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Food of the Threadfin Shad, *Dorosoma petenense*, in Lake Chicot, Arkansas[1]

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ABSTRACT

Forty-nine threadfin shad (36–119 mm SL) were collected in Lake Chicot, Arkansas, from 27 February to 7 November 1959. They appeared to feed on any available organism of suitable size. Organisms eaten represented more than 60 genera. Animal and plant foods were present in approximately equal amounts; protozoans and invertebrate eggs composed most of the animal food, and green algae (Chlorophyta) most of the plant food. Individual threadfin shad within a sample ate the same kinds of organisms in similar proportions. Correlations between ingested organisms and those in the plankton were significant, indicating a lack of food selectivity. There was no apparent difference in the food of fish of different sizes.

INTRODUCTION

In recent years the threadfin shad, *Dorosoma petenense* (Günther), has stimulated the interest of fishery biologists because of its value as a forage species. Threadfin shad move in large schools, feed on plankton, and are easily caught by predators. They reach a maximum length of about 9 inches, which is within the forage size of predator species such as largemouth bass. The threadfin shad is known to occur, either natively or by introduction, in lakes and rivers in West Virginia (Schwartz, 1958), Florida, Tennessee, Kentucky, Virginia, Alabama, Mississippi, Louisiana, Texas, Oklahoma, Arkansas, and California (Isaacson, 1965). The food of threadfin shad in Lake Chicot was studied because the lake was to be the source of stock for introductions of the species into new environments in Arkansas. The main objectives of the study were to identify the kinds of food organisms eaten and to determine if food selectivity was practiced.

MATERIALS AND METHODS

Forty-nine shad, 36–119 mm SL, were examined from eight collections made in 1959, from 27 February to 7 November. The collections were made with a 10-, 20-, or 40-foot seine in a small embayment of Lake Chicot, about 1.5 m deep. Immediately after capture, the fish were pithed to prevent regurgitation, and frozen on dry ice to preserve color characteristics of certain plankters.

Plankton was sampled at the time of each collection with a 10-liter, Juday plankton trap (bucket and net of No. 25 silk bolting cloth). One plankton sample was taken at mid-depth in the collecting area. Samples in the deeper, open water (6–8 m) were taken at the surface and at 1-meter depth intervals to the bottom. No major differences were found in the species and abundance of plankters in samples collected in deep and shallow water.

Organisms were identified to genus, if feasible. Identifications of invertebrates were based on Pennak (1953), and phytoplankters on Prescott (1954) and Ward and Whipple (1959). Plankton analyses using subsamples conformed to the standard methods of Welch (1948). The results for separate subsamples were averaged to determine rankings of the organisms.

After the fish were measured, weighed, and sexed, the two sections of the foregut (the pharyngeal organs and the stomach-esophagus) were removed. The contents of the pharyngeal organs were flushed into a Sedgwick-Rafter cell, and were examined as described by Miller (1964). The contents of the stomach-esophagus were subsampled because the large number of organisms present made total counts impractical. Estimates based on subsamples were compared with total counts of the various kinds of organisms for five fish caught on 7 July and two caught on 19 August. Rank correlations of the samples (0.936 and 0.983), calculated according to Snedecor (1956), were significant at the 1% level.

A modified "point system" was used to

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TABLE 1.—*Stomach contents of 49 threadfin shad collected from Lake Chicot, Arkansas, in 1959*

Ingested organisms	Frequency of occurrence (%)	Date of collection, and number of organisms: Feb. 27	Apr. 1	May 29	Jul. 7	Jul. 30	Aug. 19	Sep. 28	Nov. 7	Total	Estimated contribution to food volume[1]: Volume factor (Avg.)	Relative unit contribution	Percentage of total
Rotatoria	100	60	800	3,080	157	143	97	416	7	4,760	3.4	16,100	3.6
Cladocera	61	196	364	28	0	2	1	5	0	956	14.0	8,340	1.9
Copepoda	82	60	56	48	14	9	3	253	0	435	13.7	5,960	1.3
Insecta	12	1	0	1	1	1	0	8	0	12	41.6	500	0.1
Ostracoda	27	6	1	5	0	2	0	26	0	40	15.0	600	0.1
Hydracarina	4	0	0	2	0	0	0	0	0	2	20.0	40	–
Protozoa	94	156	6,084	188	9,595	30,856	79,236	42,707	37	168,859	0.9	151,970	33.6
Eggs of invertebrates	96	79	522	1,069	752	11,800	612	1,160	5	15,999	1.5	24,000	5.3
Chlorophyta	98	922	105,559	2,521	25,537	123,336	435,908	69,162	330	764,377	0.3	229,310	50.6
Pyrrhophyta	35	40	67	1	0	10	0	0	0	118	1.2	142	–
Chrysophyta	92	69	1.702	311	316	13,216	709	798	84	17,115	0.5	8,550	1.9
Cyanophyta	60	6	99	14,036	242	44	180	100	0	14,707	0.5	7,350	1.6
												452,862	100.0
Number of fish	49	9	12	12	5	3	3	4	1				
Standard length (mm)		41–84	43–71	48–77	39–67	54–104	36–65	53–119	88				
Weight (gms)		1.3–9.6	0.5–5.7	1.6–6.9	0.6–5.3	3.3–19.6	0.6–4.8	2.6–27.0	10.2				

[1] See text for details of procedure.

designate the volume of organisms. A volumetric factor was assigned to the largest organism, based on its length, width, and depth, and decreasing factors were assigned to smaller organisms. The total number of a given group was multiplied by its assigned factor to obtain an estimate of the contribution of the group to the total food ingested. Colonial forms, such as *Eudorina, Pandorina, Platydorina, Pediastrum,* and *Hydrodictyon* (all Chlorophyta), and *Anabaena* (Cyanophyta) were assigned factors based on the size of their individual cells.

Kendall's coefficient of concordance (Siegel, 1956) was used to compare the relative abundance of organisms in the stomachs of individual specimens from the May collection. The probability of the observed agreement between the stomach contents of the 12 specimens occurring by chance alone, was less than 0.01. These results permitted conclusions on food habits to be based on a limited number of specimens, and all specimens in a sample were subsequently lumped, in computing rank correlations. The similarity of the stomach contents of individuals probably was a result of the schooling behavior of the species.

FOOD COMPOSITION

The primary constituents of the diet of threadfin shad in Lake Chicot were algae (54.1%), and animal material (45.9%). Threadfin shad fed upon Diptera larvae (*Chaoborus* and tendipedids), Hydracarina, adult insects, and every major group of plankton. Over 60 genera were identified. Filamentous algae were found, predominantly as 1- or 2-cell segments. Another important group included eggs of rotifers, cladocerans, and other invertebrates. The length and weight ranges of 49 threadfin shad, the various groups of food organisms found, their frequency of occurrence, number per sample, volumetric factor, and the subsequent expansion to illustrate the relative contribution of the various organisms to the total food volume are listed in Table 1.

There were no qualitative differences between food eaten by young-of-year and yearlings (the only age groups represented). In almost all specimens, the same organisms were present in both regions of the foregut, although quantities of the various forms were less in the pharyngeal organs. For most genera (or groups) the ratio of the numbers of organisms in the stomach-esophagus to numbers in the pharyngeal organs was similar (from 3 to 4). For the rotifers, the ratio varied significantly (as shown by a chi-square test) between genera. *Conochilus*, *Polyarthra*, and *Trichocerca* were most abundant in the pharyngeal organs, *Brachionus* was present in essentially equal numbers in the two foregut segments, and *Keratella* and *Monostyla* were most numerous in the stomach. Miller (1964) suggested that forms predominant in the stomach may have been less digestible and may have accumulated there, whereas those predominant in the pharyngeal organs probably were digested quickly upon reaching the stomach.

Based on frequency of occurrence, the important food groups were several genera of Chlorophyta and Chrysophyta, rotifers, protozoa, cladocerans (e.g., *Bosmina*, *Cyclops*), and copepod nauplii.

Volumetric contributions of *Pandorina*, eggs, and filamentous algae cells were similar. The eggs and algae contributed substantially to most samples collected throughout the period, whereas 85% of the total number of *Pandorina* occurred in the August sample. Insects (including larvae) and ostracods were present in small numbers. These were consumed by a relatively small number of fish and contributed greatly to the food volume, when present. Rotifers, crustaceans, and *Eudorina* were sufficiently common to indicate that they were a steady source of food to shad.

SELECTIVITY

Selectivity of specific forms of plankton by fishes is considerably more difficult to establish than determination of qualitative feeding habits. Plankton-feeding, pelagic fishes, such as the threadfin shad, may feed in several localities or on isolated swarms of plankton. In several samples of plankton and threadfin shad, many genera of the forage organisms were present in either the foregut of the shad or the plankton, but not in both. These forms, found in small quantities (1 or 2 individuals), could have been missed in the shallow-water plankton samples, or they could have been eaten by the shad in another locality but not digested when the fish were collected.

TABLE 2.—*Rank correlations of the occurrence of food organisms in plankton samples and in contents of foreguts of threadfin shad*

Sample date 1959	Foregut and plankton	Foregut only	Plankton only	Coefficient of correlation (R's)
27 February	8	30	3	−0.40
1 April	18	17	5	0.46*
29 May	23	13	5	0.67**
7 July	17	17	6	0.78**
30 July	21	16	4	0.86**
19 August	19	15	6	0.70**
28 September	25	13	10	0.82**
7 November	12	12	12	0.81**

* Significant at the 5% level.
** Significant at the 1% level.

Rank correlations were computed for each sample in this study to compare the abundance of the various forms in the foregut of the shad with their abundance in the plankton (Table 2). In six of the eight samples, the correlation was significant at the 1% level, indicating that threadfin shad are primarily nonselective plankton feeders.

Many of the planktonic forms present in the foreguts were small enough to pass through the gill rakers, indicating that clumping of organisms or blocking of raker spaces must occur. Some bottom feeding is indicated by the occasional presence of *Chaoborus* and tendipedid larvae and unusual amounts of sand and mud. Occasional sight feeding is suggested by the presence of adult insects and mites, which probably would not have been taken if the shad fed solely by non-directed filtering of water.

DISCUSSION

Kimsey *et al.* (1957) reported that the majority of the food of threadfin shad from Lake Havasu (an impoundment on the California-Arizona border) was micro-crustacea (100% frequency of occurrence, 52% by volume). They also found that algae, present in 97% of the stomachs (40% by volume), was a major part of the diet. Kimsey (1958) determined that the principal food of threadfin shad from the Salton Sea consisted of eggs and fry of the gulf croaker (*Bairdiella icistius*), micro-crustacea, and phytoplankton, in that order.

Haskell (1959) reported that diatoms, unicellular green algae, rotifers, and crustaceans, were the principal constituents of the diets of threadfin shad he examined. He maintained that shad feed both pelagically and off the bottom by filtering water through their numerous gill rakers. These conclusions are supported by the present study.

Kimsey (1958) used the forage ratio (the "ratio of the percentage a group of organisms makes up of the total stomach contents to the percentage this group makes up of the total population of food organisms in the fish's environment") to determine that threadfin shad selected the eggs and fry of *Bairdiella* in the Salton Sea. In this study, rank correlations of foregut contents and plankton showed that threadfin shad in Lake Chicot were nonselective in their feeding. Other species of plankton-feeding, pelagic fishes have been shown to be nonselective feeders. Kutkuhn (1958) plotted regression analyses of the quantities of major taxa present in the plankton against the quantities ingested by gizzard shad (*Dorosoma cepedianum*) and concluded that, essentially, they consumed a given organism in proportion to its abundance. As the proportion of a particular organism increased in the environment, consumption by gizzard shad also increased. Using rank correlations, Hand and Berner (1959) found agreement between the occurrence of organisms in the plankton and those in the stomachs of the Pacific sardine, *Sardinops caerulea*.

Although there are several advantages of threadfin shad as a forage species (e.g., relative small size of adults, silvery color, and high reproductive potential), proposed introductions into new environments must consider the temperature range of the new body of water and the type and availability of food. Mortalities of shad have occurred in several areas when the temperature of the water dropped below approximately 45 and 54 F (Parsons and Kimsey, 1954; Hubbs, 1951). Threadfin shad are flexible in their feeding habits and probably adapt to available food supplies. Attempts at establishment of this species, therefore, should be limited to bodies of water with the required temperature range and with moderate amounts of plankton, bottom organisms, small insects, or other easily-ingested organisms.

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