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GEOGRAPHIC VARIATION IN SELECTED LIFE HISTORY TRAITS OF THE EASTERN NARROWMOUTH TOAD, *GASTROPHRYNE CAROLINENSIS* (HOLBROOK, 1836), ALONG THE NORTHEASTERN EDGE OF ITS GEOGRAPHIC RANGE

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ABSTRACT: We examined the Eastern Narrowmouth Toad,*Gastrophryne carolinensis*, along the northeastern edge of its geographic range in Virginia to determine the extent to which selected life history traits in this region adhered to patterns associated with a latitudinal gradient in this species. As in studies elsewhere, a significant difference in mean adult body size between males (28.3 mm SVL) and females (30.1 mm SVL) was typical of this species as was the absence of a relationship between clutch size and female body size. Mean body sizes of both sexes appeared larger in northern populations than southern counterparts. Geographically predictable, the breeding season in Virginia was severely curtailed in response to climatic constraints despite extended fertility, and its breeding activity peaked in mid-summer as it has been reported to do throughout its geographic range. Thus, along the northern edge of its geographic range, the Eastern Narrowmouth Toad retains its ability breed for a longer season despite present climatic constraints, an advantage in the face of climate change that could alter timing and duration of acceptable breeding atmospheric conditions.

INTRODUCTION

The Eastern Narrowmouth Toad, *Gastrophryne carolinensis* (Holbrook, 1836), is a small-bodied microhylid anuran of eastern North America, whose geographic range extends southwesterly from eastern Maryland to southeastern Missouri and south to eastern coastal Louisiana and the Florida Keys (Conant and Collins, 1998; Mitchell and Lannoo, 2005). Throughout much of its range, the Eastern Narrowmouth Toad breeds from late-Spring through early-Fall (Meshaka and Woolfenden, 1999); exceptionally, breeding may extend for a longer season in the South (Meshaka and Woolfenden, 1999). Conversely, along the northern edge of its range the breeding season is restricted to just a few months (Meshaka and Woolfenden, 1999; Trauth et al., 1999). Despite geographic differences in breeding seasons, a mid-Summer peak in breeding was common to all sites, and Meshaka and Woolfenden (1999) found that the shorter breeding seasons observed in the North closely overlapped those predicted using threshold weather data associated with movements and calling in Florida. To that end, predictions for Richmond, Virginia, were for movements and calling to occur during June-August which was consistent with reported calling during 22 July-18 August 1979 and 22 July 1980 in nearby Chesterfield County, Virginia by Mitchell (1986). Mitchell's (1986) subsequent finds of metamorphosis during 26 August-9 September 1979 corroborated the short summer breeding season of that site. We used museum specimens to compare fertility rates and length of breeding season of the Eastern Narrowmouth Toad in Virginia to those attributes in other portions of its range. In addition, we assessed adult body size and clutch characteristics, life history traits that appear less variable within this species throughout its range.

MATERIALS AND METHODS

We examined 79 Eastern Narrowmouth Toad museum specimens collected from eight counties in Virginia (Figure 1) during 1940-1990 and eight field-collected clutches stored at the Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, USA. We measured the snout-vent length of all individuals to the nearest 0.1 mm using calipers. We determined sexual maturity in males by the presence of enlarged testes and enlarged thumbs. We used the length and width (measured to the nearest 0.1 mm using calipers) of the left testis as a proportion of snout-vent length to quantify seasonal differences in tes-

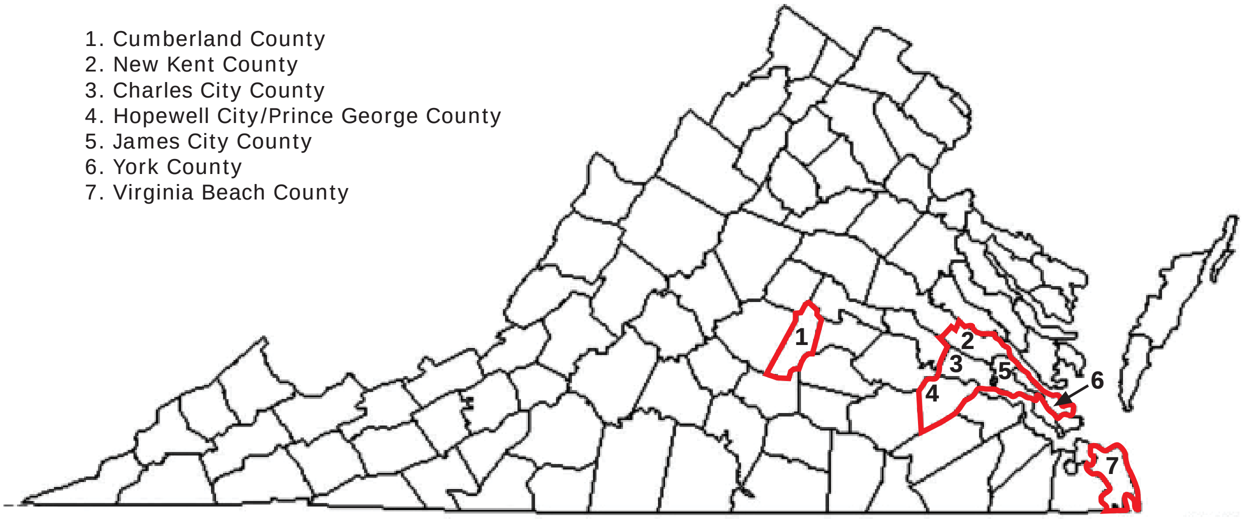

Figure 1. Virginia counties from which 79 specimens of the Eastern Narrowmouth Toad (*Gastrophryne carolinensis*) captured during 1940-1990 were examined in this study.

tis dimensions. Monthly frequencies of enlarged thumbs also served as a measure of seasonal patterns of reproductive activity. We associated sexually mature females with one of four ovarian stages. In the first ovarian stage oviducts were thin and just beginning to coil, and the ovaries were somewhat opaque. In the second ovarian stage, the oviducts were larger and more coiled, and the ovaries contained some pigmented oocytes. In the third ovarian stage, oviducts were thick and heavily coiled, and the ovaries were in various stages of clutch development. In the fourth ovarian stage, oviducts were thick and heavily coiled, and the ovaries were full of polarized ova with few non-polarized ova, signifying a fully ripened clutch and gravid female (Meshaka 2001).

We examined a subset of females for clutch characteristics. We made complete egg counts for each gravid female to estimate clutch size and to assess the relationship between female snout-vent length and clutch size. In addition, we measured the diameter of 10 randomly selected ova using an ocular micrometer; we used the largest ovum from each individual to assess the relationship between female snout-vent length and ova size.

For each individual, we scored fat body development as: 1) absent, 2) intermediate in volume in the body cavity, or 3) extensive development that reached cranially in the body cavity. The latter amount was used as an estimation of monthly incidence of extensive fat as a percentage of all males or females examined in each month. The presence of food in digestive tracts was used as an estimation of monthly incidence of individuals that had been feeding for all males or females examined in each month.

Because body size differences were expected in our comparisons, one-tailed t-tests were used to compare means between samples. F-tests were calculated to determine significant differences in variance of samples. We defined statistical significance as $p < 0.05$. We presented results as mean $\pm$ 1 standard deviations. All statistical analyses were conducted using Microsoft Excel™.

RESULTS

Seasonal activity — Adult Eastern Narrowmouth Toads were collected during March-September, with the greatest number of captures or both sexes having occurred

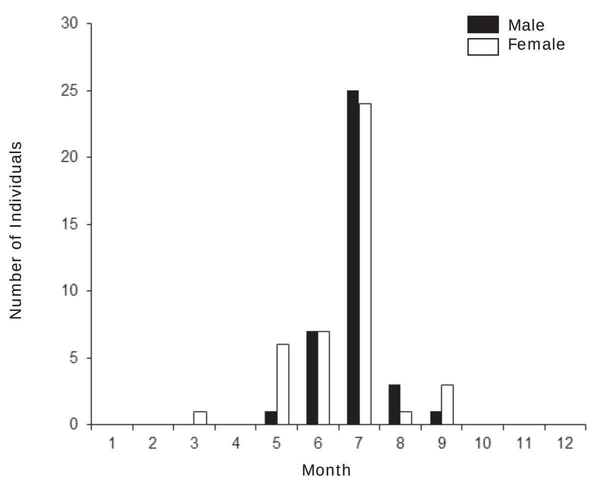

Figure 2. Monthly distribution of captures of 36 male and 42 female Eastern Narrowmouth Toads (*Gastrophryne carolinensis*) from Virginia.

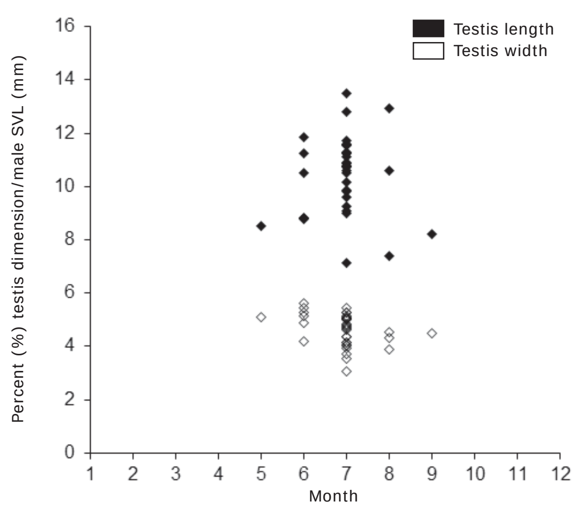

Figure 3. Monthly distribution of testis length and width of 36 male Eastern Narrowmouth Toads (*Gastrophryne carolinensis*) from Virginia.

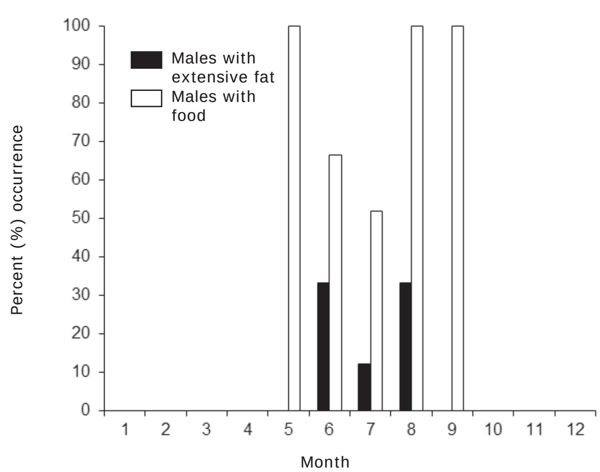

Figure 4. Monthly frequency of extensive fat (n = 36) and the presence of food (n = 54) in male Eastern Narrowmouth Toads (*Gastrophryne carolinensis*) from Virginia.

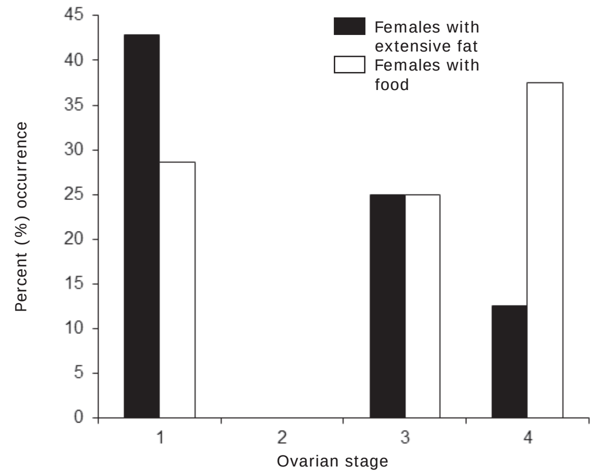

Figure 6. Frequency of extensive fat and the presence of food in each of the four ovarian stages of 42 female Eastern Narrowmouth Toads (*Gastrophryne carolinensis*) from Virginia.

in July (Figure 2). Mean adult body size of males (mean = 28.3 ± 1.4 mm SVL; range = 25.5-32.2 mm; n = 37) was significantly smaller than that of females (mean = 30.1 ± 2.4 mm SVL; range = 24.4-34.2 mm; n = 42; t = -4.041; df = 67; p < 0.001). Body sizes of adult males were significantly more variable (F = 0.335; df = 36; p = 0.001) than those of females.

Male reproduction — The longest testis measurements and the shortest measurements of testis width were recorded in July (Figure 3). Thereafter, testis length began to shorten concomitant with subsequent increase in testis width (Figure 3).

Male fat and food — Monthly distribution was of incidence of extensive fat and the presence of food was lowest in July (Figure 4) and suggestive of a seasonal depletion and subsequent build-up of fat and a lower incidence of feeding commensurate with breeding activities.

Female reproduction — Twenty-nine gravid females (stage IV) and four nearly gravid females (stage III) were detected during May-September (Figure 5). Numbers of gravid females increased from May and peaked in July. August and September were represented each by a single gravid female among a total of four females for both months. Two clutches were collected on 30 June 1986 in Suffolk City, and six clutches were collected on 10 July 1988 at the Harrison Lake National Fish Hatchery.

Incidence of females containing extensive coelomic fat decreased steadily from a high of 42.9% among stage I (spent) females to a low of 12.5% among stage IV (gravid) females (Figure 6). Conversely, the highest incidence of females containing food was found among stage IV individuals (Figure 6). Seasonally, the incidence of well-developed fat bodies was highest among females (66.7%) in September at the approach of fall and was lowest in July and August, commensurate with oviposition and after a substantial drop in May (16.7%) and June (14.3%) from September (Figure 7).

Fourteen gravid females (mean = 29.7 ± 2.03 mm SVL; range = 26.9-34.1) were examined to determine clutch characteristics. Among these females, clutch size ranged 278-1618 eggs (mean = 824.6 ± 353.9) and was not significantly related to female snout-vent length (p = 0.35). Diameter of 10 mature ova from each of the 14 gravid females ranged 0.7-1.3 mm (mean = 1.10 ± 0.13 mm; N = 140). Maximum (Figure 8) and mean (Figure 9) ovum diameter co-varied significantly with female body size but neither co-varied significantly with clutch size (p= 0.96).

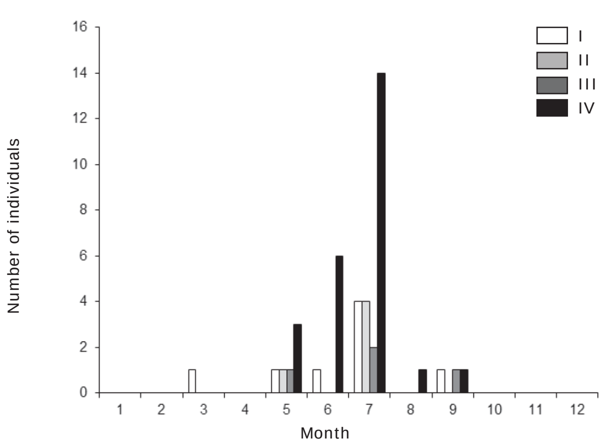

Figure 5. Monthly distribution of ovarian stages of 42 female Eastern Narrowmouth Toads (*Gastrophryne carolinensis*) from Virginia.

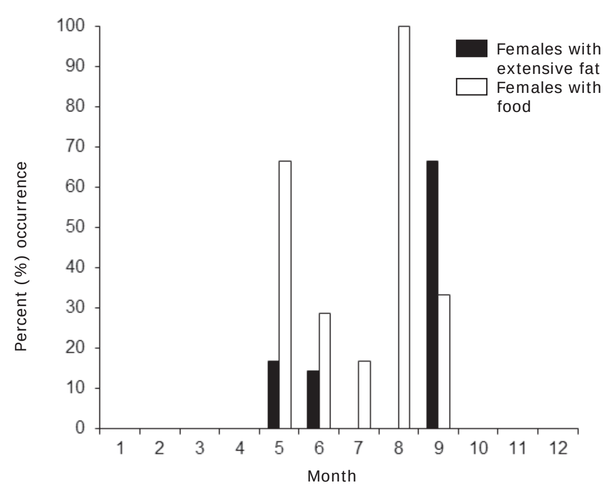

Figure 7. Monthly frequency of extensive fat and the presence of food in 42 female Eastern Narrowmouth Toads (*Gastrophryne carolinensis*) from Virginia.

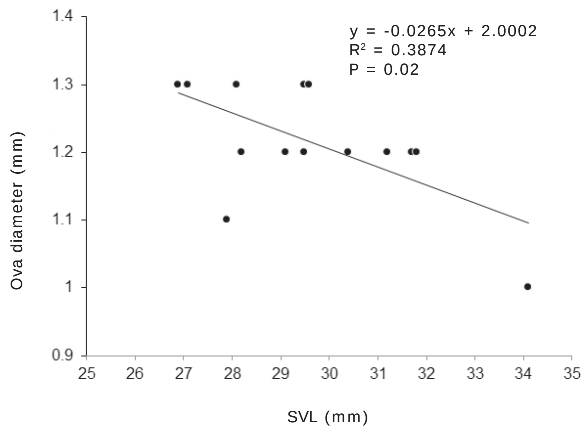

Figure 8. Relationship between largest ova diameter and female body size in 14 female Eastern Narrowmouth Toads (*Gastrophryne carolinensis*) from Virginia.

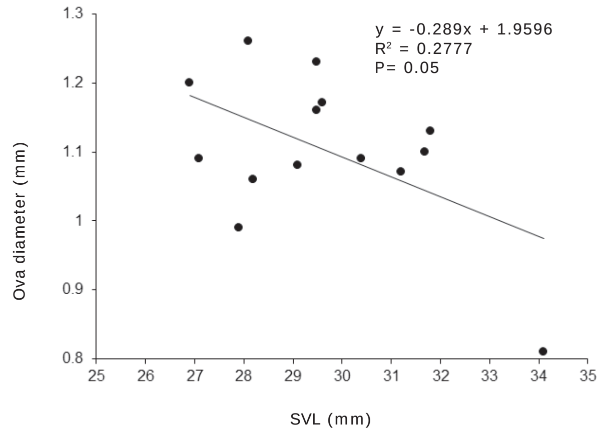

Figure 9. Relationship between mean ova diameter and female body size in 14 female Eastern Narrowmouth Toads (*Gastrophryne carolinensis*) from Virginia.

DISCUSSION

Our findings for the Eastern Narrowmouth Toad in Virginia conformed to those found elsewhere with respect to both traits that remained stable and those that varied with latitude. Mean snout-vent lengths of adult males and females appeared to be larger in northern populations, such as Virginia (28.3 and 30.1 mm, respectively), Arkansas (27.6 and 29.6 mm, respectively) (Trauth et al., 1999) as compared to southern populations such as those of Florida (25.7 and 26.4 mm, respectively) (Meshaka and Woolfenden, 1999), and the Okefinokee (mean = 24.9 $\pm$ 2.0 mm; range = 23-28; n = 17 and mean = 26.9 $\pm$ 2.4 mm; range = 23-30; n = 9, respectively), the latter data of which were derived by our analysis of adult body sizes presented for Eastern Narrowmouth Toads from the Okefinokee by Wright (1931). Additional data will be necessary to more fully evaluate the strength of this trend as a result of latitude. As found in northeastern Arkansas (Trauth et al., 1999), in south-central Florida (Meshaka and Woolfenden, 1999), and in the Okefinokee (Wright, 1931) (t = 2.064; df = 24; p = 0.03) mean body size of males and females differed significantly from one another in Virginia.

Mean (824.6 eggs) and median (726.5 eggs) clutch size from Virginia corroborated the notion that latitude alone is not an explanation for range-wide variation in this trait: Florida (928.8 eggs) (Meshaka and Woolfenden, 1999), Louisiana (510 eggs) (Anderson, 1954), Arkansas (673.2 eggs) (Trauth et al., 1999). Absence of a correlation between clutch size and female body size was found in Arkansas (Trauth et al., 1999) and in our study, and the relationship remains unexamined elsewhere. Maximum and mean ovum size negatively co-varied with female body size in Virginia, but mean ovum size did not co-vary with female body size in Arkansas (Trauth et al., 1999). Typical across the geographic range of this species, peak breeding activity occurred in mid-summer (Meshaka and Woolfenden, 1999), which was evident in Arkansas (Trauth et al., 1999) and in our study. Across its geographic range, adults were typically fertile through September even if breeding was unlikely to occur because of climatic constraints (Meshaka and Woofenden, 1999). Populations from Arkansas (Trauth et al., 1999) and our study also adhered to this pattern.

Adhering to narrow climatic constraints associated with northern edge populations of this species, Virginia populations of the Eastern Narrwomouth Toad could breed during the very short June-August season. This finding for Virginia was similar to that for nearby Chesterfield with respect to the months for calling (22 July-18 August), egglaying (22 July), and subsequent presence of metamorphosed individuals (26 August-9 September) (Mitchell, 1986). Our findings and those of Mitchell (1986) overlap the predictions of a June-August calling season in Richmond, Virginia, that were based upon monthly average maxima and minima for air temperature and monthly rainfall totals associated with calling by this species in Florida (Meshaka and Woolfenden, 1999).

The findings of this study bring with them implications for effects of climate change, a phenomenon that is accompanied by overall warmer climate and more extreme weather. The Eastern Narrowmouth Toad, so well-adapted to the ephemeral breeding pools in warm weather, has not lost its potential for extended breeding along the northern edge of either Virginia or Arkansas. Fertility that extends beyond climatically-constrained breeding season bodes well for this species in the face of anticipated changes in climate that will subsume what is now the northern edge of its geographic range.

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LITERATURE CITED

Anderson, P. K. 1954. Studies in the ecology of the narrow-mouthed toad, *Microhyla carolinensis carolinensis*. Tulane Studies in Zoology, 2:13-23.

Conant, R. and Collins J. T. (1998). *Reptiles and Amphibians of Eastern/Central North America.* 3rd ed. Houghton Mifflin Co. New York, New York.

Dundee, H. A. and D. A. Rossman. 1989. The Amphibians and Reptiles of Louisiana. Louisiana State University Press. Baton Rouge, Louisiana.

Meshaka, W. E., Jr. 2001. The Cuban Treefrog in Florida: Life History of a Successful Colonizing Species. University Press of Florida. Gainesville, Florida.

Meshaka, W. E., Jr., and G. E. Woolfenden. 1999. Relation of temperature and rainfall to movements and reproduction of the eastern narrowmouth toad (*Gastrophryne carolinensis*) in south-central Florida. Florida Scientist, 62:213-221.

Mitchell, J. C. 1986. Life history patterns in a central

Virginia frog community. Virginia Journal of Science, 37:262-271

Mitchell, J. C. and M. L. Lannoo. 2005. *Gastrophryne carolinensis* (Holbrook, 1836); Eastern Narrow-mouthed Toad. Pp. 501-503 *In* M. Lannoo, editor, *Status and Conservation of North American Amphibians.* University of California Press. Berkeley, California.

Trauth, S. E., W. E. Meshaka, Jr., and R. L. Cox. 1999. Post-metamorphic growth and reproduction in the eastern narrowmouth toad (*Gastrophryne carolinensis*) from northeastern Arkansas. Journal of the Arkansas Academy of Sciences, 53:120-124.

Wright, A. H. 1931. Life-Histories of the Frogs of the Okefinokee Swamp, Georgia. The Macmillan Co. New York, New York.