Transactions of the Illinois State Academy of Science
(2011) Volume 104, #3&4, pp. 151-160

received 3/11/10
accepted 7/25/10

Status, Distribution, and Habitat Preferences of the Stripetail Darter *Etheostoma kennicotti* and Spottail Darter *Etheostoma squamiceps* in the Shawnee National Forest, Illinois

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ABSTRACT

In Illinois, the stripetail darter *Etheostoma kennicotti* and spottail darter *Etheostoma squamiceps* are restricted to tributaries of the Ohio River. Because of their narrow ranges, we examined the status, distribution, and habitat preferences of *E. kennicotti* and *E. squamiceps* in streams in the Shawnee National Forest, Illinois, during June 2009 to determine whether these species warrant listing under the Illinois Endangered Species Protection Act. These two fishes were the most abundant darters found and were commonly collected under slab rock and occurred in multiple basins throughout the Shawnee National Forest. Because of its high abundance and occurrence in multiple basins, we feel that neither *E. kennicotti* nor *E. squamiceps* warrant listing at this time.

Key Words: stripetail darter, *Etheostoma kennicotti*, spottail darter, *Etheostoma squamiceps*, Shawnee National Forest, Ohio River tributaries, endangered species

INTRODUCTION

The stripetail darter *Etheostoma kennicotti* and spottail darter *Etheostoma squamiceps* are diminutive (typically < 100 mm), short-lived (typically ≤ 3 years) fishes in the family Percidae, subgenus *Catonotus* (Page, 1974; Page, 1975). These sympatric species are found within the Ohio River drainage, including direct Ohio River tributaries of southern Illinois and Indiana and the Green and Cumberland river basins in central Kentucky and Tennessee (Page, 1983; Etnier and Starnes, 1993). Within Illinois, they are restricted to direct tributaries of the Ohio River (e.g., Lusk, Big Grand Pierre, and Big creeks) in the southern portion of the state (Gunning and Lewis, 1956; Simon, 1987). *Etheostoma squamiceps* is believed to be extirpated from the Little Wabash River basin (Smith, 1979), but is known from a few small direct Wabash River tributaries in Posey County, Indiana (Fisher, 2008). Also, *E. squamiceps* reported from the Cache River basin have been suggested to be misidentified fringed darters *Etheostoma crossopterum* (Poly and Wilson,

1998), and earlier references (e.g., Forbes and Richardson, 1908; O'Donnell, 1935) to *E. squamiceps* having been collected in the Kaskaskia River drainage were misidentified mud darters *Etheostoma asprigene* (Smith, 1979). The biogeographic explanation of *E. kennicotti* and *E. squamiceps* species can be attributed to geological and ecological barriers, dispersal routes, suitable habitats, and competition between species (Page and Schemske, 1978; Braasch and Mayden, 1985). Both species have been described as habitat specialists (Page et al., 1992a). They are found in small, headwater streams; *E. kennicotti* commonly occupies slab pools, whereas *E. squamiceps* typically inhabits slab riffles (Page, 1974; Page, 1975). As with most benthic fishes, darters are negatively affected by anthropogenic disturbances, including channelization, siltation, dredging, mining, oil wells, and impoundments (Page, 1983; Fisher, 2008). Neither *E. kennicotti* nor *E. squamiceps* are listed under the Illinois Endangered Species Protection Act (IESPB, 2005). The purpose of this study was to determine the status, distribution, and habitat preferences of *E. kennicotti* and *E. squamiceps* in direct tributaries of the Ohio River in the Shawnee National Forest, Illinois, and to determine whether either species warrants listing at the state level.

STUDY AREA

The direct tributaries of the Ohio River in the Shawnee National Forest, Illinois, encompass about 250 km^2 of southern Illinois (Page et al., 1992b). In this mostly forested area, the upstream stream segments flow through bluffs fed by numerous small rocky springs, whereas the lower reaches flow through deep cut banks with silt deposits over rocky substrates. These clear, free-flowing streams typically flow over coarse gravel - slab rock riffles and shallow rocky pools. The streams are relatively free of domestic and industrial pollutants but have been degraded by certain agriculture practices. The region historically supported around 80 species of fishes (Smith, 1971; Page et al., 1992b).

METHODOLOGY

Twenty-four sites were sampled in tributaries of the Ohio River in the Shawnee National Forest, Illinois, during June 2009 (Table 1). Sites were established based on habitat characteristics (e.g., rocky substrates) or historical records for *E. kennicotti* and *E. squamiceps*. At each site, at least five transects were uniformly spaced 5-m apart, perpendicular to the river channel, and up to five points were evenly established 0.5-m apart along the length of each transect. The number of transects was dependent upon the length of the run/riffle/pool sequence, and the length of transects was from bank to bank. At least 15 points were sampled per site. Fishes were collected from a 4.5 m^2 area at each point by kicking the substrate 3-m upstream from a stationary 1.5-m wide, 3-mm mesh seine and proceeding downstream to the seine in a back and forth path covering the width of the seine. To minimize disturbance, transects were sampled from downstream to upstream and points were sampled from near shore to far shore. This kick-seining method has been shown to be an appropriate quantitative method for sampling benthic fishes, including darters (Tiemann et al., 2004; Tiemann, 2008). Most fishes were identified, counted, and released upon completion of sampling at a site; at least one voucher specimen of each darter species was retained and deposited in the Illinois Natural History Survey Fish Collection, Champaign.

Subsequent to fish sampling, habitat observations were made at each point by visually assessing substrate size and composition as the percentage of clay/silt, sand, gravel, pebble, cobble/slab rock, and boulder (Tiemann et al., 2004; Tiemann, 2008). For the purpose of this paper, we combined cobble (round) and slab rock (flat) in the same size category. The fredle index was then calculated at each point at each site (McMahon et al., 1996). A high fredle index score represents the predominance of larger substrates, whereas low scores indicate smaller substrates. Mean fredle index scores of occupied points were subtracted from those of unoccupied points for each site, and the resulting values were pooled among sites. A one-sample *t* -test was then used to test for non-random use of available habitat (Gillette et al., 2006; Tiemann, 2008). If *E. kennicotti* and *E. squamiceps* randomly chose substrates then the expected value for the difference between occupied and unoccupied would be close to zero and the *t* would be non-significant; however, a significant positive *t* would indicate occupied > unoccupied and suggest that habitat is non-random. Pearson's correlation coefficient also was calculated to examine potential relationships of substrate composition percentages with *E. kennicotti* and *E. squamiceps* abundances (Tiemann, 2008). Substrate variables were arcsine–square-root transformed because they were proportional data (Zar, 1999), and sequential Bonferroni-correction of $\alpha = 0.05$ was applied to help limit the Type I error of multiple tests (Rice, 1989). Statistical analyses were performed with SAS, Version 8 (SAS Institute Inc., Cary, NC). We did not measure size of fishes; therefore, we could not differentiate among age classes for non-random use of available habitat and habitat correlations, nor could we test the theory proposed by Page and Schemske (1978) that *E. kennicotti* would be smaller with the presence of *E. squamiceps*.

Distribution models for both species were generated using georeferenced locality data, GIS environmental layers of the sample area, and the Maxent species distribution algorithm (Phillips et al., 2006). Maxent is a general-purpose machine learning approach to the modeling of species distributions using presence-only data (Phillips et al., 2006). Maxent predicts the potential distribution of a species by estimating the probability distribution of maximum entropy across a specified region, subject to a set of constraints that represent the incomplete information about the target distribution (Phillips et al., 2006). Occurrence locations of each species throughout the sample area were combined with topographic, land use, and geologic GIS data to predict suitable habitat within the sample area. Factors included in the GIS data were elevation, slope, soil association, flow accumulation, and land use data.

RESULTS / DISCUSSION

Thirty-three species from 11 families were collected at the 24 sites (329 points) sampled in the Shawnee National Forest (Table 2). A total of 313 stripetail darters were found at 17 sites and 68 spottail daters were found at 13 sites (Table 1; Table 2; Figure 1; Figure 2). We failed to find *E. kennicotti* at three historical sites and *E. squamiceps* at two historical sites (Table 1). Both darters were found throughout the Shawnee National Forest and in multiple basins, including Lusk, Big, and Big Grand Pierre creeks; Haney Creek was the only basin where we collected only one of the two target species (Table 1). Where encountered, *E. kennicotti* densities ranged from 0.01 to 0.68 indiv/m^2 (mean: 0.21 ± 0.20 indiv/m^2 SD – Table 1) and was the most abundant fish collected (Table 2) whereas, *E. squamiceps* densities ranged from 0.01 to 0.21 indiv/m^2 (mean: 0.05 ± 0.06

indiv/m^2 SD – Table 1) and was the third most abundant fish captured (Table 2). Although not sampled, both darters also are known from the Saline River basin, Illinois, and *E. kennicotti* is known from the Cache River basin, Illinois (Page and Smith, 1976; INHS Fish Collection data).

Non-random habitat use was evident for both *E. kennicotti* and *E. squamiceps*, which is common in darters (Gillette et al., 2006; Tiemann et al., 2008). These syntopic species were found in areas with higher fredle index scores (*E. kennicotti* - $t = 4.57$, $P = 0.0002$ and *E. squamiceps* - $t = 5.63$, $P < 0.0001$), which is indicative of areas with larger substrates. *Etheostoma kennicotti* abundance was positively correlated with percent gravel ($r = 0.36$, $P = 0.003$) and cobble/slab rock ($r = 0.43$, $P = 0.0002$), whereas *E. squamiceps* abundance was positively correlated with percent cobble/slab rock ($r = 0.56$, $P < 0.0001$); no other correlations were significant. *Etheostoma kennicotti* and *E. squamiceps* were seldom collected in other habitats, but both species have been known to inhabit other areas if suitable habitat is not present. *Etheostoma kennicotti* has been reported from gravel areas (Braasch and Mayden, 1985; Simon, 1987), whereas *E. squamiceps* has been recorded from woody debris and rip-rap piles (Strange, 1992; Fisher, 2008).

In order to develop and test the Maxent distribution model, locations containing each species were evenly divided into training and test groups. The training groups were used to develop the model for each species. After developing the model, the test sites were entered to quantify the predicting power of the model. Four recent (post-1990) historical locations for *E. squamiceps* were used to increase the number of locations to 17. The Maxent models for both species were significant (*E. kennicotti* - $AUC = 0.888$, $P = 0.02$ and *E. squamiceps* - $AUC = 0.954$, $P < 0.01$). Elevation (45.3%), land cover (43.3%) and soil association (11.3%) were the most important variables in explaining the distribution of *E. kennicotti* in the study area. The percent contribution of each variable in the *E. squamiceps* model was 36.2% elevation, 26.8% soil association, 23.6% slope and 13.4% land use. Land use contribution may be slightly elevated due to the inclusion of roads in the land use data and the close proximity of each sample site to a road/bridge. The results of the Maxent distribution model suggest that both species tend to favor the wooded valleys of the Shawnee National Forest. Suitable areas for both species tend to occur in areas of steep, shallow, rocky soils; streams with less of a slope and deeper soils also appear to be suitable for *E. kennicotti*. This result was most apparent in the Haney Creek basin, which contains a different soil association than most of the sample area and is the only basin where *E. kennicotti* was found in the absence of *E. squamiceps*.

MANAGEMENT CONSIDERATIONS

Neither *E. kennicotti* nor *E. squamiceps* warrant listing at this time. Although both *E. kennicotti* and *E. squamiceps* have a small distribution within the state, both species are common in several sub-basins, and the Shawnee National Forest offers ample habitat and some protection from anthropogenic disturbances. After examining the Maxent distribution model for each species, it appears that the majority of the suitable habitat in the Shawnee National Forest is already being occupied by that species. Regarding *E. squamiceps* and its affinity for specialized habitats, other studies have suggested that habitat is a limiting factor in determining the fish's distribution or reproductive locations (Bandoli et al., 1991; Strange, 1992). Because of the lack of habitat in large rivers (e.g.,

the Ohio River), populations are isolated from one another and it is unlikely that they will intermix or expand their range into new basins (Braasch and Mayden, 1985; Page et al., 1992a). *Etheostoma kennicotti*, on the other hand, can occupy a variety of habitats and has excellent dispersal capabilities (Braasch and Mayden, 1985; Etnier and Starnes, 1993). Therefore, it might be able to regionally recolonize a basin should it become extirpated (e.g., short distances within Illinois, such as from one direct tributary to another); however, Page and Smith (1976) suggested that the Ohio River is an effective barrier, so if *E. kennicotti* becomes extirpated from Illinois, it might not be able to recolonize from either the Green or Cumberland rivers.

ACKNOWLEDGMENTS

Funds were provided in part by a grant from the Illinois Department of Natural Resources' Wildlife Preservation Fund and the Illinois Department of Transportation. C. Abert (ISGS) assisted in map creation. C.A. Phillips (INHS) offered constructive criticism.

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Table 1. Sampling locations and densities of *Etheostoma kennicotti* ('*E. kenn*') and *Etheostoma squamicpes* ('*E. squam*') during the 2009 survey in tributaries of the Ohio River in the Shawnee National Forest, Illinois. Densities are the number of individuals / meter^2. 'Hist" indicates that a historic record resides in the Illinois Natural History Survey Fish Collection, Champaign, for that species at that site.

County	Sub-basin	Stream	Latitude	Longitude	*E. kenn*	*E. squam*
Pope	Lusk	Lusk Creek	37.54469	-88.53918	0.43	0.00
Pope		Lusk Creek	37.50596	-88.53747	0.28	0.03
Pope		Lusk Creek	37.47249	-88.54800	0.16	Hist
Pope		Little Lusk Creek	37.56771	-88.50655	0.00	0.16
Pope		Trib. Little Lusk Creek	37.53390	-88.48281	0.25	0.09
Pope		Quarrel Creek	37.42534	-88.60246	0.00	0.00
Pope		Rocky Branch	37.36918	-88.54693	0.00	0.06
Pope	Big Grand Pierre	Big Grand Pierre Creek	37.58130	-88.43659	0.04	0.12
Pope		Big Grand Pierre Creek	37.48247	-88.44096	0.68	0.00
Pope		Simmons Creek	37.43196	-88.47972	0.36	0.01
Pope		Hobbs Creek	37.49784	-88.41932	0.31	0.03
Hardin		Pinhook Creek	37.56157	-88.40825	Hist	0.00
Hardin	Threemile	Threemile Creek	37.46004	-88.37715	0.00	0.02
Hardin		Threemile Creek	37.44198	-88.37355	0.12	0.04
Hardin	Big	Big Creek	37.57698	-88.30192	0.15	0.10
Hardin		Big Creek	37.53343	-88.32653	0.12	Hist
Hardin		Big Creek	37.47944	-88.34226	Hist	0.00
Hardin		Goose Creek	37.50623	-88.33540	0.10	0.10
Hardin		Hogthief Creek	37.51082	-88.27707	Hist	0.21
Hardin	Peters	Peters Creek	37.51762	-88.21803	0.00	0.00
Hardin		Peters Creek	37.48720	-88.25596	0.56	0.07
Hardin	Haney	Haney Creek	37.52301	-88.16102	0.47	0.00
Hardin		Haney Creek	37.52801	-88.11980	0.36	0.00
Hardin		Haney Creek	37.51495	-88.11093	0.29	0.00

Table 2. Fishes collected during the 2009 survey in tributaries of the Ohio River in the Shawnee National Forest, Illinois.

Family	Common name	Scientific name	No. indiv.
Clupeidae	Gizzard shad	*Dorosoma cepedianum*	8
Cyprinidae	Central stoneroller	*Campostoma anomalum*	58
	Spotfin shiner	*Cyprinella spiloptera*	19
	Blacktail shiner	*Cyprinella venusta*	1
	Striped shiner	*Luxilus chrysocephalus*	17
	Redfin shiner	*Lythrurus umbratilis*	35
	Emerald shiner	*Notropis atherinoides*	14
	Bluntnose minnow	*Pimephales notatus*	52
	Creek chub	*Semotilus atromaculatus*	46
Catostomidae	Creek chubsucker	*Erimyzon oblongus*	7
	Northern hogsucker	*Hypentelium nigricans*	12
	Golden redhorse	*Moxostoma erythrurum*	1
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	3
	Tadpole madtom	*Noturus gyrinus*	2
Aphredoderidae	Pirate perch	*Aphredoderus sayanus*	17
Atherinidae	Brook silverside	*Labidesthes sicculus*	12
Fundulidae	Blackspotted topminnow	*Fundulus olivaceus*	3
Cottidae	Banded sculpin	*Cottus carolinae*	7
Centrarchidae	Rock bass	*Ambloplites rupestris*	3
	Green sunfish	*Lepomis cyanellus*	11
	Warmouth	*Lepomis gulosus*	1
	Bluegill	*Lepomis macrochirus*	7
	Longear sunfish	*Lepomis megalotis*	13
	Spotted bass	*Micropterus punctulatus*	3
Percidae	Rainbow darter	*Etheostoma caeruleum*	146
	Slough darter	*Etheostoma gracile*	2
	Stripetail darter	*Etheostoma kennicotti*	313
	Johnny darter	*Etheostoma nigrum*	12
	Orangethroat darter	*Etheostoma spectabile*	52
	Spottail darter	*Etheostoma squamiceps*	68
	Logperch	*Percina caprodes*	5
	Blackside darter	*Percina maculata*	1
Sciaenidae	Freshwater drum	*Aplodinotus grunniens*	7

Figure 1. Distribution of stripetail darter *Etheostoma kennicotti* in Pope and Hardin counties, Illinois. During this 2009 survey, solid squares indicate positive sites, open squares indicate negative sites, and solid diamonds indicated historical record (e.g., fish collected during previous surveys).

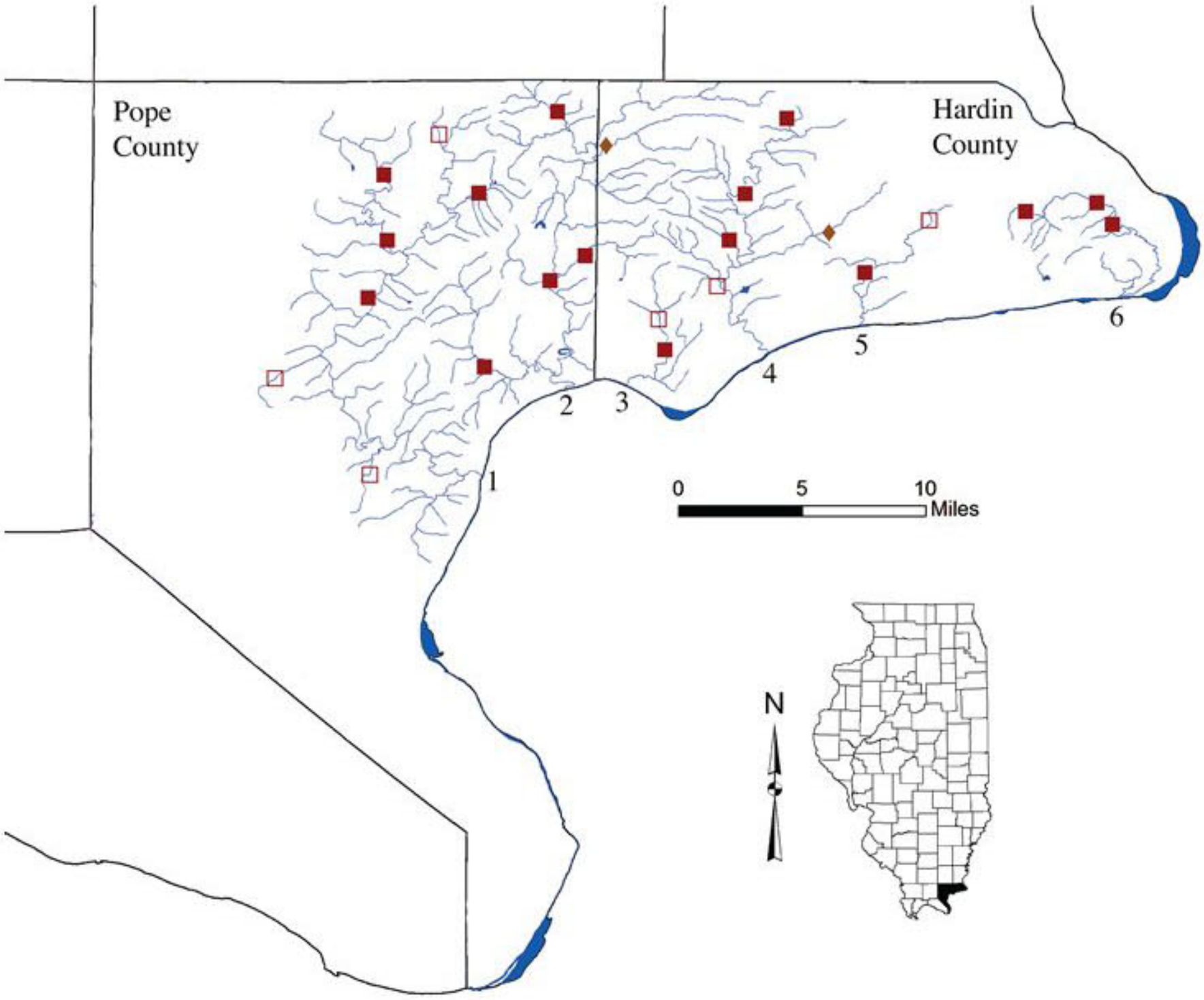

Figure 2. Distribution of spottail darter *Etheostoma squamiceps* in Pope and Hardin counties, Illinois. During this 2009 survey, solid squares indicate positive sites, open squares indicate negative sites, and solid diamonds indicated historical record (e.g., fish collected during previous surveys).