# Further Notes on the Habitat of the Oklahoma Salamander, *Eurycea tynerensis*

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**Habitat for the Oklahoma salamander *(Eurycea tynerensis)* was once thought to be restricted to gravel substrates in clear, spring-fed, Ozark Mountain streams. Salamanders discovered in isolated springs and seeps which had been dry during a drought-year study, and under the detritus lying over bedrock in a formerly dry creek bed, recently provided evidence of the use of wet fissures by Oklahoma salamanders. These wet fissures, an unreported component of their habitat, connect with seeps and springs, and likely provide protected corridors, which allow the movement of salamanders among resource-rich habitat patches.** 

## INTRODUCTION

Moore and Hughes (*1*) describe the Oklahoma salamander *(Eurycea tynerensis)* based on collections made at Tyner Creek, Adair County, Oklahoma. *Eurycea tynerensis* is a neotenic species found in the streams of the Springfield Plateau of Arkansas, Missouri, and Oklahoma. Descriptions of its habitat typically focus on the gravel substrates of flowing streams (*1*-*3*). Originally, its habitat was described as the interstitial spaces in gravel under the cold, swift, shallow water of springs and small streams (*1*), but during drought *E. tynerensis* was found to live well below the substrate surface (*4*). The most recent habitat evaluation (*3*) was conducted during a drought year (1988) and was limited to those permanent streams and feeder springs that would flow under drought conditions. Evidence presented in that habitat evaluation supported the belief that *E. tynerensis* moves through gravel beds within streams, which prompted the authors to treat that study as one of surface habitat only.

Foods used during the drought included subterranean isopods (*5*), which provides circumstantial evidence that *E. tynerensis* might use subterranean corridors to move within or between surface stream systems. The isopods were recovered from the stomachs of salamanders found in isolated, thin (< 8 cm deep) patches of gravel that were scattered over scalloped bedrock. Gaining refuge from a loss of stream flow did not appear possible except through a spring that emerged from the bedrock 1.5 m from the gravel bed. This combination of topological and food consumption data led to an assumption that the salamanders had entered the sample site via the spring.

Droughts likely restrict the distribution of these salamanders from the intermittent streams that usually are appropriate surface habitats during other periods. Springs probably serve as refugia against drought conditions, much as they are believed to function for another neotenic salamander, *Eurycea neotenes,* on the Edwards Plateau of Texas (*6*). However, springs may serve a second function as windows into resource-rich surface habitat patches, and fissures or subterranean gravel beds may serve as movement corridors between patches and refugia. We field tested the hypothesis that *E. tynerensis* uses underground corridors by 1) searching for salamanders in springs that are isolated from streams and did not flow during the dry year (1988); and 2) searching a temporary stream with a bedrock bottom and detritus cover (atypical habitat), which had only isolated pockets of water, no springs, and no salamanders during the drought year.

## METHODS

We continued our studies (*3,5*) of Oklahoma salamander habitat during 1989 and 1991. From the observed local conditions, these were years of greater precipitation, greater stream flow, and more elevated ground water than in our previous studies conducted in 1988. The study site was near Camp Egan, a church camp located at the confluence of Rock Creek and the Baron Fork River, on Highway 62, 4.5 km east of the junction of Highways 51 and 62, Cherokee County, Oklahoma. This site was selected because it has supported a large population of *E. tynerensis* and because an unnamed, intermittent stream joined Rock Creek (a permanent stream) at this site. With the exception of a pair of depressions hollowed into the limestone bedrock, the intermittent streambed was completely dry during our previous studies (*3,5*) and no *E. tynerensis* had been found there despite intensive searches. The streambed possessed a quantity of gravel and cobble, considered typical *E. tynerensis* habitat, only near its confluence with Rock Creek; otherwise, gravel occurred only in thin and scattered patches on bedrock. The topography created a steep stream gradient. An abrupt 4-m rise was located approximately 100 m upstream from the mouth, which would be a waterfall when sufficient rain had fallen. Neotenic salamanders should not be able to travel distances greater than a few meters over essentially dry terrestrial habitats because their gills and skin might desiccate and impede adequate respiration. No Oklahoma salamanders were ever seen out of water during day or night field observations during our previous studies. Thus, the salamanders should not be able to travel the 50-m distance over dry bedrock from Rock Creek to the depressions in the intermittent stream. During this study, water flowed from several seeps and small springs, but exited through cracks in the bedrock before reaching Rock Creek. Because salamanders found upstream at this site would have to enter via the springs, seeps, or through wet cracks in the bedrock, this site provided a reasonable field test of our hypothesis that *E. tynerensis* uses wet, underground corridors to move between surface habitat patches.

## RESULTS and DISCUSSION

The appearance of springs that were previously unknown to us, and of flow in the intermittent creek, indicated that 1989 was a wetter year than 1988. During March and April, we first noted a small spring, which trickled through detrital materials and moss at the edge of the streambed of this intermittent creek, about 40 m from Rock Creek. One *E. tynerensis* was discovered and tried to escape into the spring source. Further upstream, other small springs or seepages from cracks in the bedrock also yielded *E. tynerensis.* Sufficient water flowed from these sources to create flow in the streambed, where dozens of *E. tynerensis* were discovered in water less than 10 cm deep, under leaves on a solid bedrock substrate (very atypical habitat according to previous studies). A pool up to 40 cm deep located at the base of the waterfall contained gravel, detritus, and *E. tynerensis*. When disturbed, the salamanders in the pool attempted to escape into the cracks from which spring water flowed. Local topological features indicated that movement farther upstream from the base of the waterfall should be exceptionally difficult for the salamanders, except via passages through the rock. A search of the bedrock surface of the stream above the waterfall did yield *E. tynerensis,* although they were much less numerous than below the waterfall. During April 1991, the stream had little flow, but salamanders were present in the pool areas, which until now has been considered unsuitable habitat (*3*).

During 1989, we also examined Rock Creek about 400 m upstream from the intermittent creek. An unexpected water source joined Rock Creek at this site, flowing from a previously unknown spring of about 1 m width; it had been dry during the drought year. This spring was about 40 m from Rock Creek, flowed over soil, but not gravel, to join the creek, and emerged from under a boulder. Its mud-and-detritus substrate is atypical Oklahoma salamander habitat; however, we found about a dozen E. *tyneren*sis among the submerged leaves. Most escaped by orienting toward and moving into the spring source, and no salamanders were found over the soil where the spring flowed into the creek.

Another spring, located along Highway 10 in Cherokee County, flowed into a muddy, roadside ditch and was isolated by several hundred meters from any stream. The presence of several *E. tynerensis* in the 2-m-wide spring and its isolation from areas of typical habitat for *E. tynerensis* further supports the hypothesis of subterranean dispersal.

These descriptions of habitats contrast with published accounts of typical Oklahoma salamander habitat. This may be because previous authors derived information from stream-based studies; the original description of *E. tynerensis* was made by an ichthyologist (*1*), who discovered the salamander while seining fishes. The habitats we describe are not marginal or incidental, evidenced by the numbers of salamanders encountered at the sites.

Substrates of detritus over mud or bedrock are not mentioned elsewhere in the literature. We propose that clear water (no specimens have been found in turbid water), sufficient cover (gravel or leaves), accessibility (underground corridors to isolated sites), and a prey base are the key elements for *E. tynerensis* habitat, and that these characters are most common in gravel-bottomed streams, particularly in limestone-dominated areas (*5*). Characteristics of such typical surface habitat essentially are the same as those required by the primary prey, e.g., chironomids and ephemeropterans (*7*). We observed that hatchling salamanders (about 15 mm snout-vent length) began to appear in September in synchrony with hatching ephemeropterans in the same streams. Tumlison et al. (*5*) noted that ephemeropterans were a dominant food item, and that smaller salamanders ate smaller prey of the same taxa as those consumed by adults. The movement and abundance of salamanders appear to track patches of prey.

Previous observations of habitat and food (*3,5*) supported an hypothesis that clear, gravel-bottomed streams provided patches of nutrient-rich and energy-rich habitat. Present observations suggest that prey patches may be exploited by *E. tynerensis* by using underground corridors. Resource-rich, surface habitat patches likely are physiologically beneficial as energy sources for yolk deposition and for rapid growth of juveniles because of the increased food supply and the effects of warmer temperatures on their metabolic rate. In this view, springs would serve as windows that allow passage among habitat patches through corridors composed of wet fissures or areas of dissolution. Ground water levels would dictate which corridors were available for movement. If our interpretations are valid, *E. tynerensis* has a specialized ecology similar to that of the grotto salamander *(Typholotriton spelaeus)*, though to a lesser degree. Larvae of the grotto salamander often feed in a nutrient-rich, surface environment until maturity, at which time they return through springs or fissures to the cave system to spend their adult lives (*8,9*).

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