$; $p < 0.001$) from those of females (mean = 28.2 ± 1.3 mm SVL; range= 26.5-30.4; n = 11); however, the variances did not differ significantly . For Pennsylvania generally, males (mean = 25.2 mm SVL) were also significantly smaller than females (mean = 31.8 mm SVL) (Hulse et al., 2001). In populations from Connecticut, males (24.6 mm SVL) were smaller than females (28.0 mm SVL) (Klemens, 1993).

At our site, the mean estimated clutch size (560.3 ± 226.8; range = 170-820; n = 11) did not co-vary significantly ($r2 = 0.06$; $p = 0.47$) with female body size. Mean ovum diameter was small (mean = 0.91 ± 0.08 mm SVL; range= 0.8-1.2; n = 110) and did not co-vary significantly with clutch size ($r2 = 0.03$; $p = 0.61$) or female body size ($r2 = 0.07$; $p = 0.43$). A calculation of the raw data provided by Oplinger (1967) from Ithaca, New York, revealed an estimated clutch size for 69 females (mean = 28.2 ± 2.1 mm SVL; range= 23-33) that averaged 580.5 eggs (± 185.3; range = 250-1000) and that significantly co-varied ($r = 0.45$; $p < 0.001$) with female body size, where clutch size = 58.409X-1068.5. In populations farther south, the estimated clutch sizes of 22 females (< 35 mm SVL) from Arkansas averaged 846.64 eggs (range = 505-1201), and the relationship between clutch size and female body size was not significant (Trauth et al., 1990). In northwestern Louisiana, estimated clutch size for nine females (mean = 32.8 ± 1.80 mm SVL; range = 30.2-35.0) averaged 551.94 eggs (± 380.28; range= 195-1380) and did not significantly co-vary with female body size (Meshaka and Marshall, 2011). The aforementioned data suggest that clutch sizes of this species generally averaged less than 600 eggs. The presence of a significant causal relationship between clutch size and female body size either varied among sites or perhaps could not be detected by us without a larger sample as in that by Oplinger (1966).

The breeding season of the Spring Peeper was found to begin later and end sooner in northern populations than in the South (Butterfield et al., 2005). Initiation of 2011 breeding at LEAD provided corroboration of a latitudinal gradient in commencement of breeding in this species (Butterfield et al., 2005), and females in our sample would have been among the first females to have moved to breeding areas at our site in 2011. Although calling was heard as late as May at LEAD, both the duration of egglaying and the likelihood of clutch size differences in later breeding females remain unknown. The ubiquity of the Spring Peeper and the dearth of reproductive information on this species provide both opportunity to answer a wide range of questions in its reproductive ecology and a need to answer the most basic of these questions both in Pennsylvania and elsewhere. In light of current global climatic changes, this species might offer a feasible biological model where to assess the impact of these critical abiotic factors on basic life history traits of generalist and common species.

We extend our gratitude to the staff of Letterkenny Army Depot, led by COL Cheri A. Provancha. We want to give special thanks also to Resources Manager, Craig Kindlin, for his continuous support in this and other research projects we have undertaken on the base. We also thank James M. Vaughan, Executive Director of the Pennsylvania Historical and Museum Commission, for his support of research endeavors conducted in the Section of Zoology and Botany of the State Museum of Pennsylvania.

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ARTICLES

Reproductive Characteristics and Sexual Maturation of the Eastern Collared Lizard, *Crotaphytus collaris* (Say, 1823), at the Northern Edge of its Geographic Range

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Abstract- *Reproduction and growth to sexual maturity were examined in the Eastern Collared Lizard (*Crotaphytus collaris*) from two regions in Kansas, near the northern edge of its geographic range. Findings were similar between both sites. Individuals were active during early April-mid September. Monthly distributions of testis dimensions were indicative of spring mating. Females were detected with oviductal eggs as early as May, and clutch sizes averaged 6-7 eggs per clutch. However, no significant relationship existed between clutch size and female body size nor was multiple clutch production detected in either sample. Sexual maturity was reached at an age of 9-10 months in some individuals and 20-21 months in others. Minimum body size at sexual maturity was smaller in males (59-60 mm SVL) than females (65-67 mm SVL), but adult body size averaged 86 mm SVL for both sexes. Successful colonization of northern latitudes by the Eastern Collared Lizard brought with it responses in duration of seasonal activity, adult body size dimorphism, annual reproductive output, and age at sexual maturity, the latter two of which place these edge populations at greater risk by density-independent catastrophes.*

INTRODUCTION

The Eastern Collared Lizard, *Crotaphytus collaris* (Say, 1823), is a North American species whose geographic range extends from northern Kansas to southern Texas (Conant and Collins, 1998). In Kansas, the species is widely distributed in the eastern two-thirds of the state but is conspicuously absent from much of the southeast, northeast, and central (Collins et al., 2010)(Figure 1). Previous studies on Kansas populations have found that some individuals were capable of reproduction in the spring of their first year, having hatched 9-10 months the previous summer (Fitch, 1956). Mean clutch size ranged from 5.8 eggs in an introduced population in the northeastern part of the state (Fitch, 1956) to 9.5 eggs in western Kansas (Werth, 1972). In northern Kansas, multiple clutch production was rare (Fitch, 1956) if present (Ferguson, 1976). Across its range, the reproductive cycle was found to be uniform, with no evidence of geographic variation in clutch size (Ballinger and Hipp, 1985). However, three life history traits related to reproduction were found to vary latitudinally. The breeding season was shortest in the northern edge of its geographic range and its length could be further shortened by degradation of habitat (Sexton et al., 1992). In turn, multiple clutch production, found to be typical throughout much of the Eastern Collared Lizard's geographic range, was a rare phenomenon near its northern range limit (Ballinger and Hipp, 1985). Lastly, the frequency of hatchlings that reached sexual maturity and bred for the first time the following summer was higher in the South (Ballinger and Hipp, 1985) than in the North (Sexton et al., 1992). We undertook a study of the Eastern Collared Lizard from two regions of Kansas to clarify aspects of the reproductive biology of this species near the edge of its geographic range and to test findings of geography as an explanation of the variation of several of its reproduction-related life history traits.

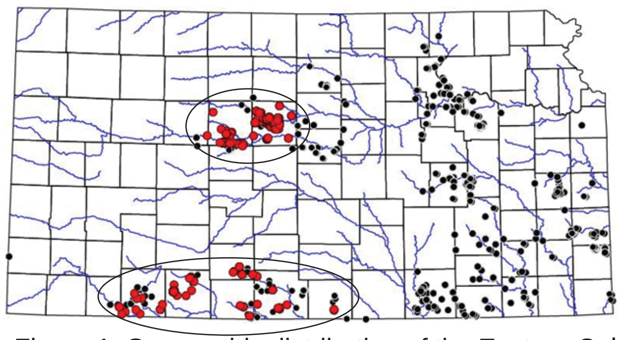

Figure 1. Geographic distribution of the Eastern Collared Lizard (*Crotaphytus collaris*) in Kansas. Circled areas denote regions from which the 258 specimens were examined. (Adopted from Collins et al., 2010)

MATERIALS AND METHODS

We examined 258 specimens from northern (n = 199) and southern (n = 59) Kansas (Figure 1) from the holdings of the Sternberg Museum of Natural History (FHSM), Fort Hays State University, Hays, Kansas. Body size was measured as snout-vent length (SVL) to the nearest 0.1 mm using calipers. Sexual maturity in males was determined by the presence of enlarged testes. The monthly distribution of testis length and width as a percentage of male SVL was used to determine seasonal differences in fertility. In females, yolking ovarian follicles > 3 mm signified the commencement of vitellogenesis. The monthly distribution of largest ovarian follicles and oviductal eggs was used to measure the ovarian cycle. Secondary follicles were recorded to determine if second clutches were being produced by females that would have shown follicular enlargement concurrent with oviductal eggs (Trauth, 1989). Clutch sizes were separately estimated by counts of enlarged ovarian follicles and oviductal eggs. All statistical analyses were conducted using Microsoft Excel 2007. T-tests were 2-tailed, with statistical significance at $p < 0.05$ for all tests.

RESULTS

Seasonal Activity- The range of individual capture dates in northern Kansas (5 April-20 September) was slightly longer than that of southern Kansas (3 April-12 September). Early April-mid-September captures likewise occurred in males of northern (5 April-18 September) and southern (3 April-12 September) Kansas. Capture dates ended sooner among females than males from both northern (9 April-14 June) and southern (6 April-22 July) Kansas. Among juveniles, earliest capture dates were similar between sites, but the range of capture dates in northern Kansas (8 April-20 September) was more similar to that of males than the 15 April-20 May range of capture dates of southern Kansas juveniles, from which few individuals were available.

Monthly changes in testis size- Testis dimensions were large during April and May in both northern (Figure 2a) and southern (Figure 2b) Kansas. Testicular regression was evident in a June sample from southern Kansas (Figure 2b), indicating spring mating, with the smallest values having been recorded in the last month of collection in September (Figure 2a,b).

Ovarian cycle- The commencement of rapid follicle enlargement (>3.0 mm) was evident during April in both northern (9 April) and southern (6 April)

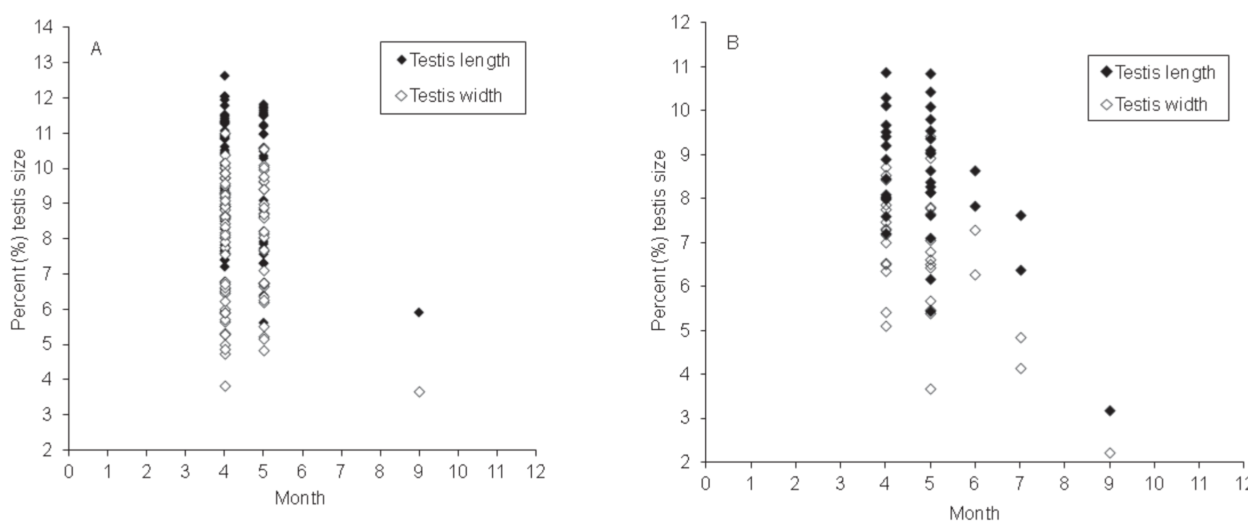

Figure 2. Monthly distribution of testis length and width as a percentage of male body size of the Eastern Collared Lizard (*Crotaphytus collaris*) from northern (A) (n = 87) and southern (B) (n = 36) Kansas.

Kansas samples (Figure 3a,b). No oviductal eggs were present at either site until May, nor did it seem likely based upon the distribution of follicle sizes in April (Figure 3a,b). Too few specimens were available after May to determine the length of the egg-laying season for either region in Kansas.

Clutch characteristics- In northern Kansas, estimated clutch size based on follicle count ranged 3-8 eggs (mean = 5.94 ± 1.21 eggs) for 18 females and measured 6 and 8 oviductal eggs in two females. In southern Kansas, estimated clutch size based on follicle count ranged 5-9 eggs (mean = 7.33 ± 1.37 eggs) for six females and measured 7,7, and 8 oviductal eggs in three females. No statistical significance (p = 0.30) was detected in a positive relationship between clutch size and female body size (r2 = 0.07) from the northern Kansas sample.

Clutch frequency- Secondary follicles did not exceed 3.3 mm in northern Kansas or 2.9 mm in southern Kansas. No females in either sample contained enlarged follicles and oviductal eggs concurrently, nor were luteal scars concurrent with a new set of enlarged follicles. These findings did not provide support for multiple clutch production in either Kansas sample.

Growth and sexual maturity- Males reached sexual maturity at similar body sizes in northern (59.1 mm SVL) and southern (59.6 mm SVL) Kansas. Maximum body sizes of males from both sites were likewise similar (104.4 and 102.1 mm SVL, respectively). However, the mean body size of males from northern Kansas (mean = 88.5 ± 11.7 mm SVL; n = 86) differed significantly (t = 3.704; df = 120; p = 0.000) from those of southern Kansas (79.8 ± 12.3 mm SVL; n = 36).

Females reached sexual maturity at similar body sizes in northern (65.0 mm SVL) and southern (66.6 mm SVL) Kansas. Maximum body sizes of females from both sites were likewise similar (99.24 and 92.4 mm SVL, respectively). However, the mean body size females from northern Kansas (86.2 ± 6.1 mm SVL; n = 72) was not significantly different (p = 0.46) from that of southern Kansas (84.9 ± 6.6 mm SVL; n = 15).

In the North, body size differed between the sexes with respect to variance (F = 3.716; p = 0.000) but not mean (p = 0.11). In the South, body size did not differ between the sexes in either variance (p = 0.08) or mean (p = 0.14). Combined samples for adults of each sex underscored the similarity of mean body size of males (mean = 86.0 ± 12.5 mm SVL) and females (mean = 86.0 ± 6.2 mm SVL).

Hatchlings and young-of-the-year were collected in September in northern Kansas (Figure 4a). The smallest juveniles in northern (47.1 mm SVL) and southern (50.3 mm SVL) Kansas were collected in April. The largest juveniles in northern (66.2 mm SVL) and southern (61.7 mm SVL) were collected in April and May, respectively. The range of fall hatchling body size and those of individuals captured the following spring and early summer revealed a wide range of lizards both sexually mature and those incapable of breeding their first spring of life (Figure 4).

DISCUSSION

The Eastern Collared Lizard is a geographically widespread species in the United States whose variation in life history traits pertaining to reproduction was examined in the northern and southern regions of Kansas, near the northern edge of

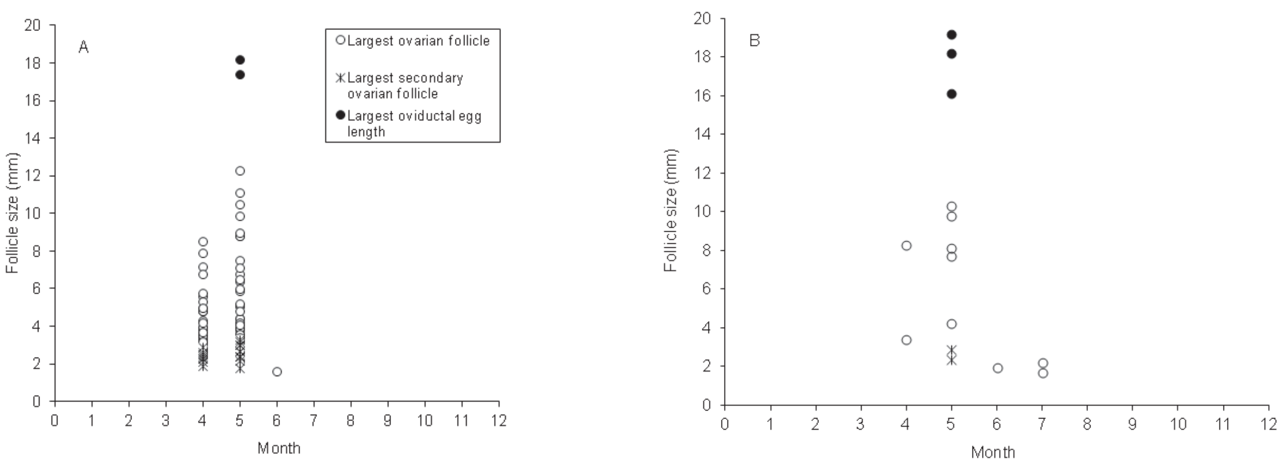

Figure 3. Monthly follicle size distribution of the Eastern Collared Lizard (*Crotaphytus collaris*) from northern (A) (n = 20) and southern (B) (n = 9) Kansas.

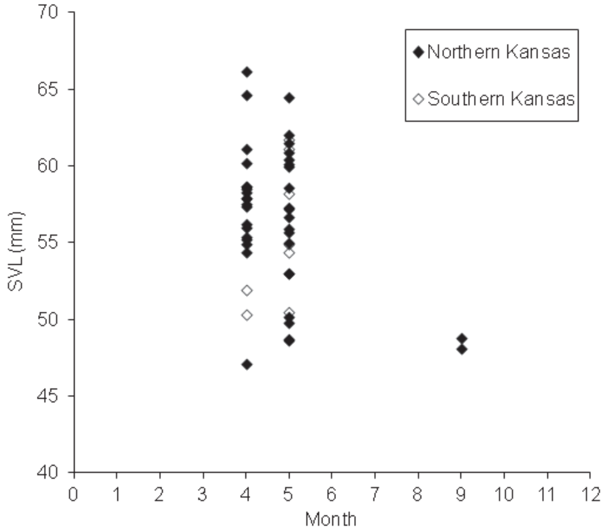

Figure 4. Monthly body size distribution of juvenile Eastern Collared Lizards (*Crotaphytus collaris*) from northern (A) (n = 41) and southern (B) (n = 8) Kansas.

its geographic range. Among the traits subject to geographic variation was the length of the breeding season, which was determined to be shorter in the North and subject to local conditions associated with habitat quality (Sexton et al., 1992). Likewise, multiple clutch production, which typified southern populations, was found to be rare in the North (Ballinger and Hipp, 1985). The frequency of later-maturing hatchlings was found to be greater in extreme northern populations (Sexton et al., 1992) than in southern counterparts (Ballinger and Hipp, 19850. On the other hand, neither the reproductive cycle nor mean clutch size appeared to have varied with respect to geography (Ballinger and Hipp, 1985).

Our findings corroborated earlier conclusions regarding geographic variability in certain life history traits and also served to provide comparisons with other aspects of the Eastern Collared Lizard's biology within the context of geographic versus local variation. Seasonal activity of the Eastern Collared Lizard in our study as determined by captures ranged from early April through the third week of September, with females becoming scarce in late July, males in early September, and juveniles in late September. Seasonal activity patterns from our study areas were similar to those of other northern populations, even if the duration was shorter among juveniles. In turn, northern populations emerged later in the spring than did southern counterparts. For example, in northeastern Kansas (Fitch, 1956), adults and juveniles emerged from hibernation in late April and early May. In Fitch's (1956) study, older adults were rarely seen after early August and were gone for the season by late August or early September, whereas juveniles remained active into late September and October. Elsewhere, seasonal activity ranged from 28 March (mean date = 10 April) for all animals to 30 September (mean date = 20 September) for adults and 5 October (mean date = 29 September) for juveniles in east-central Missouri (Sexton et al., 1992). However, farther south in west-central Texas, individuals were active in late March when the study began through the termination of the study in late August (Ballinger and Hipp, 1985).

Initiation of vitellogenesis from both regions in our study occurred in early April, which was a finding shared in all but the extreme southern edge of its geographic range; in previous studies, vitellogenesis was observed in May when the first samples were taken in north-central Kansas (Ferguson, 1976), late April in northern Kansas (Malaret, 1985), early April in northwestern Arkansas (Trauth, 1978) and west-central Texas (Ballinger and Hipp, 1985), and in late March in Mexico (Malaret, 1985).

Oviductal eggs were detected in May at our sites and corroborated earlier findings of a restriction in the gravid season in northern populations, such as during 1 June-4 July in north-central Kansas (Ferguson, 1976), June-July in northeastern Kansas (Fitch, 1956), and the presence of shelled eggs from the last third of May to the end of June in east-central Missouri (Sexton et al., 1992) as compared to the presence of oviductal eggs from early to mid-April to mid-to-late-July in west-central Texas (Ballinger and Hipp, 1985), and extending through late July in Mexico (Malaret, 1985).

No evidence of multiple clutch production was detected in our Kansas samples. Likewise, production of only one clutch per year was found in a study conducted in north-central Kansas (Ferguson, 1976). Multiple clutch production was more readily detected to the east and south of our study region, and numbers of clutches produced per year increased in these areas. For example, two clutches were produced each year, albeit rarely, in northeastern Kansas (Fitch, 1956), some females produced two clutches each year in east-central Missouri (Sexton et al., 1992), two clutches each year typified populations in northwestern Arkansas (Trauth, 1978), three clutches were produced annually in west-central Texas (Ballinger and Hipp, 1985), and at least two clutches were produced annually in Mexico (Malaret in Ballinger and Hipp, 1985).

At our sites, early sexual maturity at 9-10 months of age was more likely to be reached among males than females. This discrepancy was explained by the smaller minimum body size in males. For both sexes, later hatching dates increased the time necessary for hatchlings to reach sexual maturity and easily delayed first reproduction until the their second spring of life at age 20-21 months. This trait was variable geographically. In northeastern Kansas (Fitch, 1956) some individuals were sexually mature in time to breed the following spring, while others did not mature in their first year. In northwestern Arkansas (Trauth, 1978), individuals could mature within their first year of life and breed for the first time the following spring. In east-central Missouri (see Figure 2 in Sexton et al., 1992), early clutches could produce reproductive females for the next spring, whereas individuals hatched later in the season could have to wait until the second spring of life to breed for the first time. In contrast, in west-central Texas (Ballinger and Hipp, 1985) most individuals bred for the first time during their first year of life with only some individuals having to wait until they were nearly two years of age to breed for the first time. Thus, it appeared that Eastern Collared lizards were more likely to breed for the first time at 10 months of age in the South than in the North.

Geography did not appear to explain variation in four traits that we examined in our study. Our data corroborated findings by Ballinger and Hipp (1985) that mating season and the monthly distribution of testes sizes did not vary geographically. In our study regions, testes were enlarged in April and May, and showed signs of regression in June, thereby indicating spring and early summer breeding. Similar to our findings, mating in northeastern Kansas was noted during late May-early June (Fitch, 1956). In northwestern Arkansas, mating occurred during spring-late June concomitant with testes entering regression (Trauth, 1979). In the South, west-central Texas populations mated during April-May and regression of the testes began in June (Ballinger and Hipp, 1985).

Our data supported conclusions by Ballinger and Hipp (1985) that clutch size did not vary geographically. Mean estimated clutch size based on counts of enlarged ovarian follicles in our study ranged 5.9 eggs in northern Kansas to 7.3 eggs in southern Kansas. Combined estimated clutch size based on oviductal eggs from both of our sites ranged 6-8 eggs. Our data and values from the literature revealed no notable geographic pattern to clutch size: 5.8 eggs in northeastern Kansas (Fitch, 1956), 9.5 eggs from a sample fo five females in western Kansas (Werth, 1972), 6 eggs in northwestern Kansas (Trauth, 1978), 5.3 eggs in New Mexico (parker, 1973), 7-8 eggs in west-central Texas (Ballinger and Hipp, 1985), and 6.1 eggs in Mexico (Malaret, 1985).

An examination of minimum body size at sexual maturity revealed uniformity in this trait across the geographic range of the species, with males generally maturing at smaller body sizes than females: 59-60 mm SVL in males and 65-67 mm SVL in females from Kansas (this study), 71 mm SVL in east-central Missouri females (Sexton et al., 1992), 76 mm SVL in males (Trauth, 1979) and 71 mm SVL in females (Trauth, 1978) from northwestern Arkansas, 64-70 mm SVL in west-central Texas females (Ballinger and Hipp, 1985). Mean adult body size of the Eastern Collared Lizard was not uniform for either sex across the geographic range of the species, nor were the differences associated with latitude. However, unlike our sample, which was comprised of males and females whose mean body sizes were similar to each other (mean = 86 mm SVL), sexual dimorphism in body size favoring larger males typified other locations. For example, mean values of adult males from three sites ranged 93.7-108 mm SVL as compared to those of females 87.0-92.4mm SVL in Oklahoma (McCoy et al., 1994). In New Mexico (Best and Pfaffenberger, 1987), mean body size of males (93.8 mm SVL) was larger than that of females (86.4 mm SVL). In northern Mexico (Lemos-Espinal et al., 2009), mean body size of males (101.8 mm SVL) was larger than that of females (94.6 mm SVL). The reasons for similarity in mean body size between the sexes in our study are unknown; however differential growth rates or survivorship are possible causes that would be testable in a field study.

Two traits, the relationship between clutch size and female body size and hatching time remained unresolved with respect to their relationship to latitude or local selection. Very few data exist on the relationship between clutch size and female body size in this species. As estimated by number of enlarged follicles, clutch size in our study was positively, but not significantly, related to female body size. This relationship was positive and significant in two other studies (Trauth, 1978; Ballinger and Hipp, 1985). September captures of near-hatchlings in our study were within the range of hatching times in the northern part of the Eastern Collared Lizard's range, such as during August-September in northeastern Kansas (Fitch, 1956), late July-early October in northwestern Arkansas (Trauth et al., 2004), and mid-July-end of September with a mean hatching date of 19 August in east-central Missouri (Sexton et al., 1992). One would expect longer hatching seasons in the southern part of its range where the egg-laying season is also longer, but as in the case of clutch size-body size relationships in this species, an insufficient number of studies precludes determination of geographic patterns in this trait.

Successful colonization of the northernmost latitudes by the Eastern Collared Lizard was associated with a loss of body size dimorphism and also at a cost of annual reproductive output and age at first reproduction. A decrease in the likelihood of multiple clutch production and increase in later-maturing individuals in the North have placed northern edge populations of this species at greater risk of extinction following density-independent catastrophes, such as drought, habitat succession, or extended frosts, the latter of which is less likely to impact populations in the center of its range.

ACKNOWLEDGMENTS

We dedicate this work to the memory of Joseph T. Collins, whose passing is a personal loss to us and a professional loss to North American herpetology and Kansas herpetology in particular. We thank Travis W. Taggart for helping with the creation of Figure 1.

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A Riverfront Population of the Eastern Garter Snake (*Thamnophis sirtalis sirtalis*): Conservation Implications of Successful Colonization of a Linear Urban System

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Abstract- *A riverfront population of the Eastern Garter Snake,* Thamnophis sirtalis sirtalis*, was studied during March-October 2010, along the Susquehanna River in Harrisburg, Dauphin County, Pennsylvania, to ascertain the body size structure and clutch characteristics of a population situated in a heavily urbanized setting. Mean body size of adult males (35.3 mm SVL) was significantly smaller than that of adult females (47.2 mm SVL). The early season need for basking and the near absence of verdure best explained the high proportion of (91%) captures of the 79 Eastern Garter Snakes on and between the exposed rocks along the berm during April-May. Estimated clutch size averaged 20 young and increased with the body size of the female. Young were produced annually and by August. Body size dimorphism in this population was typical of the species generally; however, the mean body size of adult females at this site was more similar to other Pennsylvania sites that also had high Easter Garter Snake densities and whose dietary mainstay was earthworms. The combination of early maturity, high fecundity, broad diet, and crypsis provided this species with a colonizing advantage as the nearly exclusive snake species to thrive in a heavily human-impacted site such as that of the riverfront along a city.*

INTRODUCTION

Urban areas constitute approximately 4% of the earth's surface and support 50% of the human population (Mock 2000). Urban areas also support populations of amphibians and reptiles but the characteristics and trends in these populations are highly heterogeneous and poorly understood (Delis and Mushinsky, 2005; Mitchell and Jung Brown 2008). Residential and urban sites are most of the habitats that are being colonized by snakes and many other animals, because of human development destroying natural environments. A great importance is placed on sites like these because of their ability to provide shelter, food, and breeding conditions that are outside the realm of natural areas. Generalist species seem to dominate these disturbed habitats. The Eastern Garter Snake (*Thamnophis s. sirtalis*) is a geographically widespread species in Pennsylvania (Hulse et al., 2001; Meshaka and Collins, 2009) but scarcely studied with respect to its ecology in the state (Hulse et al., 2001; Meshaka, 2009, 2010; Meshaka and Delis, 2010; Gray, 2011). The paucity of studies in areas of urban development causes problems of not understanding how these snakes are cohabitating with humans and surviving in communities. Harrisburg is a medium-sized city, located in the south-central region of the state, and bordered along the western edge by the Susquehanna River. Areas with urban development interacting with streams and rivers can be related to where snakes occur. Anecdotal observations were of high numbers of Eastern Garter Snakes on the berm of the levee. Studying these interactions of an urban and river system interface will give insights of their community structure and reproduction abilities. The objectives of our study were to determine the response in body size distribution and reproductive characteristics of an Eastern Garter Snake population along linear disturbed habitat that bordered a city and a river.

MATERIALS AND METHODS

Eastern Garter Snakes were captured by hand along the berm of the riverfront in Harrisburg, Dauphin County, Pennsylvania (Figure 1a,b), as they basked (Figure 1c) or were moving during the daytime. Occasional individuals were collected and euthanized for study. All specimens were fixed in formalin and preserved in 70% ETOH and deposited in the Section of Zoology and Botany of the State Museum of Pennsylvania, Harrisburg. Body lengths of preserved specimens were measured in mm snout-vent length (SVL). Sex of each individual was determined by examination of gonads of all dissected specimens. Sexual maturity in males was determined by the presence of enlarged testes. Testis length and width were measured with hand calipers to 0.1 mm. The monthly distribution of testis length and width in cm as a percentage of male SVL in cm was used to determine seasonal differences in fertility. In females, yolking follicles > 4 mm signified the commencement of vitellogenesis. The monthly distribution of largest follicles and oviductal eggs was used to measure the ovarian cycle. Clutch sizes were separately estimated by counts of enlarged ovarian follicles and oviductal eggs. All statistical analyses were conducted on Microsoft Excel2007. T-tests were 2-tailed, with statistical significance at $p < 0.05$ for all tests means are followed by ± 1 standard deviation.

RESULTS

Seasonal incidence of captures- Thirty-six males, 37 females, and five juveniles were captured during March-September 2010 (Figure 2 & 3). Earliest captures occurred on 23 March (female) and 24 March (male), and the latest capture was a male on 29 September. Most captures of adults occurred during April-May, which were also the only months in which juveniles were captured (Figure 2 & 3). Three individuals of unknown sex escaped capture. Two adult female Northern Brown Snakes (*Storeria dekayi dekayi*) were seen and captured, and one adult

Figure 1. A section of the berm from which Common Garter Snakes were captured along a riverfront in Harrisburg, Dauphin County, Pennsylvania during March-October 2010 (A). Arrow points to a basking female (B). A close-up of the basking female (C).

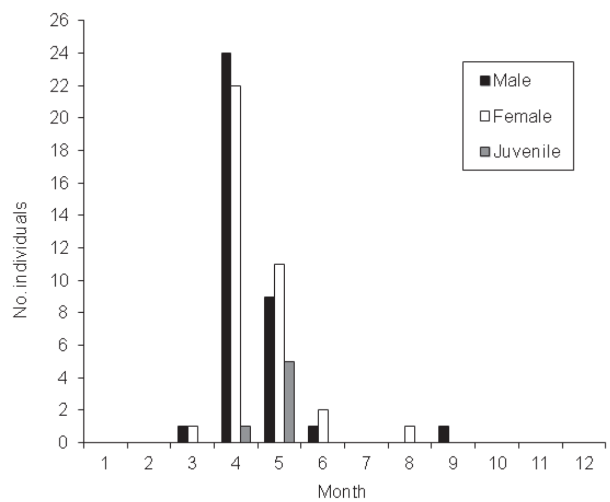

Figure 2. Monthly incidence of captures of 36 male, 37 female, and 5 juvenile Common Garter Snakes (*Thamnophis sirtalis*) captured along a riverfront in Harrisburg, Dauphin County, Pennsylvania during March-October 2010.

female Northern Water Snake (*Nerodia sipedon sipedon*) escaped capture.

Male and female reproduction- A visual inspection of Figure 4 was suggestive of an increase in testis dimensions in spring. During April and May, males were seen resting near and following females. The monthly distribution of follicle size (Figure 5) indicated that vitellogenesis was underway when the first female was captured in March. The August datum in Figure 5 indicated parturition having taken place in that female. All other females examined contained yolking follicles, which, in turn, was indicative of annual reproduction by that population that year. Mean estimated litter size was similar between counts of ovarian (mean = 19.5 ± 12.0; range = 5-34: n = 4) and oviductal (mean = 19.2 ± 11.2; range = 7-57: n = 26) follicles. Using the latter dataset, clutch size significantly increased with an increase in female body size (Figure 6).

Growth and maturity- Adult body size dimorphism was pronounced in this population with respect to body size minima, maxima, and mean (t= -7.119; df = 71; p = 0.000), but not variance (p = 0.08) of males (mean = 35.3 ± 6.3 cm SVL; range = 23.5-45.4; n = 36) and females (mean 47.2 ± 7.9 cm SVL; range = 30.6-67.6; n = 37). Body size of six juveniles ranged 21.4-28.7 cm SVL, and no small juveniles were found early in the season (Figure 3). Recently-matured males were detected in late summer, a few months after their birth, and all males were mature in spring (Figure 3). Most females were mature by April and all were mature by May, having matured by approximately 10 months of age.

DISCUSSION

The need to bask and search for mates early in the season by this species and the absence of summer verdure for camouflage best explained the higher numbers of individuals detected above cover during April-May despite seven months of observations in the eight month study. By summer, the need to bask had lessened. In northeastern Pennsylvania, most Common Garter Snakes (*Thamnophis sirtalis*) were found in the open through April, after which time the pattern was reversed (Gray, 2011). As in sites in western Pennsylvania, gravid females typically remained under warm cover (Meshaka, 2010) with other gravid females (Meshaka, pers. obs.). Seasonal activity patterns of Pennsylvania populations were found generally to be unimodal (Hulse et al., 2001; Meshaka, 2001, 2010; Gray, 2011) but not always (Meshaka, 2009).

The sex ratio of all adults at our study was even, whereas the sex ratio throughout the active season was strongly biased to females at a residential site (0.22:1.00) and at an urban park (0.23:1.00) (Meshaka, 2009), both near our study site. Comparatively, in western Pennsylvania, the combined male: female sex ratio

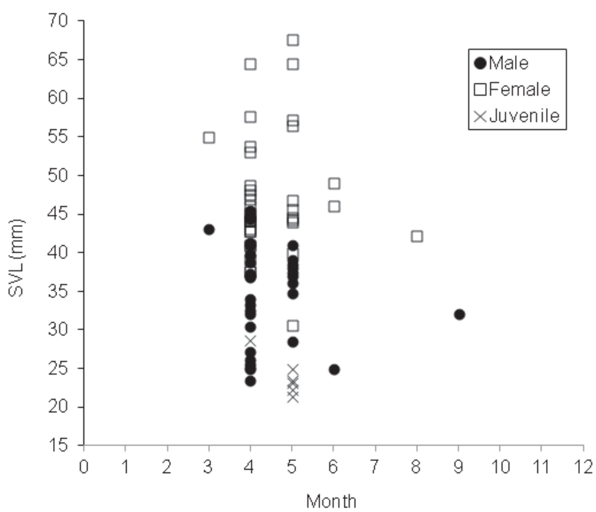

Figure 3. Monthly distributions of body size of 36 male, 37 female, and 5 juvenile Common Garter Snakes (*Thamnophis sirtalis*) captured along a riverfront in Harrisburg, Dauphin County, Pennsylvania during March-October 2010.

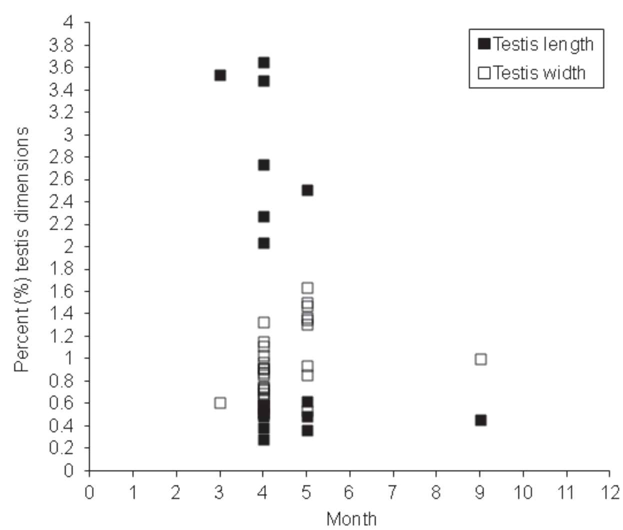

Figure 4. Monthly distribution of testis dimensions of 33 male Common Garter Snakes (*Thamnophis sirtalis*) captured along a riverfront in Harrisburg, Dauphin County, Pennsylvania during March-October 2010.

during the multi-year May-September study was 0.27:1.00; however, May and September sex ratios were closer to even (Meshaka, 2010). Thus, the true sex ratio at our site remains unknown if biases in sampling dates and techniques exist. Likewise, the excess of females in western Pennsylvania could be an artifact of sampling technique that differentially favored sedentary and gestating females over more actively foraging males (Meshaka, 2010).

As elsewhere in western and south-central Pennsylvania (Meshaka and Delis, 2010) and Pennsylvania generally (Hulse et al., 2001), female body size was a strong predictor of litter size in our sample. We suggest that the greater litter size estimates in our study (19.2) than in western (13.0) and south-central (16.4) Pennsylvania (Meshaka and Delis, 2010) was best explained by the possible loss of re-absorption of embryos later in the season and by differing accuracy of dissection compared to palpation of marked individuals. To that end, a mean litter size of 22.4 young, estimated from dissections of gravid females from Pennsylvania (Hulse et al., 2001), was more similar to our estimations than those of the latter sites.

No spent females were detected in our study, although a 42.2 cm SVL female captured on 2 August contained ova < 1.2 mm, indicating having given birth. A dearth of adult females or juveniles after May preclude determination of the birthing season beyond the low likelihood of it having commenced earlier than June. Parturition occurred as early as June in western Pennsylvania (Meshaka, 2010) and was detected beginning in July and August in nearby urban settings (Meshaka, 2009).

The earlier age and size at sexual maturity in males at our study site typified those of western Pennsylvania (Meshaka, 2010), where a small body size at sexual maturity (26.0 cm SVL) could be reached quickly. On the other hand, females were larger at sexual maturity at our site and in western Pennsylvania (38.1 cm SVL) (Meshaka, 2010). More time was needed for females to reach their minimum body sizes at both sites than males. Between sites, females in western Pennsylvania required 13-14 months to mature, slightly longer than at our site, perhaps because of the shorter active season and their larger minimum body size than at our site.

The mean adult male body size of our study was smaller than that of a western Pennsylvania population (39.6 cm SVL) (Meshaka, 2010) and of two nearby urban south-central populations (40 cm SVL) (Meshaka, 2009). The mean adult female body size of our study was similar to that of a western Pennsylvania population (47.3 cm SVL) (Meshaka, 2010). Mean adult female body size was larger in a nearby residential (50.8 cm SVL) and urban park (49.8 cm SVL) (Meshaka, 2009). The intersite variation in body size dimor-

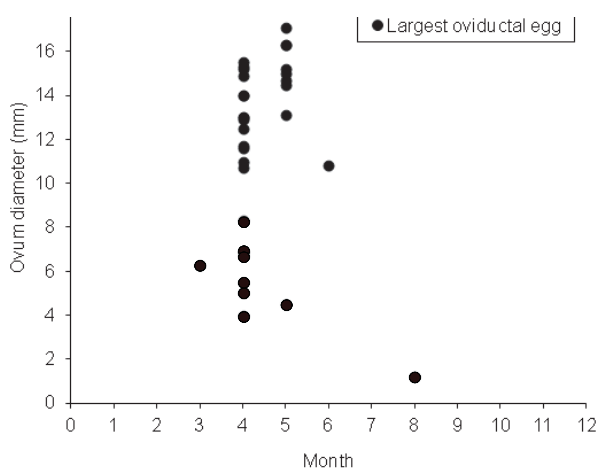

Figure 5. Monthly distribution of largest ovum diameter of 36 female Common Garter Snakes (*Thamnophis sirtalis*) captured along a riverfront in Harrisburg, Dauphin County, Pennsylvania during March-October 2010.

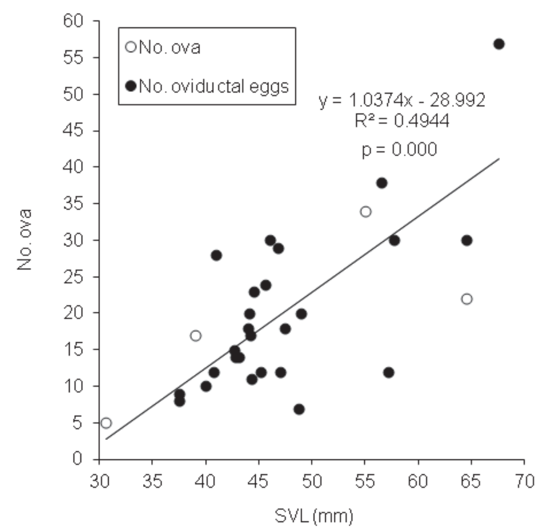

Figure 6. Relationship of clutch size and female body size of 30 female Common Garter Snakes (*Thamnophis sirtalis*) captured along a riverfront in Harrisburg, Dauphin County, Pennsylvania during March-October 2010.

phism among adults (male SVL/female SVL) was largest in western Pennsylvania (0.87) (Meshaka, 2010), intermediate at a south-central Pennsylvania suburban residence (0.81) and urban park (0.83) (Meshaka, 2009), and lowest at our site (0.75). In all cases, selection favored larger female body size as is typical for the species (Ernst and Barbour, 1989).

The persistence of this species along this urbanized waterfront provided a glimpse on the colonizing ability of a small-bodied, cryptic, fast-maturing, and fecund species whose few needs have been easily met along what was essentially a linear oldfield. In Pennsylvania, the Eastern Garter Snake, although found in a wide range of habitats (Hulse et al., 2001) and can be very abundant in open areas (Meshaka et al., 2009). The linear habitat of our study could also be mimicked in the construction of roads through forests and serve to connect otherwise separated populations of this species as well as to place forest salamanders along the new edge at risk or greater risk of predation by a species that had previously been absent or less abundant.

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Status and Distribution of the Eastern Spadefoot, *Scaphiopus holbrookii* (Harlan, 1835), in Pennsylvania: Statewide Conservation Implications for an Imperiled Species

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Abstract: *The Eastern Spadefoot,* Scaphiopus holbrookii, *is listed as a species of High-Level Concern by the Pennsylvania Fish and Boat Commission. Field research dating back to the 1970s and revisited in the last decade provided data in the form of museum vouchers specimens and high quality photographs necessary for us to examine the relationship between occurrence of the Eastern Spadefoot and geomorphology in Pennsylvania. Our results from 11 sites reveal a strong association between the presence of this species and limestone bedrock overlain by colluvial deposits. Our results provide a testable model for predicting sites suitable or once suitable for this geographically restricted and poorly studied anuran in Pennsylvania.*

INTRODUCTION

The Eastern Spadefoot, *Scaphiopus holbrookii* (Harlan, 1835), is a geographically widespread anuran in the eastern United States (Conant and Collins, 1998; Palis, 2005). In Pennsylvania, as elsewhere, the Eastern Spadefoot is restricted to sandy, well-drained soils and breeds opportunistically after heavy rain (Hulse et al., 2001; Meshaka and Collins, 2010). In Pennsylvania, the species is listed as being of High-Level Concern (Urban and

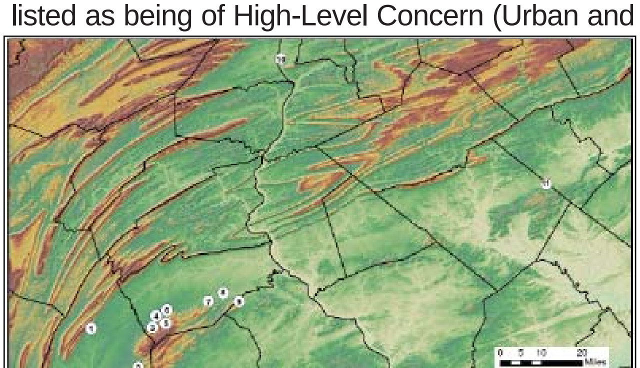

Figure 1. Locations of eleven sites in Pennsylvania from which the Eastern Spadefoot (*Scaphiopus holbrookii*) has been recorded. Numbers refer to sites that are listed in the Results section.

to use locality data from the Meshaka et al. (2011) study and additional data unrelated to reproduction to assess the geographic distribution and status of the species in the Commonwealth.

MATERIALS AND METHODS

Geological information was gathered using published sources (Becher and Root, 1981; Becher and Taylor, 1982; Ciolkosz and Hurman, 1994; Eckenrode, 1985; Hoskins, 1981; Long 1975, Smith 2002: Zarichansky, 1986). Sites included in this study were those from which proof of occurrence by the Eastern Spadefoot is available. Evidence to corroborate presence of the species is based on museum specimens or high quality photographs. Requests for records from the Pennsylvania Fish and Boat Commission were denied. Subsequent visits were made in 2011 and 2012 to evaluate the condition of the sites.

RESULTS

The 11 localities where the Eastern Spadefoot has been found were in Cumberland, Franklin, York, Northumberland and Berks Counties (Fig-

Figure 2. Adult female (Left), metamorphoseling (Middle) and juvenile (Right) Eastern Spadefoot, *Scaphiopus holbrookii*, from Letterkenny Army Depot, Franklin County, Pennsylvania, found in August 31st 2003 and August 5th 2009, and May 16th 2011 respectively. Site #1. Photographs by P.R. Delis.

ure 1). All but three sites, Letterkenny Army Depot (LEAD), East Lewisburg and Mertztown sites occur on the north and northwest toe slopes of South Mountain. Letterkenny occurs on the eastern toe slope of Blue or Broad Mountain. East Lewisburg occurs on a river terrace of the West Branch of the Susquehanna River, east of Lewisburg. The Mertztown site occurs on residual soils over limestone near toe slope deposits of sandstone or quartzite.

#1. Franklin County, southeast of Upper Strasburg. Metamorphoslings found in summer of 2011. More than one dozen Eastern Spadefoots have been found at this location sporadically during 2003 (Delis et al. 2010) -2011. All captures occurred during May-August, with most in August. Males, females, juveniles (See Figure 5 in Meshaka et al. [2011]), and a metamorphosling (Figure 2) (5 August 2009, SMP 3728) have been found and photographed at this site. Because of federal management policies this Department of Defense holding is likely to contain several long-term-protected breeding sites. To date, however, specific breeding sites have not yet been detected at LEAD. Nearest Road State is Route 533.

#2. Franklin County, near Mt. Cydonia Sand Plant. Metamorphosling found during spring 2003. Nearest Road is Sand Mine Road.

#3. Cumberland County, south of Shippensburg. During the 1960s and 1970s, numerous adults were seen at this location. Breeding was not reported at this site. As of 2011, this site does not appear to have been altered and remains a potentially viable site for the species. Nearest Road is Baltimore Road

#4. Cumberland County, southeast of Shippensburg. Metamorphoslings were found at this site in 1974 at which time the site was a small sand “borrow pit” with standing water along the road. As of 2011, it is a multi-acre sand mine and may no longer be a suitable breeding site. Nearest Road is Sand Bank Road.

#5. Cumberland County, southeast of Shippensburg. Metamorphoslings were found at this site in 1974 (Figure 3) at which time the bottom of the impoundment was open without tree cover. Much

Figure 3. Metamorphoslings of the Eastern Spadefoot, *Scaphiopus holbrookii*, from the CCC Dam near Walnut Bottom, Cumberland County, Pennsylvania, found during the third week of June, 1974. Photographs by E. Wingert.

Figure 4. An Eastern Spadefoot (*Scaphiopus holbrookii*) from an area near Mt. Holly Springs, Cumberland County, Pennsylvania in June 1986. Site #7. Photograph by R. Cassell.

Figure 5. An Eastern Spadefoot (*Scaphiopus holbrookii*) from an area west of Boiling Springs, Cumberland County, Pennsylvania, in May 2012. Site #8. Photographed by Benjamin Rosenfeld.

of the impoundment was marsh with sand islands. Today, the impoundment is pole timber and well-shaded with a stream beginning to entrench in the bottom, thus eliminating the marsh. Nearest Road is Gutshall Road. See Figure 2 in Meshaka et al. (2011).

#6. Cumberland County southeast of Shippensburg. Breeding occurred at this site in 1974. Nearby resident, John Opilo, then a biology teacher at Chambersburg High School, noted sporadic breeding in years after this episode. We documented breeding at this site in 1993. As of 2011, the site appears unaltered and acceptable for breeding. Nearest Road is Water Street. 14 May 1989. SMP 89 (adult). 23 May 2012. SMP 6123 (adult). Full breeding chorus on evening of 22 May 2012.

#7 Cumberland County, southwest of Mt. Holly Springs. Two locations were separated by only a couple hundred meters and are best treated as one site. A single adult observed in May 1986 (Figure 4) by a homeowner while spading his vegetable garden. Another adult specimen was found within a few hundred meters of the first individual by another homeowner while digging around his back porch in the spring of 1987. Nearest road is Sand Bank Road.

#8. Cumberland County, west of Boiling Springs. Single adult captured and photographed by Benjamin Rosenfeld (Figure 5) near a polyhouse of an organic farm. 11 May 2012. Nearest road is Boiling Springs to Mount Holly Road.

#9. York County, west of Dillsburg. Site of a long-term ecological study on amphibian breeding by Randy Cassell. Eastern Spadefoots bred at the site in 1989 (Figure 6). As of 2011, the site is intact and presumed acceptable for breeding. Nearest

Figure 6. Two of three amplexing pairs of the Eastern Sapdefoot, *Scaphiopus holbrookii*,found in Dillsburg, York County, Pennsylvania, on the evening of 5 May 1989. Photographs by R. Cassell.

Road is Sunset Court. See Figure 3 in Meshaka et al. (2011).

#10. Northumberland County, east of Lewisburg and east of the Susquehanna River. This site had breeding documented with photographs in 1994 (Figure 7). As of 2011, the site is intact and presumed acceptable for breeding. Nearest Road is State Route 45. See Figure 4 in Meshaka et al. (2011). 29 March 1993. SMP 141 (eggs), 142-145 (adults). 31 March 1993-28 April 1993. SMP 146 (tadpoles and metamorphoslings).

#11. Berks County, south of Mertztown Road and East of the village of Mertztown. This site has breeding documented (Urban et al., 2007). Calling was noted during July 2012 (Godfriaux, 2012)

Many of the numbered sites represent more than a single documentation of the species or breeding site locations. Sites have been documented by the Pennsylvania Fish and Boat Commission, Natural Diversity Section, in Adams, Berks, Bucks, Centre, Cumberland, Franklin, Lehigh, Northampton, Northumberland, Union and York counties in Pennsylvania. (PA F & B Comm., 2011).

DISCUSSION

Common to all of our Eastern Spadefoot sites in Pennsylvania is limestone bedrock (Becher and Root, 1981; Becher and Taylor, 1982; Hoskins, 1981; Wood and MacLachlan, 1978). All except the East Lewisburg and Mertztown sites are overlain by thick colluvium composed of sandstone rubble transported from nearby mountains. The limestone at the East Lewisburg site is overlain by old river terrace material, and the Mertztown site is overlain by thick residuum derived from weathering of limestone. Because all of these sites are over limestone, which is susceptible to slow or rapid collapse as the limestone dissolves, sinkholes or closed depressions form in the overlying soils, and make ideal sites for vernal ponds.

Soils most often associated with the Eastern Spadefoot localities, except at East Lewisburg and Mertztown, belong to the Buchanan, Laidig, and Murrill Series (Long, 1975; Smith, 2002; Zarichansky, 1986), though other soil series of similar origin occur nearby. All of these are gravelly to stony and are composed of sandstone derived from the adjacent mountains. These soils have been found to be common on toe slopes of mountains in Pennsylvania, and their acreage is substantial (Ciolkosz and Thurman, 1994): Buchanan Series (617,682 acres), Laidig Series (577,694 acres), Murrill Series (128,204 acres).

The soil at the East Lewisburg site is Holly silt loam, an alluvial soil on a river terrace (Eckenrode, 1985). Unlike all the other sites, this one is not associated with stony soils, though there are gravelly soils on uplands about 3 km to the SE. The Mertztown site is on soils of the Duffield Series (Web Soil Survey at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm), a soil derived from weathering of limestone. In this case, soils of the Murrill Series occur within about 0.5 km of the site. Because these two sites are the only ones on limestone without toe slope deposits, we have not tallied acreage on the numerous additional limestone valleys in Pennsylvania.

Our results in general conform to habitat features of this species in Pennsylvania and elsewhere (Hulse et al., 2001; Palis, 2005). More specifically, our data present a testable model for habitat association based on underlying rock type for this species in Pennsylvania, where the full extent of its past and present geographic distribution and its

Figure 7. Amplexing pairs and eggs of the Eastern Spadefoot, *Scaphiopus holbrookii*, during a breeding congress on 29 March 1993 at Lewisburg, Montour County, Pennsylvania. Photographs by E. Wingert.

basic biology are poorly known.

Our results also indicate greater occurrence than did the original interpretation when the species was added to the Endangered Species list for Pennsylvania in 2005. In light of our findings, we suggest that the status of this species should be re-evaluated for Pennsylvania.

ACKNOWLEDGMENTS

We wish to express our appreciation to Jim Ciarrocca for construction of the map. We thank the Letterkenny Army Depot Natural Resources Department, especially Mr. Craig Kindlin, as well as the Base Commander, Colonel Cheri A. Provancha for access and support at this facility

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