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Status of Darters in the Wabash River Basin in Illinois, and its Implications on Recovery Actions for Three Listed Freshwater Mussels

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CHAPTER 1* - Distribution and Life History Characteristics of the State-Endangered Bluebreast Darter *Etheostoma camurum* (Cope) in Illinois

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Abstract

The bluebreast darter *Etheostoma camurum* (Cope) has a disjunct distribution within the Ohio River drainage. I examined the distribution and life history characteristics of *E. camurum* in the Vermilion River basin (Wabash River drainage), Illinois, during the summer of 2007. The darter commonly was collected in areas of moderate to swift currents over cobble and boulder. It spawned in these areas during early summer, and consumed predominately aquatic insect larvae for its diet. Because of its small range, I recommend the species remain listed as state-endangered.

Introduction

The bluebreast darter *Etheostoma camurum* (Cope) is a diminutive (typically < 125 mm), short-lived (typically < 3 years) fish in the Family Percidae (Page, 1983). It is sporadically distributed in several streams in the Ohio River drainage, including the Allegheny River basin in New York and Pennsylvania, the Wabash River basin in Indiana and Illinois, and the Tennessee River basin in North Carolina and Tennessee (Zorach, 1972; Page, 1983). This range can be attributed to recent degradation and fragmentation of habitat following post-Pleistocene dispersal (Zorach, 1972). *Etheostoma camurum* is a habitat specialist usually found on the streambed in depths of 10 - 30 cm under boulder in fast riffles in large, clear streams (Page, 1983; Greenberg, 1991; Stauffer et al., 1996; Welsh and Perry, 1998). In Illinois, it is found only in the Vermilion River basin of the Wabash River drainage (Smith, 1979). No other Illinois streams contain the preferred habitat requirements of *E. camurum*, and earlier references (e.g., Large, 1903; Forbes and Richardson, 1920; O'Donnell, 1935) of the species having been collected elsewhere in central and southern Illinois were based on misidentifications (Smith, 1979). As with most benthic fishes, *E. camurum* is negatively affected by anthropogenic disturbances, including siltation and impoundments (Trautman, 1981; Etnier and Starnes, 1993). The bluebreast darter is listed as state-endangered in Illinois because of its small range in the state (IESPB, 2005).

Darters are an ecological important group of fishes. Not only are they a food source to many animals (Page, 1983), but they also are hosts to many freshwater mussels (OSU, 2008). The bluebreast darter is no exception. Based on data from OSU (2008), *E. camurum* is used as a host for the federally-endangered northern riffleshell *Epioblasma rangiana* (Lea) and the Illinois state-endangered rainbow *Villosa iris* (Conrad). Therefore, a reduction in *E. camurum* could have profound effects on other aquatic faunas, including freshwater mussels.

The northern riffleshell is extirpated from the state (Cummings and Mayer, 1997). Efforts are underway to propagate and reintroduce the species back into Illinois. To date, no comprehensive study has examined the distribution of *E. camurum* and compared it to the historical distribution of *E. rangiana* in the Vermilion River basin, Vermilion County, Illinois. Without such data, recovery efforts for *E. rangiana* could be unsuccessful because the host fish might not be present. The purpose of this study was to determine distribution of *E. camurum* in the Vermilion River basin and relate those data to the historical distribution of *E. rangiana* in the basin. By comparing the two data sets, natural resource managers can choose optimal reintroduction sites for *E. rangiana* in the basin. Additional objectives were to determine life history characteristics (habitat, spawning, and diet) of *E. camurum* in the Vermilion River basin.

Study area

The Vermilion River basin of the Wabash River drainage (Figure 1) encompasses nearly 4,000 km^2 of eastern Illinois and western Indiana, and contains one of the highest quality stream systems in Illinois in terms of aquatic biodiversity (Smith, 1968; Page et al., 1992). The basin historically supported at least 45 species of freshwater mussels (Tiemann et al., 2007a) and over 100 species of fishes, including 14 darter species (INHS Fish Collection). The dominant substrates in the basin are sand, gravel, and cobble, with small amounts of localized silt (Smith, 1968; Page et al., 1992). The watershed is primarily agriculture with the two major crops being corn and soybeans and has an intact riparian zone in most areas (Smith, 1968; Page et al., 1992).

During the past 150 y, the Wabash River drainage has experienced significant physical and biological changes as a result of anthropogenic disturbances (Simon, 2006), and the Vermilion River basin is no exception. Human induced modifications include draining of wetlands, dredging of streams, pollution from agriculture and industrial sources, removal of riparian areas, development of floodplains, and impounding of streams (Smith, 1968; Larimore and Bayley, 1996). The mainstem and its three largest tributaries (Salt Fork, Middle Fork, and North Fork) are relatively free-flowing, but several dams, including three in the Danville area, occur throughout the basin. However, despite these anthropogenic disturbances, which have been shown to cause alterations in fish assemblages (Smith, 1968; Tiemann et al., 2004; Santucci et al., 2005), the Vermilion River basin is one of the least altered basins in Illinois, and the fish fauna is still relatively intact (Page et al., 1992; Retzer 2005).

Methods

Fish sampling – Thirty sites were sampled in the Vermilion River basin (Table 1; Figure 1) from 12 May 2007 – 21 Aug 2007. Sites were established based on either habitat characteristics (e.g., moderate to swift flows and cobble/boulder substrates) or historical records for *E. camurum* or *E. rangiana*. At each site, at least five transects were uniformly spaced 5-m apart, perpendicular to the river channel along the length of the gravel bar, and up to ten 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 gravel bar, and the length of transects was from bank to bank. 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 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). Fishes were identified, counted, and released upon completion of sampling at a site; only four *E. camurum* were vouchered because they either represented an upstream distribution records of the species (one fish each at two sites) or were crushed while kick-seining (two fish at one site).

Natural history observations – Subsequent to fish sampling, natural history (habitat, reproduction, and diet) observations were made. For habitat, depth and substrate composition was assessed visually at each point where fishes were collected (Tiemann et al., 2004). Depth was measured with a meter stick, and substrate composition was visually estimated as the percentage of clay/silt, sand, gravel, pebble, cobble, and boulder. The fredle index was calculated for substrate composition at each point at each site (McMahon et al., 1996). A high fredle index score represents the predominance of larger substrates. Mean fredle index scores of occupied points were subtracted from those of unoccupied points for each site, and then 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). If *E. camurum* 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 habitat variables (depth and substrate composition percentages) with *E. camurum* abundance. 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).

Reproductive and feeding behaviors were observed three times by snorkeling during the study period (May 24, June 22, and July 20). Fish were observed for 4 hr during each event at Site 12 (Table 1). Site 12 was chosen because of public access and habitat characteristics (e.g., clear, shallow water with cobble/boulder substrates and moderate flows). Additional sites were not observed because of time constraints. After approximately 5 min of being in the water, fish seemed disinterested in my presence and continued with apparently normal activities.

Results / Discussion

Bluebreast darter distribution and habitat preference – Forty-seven species from 11 families were collected at the 30 sites (794 points) sampled in the Vermilion River basin (Table 2). Seventy-nine bluebreast darters were found at 17 sites (Table 1; Table 2). Densities ranged from 0.000 to 0.074 indiv/m^2 (mean: 0.021 ± 0.0232 indiv/m^2 SD – Table 1), and it was the 4th most abundant darter and 10th most abundant fish collected (Table 2). The bluebreast darter was found in all three forks of the Vermilion River and in the mainstem itself (Table 1; Figure 1). Based on literature reviews (e.g., Larimore et al., 1952; Larimore and Smith, 1963; Smith, 1968; Larimore and Bayley, 1996) and museum records (e.g., INHS Fish Collection, which has >3,500 records from >100 sites in the basin), it appears that *E. camurum* does not occur elsewhere in the basin.

The bluebreast darter was found in depths varying from 7 to 43 cm (mean: 27.5 $\pm$ 8.32 cm SD). Although flow was not measured, individuals were found in areas with moderate to swift currents (estimated as >4.5 m/s). Non-random habitat use was evident for *E. camurum*, which is common in lotic fishes. Individuals were found in areas with higher fredle index scores ($t = 6.46$, $P = 0.0002$), which is indicative of areas with larger substrates. Bluebreast darter abundance was positively correlated with percent cobble ($r = 0.54$, $P < 0.0001$) and boulder ($r = 0.34$, $P = 0.0003$) substrates; no other correlations were significant. *Etheostoma camurum* was seldom collected in other habitats. Only two individuals were found in points that lacked cobble/boulder and moderate to swift flows (individuals were found in sandy gravel area with no flow). These accounts are similar to those previously reported (e.g., Mount, 1959; Page, 1983).

Densities of *E. camurum* in the Salt Fork varied from 0.000 indiv/m^2 to 0.071 indiv/m^2 (mean: 0.025 $\pm$ 0.0282 indiv/m^2 SD – Table 1). In the Salt Fork, the darter was found from just south of Muncie to the confluence with the mainstem (Table 1; Figure 1). The habitat in this area was sand and gravel with several large areas of moderate to swift currents over cobble and boulder; upstream of this area was predominately sand and gravel with very little cobble and boulder. Goodnight and Wright (1940) reported *E. camurum* from the Salt Fork, but Smith (1979) believed this population became extirpated as a result of anthropogenic disturbances. The Salt Fork basin historically has been affected by industrial and agricultural pollution, impoundments, and strip-mining, all of which cause detrimental effects to freshwater ecosystems (Baker, 1922; Larimore and Smith, 1963; Larimore and Bayley, 1996). Downstream portions of the Salt Fork are protected by Kickapoo State Park.

The Middle Fork had the highest densities of *E. camurum* collected during this survey with values ranging from 0.000 to 0.074 indiv/m^2 (mean: 0.032 $\pm$ 0.0233 indiv/m^2 SD – Table 1). In the Middle Fork, which supports one of the healthiest aquatic ecosystems in the state (Smith, 1971), the darter was collected from the Potomac area to the confluence with the mainstem (Table 1; Figure 1). The habitat in this area was sandy gravel with large areas of swift currents over cobble and boulder; upstream of this area was mostly sand and gravel with very little cobble and boulder. The water quality of the Middle Fork has deteriorated over time, primarily as a result of agricultural and industrial runoff (Smith, 1968; Smith, 1971). Other disturbances occurring in the Middle Fork include dredging, strip-mining, and impoundments (Smith, 1968). Portions of the Middle Fork are protected by state parks.

This survey was the first to document *E. camurum* in the North Fork. One individual (INHS 101616) was collected in a small patch of cobble downstream of the lowhead dam beneath the US Hwy 150 bridge (Table 1; Figure 1). This dam (~1 km upstream from the confluence) is the most downstream of three dams on the North Fork Vermilion River, all of which are in Danville. The habitat in the North Fork is mostly sand and gravel with very little cobble and boulder. If *E. camurum* is expanding its range in the North Fork Vermilion River, it seems likely the lowhead dams will prevent further upstream movement. Impoundments fragment populations of aquatic organisms by not only altering their habitats, but also by blocking their upstream dispersal capabilities (Tiemann et al., 2004; Santucci et al., 2005; Tiemann et al., 2007b).

Etheostoma camurum was sporadically distributed in the mainstem of the Vermilion River. Densities ranged from 0.000 to 0.044 indiv/m^2 (mean: 0.012 $\pm$ 0.0175 indiv/m^2 SD – Table 1). In the mainstem, the darter was found infrequently downstream to the state line (Table 1; Figure 1), and it does not appear to occur beyond the state line in Indiana (B.E. Fisher, Indiana DNR, pers. comm.) The reason for the low densities and patchy distribution appears to be related to habitat. The habitat in the mainstem was predominately sandy gravel with small patches of cobble and boulder. As with other areas in the Vermilion River basin, the mainstem is affected by agricultural and industrial pollution and impoundments (Smith, 1968; Smith, 1971).

Carney et al. (1993) stated that the range of *E. camurum* has diminished in portions of the Wabash River drainage. However, this does not appear to be the case in the Vermilion River basin. It appears that *E. camurum* is expanding its range in the basin based on the fact that it has a larger distribution than what was reported by Smith (1968) or Smith (1979). Perhaps this pattern is the result of sampling effort. Goodnight and Wright (1940) and Fisher et al. (1998) suggested that the preferred habitats of *E. camurum* (e.g., fast flowing riffles containing boulders) might have been inadequately sampled during previous surveys, and might be a factor accounting for the infrequency with which they were taken. Goodnight and Wright (1940) suggested that, in order to collect *E. camurum*, it is "necessary to dislodge the rocks and drive the darters into the net." During the 2007 survey, the systematic kick-seining method of transects and points allowed sampling throughout the entire streambed, including those areas that had swift currents over boulder and therefore could account for the new distribution records.

Reproduction – Spawning was witnessed for *E. camurum* on 22 June 2007 when water temps were 24° C. Males did not develop breeding tubercles, as is seen with some darters. Males established territories in crevices created by cobble and boulder and became aggressive (e.g., chasing and fin biting) when other males neared their territories. I did not witness if the coloration of the males intensified during the aggressive behavior as reported by Mount (1959). The genital papillae of the females were conical tubes, which aids in burying eggs (Page, 1983). Although not witnessed during this study, reported that females become aggressive toward other females and develop black bands behind the pectoral fins during the aggressive behavior.

Females enticed males to spawn by darting over gravel near cobble and boulder at the head of the riffle. These areas appear to offer refuge from the swift current (Etnier and Starnes, 1993). When ready to spawn, a female raised her tail and put her head down into the gravel and then swam forward to bury herself. As this act was occurring, a male partially wrapped himself around her and then released sperm. During spawning, the pair vibrated and the female deposited eggs in the gravel. The vibration lasted <10 sec and occurred multiple times during the spawning act, which lasted ≤1 hr. The demersal eggs, which adhered in large clumps to the substrate, were 2 mm in diameter, transparent, spherical, and had colorless yolks. The number of eggs could not be determined but Mount (1959) reported that a female can lay approximately 100 eggs. It did not appear that the males guard the nest as reported in Etnier and Starnes (1993).

The above breeding account agrees with those reported by Mount (1959). Spawning season for *E. camurum* can run from mid-May to early August (Page, 1983). However, no spawning activities were witnessed on 24 May 2007 when water temperatures were 19° C or on 20 July 2007 when water temperatures were 27° C. Mount (1959) reported that the incubation period lasts 7-10 d at 19-23° C. The bluebreast darter has been shown to hybridize with other darters, including the Tippecanoe darter *Etheostoma tippecanoe* (Jordan and Evermann) and the greenfin darter *Etheostoma chlorobranchium* Zorach (Mayden and Burr, 1980; Eisenhour, 1995).

Diet – The bluebreast darter was witnessed eating aquatic insects, including midge larvae and small mayfly and stonefly nymphs. These food items agree with previous accounts for the species (Page, 1983; Etnier and Starnes, 1993; van Snik Gray et al., 1997). van Snik Gray et al. (1997) suggested that *E. camurum* specializes on prey <6 mm and potentially could compete for food resources with several darters, including greenside darter *Etheostoma blennioides* (Rafinesque), which is found in the Vermilion River basin. Also witnessed during my study were three separate, unsuccessful attempts made by *E. camurum* to eat the aquatic snail *Elimia livescens* (Menke) of the Family Pleuroceridae. It appeared that the fish's gape size was too small to consume the snails, which were about 8 mm in length. Darters have been shown to consume aquatic snails (Page, 1983; Etnier and Starnes, 1993), although it is unknown what percentage of snails, if any, comprises the diet of *E. camurum*.

Potential recovery efforts for the northern riffleshell – Based on literature reviews (e.g., Smith, 1979; Cummings and Mayer, 1997) and museum records (e.g., INHS Fish Collection; INHS Mollusk Collection), *E. rangiana* and *E. camurum* co-occurred in only the Vermilion River basin in Illinois. In the Wabash River drainage, *E. rangiana* is extant in the Tippecanoe and White river basins (Fisher, 2006), whereas *E. camurum* is extant in the Tippecanoe River basin (Carney et al., 1992) and Wabash mainstem (Fisher et al., 1998). Potential source populations for *E. rangiana* propagation could be the Tippecanoe River basin, and optimal relocation sites in Illinois are in the lower Middle Fork. These areas offer the highest densities of *E. camurum* and preferred habitat (e.g., gravel riffles) for *E. rangiana* (Cummings and Mayer, 1992). These areas are located in state park systems, and therefore offer instream protection. However, because of public areas, there is potential for interference in propagation methods from park users.

Bluebreast darter status –Etheostma camurum should remain listed as state-endangered. Because of its small range in Illinois and its affinity for specialized habitats, the species easily could be extirpated from the state by catastrophic events (e.g., a chemical spill). If this disaster were to occur, it would be unlikely that *E. camurum* could repopulate the Vermilion River basin naturally. With its sporadic distribution in the Wabash River drainage, the closest source population would be the Big Pine Creek basin in Indiana (B.E. Fisher, Indiana Department of Natural Resources, pers. comm.), a distance of >70 km. Although *E. camurum* can migrate if suitable substrates are present (Trautman, 1981), the habitat from the lower Big Pine Creek basin to the lower Vermilion River is mostly sandy gravel with very little cobble and boulder (pers. obser.; B.E. Fisher, Indiana Department of Natural Resources, pers. comm.). Therefore, all efforts should be taken to protect its habitat and prevent future disasters from occurring.

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Table 2. Fishes collected during the 2007 survey in the Vermilion River basin (Wabash River drainage), Vermilion County, Illinois. Special status: ^{SE} = state-endangered.

Family	Common name	Scientific name	No. indiv.
Lepisosteidae	Longnose gar	*Lepisosteus osseus*	1
Clupeidae	Gizzard shad	*Dorosoma cepedianum*	8
Cyprinidae	Central stoneroller	*Campostma anomalum*	258
	Spotfin shiner	*Cyprinella spiloptera*	19
	Steelcolor shiner	*Cyprinella whipplei*	17
	Bigeye chub	*Hybopsis amblops* ^{SE}	1
	Striped shiner	*Luxilus chrysocephalus*	7
	Redfin shiner	*Lythrurus umbratilis*	12
	Hornyhead chub	*Nocomis biguttatus*	21
	Golden shiner	*Notemigonus crysoleucas*	3
	Emerald shiner	*Notropis atherinoides*	18
	Bigeye shiner	*Notropis boops* ^{SE}	3
	Silverjaw minnow	*Notropis buccatus*	16
	Carmine shiner	*Notropis percobromus*	51
	Sand shiner	*Notropis stramineus*	72
	Suckermouth minnow	*Phenacobius mirabilis*	6
	Bluntnose minnow	*Pimephales notatus*	341
	Creek chubsucker	*Semotilus atromaculatus*	223
Catostomidae	Quillback	*Carpoides cyprinus*	1
	White sucker	*Catostomus commersonii*	3
	Northern hogsucker	*Hypentelium nigricans*	218
	Black redhorse	*Moxostoma duquesnei*	1
	Shorthead redhorse	*Moxostoma macrolepidotum*	5
Ictaluridae	Yellow bullhead	*Ameiurus natalis*	26
	Channel catfish	*Ictalurus punctatus*	17
	Stonecat	*Noturus flavus*	362
	Tadpole madtom	*Noturus gyrinus*	22
	Brindled madtom	*Noturus miurus*	49
	Flathead catfish	*Pylodictis olivaris*	3
Esocidae	Grass pickrel	*Esox americanus*	7
Atherinidae	Brook silverside	*Labidesthes sicculus*	21
Fundulidae	Blackstripe topminnow	*Fundulus notatus*	19
Centrarchidae	Rock bass	*Ambloplites rupestris*	5
	Green sunfish	*Lepomis cyanellus*	17
	Orangespotted sunfish	*Lepomis humilis*	8
	Bluegill	*Lepomis macrochirus*	31
	Longear sunfish	*Lepomis megalotis*	92
	Smallmouth bass	*Micropterus dolomieu*	29
Percidae	Greenside darter	*Etheostoma blennioides*	517
	Rainbow darter	*Etheostoma caeruleum*	481
	Bluebreast darter	*Etheostoma camurum* ^{SE}	79
	Fantail darter	*Etheostoma flabellare*	212
	Johnny darter	*Etheostoma nigrum*	72
	Logperch	*Percina caprodes*	7
	Slenderhead darter	*Percina phoxocephala*	19
	Dusky darter	*Percinia sciera*	3
Sciaenidae	Freshwater drum	*Aplodinotus grunniens*	11

a)

b)

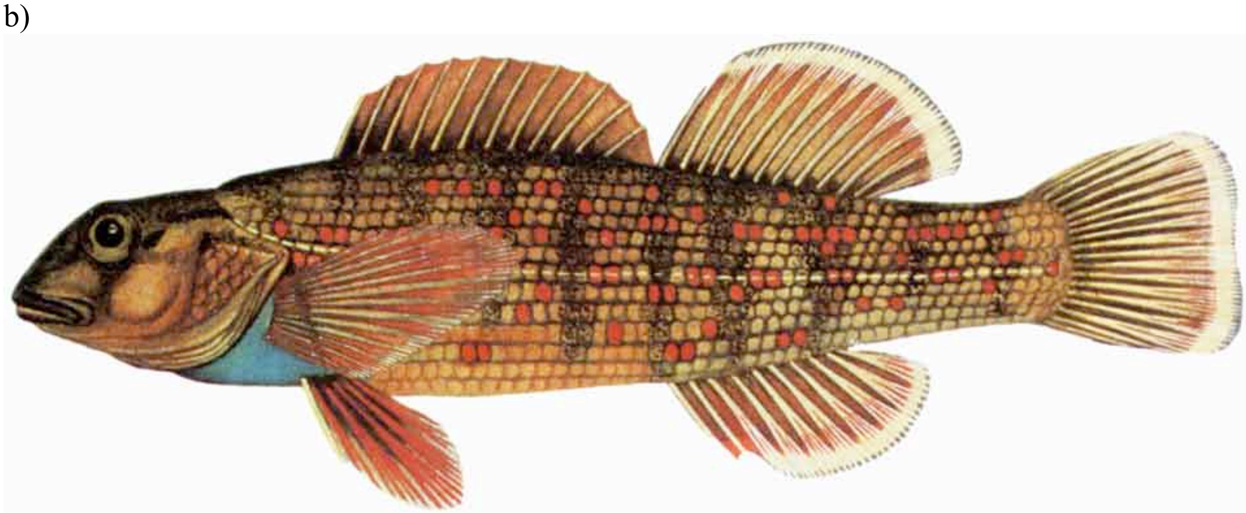

Figure 2. a) Northern riffleshell *Epioblasma rangiana* (Lea) and b) bluebreast darter *Etheostoma camurum* (Cope). Northern riffleshell photo by Kevin Cummings and bluebreast darters drawing by Rob Criswell.

Appendix 1 – Distribution of clubshell host fishes in the Vermilion River basin.

Not reported in Tiemann (2008) were the distributions of striped shiner *Luxilus chrysocephalus*, logperch *Percina caprodes*, and blackside darter *Percina maculata* during the 2007 surveys. All three species are reported host fish for the clubshell *Pleurobema clava* (OSU, 2008). The central stoneroller *Campostoma anomalum*, another host fish for *P. clava* (OSU, 2008), was found in abundant numbers throughout the Vermilion River basin during the 2007 surveys. Locations and methods follow those from Tiemann (2008). Also included below are years and sites where I have collected striped shiner, logperch, and blackside darter in the Vermilion River basin prior to the 2007 surveys.

Species	Year and sites species collected by author during 2007 surveys	Years and sites species collected by author prior to 2007 surveys
Striped shiner	2007 – Site 17	2003 – sites 4, 19, 23 2005 – Site 29
Logperch	2007 – Site 19, 20	2003 – sites 4, 23 2004 – Site 9 2005 – Site 29
Blackside darter	-	2003 – sites 4, 13, 19, 25 2004 – Site 9

* Banded darter *Etheostoma zonale* and mottled sculpin *Cottus bardi* are reported host fish for the northern riffleshell *Epioblasma rangiana* (OSU, 2008); I did not collect either species during the 2007 surveys, nor during previous surveys.

CHAPTER 2* - Status of the Snuffbox *Epioblasma triquetra* (Rafinesque, 1820) in Illinois: A Functionally Extirpated Species

*These data were submitted to the Transactions of the Illinois State Academy of Science

Abstract

The snuffbox *Epioblasma triquetra* (Rafinesque) is one of the rarest freshwater mussels in Illinois. It is found only in a small stretch of the Embarras River in Douglas and Coles counties. I estimated density, length frequency, and sex ratio of this population to note its status in Illinois, and examined the status of the snuffbox's host fish, the logperch *Percina caprodes* (Rafinesque), to determine if the host fish's occupancy could be a limiting factor. I established seven sites in the Embarras River and sampled freshwater mussels and fishes during the summers of 2007 and 2008. Densities varied from 0.00 – 0.13 indiv/m^2 per site (mean = 0.02 $\pm$ 0.05 indiv/m^2). Five *E. triquetra*, all of which were adult males (> 55 mm), were collected from two sites, suggesting the organism is functionally extirpated in the state. Logperch were collected at five sites, including the two that housed *E. triquetra*, thus indicating the host fish might not be limiting the unionid. It seems unlikely that *E. triquetra* will recover naturally in Illinois, and translocation or augmentation methods might be required to restore the species.

Introduction

Freshwater mussels (Bivalvia) are the most imperiled group of organisms in North America (Williams et al., 1993). Of the approximate 300 species native to North America, nearly two-thirds are extinct, federally–listed as endangered or threatened, or are in need of conservation. Factors responsible for the decline in freshwater mussels include habitat destruction, environmental contamination, and invasion of exotic species (Williams et al., 1993). This reduction pattern also is evident in Illinois. Of the 80 historical species known to inhabit Illinois water, only 61 are considered extant (Cummings and Mayer, 1997; Tiemann et al., 2007).

One of the rarest species in Illinois is the snuffbox *Epioblasma triquetra* (Rafinesque), which is listed as state-endangered (IESPB, 2005). The snuffbox historically was found in 14 drainages in the state, but now is found only in a small stretch of the Embarras River (Cummings and Mayer, 1997; Tiemann et al., 2007). The snuffbox inhabits medium to large steams in clear, sand/gravel riffles (Cummings and Mayer, 1992), and uses the logperch *Percina caprodes* (Rafinesque) as its host fish (Yeager and Saylor, 1995). The objectives of this study were to estimate 1) the population demographics (e.g., density, length frequency, and sex ratio) of *E. triquetra* in Illinois to note its status in the state, and 2) examine the occupancy of *P. caprodes* in the portion of the Embarras River where *E. triquetra* is extant to determine if the host fish's occupancy could be a factor limiting the distribution of the snuffbox.

Study area

The Embarras River basin drains approximately 6,200 km^2 of east-central Illinois (Page and Smith, 1970). The river originates in Champaign, Champaign County, and meanders nearly 290 km south-southeast before empting into the Wabash River near Billett, Lawrence County. The Embarras River basin historically supported 47 species of freshwater mussels (Tiemann et al., 2007) and at least 14 species of darters (Page and Smith, 1970). The middle section of the Embarras River, which is in Coles and Douglas counties, has been described as one of the outstanding streams in Illinois (Smith, 1971). The dominant substrates in this area are sand and gravel with small amounts of localized silt (Page and Smith, 1970; Page and Smith, 1971).

Methods

Seven sites were established in a 240 km^2 portion of the Embarras River basin in Douglas and Coles counties, Illinois (Table 1). Sites included the last known locations of *E. triquetra* in the state, along with those where valves had been found during previous surveys (data taken from INHS Mollusk Collection, Champaign). Freshwater mussels were systematically collected using 1 m^2 quadrats during August 2008. Area searches are better suited than timed-searches at determining densities and length frequencies of freshwater mussels (Obermeyer, 1998; Strayer and Smith, 2003). At each site, at least five transects were uniformly spaced 5-m apart, perpendicular to the river channel along a sandy-gravel riffle / run, and up to five points were evenly established 0.5-m apart along the length of each transect. At each point, a quadrat was placed on the streambed, and the substrate within the quadrat was examined for live unionids by feel and excavation. A total of 30 points were sampled at each site. Upon the completion of a site, individuals were identified to species, counted, measured to the nearest millimeter, and then returned to the stream. Fishes were collected bi-monthly from May-September 2007 and May-September 2008 by kick-seining, which is a quantitative method used to collect benthic fishes including darters (Tiemann, 2008). A transect-point method similar to that used for unionids was implemented for fishes. However, instead of using quadrats, 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 near shore to far shore. A total of 30 points were sampled at each site. Fishes were identified to species, counted, and then released back into the stream.

Results / Discussion

Snuffbox densities varied from 0.00 – 0.13 indiv/m^2 per site (mean = 0.02 $\pm$ 0.05 indiv/m^2). Only five *E. triquetra* males were collected from two sites during the course of the study (Table 1). Length frequency data (58, 59, 63, 68, and 71 mm) suggests that these individuals were all adults. The lack of smaller size classes indicates that *E. triquetra* is not reproducing in Illinois, and might be functionally extirpated in the state. Logperch were collected at five sites, including the two where *E. triquetra* was collected (Table 1), suggesting that the host fish is not a limiting factor.

The snuffbox has been collected only at two sites since 1985 (data taken from INHS Mollusk Collection, Champaign). Site 4 was sampled using timed-search techniques ten times between 1986 and 2008, whereas Site 5 was sampled three times during this time period (data taken from INHS Mollusk Collection, Champaign). The number of live *E. triquetra* collected at Site 4 during those surveys is as follows: 1986 (2), 1992 (2), 2001 (1), 2002 (2), and 2005 (1); no live individuals were collected in 1988, 1990, 1991, 1994, or 2008. Seven live individuals were found at Site 5 in 1986, but none were located in 1992 or 2005. The amount of effort during these surveys varied from one to four person-hours. Notes from the collectors indicate that only adults were collected, strengthening the argument that *E. triquetra* is not reproducing in the state.

The physical habitat (e.g., sand/gravel riffles) in this area of the Embarras River appeared suitable for *E. triquetra*. Chemical measurements were not taken, but water quality in this portion of the river in the 1960s was reported to be high and pollution minimal (Page and Smith, 1970). However, the Wabash River drainage has experienced significant physical and biological changes as a result of anthropogenic disturbances during the past century (Simon, 2006), and the Embarras River basin is no exception (Smith, 1968; Smith, 1971). Human induced modifications include draining of wetlands, dredging of streams, pollution from agriculture and industrial sources, removal of riparian areas, development of floodplains, and impounding of streams. My study was not designed to determine if anthropogenic disturbances are responsible for the reduction of *E. triquetra* in Illinois, but these factors have been shown to cause alterations in both freshwater mussel and fish assemblages (Smith, 1971; Cummings 1991).

Management Considerations – It seems unlikely that *E. triquetra* will recover naturally in Illinois given its affinity for a specialized fish host with limited dispersal capabilities. To recover *E. triquetra*, natural resource agencies should determine why the species is not reproducing in the state (e.g., whether physicochemical issues are limiting E. *triquetra*). Once the problem is rectified, the agencies could augment the existing *E. triquetra* population in Illinois by either translocation or propagation, or establish new populations in other basins with suitable fish hosts and physicochemical parameters. Fisher (2006) stated that reproducing populations of snuffbox were still found within the Wabash River drainage in Indiana. Therefore, *E. triquetra* brood stock could come from within the Wabash River drainage to help preserve the genetic integrity of the species. In the meantime, the snuffbox should remain listed as state-endangered, and all efforts should be taken to protect the last population of *E. triquetra* in Illinois.

Acknowledgments

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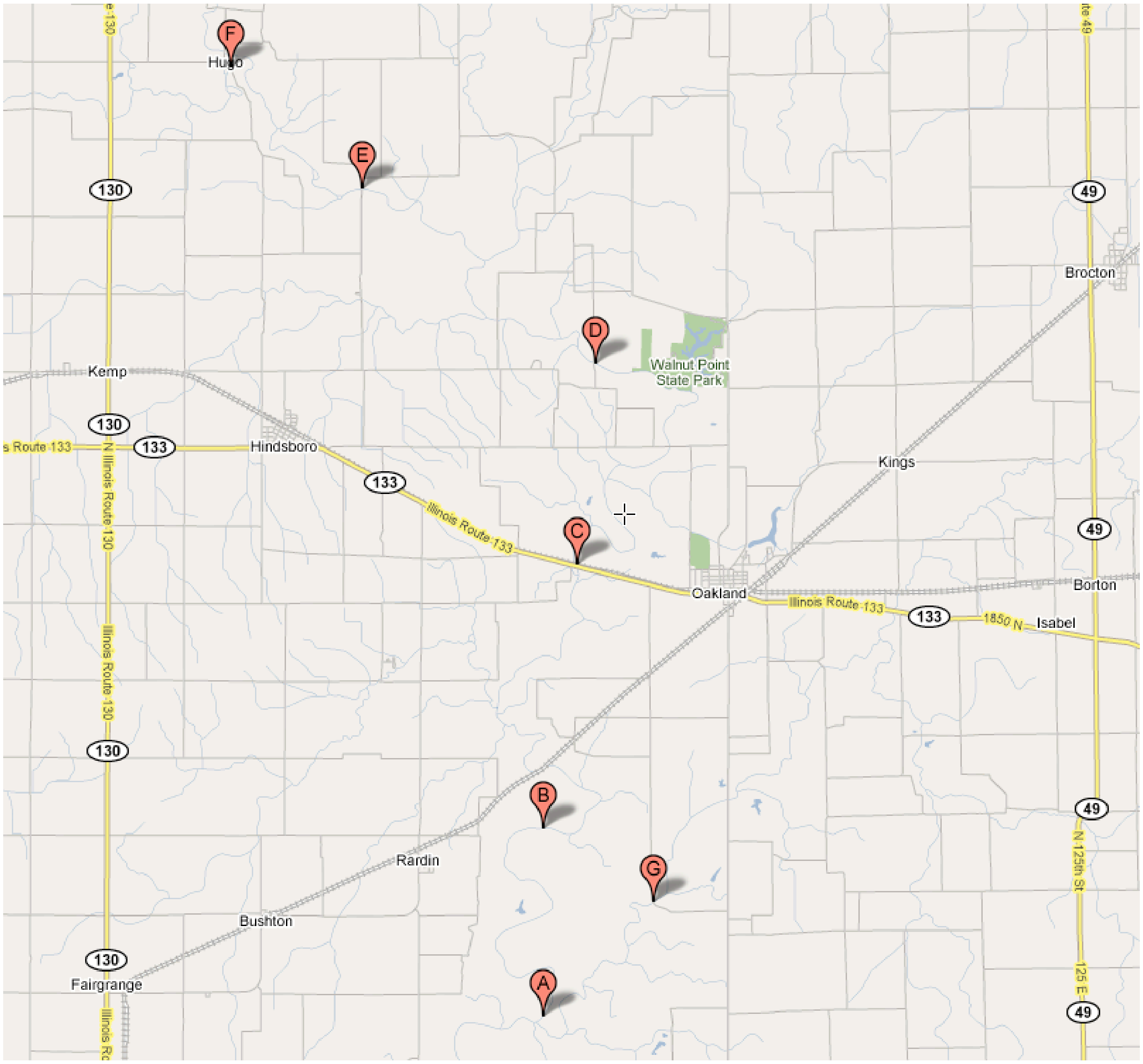

Figure 1. Station locations of the 2007-2008 survey of Embarras River (Wabash River drainage), Coles and Douglas counties, Illinois.

a)

b)

Figure 2. – a) Snuffbox *Epioblasma triquetra* (Rafinesque) and b) logperch *Percina caprodes* (Rafinesque). Snuffbox photo by Kevin Cummings and logperch drawing by Emily Demestra.