DISTRIBUTION OF THE TENNESSEE DACE, *PHOXINUS TENNESSEENSIS*, IN NORTHEAST TENNESSEE

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ABSTRACT—Eleven historic and 41 potential new locations were surveyed from September 1998–April 2001 to determine the current distribution of *Phoxinus tennesseensis* in northeast Tennessee and if current protection is warranted. *Phoxinus tennesseensis* were found to inhabit 5 (45%) historic and 4 (9.8%) new streams sampled. Dip nets proved to be the most efficient method of collection. *Phoxinus tennesseensis* always were found in pools with mostly (89%) silt substrates and woody vegetation growing along the banks. All pools had undercut banks and 67% of pools had root masses hanging into the water, which served as a refuge for adult and especially juvenile fish. *Phoxinus tennesseensis* were observed spawning over nests of *Campostoma anomalum* in Trinkle Creek and Timbertree Branch (Sullivan County). There was a slight decrease in the total number of populations in northeast Tennessee even with the discovery of 4 new populations. Possible reasons for the decline include excess silt, removal of streamside woody vegetation, and severe drought. We recommend that *P. tennesseensis* continue to be granted protection and further studies be conducted throughout its range to determine the status of all known populations.

The Tennessee dace, *Phoxinus tennesseensis* is a small minnow (family Cyprinidae) occurring with a limited distribution in eastern Tennessee and extreme southwestern Virginia (Etnier and Starnes, 1993; Jenkins and Burkhead, 1994). Originally, *P. tennesseensis* was thought to be a variant of *P. oreas* (Starnes and Jenkins, 1988). However, these species can be distinguished by morphological characters. *Phoxinus tennesseensis* has a break in the dark lateral stripe. The eye pupil diameter of *P. tennesseensis* is larger than the diameter of the dark spots above the lateral stripe. However, the eye pupil diameter of *P. oreas* is smaller than the diameter of the dark spots above the lateral stripe (Starnes and Jenkins, 1988). *Phoxinus tennesseensis* is thought to be in a monophyletic group with the blackside dace, *P. cumberlandensis,* the mountain redbelly dace, *P. oreas,* and the laurel dace, *P. saylori,* all of which are found in Tennessee (Skelton, 2001). There are 7 North American *Phoxinus* species, some with uncommon distributions. *Phoxinus cumberlandensis* has a limited distribution and is classified as endangered (Etnier and Starnes, 1993) and *P. saylori* appears to have a distribution that includes only a few streams (Skelton, 2001).

Phoxinus tennesseensis is typically found in shallow pools of spring fed first order streams. The habitat surrounding the streams has shade created by woody vegetation, silt and fine gravel pools, undercut banks, and debris in the water for cover (Starnes and Jenkins, 1988). *Phoxinus tennesseensis* is known historically from 62 locations (Shute, 2001), all of which are streams in the upper Tennessee River drainage. A high percentage of the Tennessee *P. tennesseensis* population residing in spring and seepage areas is considered jeopardized (Etnier and Starnes, 1991). Due to its limited distribution, *P. tennesseensis* is listed as "in need of management" in Tennessee (Tennessee Wildlife Resource Agency, 2000) and "endangered" in Virginia (Virginia Game and Inland Fisheries, 1989). *Phoxinus tennesseensis* was classified as an S2 (very rare and imperiled) species by the Tennessee Division of Natural Heritage, but in 2001 the species was reclassified as an S3 (rare and uncommon) species due to the discovery of new populations (Tennessee Division of Natural Heritage, 2001).

In the last five years several new populations of *P. tennesseensis* have been located. These and other additional populations might suggest that *P. tennesseensis* does not need continued protection. However, if many historic locations have been extirpated the number of viable populations could be much smaller than currently documented.

This survey was conducted to determine the current distribution of *P. tennesseensis* in northeast Tennessee by examining the status of historic locations and identifying new populations. Streams with similar habitats to those that have had or currently have *P. tennesseensis* populations were examined to locate any additional populations. The number of populations existing in northeast Tennessee could determine if protection is necessary. We present the results of a survey of northeast Tennessee of historic locations as well as a search for new locations.

MATERIALS AND METHODS

Streams known to have *P. tennesseensis* were located using the Tennessee Valley Authority's Natural Heritage Database (Shute, 2001) and sampled from September 1998–April 2001 due to low water levels in the fall and breeding congregations in the spring. Of the 62 known historic locations of *P. tennesseensis,* only 12 were located within northeast Tennessee. We defined Carter, Claiborne, Granger, Greene, Hamblen, Hancock, Hawkins, Jefferson, Johnson, Knox (northeastern portion of the county), Sullivan, Unicoi, and Washington counties as encompassing the northeast Tennessee search area. Eleven of the 12 populations

TABLE 1. Historic populations of *Phoxinus tennesseensis* sampled from northeast Tennessee.

Stream	County	Dates sampled	Number of dace	Latitude and longitude
Cedar Creek	Sullivan	September 1999	0	36°34′03″, 82°11′02″
		March 2000	0	
		February 2001	2	
Timbertree Branch	Sullivan	October 1999	1	36°34′38.05″, 82°25′47.73″
Hatcher Creek	Sullivan	September 1999	0	
		October 1999	0	
		March 2000	0	
Brice Branch	Knox	March 2000	3	36°06′21″, 83°44′48″
Cherokee Creek trib.	Washington	April 2001	0	
Roaring Fork	Greene	January 2001	0	
Palmer Branch	Hawkins	September 1999	0	
		October 1999	0	
Surgoinsville Creek	Hawkins	September 1999	2	36°29′10.94″, 82°51′41.38″
Terrill Creek	Hawkins	September 1999	1	36°26′51″, 82°49′36″
Beaverdam Creek	Johnson	October 1999	0	
		March 2000	0	
		March 2001	0	
Doe Creek	Johnson	March 2000	0	
		March 2001	0	

were surveyed and Beaverdam Creek contained 3 locations but was considered one population. If *P. tennesseensis* were found in historic locations, those streams were not sampled again. However, if *P. tennesseensis* were not located on the first sampling attempt, additional collections were often attempted at a later date.

Populations were surveyed using electro-shocking, dip nets, seine nets, and minnow traps. An electric Smith-Root model 12-b fishshocker and a blocking seine were used in large streams (> 2 meters in width), and dip nets were used preferentially in small streams (< 2 meters in width). Seine nets and minnow traps were used in both small and larger streams. Seining was conducted using the standard seine method of blocking one end of a pool or sample area and kicking into the seine (Etnier and Starnes, 1993). Seine and dip nets had a 3.5 mm mesh netting. Dip nets had a 36 by 35 by 45 cm pocket and seine nets were 10 by 1.5 meters. Since most streams were less than 1 meter in width, a dip net would block most of the stream. The dip nets were placed in the downstream side of a pool and moved to the upstream side. Fish were chased to the upper end of the pool and scooped out with the dip net. Gee minnow traps, with metal or plastic 3.5 mm mesh, were baited with dry cat food suspended in cheese cloth. Traps were placed in pools that contained suitable habitat for *P. tennesseensis* with one opening facing the upstream side of the pool and the other facing the down stream side of the pool.

All surveys were conducted under Tennessee Wildlife Resource Agency permit 1173. Historic populations were surveyed 300 meters upstream and 300 meters downstream of the known historic location, beginning downstream and moving upstream. Pools were checked more than once due to the species' preference for these areas. All specimens were released at the point of capture after the standard length of each fish was taken and one fish from each location was photographed for reference.

Potential new streams were sampled through the same methods as those used to survey historic populations. New locations were chosen based on habitat similarities to historic locations. Tributaries to historic locations were surveyed for new populations. Latitude and longitude readings were recorded for any stream, both historic and new locations, inhabited by *P. tennesseensis* using a Trimble GeoExplorer II Global Positioning System unit.

The depth and width of pools containing *P. tennesseensis* were measured. The number of root masses per pool, the presence of woody vegetation growing along the pool, and the substrate type were noted to determine a habitat preference.

RESULTS

We found dip nets to be the most successful method of collecting *P. tennesseensis.* Seine nets proved to be effective in larger and deeper pools. Electroshocking provided samples in larger streams, but in smaller streams this methods was not necessary. Minnow traps proved ineffective and may have led to the unnecessary loss of *P. tennesseensis* from streams. On 2 occasions both creek chubs, *Semotlis atromaculatus,* and *P. tennesseensis* had been captured in a minnow trap. Ten minutes later *P. tennesseensis* were absent. We presume that smaller *P. tennesseensis* captured in the traps were consumed by larger *S. atromaculatus.*

We sampled 11 historic locations throughout northeast Tennessee. This survey found the species was present in only 5 of 11 creeks (45%) sampled (Table 1). The maximum number of dace collected from any location was 3, which was Brice Branch in Knox County. Two historic locations of *P. tennesseensis* were confirmed in both Sullivan and Hawkins counties, which each had the most per county in northeast Tennessee.

Phoxinus tennesseensis were found in 4 new locations (9.8%) after searching 41 streams (Table 2). All locations were

TABLE 2. New streams sampled that did not contain *Phoxinus tennesseensis.*

Stream	County	Stream	County
Mill Creek	Sullivan	Spear Branch	Johnson
Sinking Creek	Sullivan	Harbin Branch	Johnson
Back Creek	Sullivan	Little Cherokee Creek	Washington
Beaver Creek	Sullivan	Straight Creek	Washington
Whitetop Creek	Sullivan	Pigeon Creek	Greene
Tributary to Back Creek along Bethel Dr.	Sullivan	Hoover Creek	Greene
Boozy Creek	Sullivan	Laurel Run	Hawkins
Gaines Branch	Sullivan	N. Fork Hunt Creek	Hawkins
Muddy Creek	Sullivan	Honeycut Creek	Hawkins
Indian Creek	Sullivan	Big Creek	Hawkins
Dry Creek	Sullivan	Beech Creek	Hawkins
Cold Springs Branch	Sullivan	Stoney Point Creek	Hawkins
Weaver Creek	Sullivan	Butcher Valley Creek	Hawkins
Morrell Creek	Sullivan	Bradley Creek	Hawkins
Tributary to Reedy Creek along Arcadia Dr.	Sullivan	Caney Creek	Hawkins
David Blevins Creek	Johnson	Flat Creek	Knox
Birch Branch	Johnson	Roseberry Creek	Knox
Parks Branch	Johnson	Buffalo Creek	Carter/Unicoi
Stout Branch	Johnson	Doe River	Carter

in Sullivan County and three were found within the boundaries of Steele Creek Park. One new population, Timbertree Branch, was on the state/county line between Tennessee (Sullivan County) and Virginia (Scott County). This location was over 1 km upstream from the historic location and represents a separate population since it is unlikely the dace could move 1 km upstream. Slagle Creek, Timbertree Branch, and Trinkle Creek each produced over 50 individuals, which was a large increase over all historic locations sampled. Steele Creek produced only one individual in a large pool.

All *P. tennesseensis* were captured in sluggish, shallow pools with undercut banks. Woody vegetation surrounded 89% of pools inhabited by these fish and 89% of pools had silt substrate. At least one root mass was found in 67% of the pools containing *P. tennesseensis* (Table 3). Surgoinsville Creek had no woody vegetation surrounding the stream. This section of the creek now is agriculture pasture with no shade. Brice Branch was the only stream with gravel pool substrate. When present, root masses hanging into the water always produced *P. tennesseensis* when dip nets were passed through the mass. Most root masses were growing from sycamore, *Platanus occidentalis,* or green ash, *Fraxinus pennsylvanica,* trees that were partially in the water. With the exception of Steele Creek, all pools currently inhabited by *P. tennesseensis* were less than 2 meters in width for all locations both historic and new.

While sampling Trinkle Creek and Timbertree Branch in May 2000 and 2001, we observed *P. tennesseensis* spawning. The dace were spawning over the nests of creek chubs, *Semotlis atromaculatus,* and central stonerollers, *Campostoma anomalum.* Both nests were located in shallow runs. Many of the other locations had substrate that would not be suitable for nest building minnows to construct nests.

TABLE 3. Habitat conditions of pool(s) containing *Phoxinus tennesseensis.*

Stream	Number of dace	Presence of woody vegetation	Substrate present	Mean number of root masses per pool(s)	Mean width (meters)	Mean depth (cm)
Cedar Creek	2	Yes	Silt	0.5	1.5	43.7
Timbertree Branch (Historic)	1	Yes	Silt	1.0	1.9	30.0
Timbertree Branch (New location)	63	Yes	Silt	3.2	1.7	44.3
Brice Branch	3	Yes	Gravel	1.0	0.75	33.5
Surgoinsville Creek	2	No	Silt	0	0.95	51.8
Terrill Creek	1	Yes	Silt	1.0	1.1	39.4
Trinkle Creek	83	Yes	Silt	1.3	1.05	35.7
Slagle Creek	53	Yes	Silt	1.0	1.1	48.3
Steele Creek	1	Yes	Silt	0	11.4	74.4

Of the 9 locations found with *P. tennesseensis,* both historic and new, only 3 had over 50 individuals; Timbertree Branch, Trinkle Creek, and Slagle Creek. The remaining 6 locations had less than 3 individuals in over 600 meters of stream.

DISCUSSION

We realize that fish populations can vary from year-to-year. Populations move up and down stream over periods of time. Environmental factors and habitat degradation can cause populations to become extirpated or move to another area of the stream. Therefore the results of our study will change and areas shown to no longer have *P. tennesseensis* could become reestablished. Some historic locations were sampled 3 times before one *P. tennesseensis* could be found. The presence of *P. tennesseensis* could be confirmed at other historic locations and new locations could be identified to have *P. tennesseensis* if regular sampling was conducted, especially during spawning period from (April–July).

Some of the historic locations that were not initially confirmed only had a few *P. tennesseensis* individuals recorded or the initial survey was conducted over ten years ago. The tributary to Cherokee Creek (Washington County) had only two individuals collected in 1973. The only sample from Roaring Fork (Greene County) was in 1916 and the exact number of dace collected is unclear. Doe Creek (Johnson County) was last confirmed in 1973 when 2 individuals were collected. In 1992, only 3 *P. tennesseensis* were collected from Hatcher Creek (Sullivan County). Populations of *P. tennesseensis* were most recently found in Beaverdam Creek (Johnson County), but not in large quantities. In 1998, one was found near backbone rock, 3 were found further downstream in 1997, and 3 were found in Shady Valley (Johnson County) in 1982. Palmer Branch (Hawkins County) was another recent collection when 7 individuals were collected in 1998 (Shute, 2001). Many events could have occurred during the long periods between sampling time or natural movements could have created the absence in populations successfully sampled a few years ago.

Of the four new locations found during our study, Trinkle Creek and Timbertree Branch (both in Sullivan County) had a substantial number of dace and necessary stream and shoreline habitat. Slagle Creek (Sullivan County) had over 50 individuals, but environmental conditions and an erosion problem from unauthorized trail use within Steele Creek Park could create conditions that would threaten the existence of the population.

The one dace found in Steele Creek could have been washed downstream or could represent a bait introduction. A 54-acre lake is immediately below the sample site. We had sampled this area numerous times without finding *P. tennesseensis.* In addition to our work this section of Steele Creek had been sampled numerous times by Tennessee Wildlife Resource Agency and Tennessee Valley Authority staff. The single specimen captured had visible injuries to dorsal and caudal fins. The sampling had been conducted 3 days after a rainfall event. Due to the condition of the fish we presume that the fish had been washed downstream from an upstream population. The Tennessee portion of Steele Creek was sampled at sites that had similar habitat to other *P. tennesseensis* locations and no other *P. tennesseensis* were found to inhabit the creek. Over 60% of Steele Creek occurs in Virginia. The Virginia portion of Steele Creek should be sampled to attempt to find another Virginia location for the species.

Environmental conditions were shown to have a great effect on *P. tennesseensis* populations. During our sampling of Slagle Creek in 1998 and 1999 there was a severe drought and the creek dried to only 7 pools. Many *P. tennesseensis* were preyed upon by mammals and birds in shallow pools. Other *P. tennesseensis* were lost when pools dried and the fish were left without water. *Phoxinus tennesseensis, Rhinichthys atratulus* (blacknose dace), and *Semotlis atromaculatus* were the only species that survived 2 months of drought in isolated pools. After spring precipitation events in 2000, the number of *P. tennesseensis* in Slagle Creek that could be sampled was less than 20. However, in 2001 over 50 *P. tennesseensis* were sampled in 2 pools. If locations were shown to no longer have *P. tennesseensis,* the droughts of 1998 and 1999 could have been a factor in their absence.

When only one or two *P. tennesseensis* are found in a section of stream, pools upstream and downstream should be checked for additional dace. In Timbertree Branch and Cedar Creek, pools upstream from known locations were searched and additional dace were found. Most *P. tennesseensis* locations were 400 meters downstream from the stream origin, which confirmed the habitat preference reported by Starnes and Jenkins (1988). It appears that new populations are created and exist as metapopulations when *P. tennesseensis* are washed downstream. The head waters to all streams known to contain *P. tennesseensis* should be sampled to attempt to find additional locations. Through our observations it is unlikely that individual *P. tennesseensis* have a range of more than 100 meters.

Of all the pool habitat conditions studied, the presence of root masses and woody vegetation seemed to be critical for *P. tennesseensis.* The only exceptions were Surgoinsville Creek, which did not have woody vegetation or root masses along the pool, and Steele Creek, which did not have root masses in the water, these populations are not considered sustainable due to the low number of fish encountered. However, Virginia's largest population is in a similar pasture as Surgoinsville Creek (Jenkins and Burkhead, 1994). At locations in which numerous *P. tennesseensis* were captured, over 60% were using root masses as cover. Young-of-the-year *P. tennesseensis* were always found in root masses or woody debris. The woody vegetation growing along the edges of the pool provided shade, especially during periods of low flow. Pools in Slagle Creek shaded by woody vegetation held water much longer than pools without. The debris that would fall into pools from the woody vegetation growing along the banks provided additional refuges for *P. tennesseensis.*

Our observation of the spawning of *P. tennesseensis* was the first documented evidence of *P. tennesseensis* spawning over the nest of *Campostoma anomalum. Phoxinus tennesseensis* has been observed in the pit of a *C. anomalum* nest, but spawning had not been documented (Jenkins and Burkhead, 1994). *Phoxinus tennesseensis* has been observed spawning over the nest of *Semotilus atromaculatus* (Schilling and Ryon, 1993). Our observations confirm that *P. tennesseensis* is a nest associate spawner. This dependence on the nests of other species creates another factor that should be considered when managing this species. Many minnows that are nest associate spawners are protected on a state or federal level (Johnston, 1999). If nests are not present some *Phoxinus* (*P. cumberlandensis*) are thought to use shallow riffle areas (Starnes and Starnes, 1981). *Phoxinus tennesseensis* also is thought to use riffles in the absence of nest (Starnes and Jenkins, 1998). However, this was not observed with *P. tennesseensis* and the riffle areas in some of the streams inhabited by dace were covered in silt.

Our research has shown that the number of streams in northeast Tennessee with *P. tennesseensis* populations has decreased from 11 to 9, an 18% reduction. As new populations are discovered, historic locations are becoming extirpated or are fluctuating to a degree that individuals are not detectable. Additional research should survey historic locations to greater degrees and search for new populations. Resource managers should not be hasty in lowering the amount of protection granted to *P. tennesseensis* as additional populations are discovered. A similar study should be conducted throughout the entire range of *P. tennesseensis* to gain a greater understanding of the distribution of this species throughout its restricted range.

The stream conditions of all nine streams that contained *P. tennesseensis* could predict the future of the dace. Slagle Creek, Timbertree Branch, Brice Branch, and Trinkle Creek were the only streams with clean riffle areas for spawning and little surrounding development. These populations should exist for many years given the good stream condition. However, development is beginning in the area near Trinkle Creek and silt from this development could prevent successful spawning as well as fill pools inhabited by *P. tennesseensis.* Slagle Creek is threatened by periods of drought especially in late autumn. Surgoinsville Creek, Timbertree Branch, and Terrill Creek were suffering from excess silt.

If stream conditions worsen the future of *P. tennesseensis* could be in jeopardy, especially in areas of potential human development. Continued protection and further monitoring of *P. tennesseensis* populations will be critical to detecting population fluctuations.

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