Habitat Associations, Life History, and Diet of the Blackspot Shiner, *Notropis atrocaudalis*

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Abstract - The ecology of *Notropis atrocaudalis* (Blackspot Shiner) including habitat associations, population age structure, reproduction, and food habits were examined in two east Texas streams from November 2001 through October 2002. Blackspot Shiner were generally found in relatively shallow, slow-flowing runs, but exhibited no strong seasonal habitat associations. The population consisted of four age groups (ages 0, 1, 2, and 3) present within a year, and estimated maximum life span was 3 years. Reproductively mature individuals were observed from March through August and temporal patterns in ovarian development, gonadosomatic index, and ova development indicated that Blackspot Shiner spawns multiple clutches of eggs over an extended spawning period. Blackspot Shiner diets consisted primarily of aquatic insects including Ephemeroptera, Trichoptera, and Coleoptera larvae.

Introduction

The natural distribution of *Notropis atrocaudalis* (Evermann) (Blackspot Shiner) is from the Brazos River drainage in Texas to the lower Red River drainage in Oklahoma, Arkansas, and Louisiana (Gilbert 1978). Information on the ecology of Blackspot Shiner is limited to anecdotal notes, which suggest that it inhabits small streams with sand and rubble substrates (Moore and Cross 1950), vegetation (Pigg 1977), and clear-flowing waters (Douglas 1974). Longitudinally, Blackspot Shiner is abundant in headwater streams, and abundance greatly decreases in downstream portions of streams and rivers (Evans and Noble 1979). Little additional information concerning the ecology and life history of Blackspot Shiner is available; however, the population status of Blackspot Shiner is considered to be stable by Warren et al. (2000).

The objective of this study was to provide further information on ecological and life-history attributes and population age structure of Blackspot Shiner in Bonita Creek and LaNana Bayou, Nacogdoches County, TX. Specifically, we examined habitat associations, gonadal maturation, sex ratio, number of age groups present, and food habits of the Blackspot Shiner population in this stream system.

Methods

Field methods

We collected fish and measured habitat characteristics monthly at three sites on Bonita Creek and one site on LaNana Bayou from November 2001

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through October 2002. Bonita Creek is a first-order stream at Site 1 and a second-order stream at sites 2 and 3. LaNana Bayou is a third-order stream at Site 4. Detailed stream and site descriptions are provided by Williams and Bonner (2006). Blackspot Shiners were collected from available geomorphic units (i.e., runs, riffles, pools, backwaters, and chutes) by a combination of backpack electrofishing (Smith-Root Model 12-B POW) and seining (1.2 by 1.8 m, mesh size = 3.2 mm; 1.8 by 2.4 m, mesh size = 3.2 mm). For each geomorphic unit, we placed block nets (mesh size = 4 mm) at the upper and lower boundaries, electrofished areas surrounding undercut banks and woody debris, and seined all remaining areas until only a few fish (<10) and no new species were collected. We identified all fishes to species and measured total length (nearest 1 mm) of the first 30 individuals of each species. From each site, we randomly selected ten Blackspot Shiners, exposed them to a lethal dose of MS-222, and preserved them in 10% formalin for reproductive and diet analyses.

We measured length, width, mean current velocity (measured at 60% of depth), mean and maximum depth, percent woody cover, vegetation, detritus, and substrate type for each geomorphic unit. We calculated mean current velocity (measured with a Marsh-McBirney Flowmate Model, 2000) and depth from measurements taken at 0.5-m increments across one representative transect per geomorphic unit. We visually estimated substrate type using a modified Wentworth scale (silt: <0.0625 mm, sand: 0.0625–1.99 mm, gravel: 2–63 mm, cobble: 64–255 mm, boulder: ≥256 mm, and bedrock), and woody cover, vegetation (algae and macrophytes), and detritus as the percentage of area occupied within each geomorphic unit (Taylor and Lienesch 1996, Taylor and Warren 2001).

Laboratory methods

In the laboratory, we weighed each preserved Blackspot Shiner and removed, weighed, and examined the gonads. With the aid of a dissecting microscope, we determined the sex of each individual and the stage of ovarian development (i.e., immature or resting, developing, mature, spent; Phillip 1993, Williams and Bonner 2006) for each female. We calculated a gonadosomatic index (GSI; [gonad weight/fish weight]*100) for each fish and pooled GSIs across sites each month for each sex to calculate a mean monthly GSI. We measured oocyte diameters from two to five randomly selected mature females per month from February through September 2002. For these individuals, we separated the oocytes of the left ovary by gently teasing them apart and redistributing the oocytes in a water-filled Petri dish. Diameters of 100 oocytes from each female were measured to the nearest 0.01 mm across their longest and shortest axes, and the two measurements were averaged to determine the diameter of each oocyte. Size-frequency histograms were constructed from oocyte diameters for each female examined.

For food-item analysis, we removed the digestive tract from the esophagus to the first loop of the intestine from three individuals per month. Gut contents were sorted into general taxonomic groups [i.e., aquatic insects, aquatic non-insects, terrestrial arthropods, fish eggs, unidentifiable insects (insect parts or highly masticated individuals)], plant material, detritus, and substrate. Aquatic insects were further identified and sorted to the lowest practical taxon, typically to order. The wet weight of each taxonomic group and detritus was recorded to the nearest 0.1 mg, with a weight of 0.1 mg assigned when the weight of the taxonomic group was <0.1 mg. Percent weight of invertebrate, fish egg, and detritus categories were averaged across fish by month to evaluate temporal changes in diet. Plant material and substrate were recorded as presence or absence among fish by month.

Blackspot Shiner lengths were pooled across all sites for each month and length-frequency histograms were constructed using 2-mm bin increments. Modal progression analysis was implemented in Fish Stock Assessment Tools II (FiSAT II) to determine the number of age groups present. Age groups were labeled according to their age on 1 January 2002, with fish spawned during the study period referred to as age 0. Catch per unit effort (CPUE; number of Blackspot Shiner collected/area sampled [m^2]) was calculated for each site and month to determine temporal patterns in longitudinal distribution.

Statistical methods

Principal components analysis (PCA) was used to assess temporal variation in habitat. Qualitative habitat data (i.e., geomorphic units) were scored as dummy variables, whereas quantitative habitat data (i.e., physical parameters) were z-score transformed (Krebs 1999). A scree plot was used to determine the appropriate number of axes to be retained for further analyses. PCA axis scores were grouped into four time intervals to reflect seasonality in this system: November through January (winter), February through April (spring), May through July (summer), and August through October (fall). Seasonal habitat associations of Blackspot Shiner were examined using Pearson product-moment correlations (Zar 1999) of occurrence, abundance, and density with sample scores from PCA axes I–III. A Bonferroni procedure ($\alpha = 0.05/c$, where c equals number of seasons) was used to adjust the significance level to accommodate multiple comparisons (Quinn and Keough 2002).

Concordance between male and female monthly mean GSIs was assessed using Pearson product-moment correlation ($\alpha = 0.05$). Chi-square goodness-of-fit tests were used to test for departure from a 1:1 sex ratio ($\alpha = 0.05$) and to compare expected and observed Blackspot Shiner abundance among geomorphic unit types ($\alpha = 0.05/4$). Kolmogorov-Smirnov (KS) tests were used for ordinal data to test differences between expected and observed Blackspot Shiner abundance among current velocity (0.05-m/s intervals) and depth (0.05-m intervals) gradients ($\alpha = 0.05/4$). Expected values for goodness-of-fit and KS tests were defined as the number of Blackspot Shiner expected in each geomorphic unit, current velocity interval, or depth interval if density of Blackspot Shiner was uniform among habitats. Expected values were determined by pooling abundance and habitat data across sites and months within each season, calculating the areal (m^2) proportion for each geomorphic unit type, current velocity, or depth interval, and multiplying by the total number of Blackspot Shiners collected. Independent two-sample t-tests were used to test for differences in Blackspot Shiner mean lengths between upstream and downstream sites.

Results

Habitat associations

Bonita Creek and La Nana Bayou were characterized by habitats consisting primarily of runs (78%) and riffles (18%) (Table 1). Mean stream width (± SE) ranged from 3.0 (± 0.24) to 6.8 (± 0.85) m, and mean depth ranged from 0.19 (± 0.02) to 0.29 (± 0.04) m among sites. Dominant substrate types were bedrock (31%), gravel (28%), and sand (18%). However, while bedrock was the most abundant substrate, it was absent from Site 4 at LaNana Bayou, where gravel was the dominant substrate. Woody debris was relatively common at all sites, whereas in-stream vegetation was present only at Site 3. Detritus was abundant at Site 1 in November and December 2001, but was removed by high flows in December 2001. Detritus remained low at all sites from January through September 2002, but became more abundant at sites 1 and 2 in October 2002.

Principal components I–III accounted for 45% of the variation in habitat data (Table 2). The first principal component (19.2% of total variation) represented a gradient in habitats from riffles with high current velocities and greater amounts of bedrock substrate having strong negative sample scores to wide runs with low current velocities and silt substrate having strong positive sample scores (Fig. 1). The second principal component (13.3%) represented a gradient from deep habitats with greater amounts of bedrock substrate having strong negative sample scores to habitats with greater amounts of gravel and cobble substrates having strong positive sample scores. The third principal component (12.7%) represented a gradient from wide habitats with high current velocities and gravel substrate having strong negative sample scores to backwater habitats with abundant detritus having strong positive sample scores.

Table 1. Stream order, percent habitat, and substrate and mean (± SE) monthly habitat parameters for three sites on Bonita Creek (sites 1–3) and one site on LaNana Bayou (Site 4), TX, sampled from November 2001–October 2002.

	Site 1	Site 2	Site 3	Site 4
Stream Order	1	2	2	3
Mesohabitat (%)				
Run	69.6	75.0	90.3	84.5
Riffle	25.8	25.0	9.0	10.5
Pool	4.6	-	-	2.5
Backwater	-	-	-	2.5
Chute	-	-	0.7	-
Substrate %				
Silt	13.0	7.1	19.1	16.0
Sand	1.5	6.2	33.6	21.5
Gravel	17.6	30.8	4.8	51.8
Cobble	3.7	29.5	3.2	10.7
Bedrock	64.2	26.3	39.3	-
Detritus (%)	8.0 (± 4.6)	1.8 (± 1.3)	0.7 (± 0.5)	0.7 (± 0.3)
Woody debris (%)	5.3 (± 2.3)	6.4 (± 1.9)	4.1 (± 1.5)	7.8 (± 2.2)
Vegetation (%)	-	-	0.8 (± 0.82)	-
Length (m)	171.5 (± 12.26)	92.2 (± 3.7)	112.5 (± 6.4)	116.8 (± 12.1)
Width (m)	3.0 (± 0.24)	3.4 (± 0.37)	5.6 (± 0.39)	6.8 (± 0.85)
Depth (m)	0.19 (± 0.02)	0.19 (± 0.01)	0.29 (± 0.04)	0.28 (± 0.03)
Current velocity (m/s)	0.13 (± 0.04)	0.19 (± 0.06)	0.22 (± 0.08)	0.30 (± 0.06)

A total of 2787 Blackspot Shiners were collected from November 2001 through October 2002 from 108 (72%) of 149 geomorphic units sampled. Occurrence of Blackspot Shiner was positively correlated ($r = 0.38$, $P = 0.009$; Table 3) with principal component I (i.e., habitats with greater depths, greater

Table 2. Loadings and percent variance (%) explained by qualitative and quantitative habitat parameters on principle components axes (PCA) I–III for three sites on Bonita Creek (Sites 1–3) and one site on LaNana Bayou (Site 4), TX, from November 2001–October 2002.

	PCA axis		
	I	II	III
Percent variance explained:	19.2	13.3	12.7
Parameter:			
Backwater	0.227	0.062	0.331
Pool	0.207	-0.071	-0.028
Run	0.513	-0.089	-0.025
Riffle	-0.594	0.189	-0.088
Chute	-0.290	-0.240	-0.003
Current velocity (cm/s)	-0.382	-0.018	-0.547
Depth (cm)	0.737	-0.122	-0.123
Maximum depth	0.782	-0.351	-0.223
Stream width	0.512	-0.021	-0.458
Silt substrate (%)	0.404	0.217	0.589
Sand substrate (%)	0.395	-0.125	-0.035
Gravel substrate (%)	0.136	0.680	-0.310
Cobble substrate (%)	-0.223	0.445	-0.293
Bedrock substrate (%)	-0.438	-0.822	0.098
Woody debris (%)	0.289	0.085	0.039
Vegetation (%)	0.165	-0.225	0.013
Detritus (%)	0.090	0.260	0.687

Table 3. Seasonal correlations of Blackspot Shiner occurrence, abundance, and density (CPUE), with principle component axes I–III for three sites on Bonita Creek and one site on LaNana Bayou, TX, sampled from November 2001–October 2002. Asterisk denotes significant correlation with a Bonferroni adjusted $\alpha = 0.0125$ for seasonal comparisons.

	PC axis I		PC axis II		PC axis III	
	r	*P*	*r*	*P*	*r*	*P*
Occurrence						
Winter	-0.05	0.77	-0.19	0.30	0.02	0.92
Spring	-0.41	0.03	0.01	0.95	0.06	0.75
Summer	-0.02	0.90	0.02	0.91	-0.12	0.45
Fall	0.38	0.009*	0.15	0.32	0.02	0.90
Abundance						
Winter	-0.24	0.18	-0.25	0.17	0.02	0.93
Spring	-0.15	0.44	-0.10	0.60	0.31	0.10
Summer	0.11	0.49	0.05	0.75	0.12	0.44
Fall	0.03	0.82	-0.18	0.22	0.23	0.13
Density						
Winter	-0.14	0.47	-0.21	0.26	0.13	0.48
Spring	-0.13	0.49	-0.01	0.97	0.23	0.22
Summer	-0.26	0.10	-0.24	0.12	0.07	0.63
Fall	0.07	0.64	0.08	0.59	0.41	0.005*

widths, and runs) from the PCA of habitat data in the fall. Blackspot Shiner density was positively correlated ($r = 0.41$, $P = 0.005$) with principal component III (i.e., habitats with greater amounts of detritus, silt, and backwaters).

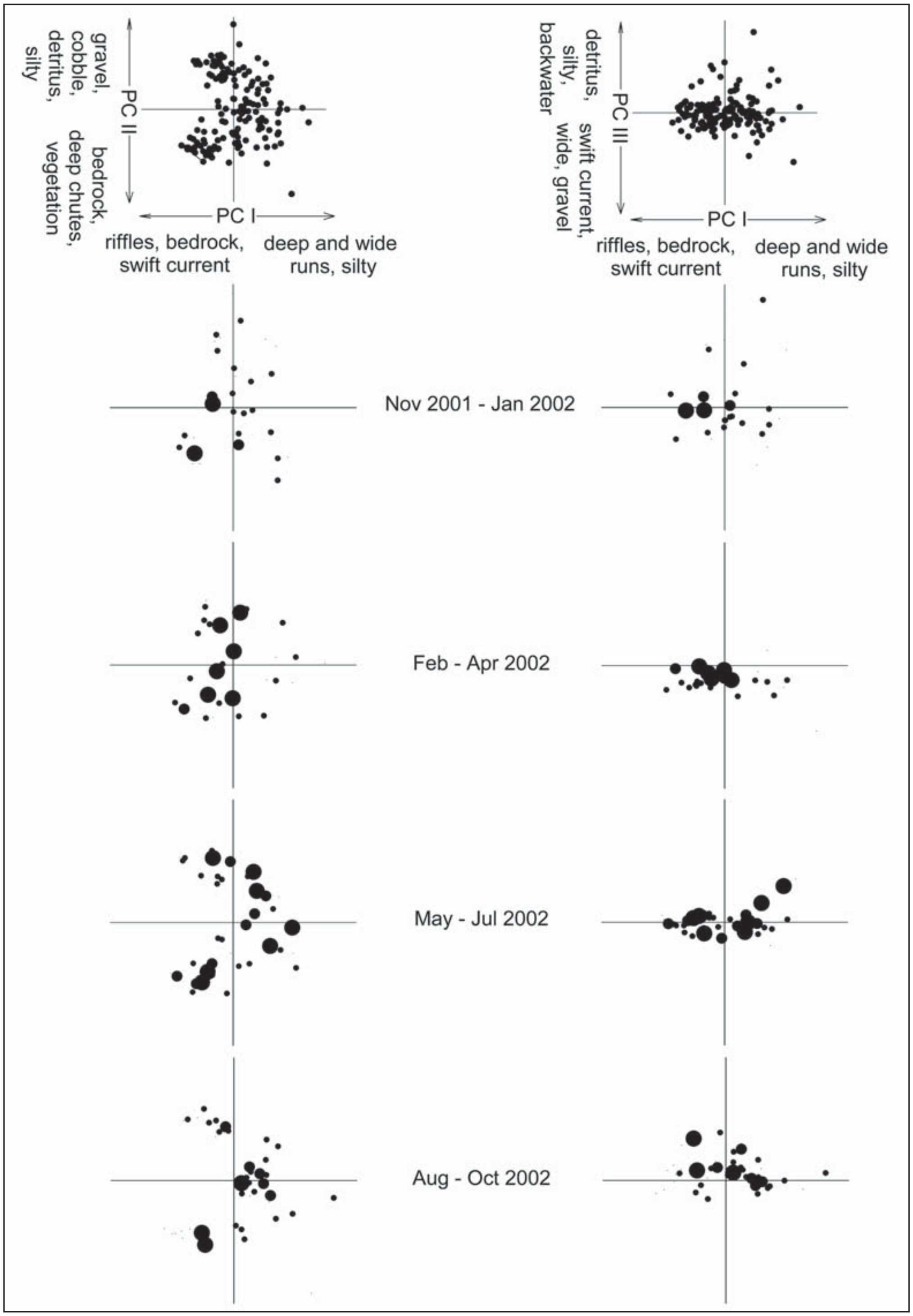

Figure 1. Plots of all geomorphic units on principal component axes I, II, and III. Subsequent plots illustrate Blackspot Shiner occurrence (circle) and abundance (circle size: small = less than 25 individuals; medium = 25–75; and large = greater than 75) by season.

Run and pool habitats contained a greater number of Blackspot Shiners than expected, whereas riffles, backwaters, and chutes contained fewer individuals than expected ($\chi^2 = 28.1$, $P < 0.001$). Among current-velocity intervals, Blackspot Shiner were more abundant (87%) in slower current velocities (0–0.3 m/s; 68% of total area) and less abundant (13%) in swifter currents (0.35–0.95 m/s; 32% of total area) (Fig. 2a). Among depth intervals, Blackspot Shiner were

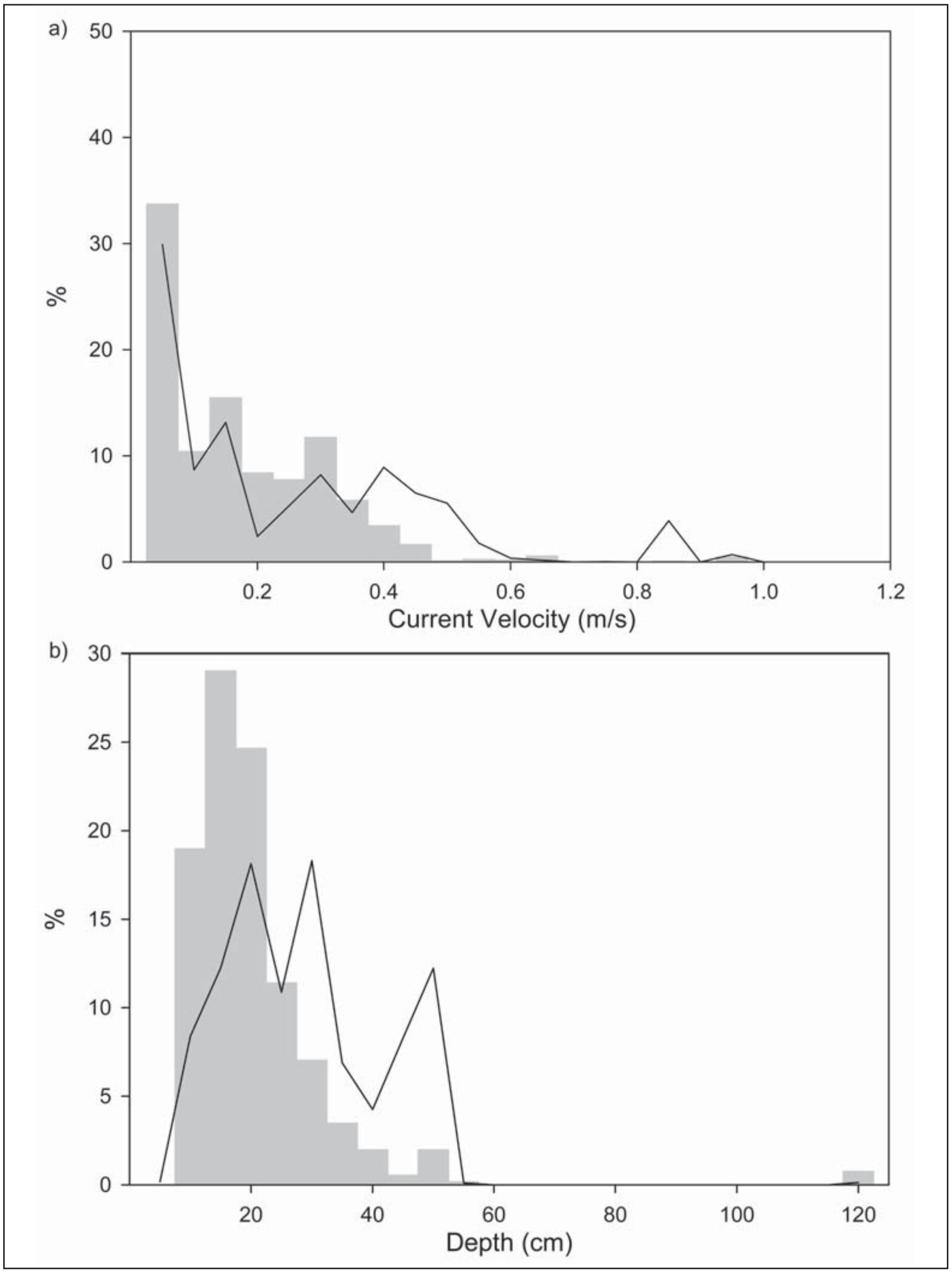

Figure 2. Percent occurrence of Blackspot Shiners along current velocity (a) and depth (b) intervals collected from three sites on Bonita Creek and one site on LaNana Bayou, Nacogdoches, TX, from November 2001–October 2002. Gray bars represent observed values and the line represents expected values.

more abundant (91%) in shallower depths (≤0.30 m; 68% of total area) and less abundant (9%) at depths ranging from 0.35 to 1.2 m (32% of total area).

Population structure

Four age groups (ages 0, 1, 2, and 3) were present in the population within the year (Fig. 3). Age-3 fish reached a maximum total length of 88 mm and were collected from February through April 2002 (1%). Age-2 fish were collected throughout the year and were the most abundant age group within the population from November 2001 through May 2002. Age-1 fish were also collected throughout the year and were the most abundant adult age group from July 2002 through October 2002. Age-0 fish were first collected in April 2002, were the most abundant age group from June 2002 through August 2002 and reached a maximum length of 56 mm TL by September 2002. Catch per unit effort of Blackspot Shiners ranged from 0–1.2 individuals/m^2 among sites. Catch per unit effort was typically >0.1 individuals/m^2 at upstream sites (i.e., sites 1 and 2) and consisted primarily of adult Blackspot Shiners. Catch per unit effort was typically <0.04 individuals/m^2 at downstream sites (i.e., sites 3 and 4), except from June–July at Site 3 and June–September at Site 4, when juvenile Blackspot Shiners were abundant (0.25–1.16 individuals/m^2) at these sites. Mean lengths of Blackspot Shiners did not differ between upstream and downstream sites in May ($t = 1.709$, $P = 0.093$), whereas mean lengths differed between upstream (mean length = 56 mm) and downstream (mean length = 36 mm) sites in June ($t = 6.960$, $P < 0.001$).

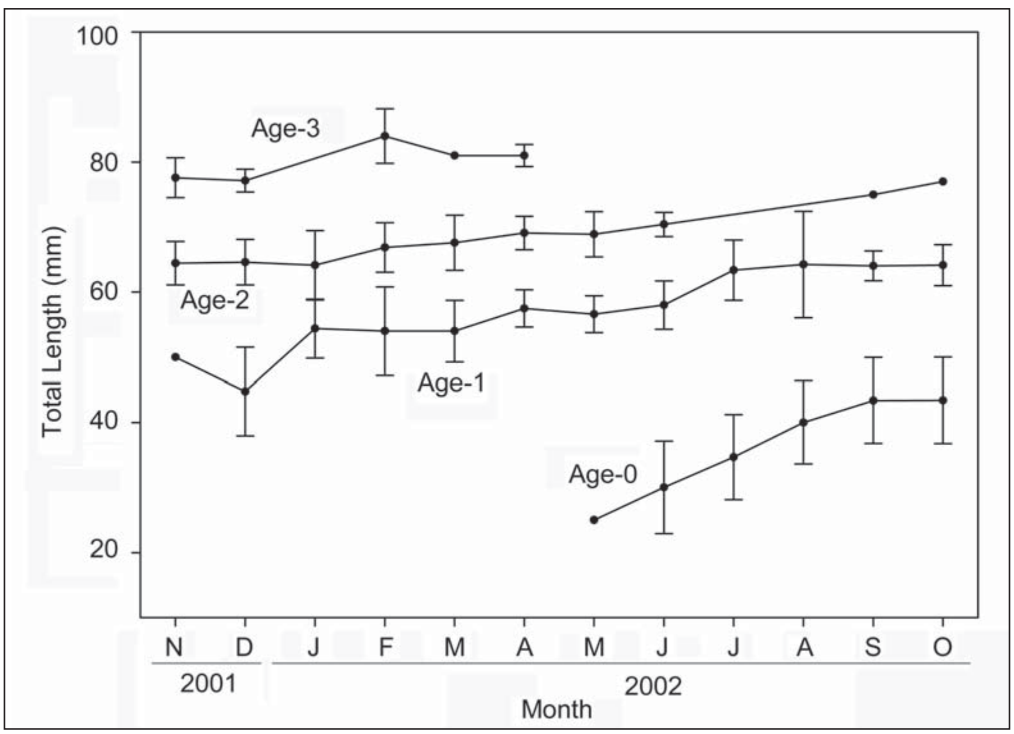

Figure 3. Monthly mean total length (± SD) for age-0, age-1, age-2, and age-3 Blackspot Shiners collected from three sites on Bonita Creek and one site on LaNana Bayou, Nacogdoches, TX, from November 2001–October 2002. Monthly collections were pooled across all sites.

Gonadal development and GSI

All ovaries from female Blackspot Shiner collected from September through November (n = 13; TL = 38–76 mm) were classified as either immature or resting. Developing ovaries were first observed in December and occurred in all females (n = 6; TL = 62–75 mm). Ovaries with vitellogenic oocytes were first observed in March and occurred in 63% of females (n = 8; TL = 59–68 mm) and were present in all females from April through June (n = 24; TL = 49–81 mm). In July, ovaries of all females (n = 2; TL = 47–48 mm) possessed only previtellogenic oocytes.

Mean monthly GSI (Fig. 4) for females corresponded with temporal patterns in ovarian developmental stages and was positively correlated with male mean monthly GSI values ($r = 0.73$, $P < 0.01$). Female GSI was <3% during gonadal quiescence, elevated (>5%) from March through May, and decreased to <3% in July and August. Mean monthly male GSI was <0.75% from October through December, elevated (>0.75%) in February and March, and decreased to below 0.75% from April through September. Sex ratio did not differ from 1:1 ($\chi^2 = 0.3$, $P = 0.58$).

Female Blackspot Shiner produced multiple cohorts of oocytes throughout the spawning period. Trimodal distributions of oocyte diameters indicated three oocyte size classes from March through June 2002 (Fig. 5). Oocyte size groups consisted of one cohort of small previtellogenic oocytes and two cohorts of vitellogenic oocytes.

Food habits

Thirty-six Blackspot Shiners were examined for diet analysis. Gut contents, by weight, consisted of aquatic insects (84%; unweighted average across months), detritus (8%), terrestrial arthropods (6%), aquatic non-insect arthropods (2%), fish eggs (<0.1%), and unidentifiable insect parts (<0.1%). Mean monthly weight of digestive tract contents ranged from 1.2 mg (September 2002) to 30.7 mg (August 2002) (Table 4). Frequency of occurrence of individuals with no food items present was 21%; however, these individuals still possessed vegetation or substrate in their gut.

Aquatic insects were the most common food item, ranging in percent weight from 29% (October 2002) to 100% (February, July, and September 2002). Diptera was the most abundant aquatic insect consumed (48% by weight of aquatic insects) followed by Ephemeroptera (26%), Trichoptera (21%), Coleoptera (5%), and Odonata (<0.1%). Terrestrial arthropods comprised 6% of gut content weight on average and up to 54%. Adult Diplopoda (85% of terrestrial arthropods) was the most abundant terrestrial arthropod consumed, followed by Arachnida (14%) and Hymenoptera (1%). Aquatic non-insect arthropods were rare (<2%) and consisted of Annelida (76%), Crustacea (14%), and Hydracarina (10%). Fish-egg consumption was rare and occurred only in June 2002. Percent weight of detritus ranged from 0 to 39%, occurrence of substrate in gut contents was 73% among individuals, and occurrence of plant material was 76% among individuals.

Discussion

Blackspot Shiner showed only occasional associations along multivariate habitat gradients and is a habitat generalist occurring in 72% of geomorphic units sampled. Although associations along these multivariate gradients were weak, Blackspot Shiner did show habitat associations in univariate analyses. Abundance of Blackspot Shiner was typically higher in habitats

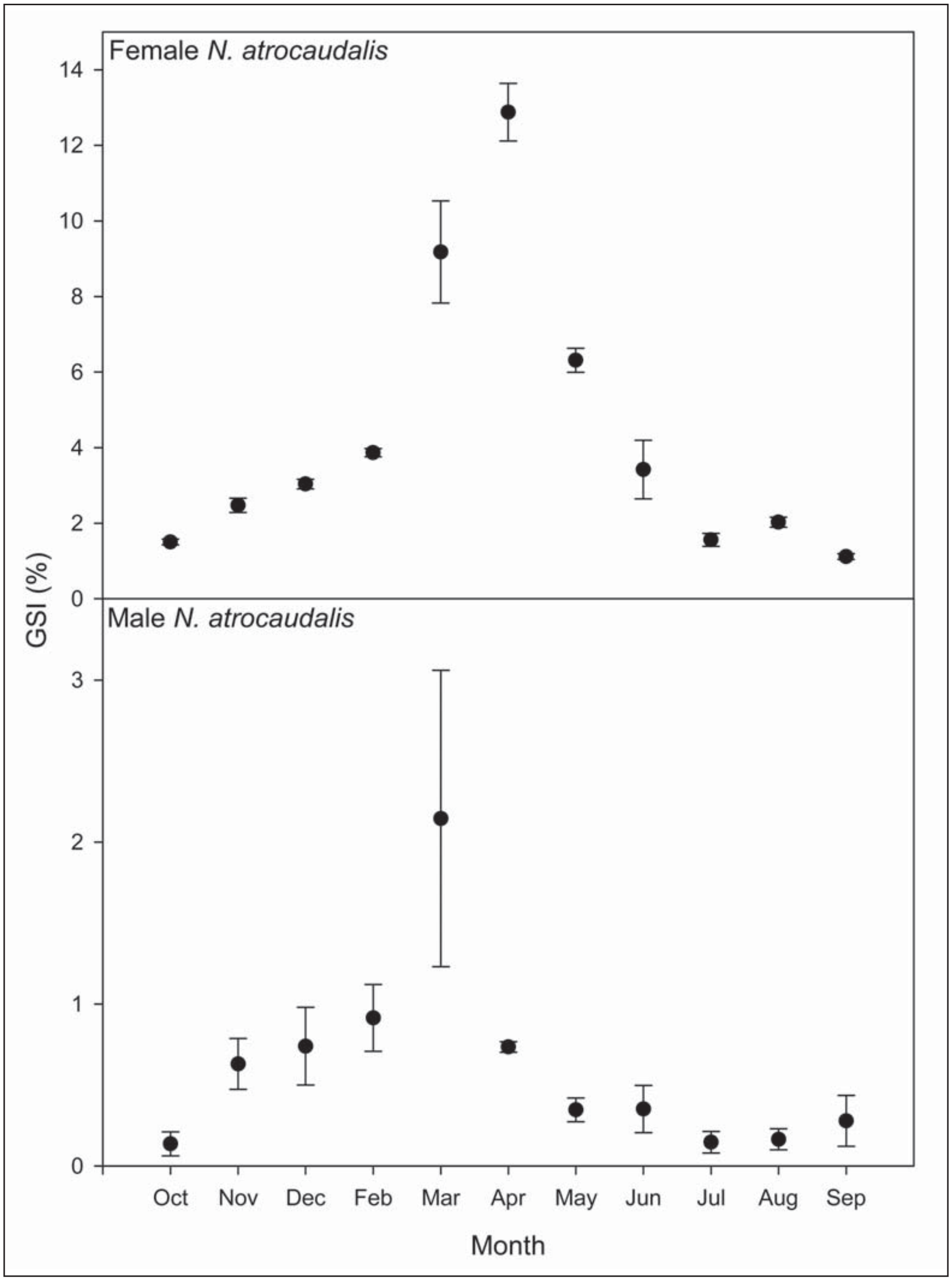

Figure 4. Mean (± SE) monthly gonadosomatic index (GSI) for female and male Blackspot Shiners from Bonita creek and LaNana Bayou, Nacogdoches, TX, collected from November 2001–October 2002.

with relatively shallow depths and slow current velocities as well as in runs and pools. Although anecdotal notes suggest that Blackspot Shiners are associated with vegetation (Pigg 1977), abundance of adult Blackspot Shiners was greatest at sites 1 and 2 where no vegetation was present and was lower at Site 3 where vegetation occurred.

Temporal patterns in ovarian development, GSI, and oocyte-diameter frequency distributions suggest that Blackspot Shiner spawns over a protracted period primarily from March through June, with some individuals possessing mature ova as late as August. The presence of three distinct oocyte size classes in individual mature females suggests the production of multiple egg cohorts by individual females (Heins and Rabito 1986). Blackspot Shiner is a relatively fast-growing species, with some individuals reaching a total

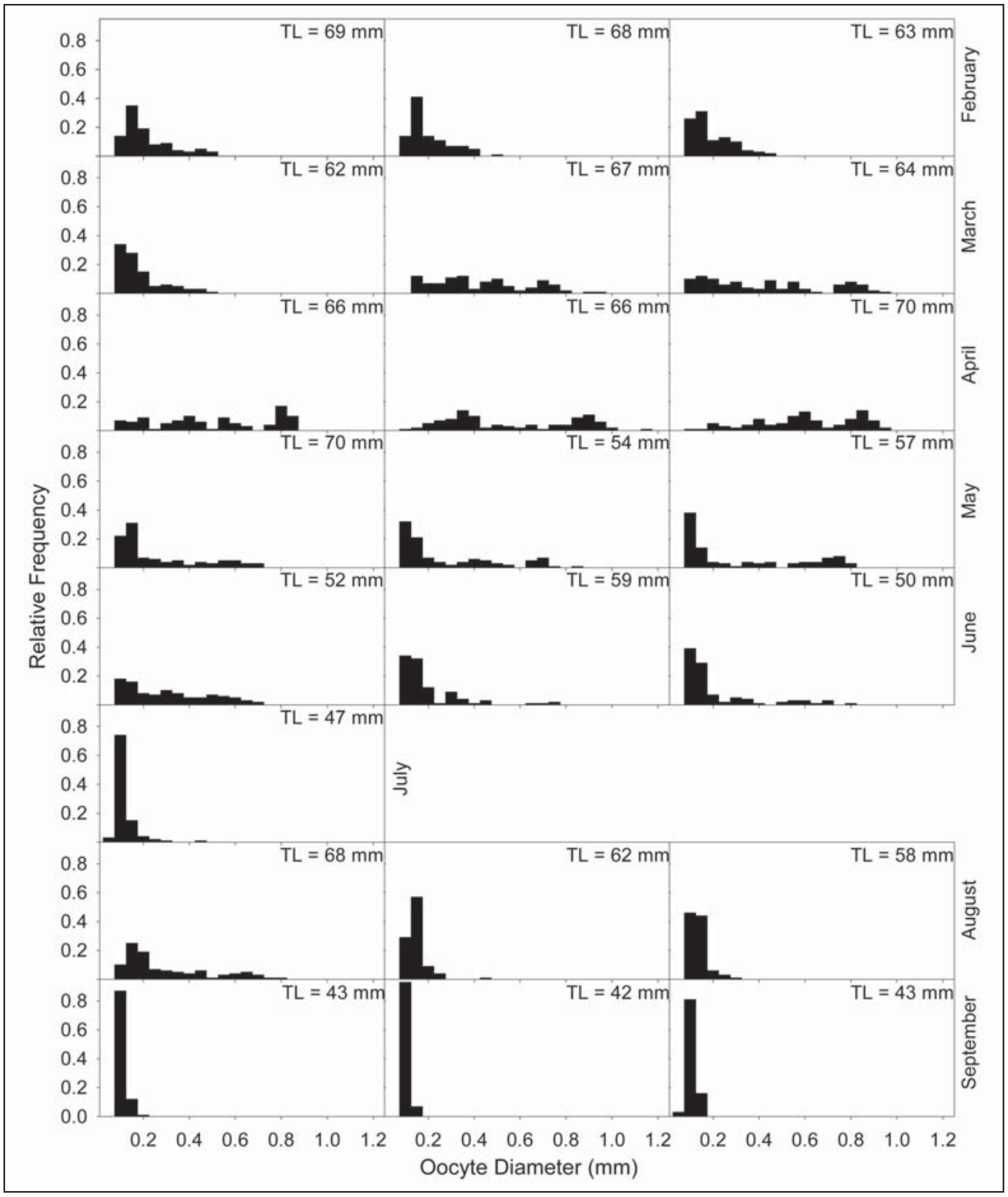

Figure 5. Monthly size-frequency distribution for ova diameters from reproductively mature Blackspot Shiners collected from March–June 2002.

length of 56 mm in their first summer. Female Blackspot Shiners typically mature by the beginning of their second spring (age-1). However, the presence of developing ovaries in individuals as small as 47 mm in July indicates that some early spawned or fast-growing individuals may reach sexual maturity at age zero. Spawning by age-0 individuals has been suggested for other cyprinids (Cowell and Barnett 1974, Heins and Clemmer 1975) including the sympatric congener *Notropis sabinae* (Jordan and Gilbert) (Sabine Shiner) (Williams and Bonner 2006) and has been confirmed in *Cyprinella lutrensis* (Baird and Girard) (Red Shiner) (Marsh-Matthews et al. 2002).

Mean lengths of Blackspot Shiner in May were 63 mm (± 1.1 SE) and 71 mm (± 3.2) at upstream and downstream sites, respectively, whereas mean lengths in June were 56 mm (± 2.3) and 36 mm (± 1.6) at upstream and downstream sites, respectively. This large shift in mean lengths, low abundance of adults, and high abundance of juveniles at downstream sites from June–September suggests downstream drift of eggs or larvae, as has been suggested for other stream fish (Heins and Baker 1989). Such drift is consistent with previous reports that Blackspot Shiner is primarily restricted to low-order streams (Evans and Noble 1979).

In contrast to these opportunistic reproductive traits, Blackspot Shiner is an aquatic insectivore. Although food item availability data was not available, aquatic insects comprised 84% of the diet of Blackspot Shiners. They were abundant in stomachs across all months and were the most abundant food source in all months except October. The abundance of aquatic insects, lack of terrestrial insects, and high frequency of substrate in their stomachs indicate that Blackspot Shiner is a benthic feeder (Heins and Clemmer 1975, Wilde et al. 2001). Invertivorous fish have significant top-down effects in streams by reducing densities of benthic grazing invertebrates (Hargrave 2006, Katano et al. 2006). Thus, Blackspot Shiner, as one of the most abundant fishes in this system, likely has a strong role in structuring the stream community.

Table 4. Mean total weight (mg); percent occurrence of plant material and substrate; and percent of food items found in the stomachs of Blackspot Shiners collected from three sites on Bonita Creek (Sites 1–3) and one site on LaNana Bayou (Site 4), TX, from November 2001–October 2002. UI parts = unidentified parts.

			Occurrence		Weight					
Month	*n*	Mean total weight (mg)	Plant material (%)	Substrate (%)	Aquatic insects (%)	Aquatic non-insects (%)	Terrestrial arthropods (%)	Detritus (%)	Fish eggs (%)	UI parts (%)
Oct.	3	6.5	0.0	33.3	29.2	-	53.8	16.9	-	-
Nov.	3	1.6	100.0	33.3	95.9	4.1	-	-	-	-
Dec.	3	8.9	100.0	33.3	98.9	1.1	-	-	-	-
Feb.	3	13.6	100.0	66.7	100.0	-	-	-	-	-
Mar.	3	7.0	66.7	100.0	63.6	-	-	36.4	-	-
Apr.	3	24.0	100.0	100.0	96.4	3.5	0.1	-	-	-
May	3	5.4	66.7	100.0	79.8	12.9	7.4	-	-	-
Jun.	3	4.5	33.3	66.7	55.9	-	4.4	39.0	0.7	-
Jul.	3	9.1	100.0	66.7	100.0	-	-	-	-	-
Aug.	3	30.7	66.7	100.0	99.9	-	-	-	-	0.1
Sep.	3	1.2	100.0	100.0	100.0	-	-	-	-	-

Blackspot Shiner possesses several traits well suited to inhabiting highly variable streams such as Bonita Creek and LaNana Bayou. Early maturation, relatively short life spans, extended spawning periods, and downstream drift of eggs or larvae are traits common to stream fishes inhabiting highly variable systems (Begsten et al. 1989, Heins and Rabito 1986, Matthews et al. 1978, Platania and Altenback 1998) and comprise an overall opportunistic life history. These opportunistic life-history traits allow for rapid dispersal and recolonization, as droughts and floods are characteristic of east Texas systems and may lead to temporary local extirpations. Despite possessing opportunistic life-history characteristics, stream fishes such as Blackspot Shiner face threats from disturbances such as impoundments or other stream impediments which may preclude upstream recolonization of streams following drought (Wilde and Ostrand 1999, Winston et al. 1991). Blackspot Shiner has persisted in Bonita Creek and LaNana Bayou despite the effects of extensive agriculture and urbanization in the surrounding landscape; however, potential breaks in the connectivity of upstream and downstream segments are likely the greatest threats to the future persistence of Blackspot Shiner in this and other stream systems.

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