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HABITAT CHARACTERISTICS OF LEATHERSIDE CHUB (*GILA COPEI*) AT TWO SPATIAL SCALES

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ABSTRACT.—Populations of leatherside chub *(Gila copei)*, a little-known species native to the eastern Great Basin, have declined and their distribution has become fragmented. To determine habitat requirements and possible factors responsible for population decline, we quantified macrohabitats and microhabitats occupied by leatherside chub. Macrohabitat was surveyed at 59 sites in the Sevier River drainage of south central Utah, and microhabitats occupied by leatherside chub were measured at 3 locations spanning the species latitudinal range. Characteristics of points in the stream where leatherside chub occurred were compared to points where they did not occur. Abundance of brown trout *(Salmo trutta)* and elevation were weakly negatively correlated with leatherside chub distribution on a macrohabitat scale. Microhabitats occupied by leatherside chub were characterized by low water velocities (2.5–45 cm sec^{-1}), intermediate water depths (25–65 cm), and low percent composition of sand-silt or gravel substrates. This study suggests that the presence of introduced brown trout may have led to the decline of leatherside chub.

Key words: microhabitat, macrohabitat, Great Basin fishes, leatherside chub, Gila copei.

The Bonneville Basin has been an endorheic basin, isolating aquatic organisms at least since the early Pleistocene (Blackwelder 1948). Fish assemblages of streams and rivers of the Bonneville Basin comprised species of Salmonidae, Catostomidae, Cyprinidae, and Cottidae (Hubbs and Miller 1948, Hubbs et al. 1974, Behnke 1992). Recent destruction of aquatic habitat and introduction of many nonnative fishes in this region by humans (Minckley and Douglas 1991) have resulted in extinctions (e.g., Utah Lake sculpin, *Cottus echinatus*; Miller et al. 1989) and population declines (e.g., Bonneville cutthroat trout, *Oncorhynchus clarki utah*; June sucker, *Chasmistes liorus*; and least chub, *Iotichthys phlegethontis* [Behnke 1992]) of native fish species. To prevent further declines in this unique fauna, we must understand the ecological requirements of native species and their interactions with other species.

The leatherside chub, *Gila copei,* is a small cyprinid native to streams and rivers of the eastern and southern Bonneville Basin of Utah, Idaho, and Wyoming; to the Wood and Raft rivers of Idaho; and possibly to areas of the upper Snake River above Shoshone Falls, Idaho and Wyoming (Hubbs and Miller 1948, Baxter and Simon 1970, Simpson and Wallace 1982). In the Sevier Lake basin of south central Utah, leatherside chub now occupy only 58% of their original range in the Sevier River system and have been extirpated from the Beaver River system (based on historical records dated from 1872 to 1989; Wilson and Belk, Utah Division of Wildlife Resources Final Report 93-0870, Salt Lake City, unpublished, 1996). Only 2 small populations of leatherside chub remain in Goose Creek drainage and portions of Raft River drainage, Cassia County, Idaho (Wilson and Belk, Idaho Department of Fish and Game Final Report 5517410, SEPA 4238, Boise, unpublished, 1996). Because of these substantial decreases in distribution and abundance, the leatherside chub is considered a species of special concern (Utah Sensitive Species List, Utah Division of Wildlife Resources, Salt Lake City, 1997; Idaho Department of Fish and Game personal communication). Conservation efforts in behalf of leatherside chub are hampered by a lack of understanding of basic ecological requirements of the species (Johnson et al. 1995).

The objective of this study was to identify characteristics of habitat use by leatherside chub on 2 spatial scales: macrohabitat and microhabitat. Quantifying macrohabitat characteristics will help determine ecological tolerance limits and possible causes of population fragmentation

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and decline. Quantifying microhabitat characteristics will provide information about possible interactions with co-occurring species and the importance of various features of stream morphology.

STUDY SITE AND METHODS

Macrohabitat

In this paper *macrohabitat* refers to general habitat features (i.e., gradient, elevation, conductivity, pH, presence of other species) that are relatively constant throughout the stream reach. Macrohabitat data were collected at numerous locations in the Sevier Lake drainage basin (Sanpete, Piute, Iron, Garfield, and Beaver counties) in south central Utah (Fig. 1). This system appeared to support the largest populations of leatherside chub within their native range.

Sevier Lake drainage basin is an endorheic basin in a region of north–south trending mountains with broad, sediment-filled valleys. Mean annual precipitation is 33 cm, with high mountain elevations receiving up to 250 cm of snowfall annually (Greer 1981). Streams are often ice-covered during winter. High runoff from mountain snowpack occurs during spring, followed by low flows during July, August, and September. Dominant riparian vegetation consists of grasses (Poaceae), forbs (numerous families), sagebrush (*Artemisia* spp.), wild rose (*Rosa woodsii*), willow (*Salix* spp.), tamarisk (*Tamarix pentandra*), and stands of mature cottonwoods (*Populus* spp.).

Macrohabitat variables were measured August through November 1995 ($n = 59$) in the Sevier and Beaver River systems (Fig. 1). At each site we electrofished approximately 100 m of stream using a backpack electroshocker. Captured fish were identified to species, enumerated, and standard length (SL) recorded to the nearest millimeter.

We measured the following macrohabitat variables: mean water depth, mean water velocity, dominant substrate, riparian vegetation, water temperature, pH, dissolved oxygen (DO), water conductivity, stream gradient, and elevation. Depth and velocity were calculated as the mean of measurements taken at 0.25, 0.5, and 0.75 stream-width intervals along 5 equally spaced transects established perpendicular to the stream. Depth was measured to the nearest centimeter with a meter stick, and water

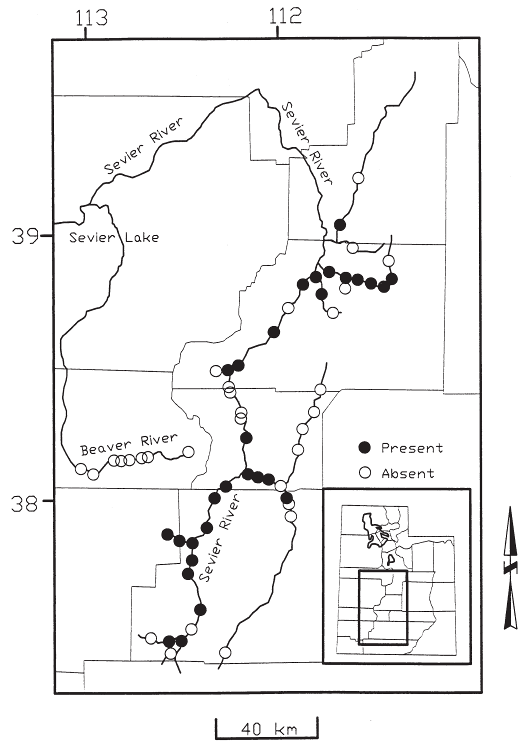

Fig. 1. Macrohabitat survey locations in the Sevier and Beaver river drainages in south central Utah, 1995. Symbols indicate presence or absence of leatherside chub at each location.

velocity (to the nearest 0.01 m sec^{-1}) was measured at 0.6 of the depth from the water surface with a global flow probe. Substrate and riparian vegetation were also measured on the 5 equally spaced transects. Substrate type was categorized as sand/silt (<2.50 mm), coarse fines (2.50–6.24 mm), gravel (6.25–74 mm), rubble (75–149 mm), cobble (150–299 mm), boulders (300–900 mm), large boulders (>900 mm), or bedrock (including hard clay bottoms) and measured as a percentage of the transect line using the line intercept method (Bonham 1989). Riparian variables categorized and measured were soil, rocks, grass, forbs, shrubs, sagebrush, tamarisk, willow saplings, cottonwood saplings, and trees. Transect lines extended 3 m from wetted stream on both right and left banks. Riparian composition was recorded as a percentage of the 3-m transect line using the line intercept method. Temperature, pH, DO, and conductivity were measured once on each 100-m station using the Hydrolab H20® multiparameter water quality data transmitter. Gradient and elevation were obtained from appropriate United States Geological Survey (USGS) 7.5-minute series topographical maps.

We used logistic regression analysis to determine the relationship between occurrence of leatherside chub and macrohabitat characteristics. Macrohabitat variables were selected for the logistic regression model using a stepwise variable selection procedure (significance level of $P = 0.10$, LOGIST procedure; SAS 1988). The 1st test compared sites where leatherside chub were present to sites where they were absent. The 2nd test compared sites where leatherside chub were abundant to sites where they were rare. Temperature and DO were ultimately removed from the macrohabitat analysis because they varied with time of day and season. We analyzed the full data set ($n = 59$) and a reduced data set ($n = 44$). Fifteen excised sites were areas where leatherside chub were absent because of recent chemical treatments or stream dewatering.

Microhabitat

In this paper *microhabitat* refers to characteristics of habitat experienced by individual leatherside chub within the stream (0.5-m radius around the focal area). Microhabitats were measured at 3 sites where leatherside chub were abundant. The 1st site, Trapper Creek, Cassia County, Idaho, is on the northern edge of the native range of leatherside chub. A 3rd-order stream and tributary to Goose Creek (determined from USGS 7.5-minute series topographical maps, blue line information), it flows into Lower Goose Creek Reservoir. Elevation ranges from 2375 m at the headwaters to 1525 m where it flows into the reservoir. Streambed gradient is 2.5% at the survey site but ranges from 5.0% at the headwaters to 1.6% near the reservoir. Dominant riparian vegetation consists of sagebrush, willow, wild rose, and birch.

The 2nd site is Thistle Creek, Utah County, Utah, located in the central part of the range of leatherside chub. It is a 3rd-order stream and tributary to the Spanish Fork River. Elevation ranges from 2370 m at the headwaters to 1550 m where it joins the Spanish Fork River. Elevation at the survey site is 1735 m and streambed gradient is 0.5%. Historically, riparian habitat was sagebrush steppe. Sagebrush has since been removed, and grasses now dominate the riparian vegetation.

The 3rd site, Salina Creek, Sevier County, Utah, is in the southern region of leatherside chub distribution. It is a 3rd-order stream and tributary to the Sevier River. Elevation ranges from 2400 m at the headwaters to 1560 m where it joins the Sevier River. Gradients range from 5.0% at high elevations to 0.05% near the confluence of the Sevier River. At the survey site the elevation and gradient are 1660 m and 1.3%, respectively. Salina Creek is canyon bound with dominant riparian vegetation consisting of sagebrush, willow, wild rose, and grasses.

To facilitate accurate sampling, we conducted microhabitat measurement July through October 1995, when water flow was minimal (Imhof and Biette 1982). At each of the 3 microhabitat study sites we established 100 transects spaced 2 mean stream widths apart (Simonson et al. 1994). Mean stream width was calculated as the average of 20 stream widths taken randomly along approximately 200 m of stream. Distance between each transect was measured along the thalweg, and the transect was established perpendicular to flow. On each transect a random point, constrained to 0.5-m intervals, was selected using a permutation table, located with a wooden stake driven into the right bank, and labeled with the location of the random point measured as distance from the right bank.

Beginning on the initial transect, at the downstream end of the site, we shocked the first randomly selected point, identified species, number of fishes encountered, and measured SL. Leatherside chub are a midwater species, and they may be pushed from one habitat to another by continuously pushing the electrode between survey points. To avoid startling the fish and biasing habitat measurements, we slowly approached each sampling point with the electrode held out of the water. We then placed the electrode in the water and began electroshocking. Fish observed in the water column showed little response to electrode placement prior to electroshocking (personal observation). At Salina Creek and Trapper Creek, turbidity was relatively high. Increased turbidity levels decrease reaction distances of many fish (Miner and Stein 1996), further reducing the likelihood of startling the fish by placement of the electrode. The following microhabitat variables were measured at each point: temperature, DO, depth, velocity, coverage of aquatic vegetation, coverage of emergent rooted vegetation, coverage of undercut banks, coverage of dead woody debris (small and large size classes), coverage of overhanging vegetation, coverage of surface turbulence, and substrate class coverage (substrate classes were the same as those used for macrohabitat evaluation). Coverage was estimated as a percentage of a circle, 1 m in diameter, placed over the sampling point.

Logistic regression analysis was used to determine the relationship between occurrence of leatherside chub and microhabitat characteristics. To avoid spurious correlations, variables with ≤10% nonzero values were excluded from analyses. Temperature and DO were not included in final analyses because they varied temporally. Variables potentially included in all analyses were water depth, water velocity, percent coverage of aquatic vegetation, percent coverage of emergent rooted vegetation, percent coverage of overhanging vegetation, and percent coverage of 4 substrate classes (sand/silt, coarse fines, gravel, and rubble). Microhabitat variables were selected for the logistic regression model using a stepwise variable selection procedure (significance level of $P = 0.05$, LOGIST procedure; SAS 1988). Points where leatherside chub were present were compared to points where they were absent. Each of the 3 sites was analyzed separately followed by analysis of all sites combined.

Because leatherside chub were abundant ($n = 1–31$ per occupied site) at Salina Creek, Utah, we used a Poisson regression model (GENMOD procedure; SAS 1993) to test for relationships between leatherside chub abundance and microhabitat characteristics. All variables were included in the model and significance was evaluated at $P = 0.05$.

TABLE 1. Range of values of physical variables recorded at locations occupied by leatherside chub in the Sevier River drainage, Utah, 1995.

Variable	Range
elevation	1567–2195 m
stream gradient	0.10–4.00%
water temperature	1.01–25.87°C
mean water velocity	6.0–77.0 cm sec^{-1}
pH	8.0–9.9
conductivity	15.7–461.0 millimhos cm^{-1}
dissolved oxygen	3.50–16.81 mg $liter^{-1}$

Juvenile fishes can occupy microhabitats that differ significantly from habitat occupied by adults. To avoid mixing habitat characteristics of different life stages, we did not include young-of-year leatherside chub in this analysis. These young-of-year are easily distinguished from adults by size (Johnson et al. 1995).

RESULTS

Macrohabitat

Leatherside chub were found at 29 of 59 sites surveyed (Fig. 1), and they occupied waters with a broad range of physical conditions (Table 1). Other native species were also found: cutthroat trout (*Oncorhynchus clarki*), mountain sucker (*Catostomus platyrhynchus*), Utah sucker (*Catostomus ardens*), speckled dace (*Rhinichthys osculus*), Utah chub (*Gila atraria*), redside shiner (*Richardsonius balteatus*), and mottled sculpin (*Cottus bairdi*). Nonnative species encountered were brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), and green sunfish (*Lepomis cyanellus*). Brown trout were the most widespread introduced species, occurring at 43 sampling sites.

No variables were significantly associated with occurrence of leatherside chub when all locations were included in the macrohabitat analysis ($n = 59$, all $P > 0.1$). After removing sites ($n = 15$) where leatherside chub were absent for reasons unrelated to availability of habitat, 2 of 12 variables were weakly negatively associated with occurrence of leatherside chub: elevation ($\chi^2_1 = 2.71$, $P = 0.0998$) and number of brown trout ($\chi^2_1 = 2.99$, $P = 0.0840$). Leatherside chub were not encountered at sites above 2195 m in elevation. As the number of brown trout increased, the probability of encountering leatherside chub decreased. Leatherside chub and brown trout were sympatric at 14 sites, with a mean of 5 brown trout per site. Brown trout occurred at 29 sites without leatherside chub, with a mean of 12 brown trout per site. Comparison of sites where leatherside chub were abundant to sites where they were rare failed to yield significant associations with macrohabitat variables (n = 29, all $P > 0.1$).

Microhabitat

At Trapper Creek, Idaho (a high-gradient location), leatherside chub were found at 16 of 100 sampling points. Water velocity was significantly negatively associated with the presence of leatherside chub ($\chi^2_1 = 10.51$, $P = 0.0012$). They were most likely to be found in water velocities of 15.0–23.0 cm sec^{-1}, and the probability of occurrence decreased at higher velocities. At Thistle Creek, Utah (a low-gradient location), leatherside chub were found at 26 of 100 sampling points. Percent coverage of sand-silt substrate was significantly negatively associated with the presence of leatherside chub at this site ($\chi^2_1 = 4.55$, $P = 0.0330$). At Salina Creek, Utah (a medium-gradient location), leatherside chub were found at 31 of 100 sampling points. Both water velocity and percent coverage of sand-silt substrate were significantly negatively associated with presence of leatherside chub (water velocity, $\chi^2_1 = 6.79$, $P = 0.0091$; sand-silt substrate, $\chi^2_1 = 11.18$, $P = 0.0008$). When all 3 sites were combined and analyzed with logistic regression, only water velocity was significantly negatively associated with the presence of leatherside chub ($\chi^2_1 = 7.71$, $P = 0.0055$).

Using data from Salina Creek, Utah, in the Poisson regression model, we determined that water depth and coverage of coarse fines substrate were significantly positively related to abundance of leatherside chub. Water velocity, percent coverage of sand-silt and gravel substrates, and coverage of overhanging vegetation were significantly negatively associated with abundance of leatherside chub. However, 2 points where large numbers of leatherside chub were found (n = 31 and 20, all other occupied sites had $1 \leq n \leq 14$) seemed to inordinately affect the results (based on scatterplots of the data). A reanalysis with the 2 points removed demonstrated that leatherside chub abundance was not significantly related to coverage of coarse fines substrate or coverage of overhanging vegetation. The significance level of all other variables in the reanalysis was unchanged. Leatherside chub were more abundant at points with deeper water ($\chi^2_1 = 20.67$, $P < 0.0001$; Fig. 2A) and lower water velocities ($\chi^2_1 = 32.11$, $P < 0.0001$; Fig. 2B). Abundance was negatively related to coverage of sand-silt substrate ($\chi^2_1 = 46.79$, $P < 0.0001$; Fig. 3A) and gravel substrate ($\chi^2_1 = 12.88$, $P < 0.0001$; Fig. 3B).

DISCUSSION

Leatherside chub occupy a broad range of physical conditions, but none of the variables designed to measure physical habitat associations were significantly associated with the presence of this species. Small streams and rivers of the Bonneville Basin occupied by leatherside chub exhibit extreme seasonal and multi-year variation in physical conditions. Water flow fluctuates seasonally with snowmelt, resulting in turbid, high-water flows in late winter and spring and clear, low-water flows in summer and fall. Correspondingly, seasonal fluctuations in water temperature range from near 0°C to above 25°C. Additionally, multi-year climatic fluctuations (e.g., El Nino southern oscillation events) result in periodic drought conditions followed by high precipitation periods. Small streams where leatherside chub are particularly abundant are especially susceptible to drought-induced low water and consequent environmental extremes. Given this wide range in physical variation, it is not surprising that there appear to be few physical limiting factors at the macrohabitat scale.

The weak negative relationship between presence of leatherside chub and elevation suggests an elevational limit to distribution, but below this limit none of the physical parameters measured appeared to limit distribution. Thus, current variation in physical habitat parameters that were measured cannot account for recent fragmentation of leatherside chub distribution in this drainage. Stream dewatering and chemical treatments were obvious contributors to the decline in occupied range, and it seems likely that these activities may account for much of the fragmented distribution.

The only other variable related to occurrence of leatherside chub was abundance of brown trout. Presently, brown trout are widely distributed in the Sevier River system. Brown trout occur at lower elevations in warmer waters and feed more extensively on fish than other species of trout (Sigler and Miller 1963). Leatherside chub occurred with brown trout

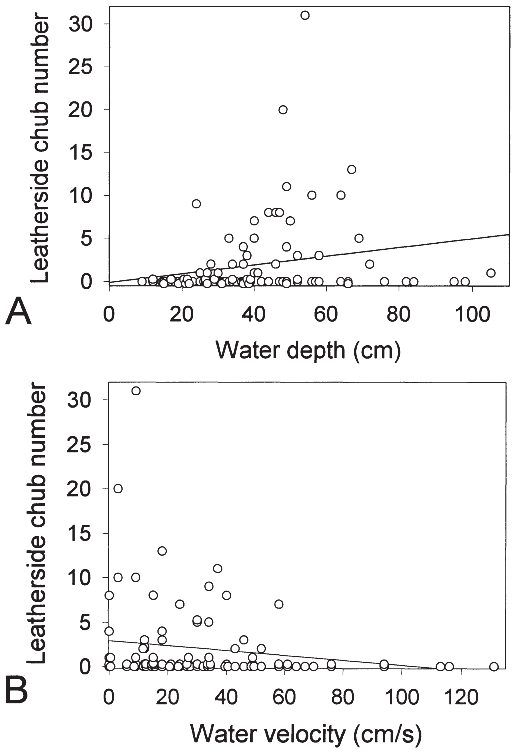

Fig. 2. Number of leatherside chub located at microhabitat survey points plotted against water depth (A) and water velocity (B). Data from Salina Creek, Sevier County, Utah, 1995. Points with equivalent values have been slightly offset to make them visible.

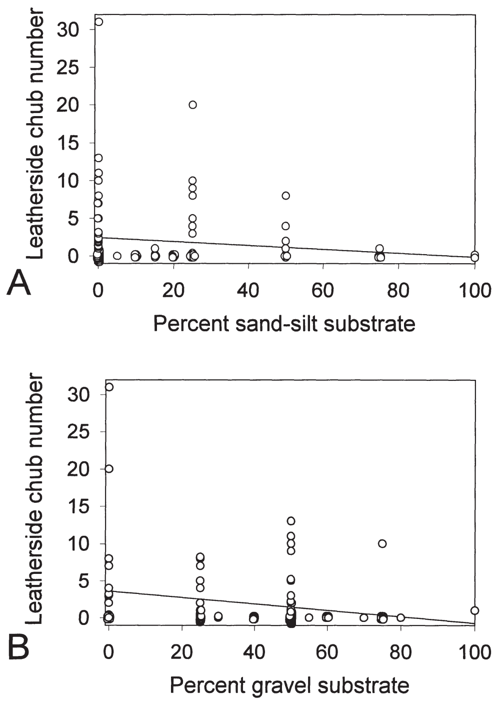

Fig. 3. Number of leatherside chub located at microhabitat survey points plotted against percent coverage of sand-silt substrate (A) and gravel substrate (B). Data from Salina Creek, Sevier County, Utah, 1995. Points with equivalent values have been slightly offset to make them visible.

at 14 locations, but only in small numbers (<50 per 100 m reach). Brown trout were rare or absent at those sites having highest densities of leatherside chub (>100 per 100-m reach). This suggests that brown trout may negatively affect populations of leatherside chub, and fragmentation of leatherside chub populations may be due to interaction with introduced brown trout. Further studies on the interaction of brown trout and leatherside chub are needed to determine the nature and magnitude of this possible negative effect. Leatherside chub were abundant and brown trout rare or absent at all 3 locations where microhabitat characteristics were measured. Because of the possible interaction with brown trout, patterns of habitat use by leatherside chub documented in this study may not coincide with patterns of habitat use in areas with brown trout (Walser et al. 1999).

Microhabitats used by leatherside chub are similar in general to microhabitats used by cyprinids documented in other studies. In stream systems cyprinids have been shown to prefer intermediate water depths and lower water velocities. They usually do not occur in areas with zero water velocity or with a high percentage of silt (Moyle and Baltz 1985, Grossman and Freeman 1987, Grossman and de Sostoa 1994). Use of low-velocity pockets in fast-flowing streams by leatherside chub is similar to patterns of microhabitat use by the Virgin spinedace (*Lepidomeda mollispinis mollispinis*), a closely related species found in the Virgin River basin of southwestern Utah and adjacent areas of Arizona and Nevada. Spinedace are reported to prefer swift streams and utilize depths between 10 and 90 cm at velocities between 10 and 100 cm sec^{-1} (Rinne 1971, Deacon et al. 1991).

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