IMPACT OF INTRODUCED RED SHINERS, *CYPRINELLA LUTRENSIS*, ON STREAM FISHES NEAR ATLANTA, GEORGIA

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Abstract. The red shiner, *Cyprinella lutrensis,* is native to watersheds in the south- and central-plains states west of the Mississippi River, but its use as a bait fish for sport fishing has resulted in its introduction in many watersheds across the country. *Cyprinella lutrensis* is a tolerant generalist that typically thrives in degraded waters. Historically, the introduction of *C. lutrensis* has resulted in significant shifts in fish assemblages, either as a result of displacement of native fishes, or by hybridization with congeneric fishes. *Cyprinella lutrensis* has been introduced into the Apalachicola-Chattahoochee-Flint (ACF) River basin and thrives particularly in the impacted streams near Atlanta, Georgia. Fish samples collected near Atlanta by the National Water Quality Assessment Program of the U.S. Geological Survey in June and November, 1993 have shown *C. lutrensis* to be the dominant or co-dominant species in degraded streams of urban watersheds, representing up to 77 % of individuals and 12.5 % of species at a site. The continued use of *C. lutrensis* as a bait fish and the continued degradation of stream systems within the Atlanta metropolitan area constitute a serious threat to native fishes including the bluestripe shiner, *C. callitaenia*, which is listed as endangered by the state of Georgia and is a C-2 candidate for protection under the Endangered Species Act.

OVERVIEW

The red shiner, *Cyprinella lutrensis*, is a hardy cyprinid that historically thrives in a wide range of habitats. Its common use as a bait fish for sport fishing has resulted in the accidental release of *C. lutrensis* into watersheds outside of its natural range. Historically the introduction of *C. lutrensis* has caused major shifts in assemblage structure due to competitive exclusion of native fishes or massive hybridization with native congeneric fishes (Hubbs and Strawn, 1956; Heckman *et. al*, 1987; Greger and Decon, 1988; Karp and Tyus, 1990). In the Apalachicola-Chattahoochee-Flint (ACF) River basin *C. lutrensis* not only thrives in more-disturbed urban watersheds, but also potentially hybridizes with the bluestripe shiner (*C. callitaenia*; a C-2 candidate for protection under the Endangered Species Act, and endemic to the ACF River basin) and the spottail shiner (*C. venusta*).

This paper explores: 1) the function of *C. lutrensis* in its natural range and habitat; 2) the function and impact of *C. lutrensis* outside of its natural range; 3) the function and impact of *C. lutrensis* within streams near Atlanta, Georgia; and 4) management strategies for the control of *C. lutrensis* populations within the ACF River basin.

CYPRINELLA LUTRENSIS IN ITS NATIVE RANGE

Cyprinella lutrensis is a cyprinid native to watersheds of the south- and central-plains states west of the Mississippi River (Page and Burr, 1991). Although its morphology is geographically variable, it can be easily identified by its deep-body and bright red fins on breeding males (Matthews, 1987).

Based on gut-content analysis, *C. lutrensis* is generally omnivorous, with 47 % of its diet insects, and 17 % of its diet algae (Hale, 1963). Plant material, mostly algae, can constitute up to 83 % of its diet (Laser and Carlander, 1971), and *C. lutrensis* has been shown to eat its eggs and fry in lab experiments (Hubbs and Strawn, 1956).

Matthews and Hill (1979) found habitat preferences of *C. lutrensis* to be most dependent on temperature, water velocity, and water depth. In late winter and spring (photoperiod increasing) *C. lutrensis* selected areas with higher temperatures. In fall (photoperiod decreasing), *C. lutrensis* chose areas of lower temperature (*ibid.*). During all seasons, *C. lutrensis* chose areas of low current velocity and were most commonly found in turbid low-velocity backwaters and pools, most often using limited cover such as leaf litter. Shallow water was consistently avoided to escape either temperature fluctuations or avian predation (*ibid.*).

Although *C. lutrensis* exhibits habitat preferences, it tolerates variations in many environmental parameters such as temperature, salinity, pH, and dissolved oxygen (Matthews and Hill, 1977). *Cyprinella lutrensis* can survive pH values between 4 and 11, salinity concentrations up to 10 ppt, rapid temperature increases of 10 °C and rapid temperature decreases of 21 °C (*ibid.*). Red shiners can also survive periods of low dissolved oxygen by making use of a thin surface layer of oxygen-rich water. When dissolved oxygen levels fall below 1.5 ppm, *C. lutrensis* surfaces and increases dissolved oxygen concentrations in this surface layer by agitating it with its mouth and fins (*ibid.*).

Most species of the genus *Cyprinella* require crevices for spawning (Mayden, 1989). *Cyprinella lutrensis*, however, uses a wide variety of substrates such as sunfish (*Lepomis* spp.) nests (*ibid.*), crevices, gravel, and aquatic plants (Vives, 1993). The ability of *C. lutrensis* to use many spawning substrates and its

tolerance of wide variations in physical and chemical parameters might explain its success and dominance in watersheds outside its native range.

CYPRINELLA LUTRENSIS OUTSIDE OF ITS NATIVE RANGE

Although *C. lutrensis* is naturally found in watersheds of the south- and central-plains states, it has been introduced into many watersheds primarily as a result of its use as a bait fish for sport fishing and secondly as a result of its sale as a "tropical" aquarium fish (Jenkins and Burkhead, 1993). Currently, *C. lutrensis* is found in watersheds across the country. Commonly, the red shiner dominates or co-dominates assemblages in non-native watersheds by displacing native species through competition or predation, or by hybridizing with them.

Cyprinella lutrensis as a competitor

Significant changes in fish assemblages as a result of competitive interactions following the introduction of *C. lutrensis* have been documented. In 1938, the assemblage of the Virgin River in Nevada, Arizona, and Utah contained no *C. lutrensis* (Cross, 1975). However, in a stretch of the Virgin River within Nevada, where irrigation withdrawal has severely modified stream flow, a shift in assemblage structure occurred. By 1963 red shiners comprised 20 to 90 % of fishes collected, and by 1986 comprised 92 to 96 % (*ibid.*). Success of *C. lutrensis* in this river is attributed to its resistance to parasitism, which adversely affects the native fish fauna (Heckman *et al.*, 1987) and also to superior competitive ability for food resources during periods of food scarcity (Greger and Deacon, 1988). During these periods of resource-limitation, *C. lutrensis* out-competes speckled dace (*Rhinichthys osculus*) for chironomid larvae (*ibid.*).

Cyprinella lutrensis as a predator

Competition combined with predation has also been seen as a means by which *C. lutrensis* can alter fish assemblages. The Colorado squawfish (*Ptychocheilus lucius*), once common to abundant in the Colorado River basin, is a backwater fish that now occupies less than a quarter of its native range (Karp and Tyus, 1990). Factors responsible for the decline of *P. lucius* include blockage of migration patterns, habitat loss, and competitive and predatory interactions with many introduced fishes such as *C. lutrensis* (*ibid.*). The Green River basin of Colorado and Utah supports the largest remaining population of *P. lucius*, which is susceptible to competition and predation from introduced *C. lutrensis*.

Karp and Tyus (1990) found *C. lutrensis* to attack and consume *P. lucius* larvae and also found *C. lutrensis* to consume food sooner and at a faster rate than *P. lucius*. Although *P. lucius* is currently listed as endangered by the U.S. Fish and Wildlife service and is protected under the Endangered Species Act, low recruitment rates due to juvenile predation and inferior competitive ability during periods of food-limitation greatly hinder the survival of *P. lucius* in streams within the Green River basin.

Hybridization of other species with *Cyprinella lutrensis*

Hubbs and Strawn (1956) hypothesized that increased hybridization rates resulted from a lack of suitable spawning sites, a lack of proper mate recognition, or both. In the Guadalupe River in Kerrville, Texas, 23-62 % hybridization rates were found between *C. lutrensis* and *C. venusta* in an unusually turbid area downstream from a gravel pit (Hubbs and Strawn, 1956). In the San Marcos River, southeast of San Marcos, Texas, hybridization between *C. lutrensis* and *C. venusta* was associated with pollution from a nearby oil field (*ibid.*). In both of these cases, offspring were reproductively viable. The cause of the hybridization was either removal of preferred spawning habitat due to siltation or inability to choose a conspecific mate due to increased turbidity.

Cyprinella lutrensis is also of concern in the Coosa River drainage of northwest Georgia because of possible hybridization with the Blue Shiner (*C. caerulea*), which is federally listed as threatened (B. Freeman, University of Georgia, personal communication, 1994).

CYPRINELLA LUTRENSIS IN THE A.C.F. RIVER BASIN

Like *C. caerulea* of the Coosa River basin, *C. callitaenia* and *C. venusta* of the ACF River basin are also of concern because of possible hybridization with *C. lutrensis* (B. Freeman, University of Georgia, personal communication, 1994). As a result of diminishing populations following the introduction of *C. lutrensis*, the endemic *C. callitaenia* is currently listed as endangered by the state of Georgia and is a C-2 candidate for protection under the Endangered Species Act. Due to its wider distribution, *C. venusta* is not currently protected.

The National Water Quality Assessment (NAWQA) program of the U.S. Geological Survey is responsible for assessing the effects of land use practices on physical, chemical, and biological factors of water quality. As a part of routine biological assessment, fish samples were collected by the NAWQA program at four sites within forested watersheds and two sites within urban watersheds within the Piedmont physiographic region of the ACF River basin near metropolitan Atlanta, Georgia in June and November, 1993.

Four sites in forested watersheds are designated reference sites for this study and are located south of metropolitan Atlanta. These watersheds drain areas of comparable size and are of stream order comparable to the urban watersheds. Land use within these watersheds averages around 85 % forested, and represents a current standard of minimum-impact (Figure 1). In-stream habitat at all of these sites was primarily sand, but a diversity of other habitat types such as gravel, cobble, snag, detritus, bedrock, and boulder was present and evenly distributed. *Cyprinella lutrensis* was not captured at any of the reference sites.

The two urban-watershed sites, Peachtree Creek and Proctor Creek, are located in northwest metropolitan Atlanta and have a large percentage of residential and urban land uses within the watershed (Figure 1). The forested land use in these two watersheds averages less than 12 %. In-stream habitat at both of these sites consists of significantly more sand than at sites within

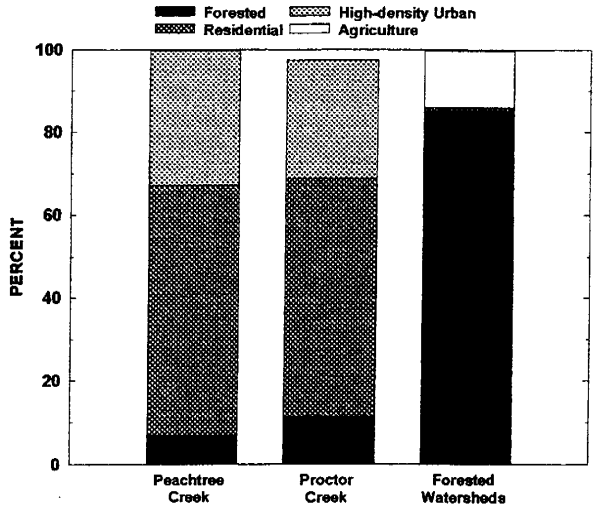

Figure 1. Landuse in the Peachtree and Proctor Creek watersheds, and average landuse in forested watersheds near Atlanta, Georgia (from Atlanta Regional Commission, 1990).

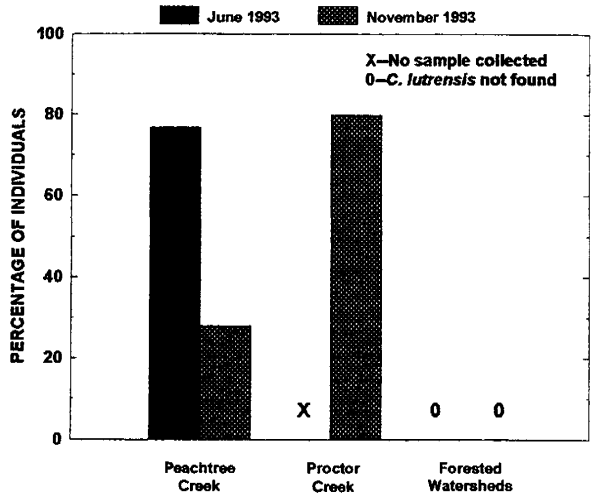

Figure 2. Percentage of individuals captured as *C. lutrensis* in Peachtree Creek, Proctor Creek, and four forested watersheds near Atlanta, Georgia in 1993.

the forested watersheds; secondary habitats are unevenly distributed.

In samples collected at both Peachtree Creek and Proctor Creek, *C. lutrensis* was the dominant or co-dominant species. Fish samples were collected using a combination of backpack electroshocking and seining from reaches of standardized length and geomorphic characteristics (Meador *et al.*, 1993). All fish were preserved and brought to the University of Georgia Museum of Natural History for taxonomic identification.

Peachtree Creek, Fulton County, Georgia

Peachtree Creek is a fourth-order tributary of the Chattahoochee River in northwest Atlanta that drains an area of 85.47 km^2. Sixty percent of the watershed is residential, 32 % is urban, and only 7 % is forested (Figure 1). A 150 m reach of the stream downstream from the bridge crossing on Northside Drive (U.S. 31) was sampled twice by the NAWQA program in June and November, 1993.

In June 1993, 237 fish from 12 species and 6 families were collected at Peachtree Creek. *Cyprinella lutrensis* dominated the assemblage, comprising 76.8 % of the individuals (182) and 8 % of the species, but the true percentage of *C. lutrensis* individuals is probably over-reported due to an inability of capturing large schools of small juvenile *Gambusia* sp. cf. *affinis* (Figure 2). Adult *C. lutrensis* were most commonly captured in swift shallow riffles. Few juvenile *C. lutrensis* were captured.

In November 1993, 1740 fish from 14 species and 5 families were collected from Peachtree Creek. *Cyprinella lutrensis* (479 individuals, 28 %) co-dominated the assemblage with *G. affinis* (1143 individuals; Figure 2). Both *C. lutrensis* (predominantly juvenile) and *G. affinis* were most often captured in shallow, turbid backwater pools.

Proctor Creek, Fulton County, Georgia

Proctor Creek is a second-order tributary of the Chattahoochee River in Northwest Atlanta that drains an area of 15.83 km^2. Landuse within the watershed is 57 % residential, 29 % urban, and 11 % forested (Figure 1). The reach was sampled once by the NAWQA program. The sample reach was located upstream from the bridge crossing on Georgia 70, near the intersection of Georgia 70 and I-285 in Fulton County, Georgia.

In November 1993, 239 fish from 8 species and 3 families were collected from Proctor Creek. Of these, *C. lutrensis* accounted for 191 individuals (79.9 %) and represented 12.5 % of the species (Figure 2). Eleven *Lepomis cyanellus* X *L. macrochirus* hybrids were also captured.

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

Because *C. lutrensis* is an exotic in Georgia, its sale and use as a bait fish is illegal (M. Spencer, Georgia Department of Natural Resources, personal communication, 1994). In 1978, however, small numbers of *C. lutrensis* first appeared in surveys within the ACF River basin (B. Freeman, personal communication, 1994). Cross (1967) stated that *C. lutrensis* "seems to thrive under conditions of intermittent flow, frequent high turbidity and other environmental variations... In general, red shiners are most numerous where few other kinds of fish occur." Since its introduction, *C. lutrensis* has gained strong footholds in degraded streams around Atlanta, has become the dominant or co-dominant species, and has done so at the expense of native species.

Based on fish surveys conducted between 1929 and 1953, a typical fish assemblage in second to fourth order streams around metropolitan Atlanta should consist of 18 species from 6 families. Fish samples taken from two the streams within metropolitan Atlanta in 1993, however, show a loss of 11 to 14 species, mostly cyprinids, and the introduction of 5 to 7 new species. Of these

new introductions, 5 species have migrated from elsewhere within the ACF River basin (*Notemigonus chrysoleucas*, *Notropis lutipinnis*, *Dorosoma cepedianum*, *Gambusia* sp. cf. *affinis*, and *Lepomis microlophus*), and 4 species are exotic (*Cyprinella lutrensis*, *Catostomus commersoni*, *Ameiurus melas*, and *Lepomis cyanellus*). Assemblage shifts toward dominance by *C. lutrensis* within the ACF River basin were first recorded in 1991 (Cunningham, *et al.*). These findings from Peavine Creek, together with the NAWQA findings in Peachtree Creek and Proctor Creek are the only known occurrences of this phenomenon within Georgia (M. Spencer, personal communication, 1994).

Currently fathead minnows (*Pimephales promelas*) and golden shiners (*Notemigonus chrysoleucas*) are legally sold as bait fish in Georgia (M. Spencer, personal communication, 1994). Arkansas minnows (*Lythrurus umbratilis*) and *Cyprinella lutrensis*, both exotics, continue to be sold as bait fish in Georgia (G. Helfman, University of Georgia, personal communication 1994; B. Freeman, personal communication, 1993). Existing laws that prohibit the sale of red shiners (as well as other introduced fishes) as a bait fish in Georgia need to be enforced to minimize further introductions.

Reproducing populations of *C. lutrensis* will likely remain intact as long as in-stream habitat remains degraded. Increased erosion control through riparian zone restoration and better control of development-induced siltation would reduce turbidity and increase necessary spawning habitat for native congeneric fishes. Better control of these two environmental variables might remove any competitive advantage that *C. lutrensis* has. Further studies are clearly needed to determine the true relation between the success of *C. lutrensis* and water quality in urban metropolitan Atlanta streams. Fortunately, fishes that are absent from these degraded streams are not extirpated, so recolonization is possible and assemblages can return to more typical composition.

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