

Miscellaneous Notes on the Natural History of the Oklahoma Salamander (*Eurycea tynerensis*)

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The Oklahoma salamander (*Eurycea tynerensis*) occurs in the western Springfield Plateau of the Ozark Mountains of Arkansas, Oklahoma, and Missouri. There is little published information relating to age structure, sex characteristics and reproduction, predation upon, and parasites of this species. Data collected from 279 specimens indicate that there may be at least three age classes, that overall sex ratio is 1:1 (females per male), and that no sexual dimorphism is apparent. Losses of portions of the tail, used as an index of risk of predation, occurred in 22% of the specimens. Gastrointestinal parasites occurred in 20% of the specimens, and included nematodes, acanthocephalans, and trematodes. © 2010 Oklahoma Academy of Science.

INTRODUCTION

Recent molecular analysis of the *Eurycea multiplicata* complex suggests that both pedomorphic and transforming populations exist in the western Ozarks, and that the populations formerly known as *E. multiplicata* are to be considered members of *Eurycea tynerensis* (Bonnett and Chippindale 2004). We studied populations of the less robust pedomorphic form, to which the name *E. tynerensis* formerly had been limited (Tumlison et al. 1990a). This is a small salamander endemic to gravel-bottomed streams located along the western slopes of the Ozark Mountains of Oklahoma, Missouri, and Arkansas (Dowling 1956; Dundee 1958; Johnson 1987; Cline and Tumlison 2001). The Springfield Plateau is a unique subregion of the Ozarks due to the presence of deep cherty limestone deposits which serve as habitat for pedomorphic populations of *E. tynerensis* (Tumlison and Cline 2003).

An extensive survey of the status of the Oklahoma salamander in Oklahoma, Missouri, and Arkansas documented relative abundance and distribution (Cline and Tumlison 2001), foods (Tumlison et al. 1990b), habitat selection (Tumlison et al. 1990c; Tumlison and Cline 1997) and behavior (Tumlison and Cline 1990). Herein, we describe analysis of the museum specimens collected during that study, to provide observations of sex ratio, frequencies of tail-break (which may relate largely to risk of predation by crayfish), and parasitism. These details of life history are not documented for this salamander, thus our objective was to add such information to the knowledge of this endemic species.

MATERIALS AND METHODS

Specimens were collected during sampling of 213 sites from 1 March through 10 October, but primarily during June and July of

1988 (Cline and Tumlinson 2001). Salamanders were collected by turning submerged stones and catching exposed individuals in aquarium nets. Voucher specimens of *E. tynerensis* (N=279) collected during sampling were deposited in the Oklahoma State University Museum of Zoology. These were examined internally and externally to reveal parameters of life history.

Age Structure and Sex Ratio

We evaluated age structure by plotting cumulative frequency of occurrence against snout-vent length (SVL) to look for breaks in age classes in the samples. Sex ratios (number of females per male) were determined by internal examination of gonads and frequencies were compared among the seven drainages from which samples were collected.

Sexual Characteristics and Dimorphism

Via internal examination, the appearance of gonads was noted and number of yolked and unyolked ovarian follicles was recorded for all females. Testes were coded as either swollen (reproductive) or tubular (non-reproductive).

The Oklahoma salamander is not sexually dimorphic for visible characters. We evaluated dimorphism for the mensural characters of SVL, tail length (TL), and total length (TTL) by use of Analysis of Variance (ANOVA). Also, multiple regression analysis was used to test for differences in allometric growth between sexes and age classes.

Frequency of Tail Break

The Oklahoma salamander spends its entire life in the substrate of aquatic habitats, which exposes it to crayfish and other potential predators (Tumlinson and Cline 2002). The streams sampled during the survey of distribution (Cline and Tumlinson 2001) commonly supported populations of crayfish, especially *Orconectes neglectus* (Tumlinson et al. 1990b). The frequency of tail breaks, then, can serve as an index of the pressure

exerted by crayfish as predators, although actual frequency of predation cannot be estimated without further data. We examined tails of specimens in our sample to evaluate the frequency of tail loss.

Parasites

Parasites were removed from the stomach and intestines and categorized as nematodes (roundworms), trematodes (flukes) or acanthocephalans (spiny-headed worms). Frequency of occurrence was compared between sexes and age classes (juvenile vs. adult) and among drainages.

RESULTS AND DISCUSSION

In the three-state area, *E. tynerensis* was found in the Baron Fork, Illinois, Spavinaw, Honey, Saline, Spring, Grand, Elk, and White River drainages (Cline et al. 1988; Cline and Tumlinson 2001). Of the 279 specimens examined, fifteen were too small to be sexed.

Age Structure and Sex Ratio

A plot of the frequency of occurrence against SVL revealed points of inflection at 22-23 mm and 32-36 mm SVL (Fig. 1). These points may represent juvenile classes (below 22 mm) yearlings (between 22 and 32 mm SVL), and older adults (above 32 mm SVL). However, the upper end of the curve does not indicate a clear distinction of older size classes. These observations are consistent with the three age classes suggested by Dundee (1958), who estimated that it took two years for these salamanders to mature sexually.

The expected distinction of ages based on SVL could be obscured if these salamanders have a long breeding season or multiple clutches per year, which could cause SVLs of different age classes to overlap. Published information about reproduction is too scanty to know if these factors could be at work. Another interpretation is that the curve above SVL of 32 mm reflects the slowing of growth that occurs near maturity,

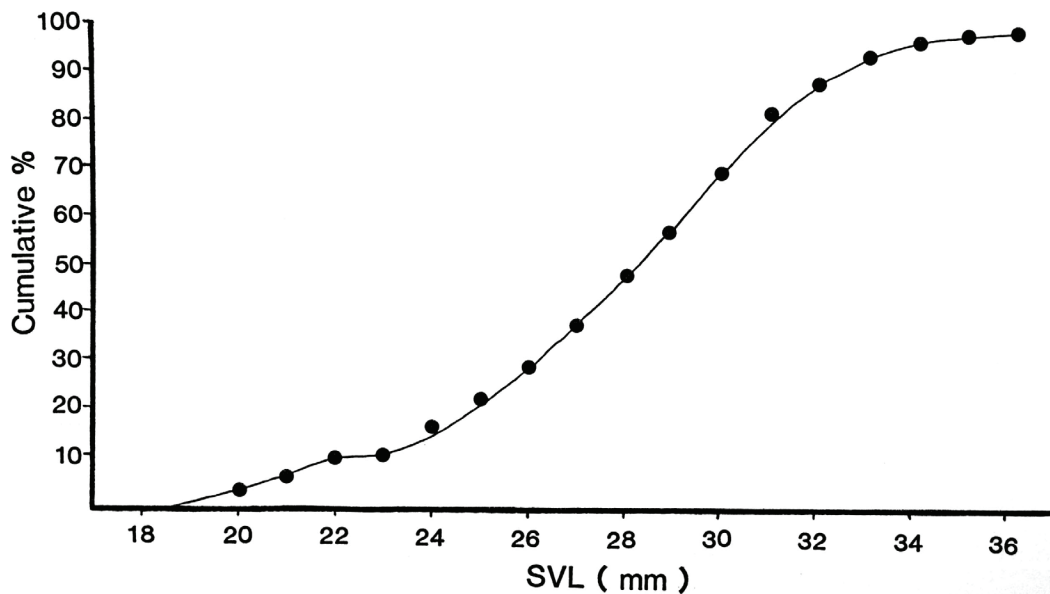


Figure 1. Plot of cumulative percent versus snout-vent length of 279 *E. tynerensis* collected from AR, OK, and MO in 1988. Salamanders were grouped in 1 mm size classes. Note the plateaus at 22-24 mm and 32-36 mm.

which would be confounded by the various temperatures in which these salamanders grow.

The effects of Q_{10} causes ectotherms to grow more slowly at lower temperatures and more rapidly in warmer conditions (Ricklefs and Miller 1999). Oklahoma salamanders spend much of their lives in warmer streams but also in cool springs, which would vary rates of growth seasonally and obscure the interpretation of age classes based on SVL.

The sex ratios among sites ranged from 0.3:1 (females per male) to 4.1:1, and both extremes were from the Spavinaw drainage (Table 1). Females tended to occur in samples slightly more often than did males. However, due to small sample sizes producing some of the more disparate ratios, only Spring Creek produced a sex ratio significantly different from 1:1 (Chi-square, $P < 0.05$). No temporal pattern of sex ratios was observed, indicating no difference in movement patterns effected by sex.

Table 1. Comparison of sex ratios (number of females per male) in *E. tynerensis* collected from seven drainages in north-eastern Oklahoma in 1988. Where drainages were represented by more than one sample, the range of sex ratios from those samples is provided.

Drainage	Sex Ratio	
	Overall	Range among sites
Spring Creek	3.3:1	3.3:1
Grand River	1.5:1	1.5:1
Honey Creek	1.3:1	1.3:1
Baron Fork River	1.2:1	0.5:1 - 2.0:1
Illinois River	1.1:1	0.4:1 - 2.0:1
Saline Creek	1.0:1	1.0:1
Spavinaw Creek	0.7:1	0.3:1 - 4.1:1

Sexual Characteristics and Dimorphism

Ovaries and testes were distinguishable in specimens as small as a SVL of 18.3 mm. Testes were gray with black stellate blotches, whereas ovaries were translucent with a faint yellow tone. Testes were tubular in most specimens under 23 mm SVL; however, one 20.8 mm specimen had distinctly bilobed testes. Testes developed a moderately swollen appearance in specimens about 25 mm SVL and were swollen distinctly at SVLs of 27 mm. The swelling was interpreted to reflect sexual maturity and the production of sperm.

Females 18.3 mm SVL contained small, white, disc-like follicles, but follicles in the process of yolking were not observed in females < 26.3 mm SVL. The percentage of females with developing follicles peaked in early May, dropped dramatically in June, but increased slightly in July. Yolked eggs were found in females collected from mid-May into early July, therefore oviposition likely also occurs during that interval, which is consistent with the observations of Dundee (1958). Although mating was not observed, we found pairs of salamanders under rocks in mid-May, which corresponded with the data concerning gonadal development.

Salamanders were not sexually dimorphic for SVL, TL, or TTL (ANOVA, $P > 0.05$). Multiple regression models also revealed no differences in rates of growth between sexes and age classes ($P > 0.05$).

Frequency of Tail Break

Twenty-two percent of the 279 salamanders sampled had lost portions of their tails, presumably due to being pinched by the chela of crayfish we found among the same stones occupied by the salamanders. Crayfish were found in all portions of the streams, but fish predators (primarily the banded sculpin, *Cottus caroliniae*, and the slender madtom, *Noturus exilis*) were more restricted to deeper waters than were the crayfish and salamanders (pers. obs.). A study of sculpin foods from *E. tynerensis* habitats did not indicate sculpins to be

major predators (Tumlinson and Cline 2002), therefore we presumed that most damage to the tail was caused by failed attempts at predation by crayfish.

Frequency of tail breaks among some drainages with reasonable sample sizes were: Spring Creek, 38.9% ($N = 18$); Illinois River, 33.1% ($N = 133$); Spavinaw Creek, 14.5% ($N = 55$); Baron Fork River, 7.5% ($N = 53$). No differences were found in the frequency of tail loss between sexes (males = 27.2%, females = 26.0%; Chi-square, $P > 0.05$). Adults had tail damage more often than did juveniles (31.2% and 13.9%, respectively). Although statistical significance of this difference is likely, it would have no biological meaning except that the likelihood of damage increases with exposure (age).

Parasites

Parasites were found in the stomachs and intestines of 53 (20%) of the specimens examined. Frequency of occurrence did not differ between sexes (20.0 and 20.1% for males and females, respectively; Chi-square, $P > 0.05$) or age classes (27.1% and 18.6% for juveniles and adults, respectively; Chi-square, $P > 0.05$).

Heavy parasite loads could place individuals at higher risk of predation, but no significant difference was found in frequency of tail break (a possible index of predation pressure) between parasitized and nonparasitized individuals (Chi-square, $P > 0.05$).

The frequency of parasitism ranged from 0-80% of the specimens collected within a drainage (Table 2). Parasites were encountered most often in *E. tynerensis* from the Grand River and Spavinaw drainages, and least often from the Baron Fork River and Spring Creek drainages.

Nematodes occurred in 90% of the individuals parasitized and accounted for 74% of the total number of parasites. Acanthocephalans occurred in 16% of the salamanders and accounted for 21.4% of the total parasite load. Trematodes occurred less

Table 2. Comparison of the incidence of parasites among drainages. The number of each kind of parasite is given, with the number in () indicating the number of salamanders in which they occurred. Percent incidence is based on the number of salamanders with parasites, but some specimens had more than one kind of parasite.

Drainage	N	% Incidence	Nematodes	Trematodes	Acanthocephalans
Illinois	124	16.1(20)	41 (17)	3 (2)	16 (6)
Spavinaw	67	31.3(21)	53 (19)	4 (2)	1 (1)
Baron Fork	53	3.8(2)	2 (2)	0	16 (1)
Spring Creek	18	5.6(1)	5 (1)	0	0
Honey Creek	9	22.2(2)	3 (2)	0	0
Grand River	5	80.0(4)	10 (4)	0	0
Others	3	0.0(0)	0	0	0
Total	279	18.0	114 (45)	7 (4)	33 (8)

frequently (8%) and accounted for 4.5% of all parasites. Parasite loads including mixes of taxa were found in 6% of the specimens. These parasite loads are lower than those reported by Hughes and Moore (1943a,b) for echinorhynchid worms and flukes.

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