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New Species of *Etheostoma* (Teleostei: Percidae) from the Upper Tennessee River

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A new species of darter in the genus *Etheostoma* (Teleostei: Percidae) and subgenus *Nothonotus* is described from the upper Tennessee River. The new species closely resembles *Etheostoma tippecanoe* and was historically regarded as a distinct population. The presence of 1–4 scales on the cheek, a light transverse bar directly anterior to the dorsal-fin origin, and fewer scales in the lateral series distinguishes the new species from *E. tippecanoe.*

THE subgenus *Nothonotus* (Bailey and Etnier, 1988) is considered to be monophyletic (Page, 1981) and is characterized by the following synapomorphies: slab-sided body shape, darkened anterior membranes in the spinous portion of the dorsal fin, and horizontal lines on the lateral sides (Bailey and Etnier, 1988). The smallest member of the subgenus is *Etheostoma tippecanoe,* which differs from the other *Nothonotus* by consistently having an incomplete lateral line (Bailey and Etnier, 1988). *Etheostoma tippecanoe* was described by Jordan and Evermann (1890) from the Tippecanoe River, Marshland, Indiana. In their review of the type specimens of the darters, Collette and Knapp (1966) designated a lectotype (USNM 40080) and paralectotype (USNM 197919) and concluded that the larger of the remaining syntypes (UMMZ 187513) was *Etheostoma camurum* and the smaller one was most probably *E. camurum* as well.

Etheostoma tippecanoe is widespread but with a very disjunct distribution in the Ohio, Cumberland, and Tennessee River drainages (Etnier and Starnes, 1993). The northeastern limits to its range is the upper Allegheny River in northwestern Pennsylvania, and the southeastern boundary is the Clinch River in Tennessee and Virginia. Zorach (1969) recognized the distinctiveness of the Clinch River population and Jenkins and Burkhead (1994) postulated that this population may be a separate species. The cheeks of *E. tippecanoe* from the Ohio and Cumberland River drainages are scaleless, whereas individuals from the upper Tennessee River have 1–4 scales on the cheek, immediately behind the eye (Zorach, 1969). Zorach (1969) further noted that males from the Clinch River have a light bar anterior to the first dorsal fin, instead of the typical light saddle bordered anteriorly and posteriorly by dark saddles, which is found in the populations from the Ohio and Cumberland drainages. The purpose of this paper is to describe the species from the Clinch River and compare these populations to those of *E. tippecanoe.*

MATERIALS AND METHODS

Institutional abreviations are listed in Leviton et al. (1985). *Etheostoma tippecanoe* from the upper Allegheny River (Allegheny River, PSU 1650 [11]; French Creek, PSU 2520 [10]; PSU 1832 [9]; PSU 1652 [18]), middle Ohio River (Little Kanawha River, PSU 3022 [10]; Elk River, PSU 1304 [10]; Big Darby Creek, OSU 13894 [10]), lower Ohio River (Licking River, SIUC 9988 [10]; Redbird Creek, UMMZ 168882 [10]), Tippecanoe River (UMMZ 66560 [1]; INHS 68830 [8]; INHS 63837 [4]; USNM 40080 [lectotype]; USNM 197919 [paralectotype]), and the Cumberland/Green Rivers (Big South Fork of Cumberland River, UT 91.661 [6]; Harpeth River, UT 91.1122 [4]; Green River, INHS 33515 [7]) were compared to the new species from the Tennessee River Drainage (Clinch River, UT 91814 [10]; UT 91.1676 [3]; Copper Creek, CU 62822 [4]; CU 62923 [4] Sequatchie River, UT 91.2626 [9]). Standard length is used throughout. Counts and measurements follow Hubbs and Lagler (1964), except that the following distances also were recorded: anterior insertion of dorsal fin to anterior insertion of anal fin, posterior insertion of second dorsal fin to posterior insertion of anal fin, anterior insertion of second dorsal fin to posterior insertion of anal fin, posterior insertion of first dorsal fin to anterior insertion of anal fin, posterior insertion of second dorsal fin to ventral origin of caudal fin, posterior insertion of anal fin to dorsal origin of caudal fin, anterior insertion of dorsal fin to pelvic-fin origin, and posterior insertion of first dorsal fin to pelvic-fin origin (Stauffer, 1991). These measurements were recorded so that a truss network could be completed, as described by Humphries et al. (1981). All measurements were made point-to-point except caudal peduncle length, for which the distance form a point

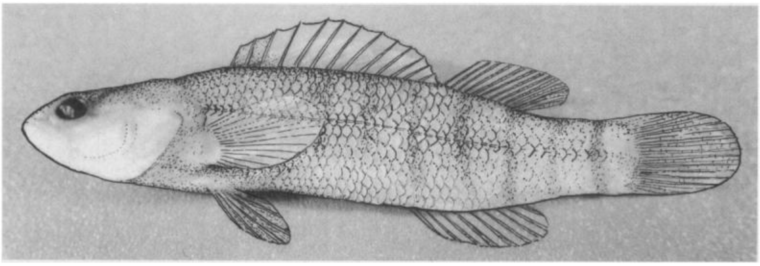

Fig. 1. Holotype of *Etheostoma denoncourti* (CU 77101, 26.4 mm SL).

on the lateral line directly above the posterior insertion of the anal fin to the hypural plate was measured. Lateral scales are all scales along the midline of the body from opercle to hypural plate, pored lateral scales are those scales in the lateral series that have an opening, and postlateral scales are those scales posterior to the hypural plate and may or may not be pored. All counts and measurements were made on the left side of the fish.

TABLE 1. MORPHOMETRIC AND MERISTIC CHARACTERS OF *Etheostoma denoncourti*. Range and mean include holotype and 29 paratypes.

Character	Holotype	Mean	SD	Range
Standard length, mm	26.4	24.4	2.1	20.0–28.6
Head length, mm	7.1	6.7	0.7	5.3–8.2
Percent of standard length				
Head length	27.0	27.5	1.8	23–31
Body depth	23.4	23.9	1.5	20–28
Snout to first dorsal-fin origin	38.3	38.0	2.2	33–43
Snout to pelvic-fin origin	36.6	37.0	2.0	33–41
Dorsal-fin base length	59.3	57.6	2.8	51–64
Anterior first dorsal to anterior anal	45.5	40.8	3.5	32–47
Anterior first dorsal to posterior anal	26.0	27.4	1.4	25–30
Posterior second dorsal to anterior anal	26.3	29.8	2.1	25–35
Posterior second dorsal to ventral caudal	14.9	15.9	1.2	13–18
Posterior second dorsal to pelvic-fin origin	45.6	42.8	2.6	35–47
Posterior anal to dorsal caudal	19.8	17.5	1.9	14–23
Caudal peduncle depth	14.3	13.0	1.1	10–15
Posterior first dorsal to anterior anal	23.4	23.2	1.3	20–25
Pelvic-fin origin to posterior anal	16.6	15.5	1.7	12–19
Posterior first dorsal to posterior anal	26.0	27.4	1.4	25–30
Caudal peduncle length	10.7	10.5	2.3	6–16
Pelvic-fin origin to anterior anal	40.5	33.7	3.2	27–42
Anal-fin base length	14.4	21.5	2.9	14–27
Percent of head length				
Snout length	26.1	26.6	2.2	21–30
Postorbital head length	58.2	57.4	3.4	48–62
Horizontal eye diameter	20.8	21.3	2.8	17–28
Vertical eye diameter	15.4	17.6	2.7	13–23
Head depth	84.4	75.8	7.1	61–88
Counts	Holotype	Mode	Freq.	Range
Dorsal-fin spines	13	13	86.7	12–14
Dorsal-fin rays	12	11	50.0	11–13
Anal-fin rays	9	9	83.3	8–10
Pored lateral scales	30	23	16.7	19–34
Lateral scales	41	46	13.3	39–51
Postlateral scales	1	1	66.7	0–2

Principal components analysis (PCA) with the correlation matrix factored was used to examine the meristic data. Sheared PCA with the covariance matrix factored was used to analyze the morphometric data (Humphries et al., 1981; Bookstein et al., 1985). This technique quantifies shape differences among the populations independent of fish size (Reyment et al., 1984). Dissimilarities among populations were illustrated by plotting the sheared second principal component of the morphometric data against the first principal component of the meristic data (Stauffer and Hert, 1992). A multivariate analysis of variance (MANOVA) was used to determine whether the clusters formed by populations were significantly ($P < 0.05$) different. If these clusters were significantly different along one axis independent of the second axis, a Duncan's Multiple Range test was used to determine which population clusters differed.

Etheostoma denoncourti, n. sp.
Golden Darter
Figure 1

Holotype.—CU 77101, adult male, 26.4 mm SL, Copper Creek, 180–460 m above mouth on route 627, 2 air km. S. of Clinchport, VA, 24 July 1967, R. F. Denoncourt and family.

Paratypes.—PSU 3023, 3 (22.6–27.4 mm) data as for holotype, CU 62923, 4 (24.9–25.9 mm) locality as for holotype, 9 August 1967, R. F. Denoncourt, D. C. Wallace; UT 91.814, 10 (20.0–28.6 mm), Clinch River at Frostford, TN, 11.8 air km. WSW of Kyles Ford, TN, 19 September 1973, D. M. Etnier and UT ichthyology class; UT 91.1676, 3 (24.3–25.8 mm), Clinch River at Frostford, TN, 11.8 air km. WSW of Kyles Ford, TN, 24 October 1978, D. M. Etnier and UT ichthyology class; UT 91.2626, 9 (21.0–25.7 mm), Sequatchie River, km. 18.5, TN, 8 July 1983, D. Biggins, C. F. Saylor, and R. Hylton.

Diagnosis.—A darter of the subgenus *Nothonotus* (genus *Etheostoma*) that closely resembles *E. tippecanoe.* The slab-sided body shape, darkened anterior membranes in the spinous portion of the dorsal fin, and horizontal lines on the lateral sides (Bailey and Etnier, 1988) clearly place this species in the subgenus *Nothonotus.* The presence of scales on the cheek and a light line directly anterior to the dorsal-fin origin distinguishes it from *E. tippecanoe.*

Description.—Morphometric ratios and meristics are presented in Table 1. Jaws isognathous. Dorsal fin with 13 spines in holotype and 12–14 in paratypes and 12 rays in holotype with 11–13 in paratypes; anal fin with 12 rays in holotype and 8–10 in paratypes. The holotype with 41 lateral scales, 30 pored; paratypes with 39–51 lateral scales, 19–34 pored. The holotype with 1 postlateral scale, and paratypes 0–2.

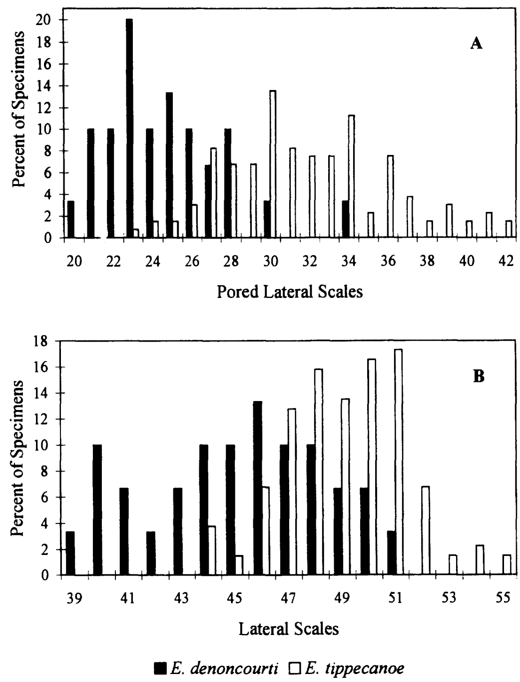

Fig. 2. Percent of specimens with pored (A) and lateral (B) scales in *Etheostoma denoncourti* and *Etheostoma tippecanoe.*

Etheostoma denoncourti typically has fewer scales in the lateral series than *E. tippecanoe* (Fig. 2, Table 2). The mode for lateral scales is 46 and for pored lateral scales is 23 in *E. denoncourti,* whereas the modes for lateral scales range between 47 and 50 and for pored lateral scales between 27 and 34 for *E. tippecanoe* (Fig. 2). More than 86% of *E. denoncourti* have 13 dorsal-fin spines, whereas the mode in *E. tippecanoe* is 12. The mode for dorsal-fin rays is 11 for *E. denoncourti* and 12 for *E. tippecanoe* (Table 2).

The first principal component of the morphometric data (69.2% of total variance) is interpreted as a size component and the sheared components as shape, independent of size (Humphries et al., 1981; Bookstein et al., 1985). Those variables that have the highest loadings on the sheared second principal component (8.4% of total variance) are caudal peduncle length, posterior anal-fin to dorsal caudal-fin insertion, and anal-fin base length (Ta-

TABLE 2. MORPHOMETRIC AND MERISTIC CHARACTERS OF *Etheostoma tippecanoe* POPULATIONS.

	Drainage														
	Upper Allegheny, n = 50			Middle Ohio, n = 30			Cumberland & Green, n = 18			Lower Ohio, n = 20			Tippecanoe River, n = 15		
Character	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Standard length, mm	28.9	2.8	24.6–35.3	25.8	2.4	22.0–31.3	26.8	3.9	22.0–34.0	22.6	1.7	19.7–26.3	29.2	3.5	23.7–36.0
Head length, mm	7.8	0.8	6.2–9.3	7.1	0.7	5.7–8.6	7.4	1.3	5.6–10.0	6.4	0.5	5.4–7.5	7.2	1.2	5.67–9.55
Percent of standard length															
Head length	26.9	1.5	24–30	27.4	1.7	24–30	27.4	2.0	24–30	28.3	1.3	26–30	24.6	1.7	22–27
Body depth	25.3	1.4	22–29	24.8	1.5	22–29	24.8	2.7	21–29	24.0	1.8	21–29	22.3	2.2	17–25
Snout to first dorsal-fin origin	37.8	1.5	34–41	39.0	2.3	34–44	36.7	2.1	31–39	37.4	2.8	28–41	34.5	2.4	29–37
Snout to pelvic-fin origin	34.7	1.6	32–38	35.9	2.0	32–43	35.6	1.9	33–38	38.2	1.7	35–41	33.7	3.1	31–41
Dorsal-fin base length	55.8	2.4	51–60	55.0	2.5	50–60	56.7	1.6	54–60	56.0	2.6	51–64	57.3	3.4	50–62
Anterior first dorsal to anterior anal	42.0	1.7	39–47	40.3	2.9	34–47	41.6	2.5	38–47	41.4	3.0	37–47	41.7	2.1	38–46
Anterior first dorsal to posterior anal	27.8	2.4	22–38	27.5	1.9	23–31	27.9	1.9	25–31	27.3	2.1	25–33	27.4	1.5	24–29
Posterior second dorsal to anterior anal	27.7	2.1	23–32	27.8	2.1	24–31	28.5	2.2	24–32	27.6	1.8	24–32	27.9	2.2	22–31
Posterior second dorsal to ventral caudal	16.2	2.0	11–21	16.5	0.7	16–18	16.4	1.8	12–19	15.9	1.5	14–19	16.5	2.3	14–22
Posterior second dorsal to pelvic-fin origin	43.3	2.3	39–49	42.3	2.2	37–47	42.6	2.3	39–47	41.6	2.6	37–48	41.1	2.9	33–45
Posterior anal to dorsal caudal	17.7	2.0	13–21	17.5	1.3	14–20	17.0	2.0	13–19	17.7	1.8	15–22	18.8	2.4	15–25
Caudal peduncle depth	11.9	1.2	9–14	12.7	0.9	11–14	12.8	1.3	9–14	12.9	1.2	11–15	11.8	1.4	8–13
Posterior first dorsal to anterior anal	23.1	1.7	20–27	22.7	1.4	19–26	22.7	2.7	18–27	22.3	1.6	20–25	21.7	1.4	20–24
Pelvic-fin origin to posterior anal	14.8	1.3	12–18	15.0	1.0	12–17	14.4	1.9	12–17	15.0	1.5	13–18	14.3	1.2	12–16
Posterior first dorsal to posterior anal	27.8	2.4	22–38	27.5	1.9	23–31	27.9	1.9	25–31	27.3	2.1	25–33	27.4	1.5	24–29
Caudal peduncle length	12.3	2.3	7–16	11.2	1.8	7–15	11.2	1.9	8–14	10.6	2.3	6–15	14.0	3.0	11–23
Pelvic-fin origin to anterior anal	36.3	3.2	31–45	35.2	2.7	30–41	35.3	2.5	32–40	35.2	3.1	29–40	35.5	2.7	30–40
Anal-fin base length	19.6	2.0	15–24	20.2	2.1	16–25	21.6	1.3	20–25	19.5	2.2	14–24	19.8	2.4	13–23
Percent of head length															
Snout length	25.6	2.6	20–31	25.3	2.6	21–30	25.1	2.6	20–30	25.1	1.9	22–29	24.1	3.7	17–29
Postorbital head length	56.9	2.6	52–62	56.1	2.6	50–61	56.3	3.8	47–61	56.8	2.6	51–62	57.5	4.5	52–67
Horizontal eye diameter	21.5	2.7	14–27	22.5	2.4	18–27	22.4	4.2	16–31	22.6	3.0	18–29	24.9	5.0	17–34
Vertical eye diameter	19.5	2.7	13–26	20.1	3.4	14–27	21.6	3.4	15–27	21.0	3.1	15–27	21.0	3.9	16–28
Head depth	71.2	5.4	60–85	73.2	8.4	62–93	76.6	5.3	68–87	73.2	5.0	62–82	81.9	6.3	62–89
Counts	Mode	Freq.	Range	Mode	Freq.	Range	Mode	Freq.	Range	Mode	Freq.	Range	Mode	Freq.	Range
Dorsal-fin spines	12	60.0	11–13	12	70.0	11–12	12	61.1	11–13	12	75.0	11–12	12	60.0	11–13
Dorsal-fin rays	12	62.0	11–13	12	70.0	11–12	12	44.4	10–13	12	60.0	10–13	12	40.0	11–14
Anal-fin rays	9	78.0	8–9	9	60.0	8–10	9	77.8	8–10	9	90.0	8–10	9	60.0	7–10
Pored lateral scales	32	10.0	24–42	30	23.3	23–36	27	27.8	24–34	31	25.0	27–36	34	33.3	25–41
Lateral scales	50	22.0	46–52	48	23.3	45–52	47	22.2	44–51	47	35.0	44–52	50	26.7	44–53
Postlateral scales	1	58.0	0–2	1	60.0	0–2	1	55.6	0–2	1	50.0	0–2	1	53.3	0–2

TABLE 3. VARIABLE LOADINGS ON SIZE AND THE FIRST TWO SHEARED PRINCIPAL COMPONENTS (MORPHOMETRICS) FOR *Etheostoma denoncourti* AND *E. tippecanoe*.

Characters	Size	Sheared PC2	Sheared PC3
Standard length	−0.176	−0.020	0.041
Head length	−0.199	0.099	0.022
Snout length	−0.200	0.187	−0.151
Postorbital head length	−0.231	0.096	−0.114
Horizontal eye diameter	−0.114	−0.007	0.597
Vertical eye diameter	−0.119	−0.027	0.682
Head depth	−0.239	0.101	0.035
Body depth	−0.228	0.077	0.008
Snout to first dorsal-fin origin	−0.172	0.050	−0.017
Snout to pelvic-fin origin	−0.167	0.059	0.010
Dorsal-fin base length	−0.178	0.003	0.047
Anterior first dorsal to anterior anal	−0.186	0.021	0.105
Anterior first dorsal to posterior anal	−0.199	0.140	−0.023
Posterior second dorsal to anterior anal	−0.232	0.010	−0.103
Posterior second dorsal to ventral caudal	−0.224	−0.052	−0.037
Posterior second dorsal to pelvic-fin origin	−0.198	0.045	0.061
Posterior anal to dorsal caudal	−0.230	−0.320	−0.153
Caudal peduncle depth	−0.230	0.140	−0.101
Posterior first dorsal to anterior anal	−0.257	0.066	−0.075
Posterior second dorsal to posterior anal	−0.211	−0.029	−0.209
Posterior first dorsal to posterior anal	−0.199	0.140	−0.023
Caudal peduncle length	−0.263	−0.829	−0.026
Pelvic-fin origin to posterior anal	−0.154	0.036	0.157
Anal-fin base length	−0.210	0.244	−0.033

ble 3). When these variables were each regressed against standard length, there was no indication that any of the variables were impacted by allometric growth (Fig. 3).

A plot of the first principal component scores of the meristic data versus the second sheared principal component scores of the morphometric data showed only slight overlap between *E. denoncourti* and *E. tippecanoe* (Fig. 4). A MANOVA indicated that the clusters formed by *E. denoncourti* and *E. tippecanoe* were significantly different. Duncan's multiple range test showed that the *E. denoncourti* cluster was significantly different from the clusters formed by each of the populations of *E. tippecanoe* along the first principal component of the meristic data, which is loaded highly on pored lateral scales, lateral scales, and dorsal-fin spines (Table 4).

Lateral body coloration of breeding males is orange with 7-9 black bars; bars on nape and caudal peduncle are more intense. Orange spotting occurs between the pectoral and pelvic fins. Breast gray/blue. Two blotches (yellow in breeding males; white in females) on the dorsal and ventral posterior portion of the caudal peduncle. There is a distinct transverse light line dorsally, just anterior to the dorsal-fin origin. Head is brown dorsally, with yellow cheek and orange lower jaw. Three black bars, more diffuse than lateral bars on the body, surround eye. The subocular bar in some individuals is obscured by yellow coloration. Distinct iridescent diagonal slash on cheek. When the head is viewed from the front the cheeks appear faint green. Dorsal fin is gray/orange with orange marginal bar; the rayed portion of the dorsal fin has dark brown blotches proximally. The caudal, anal, and paired fins are faint orange. There are gray/black melanophores present in the caudal and pelvic fins. Pigmentation patterns of females and nonbreeding males are similar to breeding males, but head and body are brown rather than bright orange.

Etymology.—The specific epithet is in honor of Robert F. Denoncourt, who first introduced JRS to the diversity and complexity of the stream fishes in the southern Appalachian drainages. We suggest golden darter as the common name.

Distribution.—*Etheostoma denoncourti* is endemic to the upper Tennessee River drainage (Etnier and Starnes, 1993:542). Historically, it was collected in the Duck, Buffalo, Clinch, and Se-

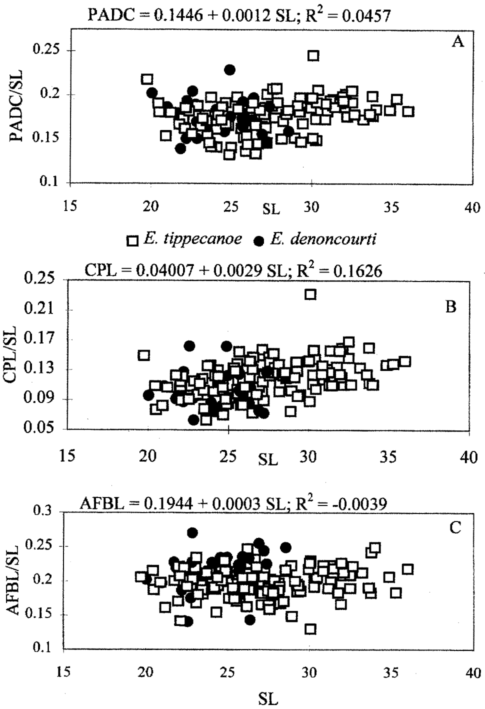

Fig. 3. Plot of ratio of posterior of anal fin to dorsal portion of caudal fin (PADC) to standard length (A), caudal peduncle length (CPL) to standard length (B), and anal-fin base length (AFBL) to standard length (C), against standard length for *Etheostoma denoncourti* (closed circles) and *Etheostoma tippecanoe* (open squares). Regression equations and adjusted R^2 values are at the top of each graph.

quatchie River drainages (Jenkins and Burkhead, 1994), although portions of the Duck River population immediately below Normandy Reservoir may be extirpated (Etnier and Starnes, 1993). When PCA of the meristic data and sheared PCA of the morphometric data are calculated and the resultant components plotted (Fig. 5), differences between the Clinch River population and the Copper Creek (a tributary of the Clinch River) population are apparent, with specimens from the Sequatchie River being intermediate.

TABLE 4. STANDARDIZED SCORING COEFFICIENTS ON MERISTIC DATA FOR *Etheostoma denoncourti* AND *E. tippecanoe.*

Characters	PC1	PC2
Dorsal-fin spines	−0.330	−0.013
Dorsal-fin rays	0.155	0.484
Anal-fin rays	−0.141	0.688
Pored lateral scales	0.431	−0.018
Lateral scales	0.424	0.018
Postlateral scales	0.042	0.439

Life history.—*Etheostoma denoncourti* is a relatively late spawner, with ripe females being collected as late as 4 August from the Clinch River (Jenkins and Burkhead, 1994). Numerous observations have demonstrated that *E. tippecanoe* females are egg buriers (Mount, 1959; Trautman, 1981; Page and Simon, 1988). It is postulated that *E. denoncourti* is also an egg burier as are other *Nothonotus* species including *E. camurum, E. rufilineatum,* and *E. juliae* (Warren et al., 1986). *Etheostoma denoncourti* feeds primarily on small aquatic insects, including mayfly, caddisfly, and midge larvae (Jenkins and Burkhead, 1994).

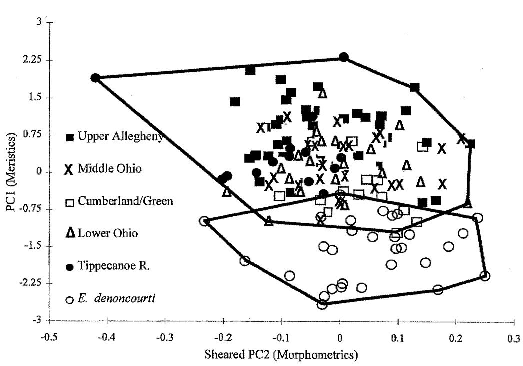

Fig. 4. Plot of individual first principal component scores (meristics) and sheared second principal component scores (morphometrics) of *Etheostoma denoncourti* and populations of *Etheostoma tippecanoe* across its range.

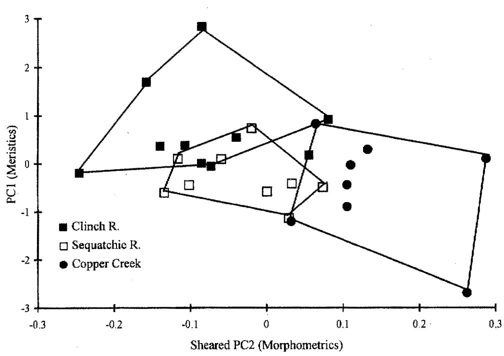

Fig. 5. Plot of individual first principal component scores (meristics) and sheared second principal component scores (morphometrics) of *Etheostoma denoncourti* from the Clinch River (closed squares), Sequatchie River (open squares), and Copper Creek (closed circles), VA and TN.

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