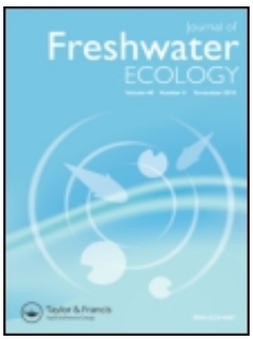

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Diets of the Arkansas River Shiner and Peppered Chub in the Canadian River, New Mexico and Texas

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ABSTRACT

We examined the digestive tract contents of 1,437 Arkansas River shiners (*Notropis girardi*) and 1,943 peppered chubs (*Macrhybopsis tetranema*) collected from the Canadian River in New Mexico and Texas from September 1996 to August 1998. Both the Arkansas River shiner and peppered chub are generalist feeders, with terrestrial and aquatic insects representing 28 and 31%, respectively, by weight, of their diets. Detritus, plant materials, and sand-silt represented 26, 6, and 40%, respectively, of the Arkansas River shiner diet and 25, 28, and 17% of the peppered chub diet. The presence of sand-silt in the diets of both species suggests they forage among sediments on the river bottom. The common occurrence of terrestrial insects (i.e., Coleoptera, Hymenoptera) in the diet of the Arkansas River shiner indicates this species also feeds in the water column on drifting invertebrates.

INTRODUCTION

The Arkansas River shiner (*Notropis girardi*) and peppered chub (*Macrhybopsis tetranema*) historically were widely distributed in larger streams and rivers of the Arkansas River drainage system of Arkansas, Colorado, Kansas, New Mexico, Kansas, and Texas (Gilbert 1980, Luttrell et al. 1999). Since the 1950s, the distribution and abundance of both species have been reduced as a result of reservoir construction, groundwater pumping, and diversion of streams and rivers for irrigation (Cross and Moss 1987, Limbird 1993, Luttrell et al. 1999, Bonner and Wilde 2000). The Arkansas River shiner has disappeared from 80% of its historic range and was listed as a threatened species in 1998 (US Fish and Wildlife Service 1998). The peppered chub has disappeared from 90% of its historic range (Luttrell et al. 1999).

There are two extant populations of both the Arkansas River shiner and peppered chub. The Arkansas River shiner is common in the Canadian River between Ute Reservoir in New Mexico and Lake Meredith in Texas where it often is the most abundant fish captured and shows no evidence of any recent change in abundance (Bonner and Wilde 2000). Downstream from Lake Meredith, for approximately 120 km, the Arkansas River shiner is rarely collected. Further downstream in the Canadian River in Oklahoma, the Arkansas River shiner is common but has decreased in abundance over the past 25 years (Pigg 1991, Pigg et al. 1999). The peppered chub now occurs only in the Canadian River between Ute Reservoir and Lake Meredith and in the Ninnescah River and a short adjacent stretch of the Arkansas River in Kansas (Luttrell et al. 1999, Bonner and Wilde 2000). The peppered chub represents about 12% of the fish assemblage in the Canadian River (Bonner and Wilde 2000) but is uncommon in the Ninnescah River and the Arkansas River (A. A. Echelle[a], personal communication).

[a]Department of Zoology, Oklahoma State University.

There are no published accounts of the diets of either the Arkansas River shiner or the peppered chub. In this paper, we describe the diets of both species in the Canadian River in New Mexico and Texas during September 1996 through August 1998.

METHODS AND MATERIALS

We collected Arkansas River shiners and peppered chubs monthly from September 1996 to August 1998 from three sites on the Canadian River, in Quay County in New Mexico and Oldham County and Potter County in Texas. A brief description of the study area is given in Bonner and Wilde (2000). Collections were made with a 1.5 x 3.6-m seine with 6.4-mm mesh. Fish were euthanized with MS-222 to prevent regurgitation of digestive tract contents (Mendelson 1975) and were preserved in 10% formalin. We attempted to collect 20 Arkansas River shiners and 20 peppered chubs at each sampling site on each sampling date.

In the laboratory, the entire digestive tract was removed from each fish and the contents of the anterior third of the digestive tract were examined under magnification (Heins and Clemmer 1975, Johnson and Dropkin 1991). Whenever possible, invertebrate prey items were identified to the lowest taxon, usually family or order; however, because of extensive maceration by the pharyngeal teeth, many prey items could not be identified. Various forms of unidentifiable organic material were treated as a single category, "detritus," and were visually separated from inorganic materials (sand and silt). For each fish, all items of each food type, including detritus, were weighed (wet weight) collectively to the nearest 0.0001 g.

RESULTS

Arkansas River shiners

Of the 1,437 Arkansas River shiners examined, 76% had food in their digestive tracts. Empty digestive tracts were encountered more frequently in fall and winter than in spring and summer (Figure 1). Mean weight of the digestive tract contents ranged from 0.0008 to 0.2206 g and showed a pronounced seasonal pattern being lowest in fall and winter and greatest in spring and summer.

Aquatic insects (Megaloptera, Odonata, Plecoptera, and Trichoptera) and aquatic and terrestrial Coleoptera regularly occurred in the diet of Arkansas River shiners, especially during the cooler months, October through March. Both aquatic insects and Coleoptera were more commonly preyed on and constituted a greater portion of the diet of Arkansas River shiners during the first year of our study. When present in the diet, aquatic insects represented 0.3 to 19% (unweighted mean across all months = 3.0%) and Coleoptera 0.6 to 37% (mean = 3.7%) of the digestive tract contents. Diptera represented 0.2 to 29% (mean = 5.5%) of the diet and were consumed throughout the year with no apparent seasonal pattern. Hymenoptera represented 0.3 to 18% (mean = 2.4%) of the diet and were most frequently consumed in July and August. Unidentified insects contributed 1 to 47% (mean = 13.7%) of the diet. Collectively, insects represented 8 to 75% (mean = 28.2%) of the Arkansas River shiner diet and generally were more prevalent in the diet during 1996-1997 than in 1997-1998.

The diet of the Arkansas River shiner contained a high proportion of detritus (26% by weight) and sand-silt (40%) (Table 1). In combination, detritus and sand-silt represented at least 50% of the diet in all months except September through November. Plant material, primarily comprising seeds of alkali sacaton (*Sporobolus airoides*), represented 0.1 to 28% (mean 6.1%) of the diet and was most commonly consumed in August through October.

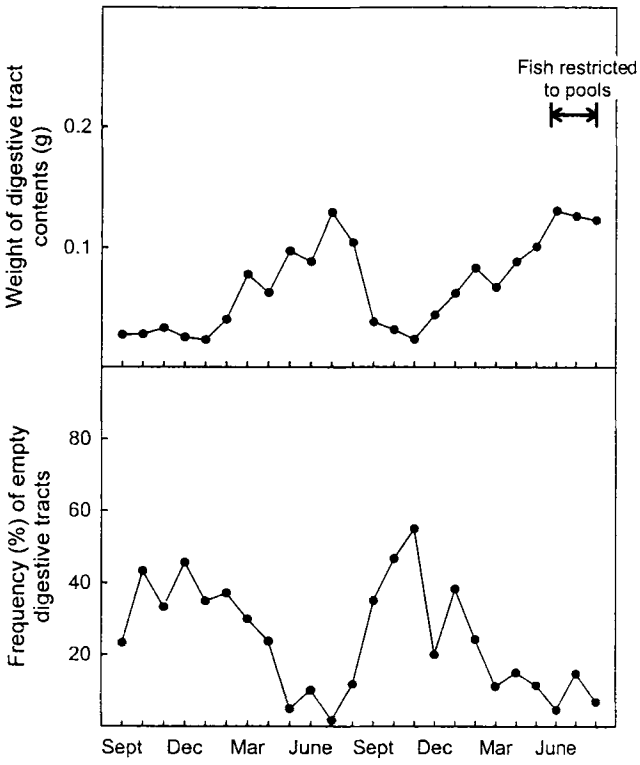

Figure 1. Mean weight of the contents of the digestive tract and frequency (%) of empty digestive tracts in Arkansas River shiners collected from the Canadian River in New Mexico and Texas from September 1996 to August 1998.

Table 1. Composition of the diet of the Arkansas River shiner collected from the Canadian River in New Mexico and Texas from September 1996 to August 1998. Tabled values are sample sizes (*N*) and the percent (%) each item contributed to the total weight of the digestive tract contents.

Month	*N*	Aquatic insects (%)	Coleoptera (%)	Detritus (%)	Diptera (%)	Hymenoptera (%)	Plant material (%)	Sand-silt (%)	Unidentified insects (%)
September 1996	29	2.4		36.5	0.2		25.4	8.9	26.5
October	33	5.5	19.5	26.1	13.5		12.5		23.0
November	40	21.7	1.6	19.1	3.4	1.1	1.9	3.8	47.4
December	32	3.5	9.1	15.2	9.0		7.5	43.7	12.0
January 1997	39	0.7	0.6	6.7	28.7			59.3	4.1
February	36		0.9	8.6	11.7		0.2	73.4	5.3
March	42	0.3	0.7	4.3	5.9	2.1		71.5	15.2
April	45	1.3	5.8	28.8	9.2	0.5	3.6	38.2	12.6
May	59	1.5	0.9	43.0	2.5	1.8	5.2	34.0	11.1
June	54	3.1	0.3	43.3	8.6	0.9	9.5	28.0	6.2
July	59	1.1	2.8	56.7	2.1	7.7	8.8	4.1	16.7
August	53	10.2		51.8	1.0	17.7	11.4	4.5	3.5
September	38	0.7	1.0	45.6	15.8	1.4	13.7	1.9	19.9
October	32	18.9	2.5	22.0		2.5	28.3	23.9	1.9
November	27		1.5	16.2	0.1	1.7	6.7	34.8	38.9
December	30			3.1	0.2	0.3	4.6	84.0	7.8
January 1998	37			18.3	7.6			38.0	36.1
February	45	0.8		16.0	2.9			73.8	6.5
March	49		36.5	36.9		0.3	0.3	18.2	7.7
April	51	0.6		21.7		0.7	0.5	67.4	9.1
May	62		3.9	36.4	3.7	4.0		41.6	10.4
June	64			14.5	0.9	0.9	6.9	70.8	5.9
July	64			5.4	0.5	9.8	0.1	84.1	
August	69			43.8	4.0	3.1	0.2	47.5	1.4

Peppered chubs

Of the 1,943 peppered chubs collected, 62% had food items in their digestive tracts. Mean weight of the digestive tract contents ranged from 0.0025 to 0.4378 g. Weight of the digestive tract contents and frequency of empty digestive tracts (Figure 2) showed seasonal patterns similar to those for the Arkansas River shiner.

Aquatic insects, aquatic and terrestrial Coleoptera, and Hymenoptera occurred infrequently in the diet of peppered chubs but were most common in the summer (Table 2). When present in the diet, aquatic insects accounted for 0.1 to 12% (mean across all months = 1.5%), Coleoptera 0.1 to 1.5% (mean = 0.1%), and Hymenoptera 0.1 to 4% (mean = 0.3%) of the diet. Diptera were present in the diet in all but two months and contributed 0.1 to 75% (mean = 22.7%). Diptera generally were most heavily consumed in winter, spring and early summer (November through June). Unidentified insects were present in the diet in all but two months and represented 0.1 to 21% (mean = 6.2%) of the diet. Because Diptera were by far the most common insects in the diet of peppered chubs, it is likely that most unidentified insect prey were dipterans. Based on this assumption, Diptera represented 1 to 84% (mean = 29%) of the peppered chub diet. Collectively, insects represented 1 to 96% (mean = 30.8%) of the peppered chub diet.

The diet of the peppered chub contained considerable proportions of detritus (25% by weight of the diet), plant materials (28%), and sand-silt (17%) (Table 2). In combination, these items represented at least 4 to 99% (mean = 69.2%) of the digestive tract contents and comprised more than 50% of the contents in all but six months. Plant materials were composed primarily of alkali sacaton seeds.

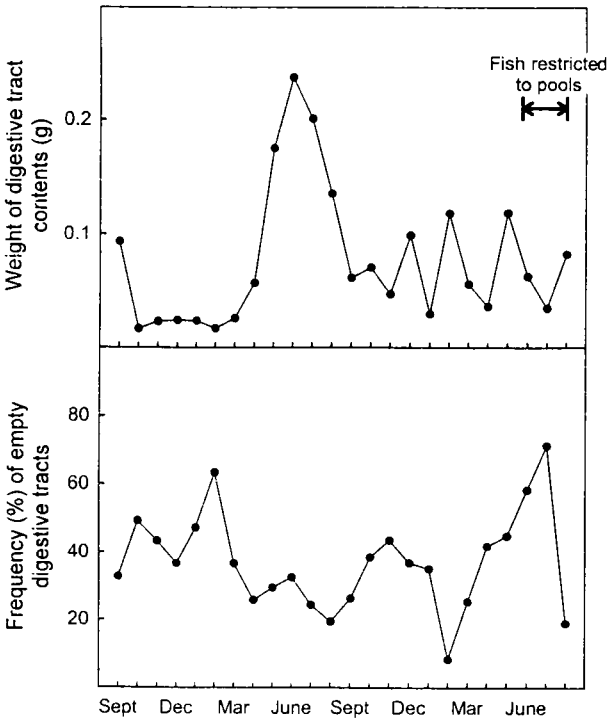

Figure 2. Mean weight of the contents of the digestive tract and frequency (%) of empty digestive tracts in peppered chubs collected from the Canadian River in New Mexico and Texas from September 1996 to August 1998.

Table 2. Composition of the diet of the peppered chub collected from the Canadian River in New Mexico and Texas from September 1996 to August 1998. Tabled values are sample sizes (*N*) and the percent (%) each item contributed to the total weight of the digestive tract contents.

Month	*N*	Aquatic insects (%)	Coleoptera (%)	Detritus (%)	Diptera (%)	Hymenoptera (%)	Plant material (%)	Sand-silt (%)	Unidentified insects (%)
September 1996	37			6.4	0.1		76.4	16.4	0.6
October	29	2.9		4.8	4.8		64.7	11.3	11.5
November	34			12.8	27.8		46.5	12.7	0.1
December	38			4.7	41.4		29.7	20.4	3.8
January 1997	30			56.9	18.4		14.6	5.1	5.0
February	22			35.7	52.0		4.5	2.1	5.7
March	38			43.5	22.7		20.3	10.8	2.8
April	43			9.4			19.3	65.3	6.0
May	84	0.1		18.6	23.7	0.1	46.7	10.0	0.8
June	81	0.4		17.6	43.5	0.2	12.2	10.2	16.0
July	87	0.2	0.1	41.9	2.9	1.3	12.3	40.4	0.9
August	96	2.4	1.5	36.9	3.0	3.7	27.6	23.6	1.3
September	45			31.8	7.6		47.3	4.1	9.2
October	37	6.1		5.1			21.4	61.4	6.0
November	34	8.8		10.2	14.8		11.7	34.0	2\.5
December	38	11.6		3.1	70.9		0.1	1.2	13.0
January 1998	39			28.0	58.0			0.1	13.9
February	55	0.6		21.2	75.0		2.6	0.6	
March	44			43.9	2.6		22.0	31.4	0.2
April	35			35.7	6.5		34.1	19.7	3.9
May	75			53.6	23.5		19.4	0.2	3.2
June	55			53.7	6.5		24.6	1.8	13.4
July	33	1.1		11.4	2.1	0.5	84.9		
August	35	1.8		19.3	37.7	0.6	29.9		10.8

DISCUSSION

The Arkansas River shiner and peppered chub are generalist feeders. Invertebrates (insects) represented 28% of the Arkansas River shiner diet and 31% of the peppered chub diet. Both species had high proportions of detritus, plant materials, and sand-silt in their diets, although neither possesses morphological adaptations, such as an elongated intestine or black peritoneum, that are commonly associated with herbivory in fishes (Cross and Collins 1995). The Canadian River is a relatively turbid stream (mean summer turbidity = 2,136 NTU; Bonner 2000), which may make it difficult for fishes to locate insect prey; however, both the Arkansas River shiner and peppered chub possess morphological adaptations for detecting prey in turbid waters (Moore 1950, Davis and Miller 1967, Huber and Rhylander 1992). Therefore, we interpret the paucity of insects in the diet of Arkansas River shiners and peppered chubs and the relatively high incidence of empty digestive tracts in both species as evidence of a scarcity of insects in the Canadian River.

The prevalence of sand-silt in the diets of Arkansas River shiners and peppered chubs suggests that both species forage among sediments on the river bottom (e.g., Davis and Louder 1971, Heins and Clemmer 1975). The Arkansas River shiner inhabits shallower, slower waters than does the peppered chub (Bonner 2000). The presence of finer sediments in microhabitats favored by the Arkansas River shiner may explain the presence of a greater proportion of sand-silt in its diet compared with the peppered chub, which is more common in microhabitats with swifter waters and sand-gravel sediments. The greater presence of terrestrial insects (Coleoptera and Hymenoptera) in the diet of the Arkansas River shiner (6.1%, by weight) than in the diet of the peppered chub (0.4%) suggests that the Arkansas River shiner feeds, at least occasionally, in the water column on drifting invertebrates (e.g., Johnson and Dropkin 1991).

Facultative feeding on detritus and plant materials, including seeds, during periods of low insect availability is common among insectivorous cyprinids (Starrett 1950, Hoyt 1970, Davis and Louder 1971, Whitaker 1977, McNeely 1987). Although detritus and plant materials are considered to have little nutritional value for insectivorous fishes (Davis and Louder 1971, Whitaker 1977), their value may be greater than generally believed (e.g., Ahlgren 1990). Neither the Arkansas River shiner nor peppered chub possesses any obvious adaptations for digestion of detritus and plant materials; however, they are likely to derive some nutritional benefit from the bacterial microflora associated with these materials. Given the prevalence of detritus and plant materials in the diet, the relatively small contribution made by insects, and the incidence of empty digestive tracts, these foods must be of considerable nutritional importance. Most of the detritus and plant material consumed by Arkansas River shiners and peppered chubs is terrestrial in origin, suggesting an important linkage between terrestrial primary production and secondary (fish) production in the Canadian River.

Quality and quantity of the diet of bottom feeding fishes are related to the availability of aquatic invertebrates, whereas drift feeding fishes are more flexible in their diets (Mendelson 1975). This dietary flexibility may explain the less frequent occurrence of empty digestive tracts in Arkansas River shiner (24%) than in peppered chubs (38%). However, there was little overall difference in quantity of the diet of the Arkansas River shiner and peppered chub (0.07 g versus 0.08 g) or in the proportion of the diet contributed by insects (28% versus 31%). Greater dietary flexibility may also explain differences in the relative abundance of the Arkansas River shiner and peppered chub, which represented 30 and 14%, respectively, of the Canadian River fish assemblage during 1996-1998 (Bonner 2000).

As a result of drought conditions during the summer of 1998, the Canadian River comprised a series of isolated pools at the two downstream sites during June and July. During this period, detritus, plant material, and sand-silt dominated the diets of both the Arkansas River shiner (91%, by weight) and peppered chub (88%, by weight). Hoyt (1970) noted a similar increase in the incidence of detritus and sediments in the diet of silverjaw minnow (*Ericymba buccata*) during periods of drought when fish were restricted to pools and other food resources became overexploited. Because of the considerable difference in the frequency of empty digestive tracts during June and July 1998, it appears that isolation in pools may be more stressful to the peppered chub than the Arkansas River shiner.

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