FEEDING INTERACTIONS OF THREE PLANKTIVOROUS FISHES IN TRINIDAD LAKE, TEXAS

An Undergraduate Fellows Report

by

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Abstract

Food habits of gizzard shad, threadfin shad, and blue tilapia were studied in summer and winter, 1975. Stomach contents of all three species consisted predominantly of organic detritus, followed by green algae, blue-greens, and diatoms. Planktonic foods correlated closely with the composition of the plankton. Although food habits differed between season, they were closely correlated among species within season. Similarity among food habits of the three species creates the potential for competition for food among the three planktivores.

Introduction

Active introduction of exotic fishes has been considered in recent years for vegetation control, recreation, and food. However, introduction of exotics presents the possibility of undesirable effects through interactions with native fishes. Competition for food is one such interaction which might be expected. Recent development of power plant cooling lakes, as well as the emphasis on utilization of *Tilapia* species in aquaculture,has provided the impetus for tilapia to be introduced and become established in the United States. The blue tilapia, *Tilapia aurea*, recently introduced into waters in Florida and Texas, utilize planktonic food resources,and overlap in food habits with native planktivorous species could occur.

The blue tilapia, a subtropical fish native to Africa and Asia, cannot withstand prolonged water temperatures below 12 C. Heated waters allow these fish to overwinter in Texas and established populations exist in several reservoirs. Blue tilapia grow and reproduce rapidly. They serve as important forage when small, but may grow to more than 2 kg and can be considered a valuable food fish. Possibilities of using young tilapia as forage and harvesting adult tilapia for food in heated waters are presently being considered. Such a management plan would utilize energy that is presently lost in thermally enriched waters of power plant cooling lakes.

Threadfin shad, *Dorosoma petenense*, and gizzard shad, *Dorosoma cepedianum*, are the two most abundant planktivores in southern impoundments. Together threadfin shad and gizzard shad comprise approximately 50% of the biomass in these waters. Shad are sufficiently vulnerable to be utilized as forage; yet they are prolific enough to maintain their populations under heavy predation. Planktonic organisms filtered from the water serve as food for these small clupeid fishes. Feeding near the base of the food web, they form an important link between the primary producers and piscivorous game fishes.

Ecological associations among fishes are often dominated by feeding interactions. Due to similar feeding habits, competition for food may occur among threadfin shad, gizzard shad and blue tilapia. Studies which deal with feeding interactions of blue tilapia and native fishes can provide information necessary for sound management divisions.

In Trinidad Lake, Texas, seine and gillnet samples from 1972 though 1974 indicated threadfin shad, gizzard shad and blue tilapia were among the most abundant species. This 305 ha impoundment, located in Henderson County, serves as a source of cooling water for a Texas Power and Light Company fossil fuel electric generating plant. Water heated by the cooling and condensing of steam which drives the generator turbines is returned to the lake. Temperatures in the lake sometimes exceed 35 C in the summer but rarely go below 13 C in the winter. The 50-year-old lake averages less than 3 m deep and is eutrophic. Twenty-two species of fish have been found in Trinidad Lake, but the only abundant planktivores are threadfin shad, gizzard shad, and blue tilapia.

The objective of this study was to determine whether threadfin shad, gizzard shad, and blue tilapia utilize the same food resources in Trinidad Lake. Food items in the diet were identified to recognizable taxa and relative contribution of these taxa to the diet were compared among the three fish species.

Literature Review

Planktonic feeding has been documented for threadfin shad, gizzard shad, and tilapia. The herring-like gizzard and threadfin shads use long, fine, closely-set gill rakers to strain microorganisms from the water. Pharyngeal organs aid in concentration and swallowing of filtered organisms (Miller, 1964). In contrast, blue tilapia are equipped principally as grazers but have developed the ability to graze plankton off the surface film. Some species of tilapia have also been reported to hold their short widely spaced gill rakers close together so that a mesh of microbranchiospines on the gill arches strains plankton (Fryer and Iles, 1972). Although shad and tilapia employ different feeding mechanisms, they appear to utilize similar food resources. However, feeding habits differ with environment and results of studies on a given species in different locations have varied widely.

Some studies have indicated that animal matter is the principal food of threadfin shad. 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 microcrustaceans. They also found that algae was a major part of the diet. Kimsey (1958) determined that the principal foods of threadfin shad from the Salton Sea consisted of eggs and fry of the gulf croaker (*Bairdiella icistius*), microcrusteacea, and phytoplankton, in that order.

In other studies, however, plant material has been the primary component. Haskell (1959) reported that diatoms, unicellular green algae, rotifers and crustaceans were the principal constituents of the diets of the threadfin shad he examined from Arizona. He maintained that shad feed both pelagically and off the bottom by filtering water through their numerous gill rakers. Miller (1969) reported that threadfin shad from Lake Chicot, Arkansas, appeared to feed on any available organisms of suitable size. Organisms eaten represented more than 60 genera. Animal and plant foods were present in approximately equal amounts; protozoans and invertebrate eggs comprised most of the animal food, and green algae (Chlorophyta) most of the plant food. Significant correlations between ingested organisms and the plankton indicated a lack of food selectivity. He also reported that there were no qualitative differences between foods eaten by young-of-the-year and yearling shad. Baker and Schimitz (1971) suggest that organic detritus may represent a significant portion of the diet of threadfin shad in two Arkansas reservoirs.

Gizzard shad have been reported to ingest a wide variety of plant and animal material. Food habits appear to change with locality and size of shad examined. Most studies indicate gizzard shad ingest large quantities of mud and organic debris. Dalquest (1966) reported that 80 to 90% of the material eaten by gizzard shad in Lake Diversion, Texas, is without food value. He reported that diatoms were the most important food item followed by copepods, ostracods, cladocerans, protozoans and other algae. Tiffany (1921) noted large quantities of mud in gizzard shad digestive tracts. His studies indicate that the gizzard shad is almost entirely vegetarian, except for a short period of time after hatching. Warner (1940) emphasized this exception and stated that the food of larval and postlarval gizzard shad consists entirely of small animal plankton (cladocerans, copepods, and a few ostracods). Dalquest (1966) notes that while shad feed on planktonic animals only as fry in northern lakes, in southern lakes relatively large gizzard shad may feed exclusively on copepods and cladocerans. Evers and Boesel (1936) reported that 85% of the contents of digestive tracts of gizzard shad in Buckeye Lake, Ohio, consisted of algae and debris while 15% consisted of cladocerans. Reid (1949) found the contents of the digestive tracts of gizzard shad from Orange Lake, Florida, to consist almost entirely of ostracods, copepods, and cladocerans with phytoplankton consumed in lesser quantity. Rice (1942) found crustaceans to be the principal food while insect larvae and diatoms were minor foods of gizzard shad in Reelfoot Lake, Tennessee. Bodola (1965) found that gizzard shad in Lake Erie captured in open waters contained mostly free-floating phytoplankton, while those captured among littoral vegetation contained cladocerans, copepods, rotifers and small aquatic insect larvae, and those collected in very turbid waters were filled with mud. He was of the opinion that gizzard shad occasionally ingest small quantities of sand to aid in mastication of food. Berry (1955) reported food items of gizzard shad from a Florida lake consisted mostly of debris with small amounts of crustaceans and algae. Jester and Jensen (1972) found unidentified organic residue, phytoplankton, cladocerans and copepods to be the most important foods of gizzard shad in Elephant Butte Lake, New Mexico. They suggested that predominance of plant or animal material in the diet of gizzard shad is controlled by availability.

Velasquez (1939) cultured phytoplankton that had passed through the digestive tract of gizzard shad and found that some were still viable. Questions remain concerning the food habits of gizzard shad and results of studies involving different size fish and different localities do not always agree.

Blue tilapia are probably best described as broadly omnivorous. Vaas and Hofstede (1952) reported tilapia to be primarily a vegetation feeder. Chen (1953) reported that tilapia feed on plankton, algae, decomposing vegetable matter, rice bran, soybean meal, chopped meat and fish, but reject live food. Hofstede (1952) stated that young tilapia feed almost entirely on diatoms, unicellular algae, and small crustaceans, with larger fish consuming decaying plants, and filamentous and unicellular algae. Hickling (1963) reported that most tilapia species feed by browsing on tiny algae and plankton. Fryer and Iles (1972) noted the diverse feeding habits found in tilapia species in the great lakes of Africa. Deposit feeding has been observed in some tilapia equipped for planktonic feeding when phytoplankton of the lake is dominated by unicellular greens and blue green algae. Because of recent revisions in classification of tilapia species, specific food habits of the tilapia cannot be elucidated from the existing literature.

Ability to utilize unicellular green algae and bluegreens hinges upon an ability to break down their cellulose walls. While the enzyme cellulase is not known to be produced by any fish, cellulase activity associated with digestive tract bacteria has been reported in fishes. Stickney (1975) determined cellulase activity on several species of fish from Trinidad Lake. Negative cellulase activity was reported for blue tilapia. Gizzard shad and threadfin shad showed both positive and negative cellulase activity. Possible mechanical means have been reported for damaging algal cell walls thus making contents available. The muscular stomachs of shad contain sand which could abrade algal cell walls. Tilapia also have pharyngeal bones which may damage algal cell walls.

In summary, food habits reported for these three fishes vary among habitats and the question of utilization of many of the food items found in their stomachs is presently unresolved. No studies comparing food habits of sympatric species were found.

Materials and Methods

Plankton samples were collected from the intake canal at Trinidad Lake during the months of November and December, 1975. Each month one 20-ml sample was filtered from 600 milliliters and preserved in 5% ethyl alcohol. Subsamples were examined using a compound microscope at 10 to 44X. Plankters were identified to recognizable taxa based on Prescott (1964) and Pennak (1953).

Three collections, consisting of 106 fish, were made at Trinidad Lake during July, November, and December, 1975. Immediately after capture by seining and electrofishing, specimens were preserved in 10% formalin. Sample size included 5 to 32 fish of each species. Contents of each stomach were flushed into a Sedgewick-Rafter cell and examined using a compound microscope at 10 to 44X. Occurrences of empty stomachs were noted. Entire stomach contents were examined at 10X while subsamples were examined using 44X. Food organisms from stomachs were identified to recognizable taxa. Identification of phytoplankters was based on Prescott (1964), invertebrates on Pennak (1953).

Due to the difficulty in making quantitative comparisons among numbers of individuals, numbers of colonies, organisms of different sizes, and animal parts, an index of importance was developed. This index of importance was based upon relative volumes of various food items estimated by observation. Values of 0, 1 and 2 were assigned to each food item, with 0 indicating absence, 1 indicating presence in small amounts, and 2 indicating that the taxon was a major food item. Ten to 15 food items were usually of markedly greater volumes than all others, and were considered major food items. An index of importance was assigned to each identifiable taxon occurring in each of the stomach examined. For each sampling period frequency of occurrence and an average index of importance were calculated for each food type, based on only those fish containing food.

Average indices of importance were assigned to over 80 identifiable taxa of food items (Appendix Table 1). Of these, 35 occurred frequently and were used as the basis for comparison of food habits among species. Because of the similarities of occurrence of these 35 principal food organisms within species, data from November and December were combined for analysis.

The 0.05 probability level was accepted as significant for all statistical tests.

Results

Plankton Samples

Plankton samples examined during November and December, 1975, indicated that the plankton of Trinidad Lake was dominated by unicellular green algae and blue-greens, with diatoms the third most important component. Microzooplankton including protozoans and smaller rotifers were occasionally identified in the plankton samples (Table 1). Macrozooplankton (cladocerans, copepods, ostracods, etc.) were not found in the plankton samples. No plankton samples were taken during summer months for comparison.

Occurrence of Empty Stomachs

No empty stomachs were found in any of the fish examined in July. In November empty stomachs occurred in 27% of the blue tilapia and 20% of the gizzard shad (Table 2). All threadfin shad examined during November contained food. In December empty stomachs occurred in 63% of the blue tilapia, 53% of the gizzard shad, and 75% of the threadfin shad. During the December sampling period the power plant was not in operation and temperatures in the lake were lower than usual. Blue tilapia were stressed during this time and threadfin shad which are subject to winterkill may also have been affected by the lowered temperatures.

Food Habits

Organic detritus was the primary constituent of the diets of threadfin shad, gizzard shad, and blue tilapia in Trinidad Lake, but it was difficult to determine its importance by the methods used in this study. An index of importance of 2 assigned to detritus probably underestimates its contribution to the diets of these three species of fish, since it far exceeded in volume all other food items. Of the remaining

Table 1. Components of the Plankton in Trinidad Lake, November-December, 1975. (Designation of 1 indicates present but uncommon; 2 indicates abundant).

Taxon	November	December
Blue-green Algae		
Anabaena	1	1
Anabaenopsis	1	1
Gloeocapsa	1	1
Merismopedia	2	2
Nostoc	2	2
Oscillatoria	2	2
Spirulina	1	2
Colonial	2	2
Diatoms		
Cyclotella	2	2
Cymbella	1	1
Melosira	1	1
Navicula	1	1
Synedra	1	1
Unident. Diatom	1	1
Green Algae		
Ankistrodesmus	2	1
Arthrodesmus	2	2
Closteriopsis	2	2
Cosmarium	2	2
Crucigenia	2	1
Golenkinia	2	2
Kirchnella	1	1
Oscystis	1	1
Pediastrum	1	1
Planktosphaeria	1	1
Scenedesmus	2	2
Tetraedron	2	2
Tetrastrum	2	2
Round green	2	2
Oval green	2	2
Protozoans		
Chlamydomonas	1	1
Chrysidiastrum		1
Difflugia	1	
Euglena		1
Rotifer	1	1

Table 2. Numbers of stomachs examined and occurrences of empty stomachs in three planktivorous fishes from Trinidad Lake, Texas, 1975.

	Threadfin Shad			Gizzard Shad			Blue Tilapia		
Month	No. examined	No. empty	% empty	No. examined	No. empty	% empty	No. examined	No. empty	% empty
July	8	0	0	10	0	0	7	0	0
November	7	0	0	5	1	20	11	3	27
December	32	24	75	15	8	53	11	7	64

constituents of the diets of threadfin shad, gizzard shad and blue tilapia, green algae (Chlorophyta), blue-greens (Cyanophyta) and diatoms (Chrysophyta) predominated (Table 3). Zooplankton identified included Protozoa, Rotifera, Ostracoda, Cladocera, Copepoda and Hydracarina. Diptera larvae (chironomids and tendipedids) were rarely found in gizzard shad and threadfin shad stomachs. Occasionally all three fish species included nematodes and bryozoans in their diets.

Food habits of all three species changed markedly from summer to winter. Spearman's rank correlation coefficients (Snedecor, 1956) for the indices of importance of all 35 principal food items were low and non-significant for each species between seasons (Figure 1, diagonal values). Individual correlations are shown in Appendix Figures 1 - 6.

In contrast, diets were more similar among the three species during each sampling period. When average indices of importance for the 35 major food items were compared among the three fish species, Spearman's rank correlation coefficients indicated a significant correlation in food habits among all three species during the winter (Figure 1, lower left). Comparison of the 35 major food items from the summer sample resulted in significant correlation coefficients for threadfin shad vs. gizzard shad and gizzard shad vs. blue tilapia, while food habits of threadfin shad and blue tilapia did not appear to be closely correlated (Figure 1, upper right). Winter correlation coefficients for gizzard shad vs. blue tilapia and threadfin shad vs. blue tilapia were higher than summer correlation coefficients for these pairs. Overlap in food habits of blue tilapia and native shad species may increase in winter when planktonic food resources are reduced. At the same time overlap in food habits of threadfin shad and gizzard shad was less in winter than in summer indicating behavioral

Table 3. Percent frequency of occurrence (% FO) and mean index of importance ($\overline{II}$) for 35 food found in stomachs of three planktivorous fishes in Trinidad Lake, 1975.

	Threadfin Shad				Gizzard Shad				Blue Tilapia			
	Summer		Winter		Summer		Winter		Summer		Winter	
No. examined	8		39		10		20		7		22	
No. containing food	8		15		10		11		7		12	
Taxon	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$
Blue-Green Algae												
Anabaena	62	1.12	6	0.13	40	0.50	0	0	86	1.40	16	0.16
Anabaenopsis	25	0.25	33	0.33	60	0.60	9	0.09	0	0	66	0.83
Gloeocapsa	50	0.88	53	0.73	70	0.70	72	1.27	28	0.28	50	0.75
Merismopedia	88	1.62	80	1.00	100	1.90	81	1.09	100	1.70	100	1.75
Nostoc	12	0.12	26	0.26	10	0.10	54	0.82	0	0	41	0.66
Oscillatoria	75	1.38	53	0.66	100	1.70	36	0.54	71	1.14	50	0.75
Spirulina	25	0.50	40	0.53	80	1.00	27	0.27	100	1.86	41	0.50
Colonial	62	1.25	80	1.40	70	1.20	36	0.54	43	0.43	83	1.33
Diatoms												
Cyclotella	0	0	33	0.33	50	0.50	27	0.27	0	0	58	0.75
Cymbella	38	0.50	13	0.13	90	1.30	9	0.09	14	0.14	50	0.50
Navicula	25	0.50	46	0.60	100	1.40	81	1.27	100	1.60	58	0.91
Synedra	25	0.50	13	0.13	0	0	45	0.63	14	0.28	66	1.00
Unidentified	25	0.38	53	0.73	50	0.90	27	0.27	0	0	25	0.33
Green Algae												
Ankistrodesmus	0	0	33	0.40	30	0.30	27	0.45	43	0.71	25	0.33
Arthrodesmus	0	0	73	1.13	70	1.30	82	1.27	71	0.86	100	1.66
Closteriopsis	12	0.12	40	0.60	30	0.30	36	0.54	28	0.57	50	0.66
Cosmarium	75	1.25	40	0.60	100	1.50	45	0.45	43	0.57	50	0.66
Dictyosphaerium	25	0.38	13	0.13	0	0	72	1.27	0	0	33	0.41
Gleotanium	0	0	26	0.33	20	0.20	54	0.81	14	0.14	25	0.25
Golenkinia	12	0.12	46	0.80	20	0.20	63	1.00	43	0.71	41	0.50
Oscystis	0	0	53	0.93	10	0.10	36	0.45	0	0	33	0.50
Pediastrum	75	1.38	86	1.20	100	1.70	100	1.81	1.00	1.80	100	1.83
Planktosphaeria	62	0.75	26	0.26	40	0.40	45	0.45	0	0	16	0.16
Scenedesmus	100	2.00	86	1.60	100	1.90	100	1.72	1.00	1.86	100	2.00
Tetraedron	25	0.38	53	0.53	0	0	27	0.27	43	0.57	83	0.83
filament	38	0.38	26	0.46	30	0.30	36	0.45	43	0.57	50	0.75
round green	88	1.75	100	1.66	100	2.00	63	1.27	28	0.57	75	1.41
oval green	88	1.62	93	1.73	100	1.50	81	1.54	14	0.14	75	1.50

Table 3. Continued.

	Threadfin Shad				Gizzard Shad				Blue Tilapia			
	Summer		Winter		Summer		Winter		Summer		Winter	
No. examined	8		39		10		20		7		22	
No. containing food	8		15		10		11		7		12	
Taxon	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$
Protozoans												
Chlamydomonas	38	0.62	33	0.66	20	0.20	27	0.54	0	0	33	0.66
Pandorina	38	0.38	0	0	80	1.60	0	0	28	0.28	0	0
Phacus	25	0.25	0	0	70	0.80	0	0	14	0.14	8	0.08
Colonial	75	0.88	33	0.40	80	0.90	9	0.09	43	0.43	41	0.58
Bryozoa	25	0.25	53	0.80	20	0.20	27	0.45	43	0.71	33	0.58
Rotataria	12	0.12	46	0.53	20	0.20	9	0.09	71	100	50	0.58
Ostracoda	0	0	73	1.20	10	0.10	18	0.18	14	0.14	25	0.25

	GIZZARD SHAD	THREADFIN SHAD	BLUE TILAPIA
GIZZARD SHAD	0.19	0.63*	0.42*
THREADFIN SHAD	0.43*	0.12	0.27
BLUE TILAPIA	0.46*	0.45*	0.22

SUMMER

WINTER

Figure 1. Coefficients of Spearman's rank correlation between indices of importance of 35 food items for three species of planktivores in summer and winter, Trinidad Lake, 1975. (Asterisks indicate significant correlation, $p. < 0.05$).

and ecological differences which may help these sympatric species avoid competition.

While the general trend was toward constancy of food habits among the three species some differences were noted. These differences were analyzed by comparing frequencies of occurrence and average indices of importance among species for major food categories (Appendix Tables 1-5).

Organic Detritus

Organic detritus was present in all fish stomachs examined. No quantitative method was developed to describe its presence. The average index of importance of 2 underestimates its importance in comparison to other material present. Organic detritus was estimated by volume to exceed all other food categories in all three fish species.

Green Algae

Thirty genera of Chlorophyta were identified in the fish stomachs examined. Twenty-nine of these genera were present in blue tilapia stomachs and gizzard shad stomachs, while 25 genera were found in threadfin shad stomachs. Fifteen of these taxa had frequencies of occurrence greater than 25% and indices of importance greater than 0.50 during at least one of the sampling periods. These 15 taxa occurred in all three fish species but frequencies of occurrence and average indices of importance varied with fish species as well as from summer to winter samples (Fig. 2). Green algae appeared to be more important in all three fish species in winter than in summer (Fig. 2, 3, and 4).

Of the green algae, desmids and unicellular forms had highest frequencies of occurrence and highest average indices of importance in the three fish species.

In blue tilapia examined during summer, two genera of desmids

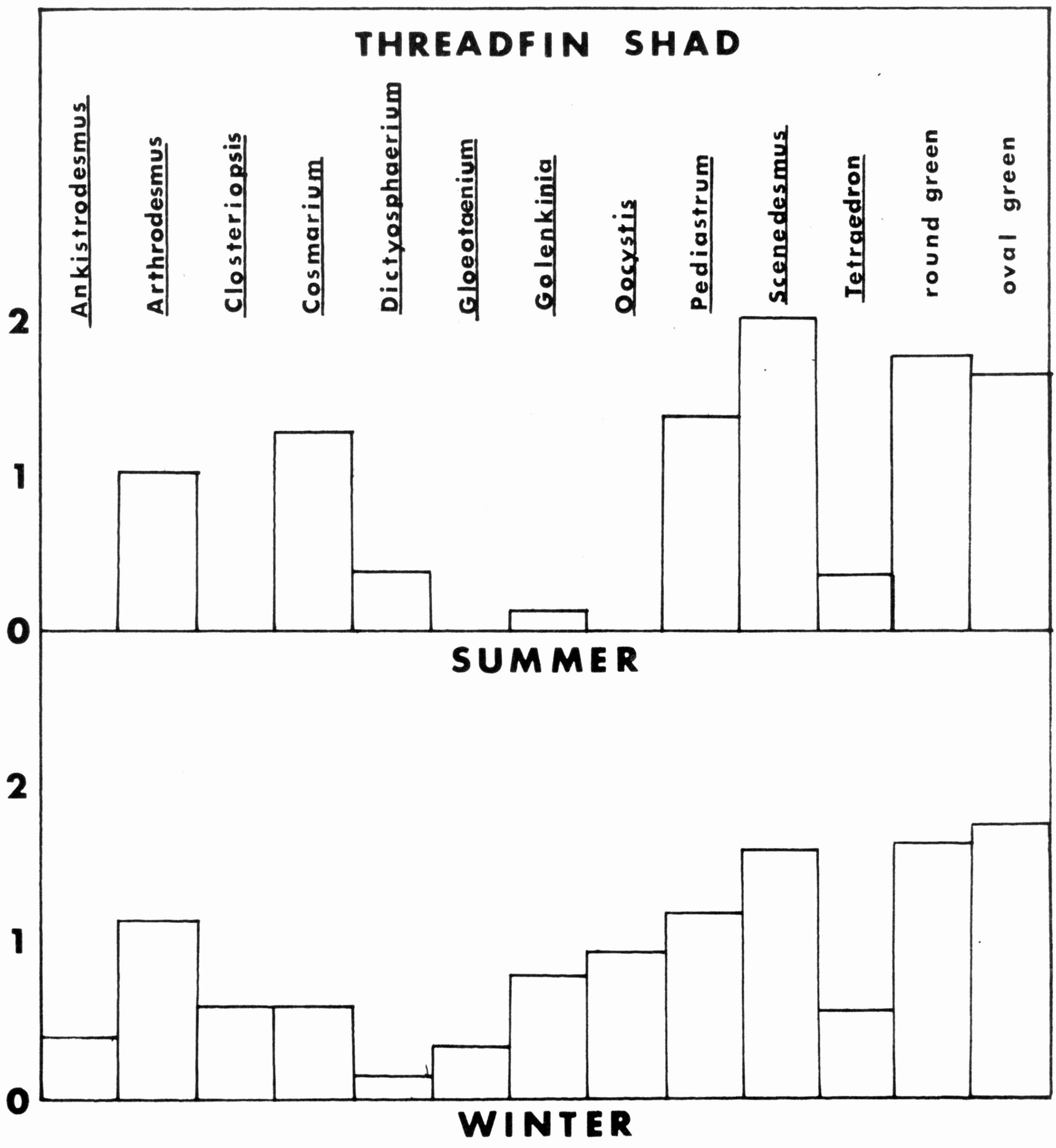

Figure 2. Mean indices of importance for thirteen green algae common in stomachs of threadfin shad from Trinidad Lake, summer and winter 1975.

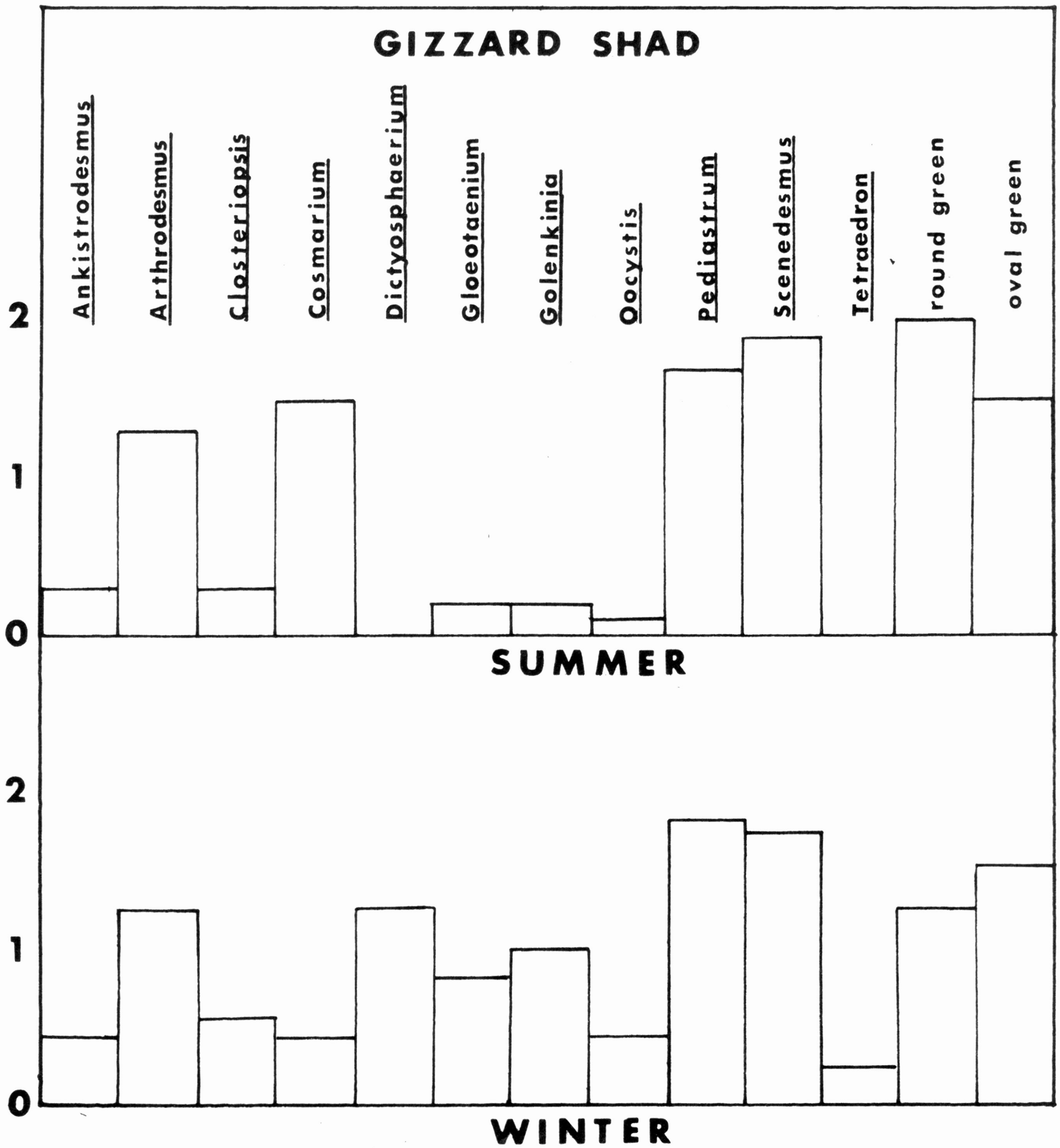

Figure 3. Mean indices of importance for thirteen green algae common in stomachs of gizzard shad from Trinidad Lake, summer and winter 1975.

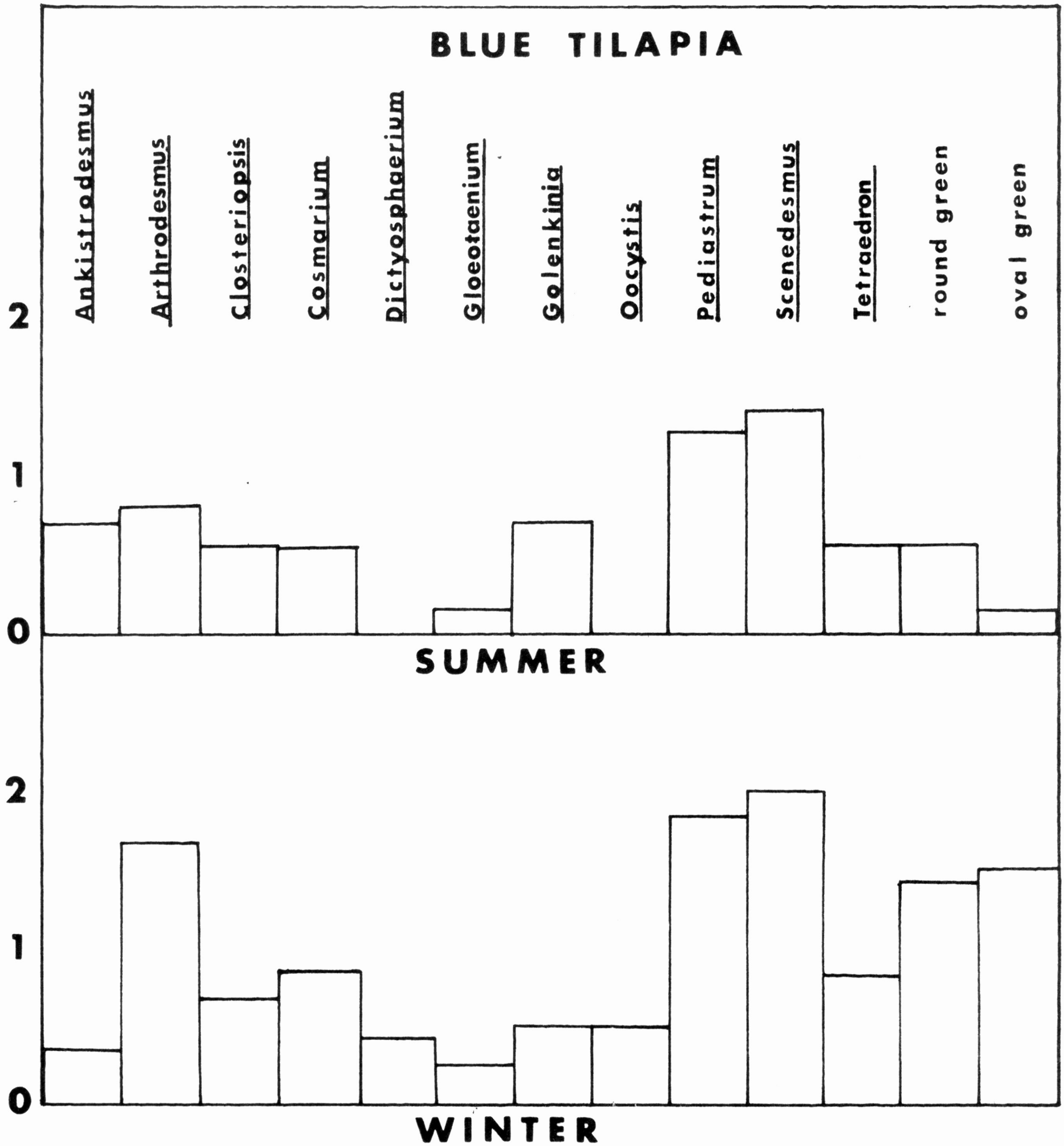

Figure 4. Mean indices of importance for thirteen green algae common in stomachs of blue tilapia from Trinidad Lake, summer and winter, 1975.

Pediastrum and Scenedesmus had 100% frequencies of occurrence. Average indices of importance were 1.86 for Scenedesmus and 1.80 for Pediastrum. Seven other taxa of desmids and unicellular forms had frequencies of occurrence ranging from 28% to 71%. Five genera of desmids (Arthrodesmus Cosmarium, Pediastrum, Scenedesmus, and Tetraedron) and two unicellular forms occurred with a frequency of at least 75% in blue tilapia during the winter. Average indices of importance for these seven food items ranged from 0.83 to 2.00. Two other desmids and one unicellular form occurred with frequencies ranging from 25% to 50%.

In threadfin shad during summer three genera of desmids (Cosmarium, Pediastrum and Scenedesmus) and two unicellular forms had frequencies of occurrence greater than 75% and average indices of importance ranging from 1.25 to 1.75. During the winter two of the desmids, Pediastrum and Scenedesmus, and two unicellular forms had frequencies of greater than 75% and average indices of importance ranging from 1.20 to 1.73. In addition five taxa of desmids and one unicellular form had frequencies of occurrence ranging from 33% to 73% and average indices of importance ranging from 0.40 to 1.13.

In gizzard shad during summer three genera of desmids (Cosmarium, Pediastrum and Scenedesmus) and two unicellular forms had 100% frequencies of occurrence and average indices of importance ranging from 1.50 to 2.00. Three other genera of desmids had frequencies of occurrence ranging from 30% to 70% and average indices of importance ranging from 0.30 to 1.30. During the winter two of the desmids, Pediastrum and Scenedesmus, had 100% frequencies of occurrence and average indices of importance of 1.81 and 1.72, respectively. Another desmid, Arthrodesmus had a frequency of occurrence of 82% and an average index of importance of 1.27. Three unicellular forms had frequencies of occurrence of 63% to 81% and average indices of importance of 1.00 and 1.54. Four other desmids had frequencies of occurrence ranging from 27% to 45% and average indices of importance ranging from 0.27 to 0.54.

Several genera of colonial forms of green algae were identified in the stomachs of all three fish species. Three of these, Dictyosphaerium, Gloeotaenium and Oscystis, occurred with frequencies of at least 25% in all three fish species. Indices of importance varied with season and fish species. Filamentous forms of green algae made small contributions to the diets of all three fish species. Blue tilapia and threadfin shad stomachs contained more filamentous green algae in December than in July or November. Gizzard shad stomachs contained filamentous algae in July only.

Five genera of filamentous algae (Cladophora, Rhizoclonium, Oedogonium, Stigeoclonium, and Ulothrix) were found in blue tilapia stomachs during December. Frequencies of occurrence ranged from 25 to 50%, while average indices of importance ranged from 0.25 to 1.00. Three of these forms were present in July. Oedogonium, Stigeoclonium, and Ulothrix had frequencies of occurrence ranging from 14 to 43% and average indices of importance of 0.14 to 0.71.

Four genera of filamentous algae (Oedogonium, Spirogyra, Stigeoclonium and Ulothrix) were identified in threadfin shad stomachs. Three of these genera occurred during December samples while one was found in July samples. Frequencies of occurrence never exceeded 12% and average indices of importance never exceeded 0.12.

Three genera of filamentous forms (Oedogonium, Spirogyra, and Stigeoclonium) were found in gizzard shad during July. Frequencies of occurrence ranged from 10 to 50% and average indices of importance from 0.10 to 0.50. No filamentous forms were found in gizzard shad during November or December.

Blue-Green Algae

Sixteen genera of blue-greens were identified in the fish stomachs examined. Eight of these occurred frequently enough to be considered major food items (Fig. 5,6,7).

In blue tilapia, during the summer, four genera of blue-greens (Anabaena, Merismopedia, Oscillatoria, and Spirulina) had frequencies of occurrence ranging from 71 to 100% and average indices of importance of 1.14 to 1.86. During the winter sampling period Merismopedia had a frequrency of occurrence of 100% and an average index of importance of 1.75 while an unidentified colonial form had an 83% frequency of occurrence and an index of importance of 1.33. Anabaenopsis, a filamentous blue-green, had a frequency of occurrence of 66% and an average index of importance of 0.83.

In threadfin shad, during summer four blue-greens (Anabaena, Merismopedia, Oscillatoria and an unidentified colonial form) had frequencies of occurrence ranging from 62 to 88% and average indices of importance ranging from 1.12 to 1.62. In threadfin shad during winter only Merismopedia and the unidentified colonial form remained important. Merismopedia had a frequency of occurrence of 80% and an average index of importance of 1.40.

In gizzard shad during summer five blue-greens (Gloeocapsa, Merismopedia, Oscillatoria and Spirulina and unidentified colonial form) had frequencies of occurrence ranging from 70 to 100% and average indices of importance ranging from 0.70 to 1.90. During winter only two of these,

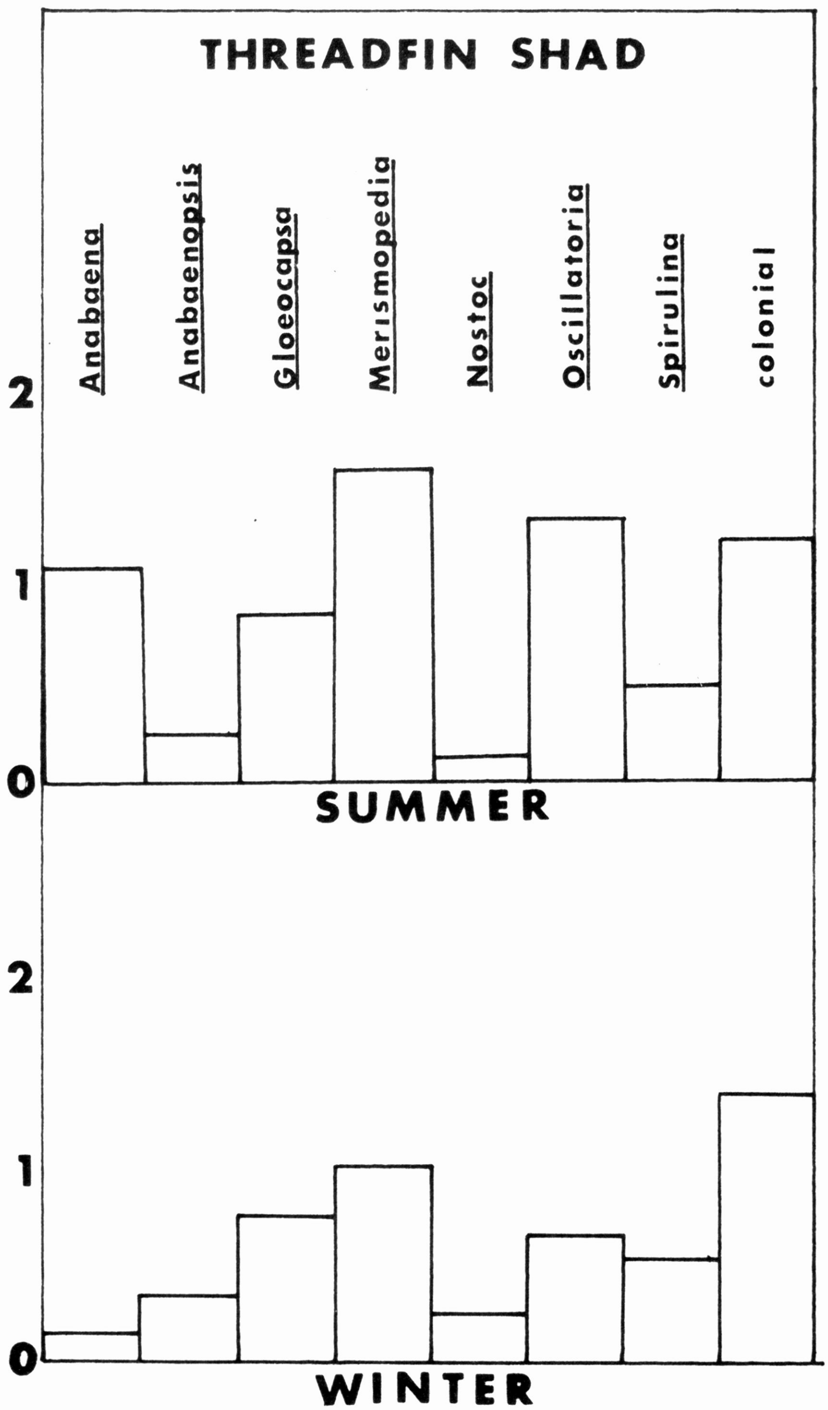

Figure 5. Mean indices of importance for eight blue-green algae common in stomachs of threadfin shad from Trinidad Lake, summer and winter, 1975.

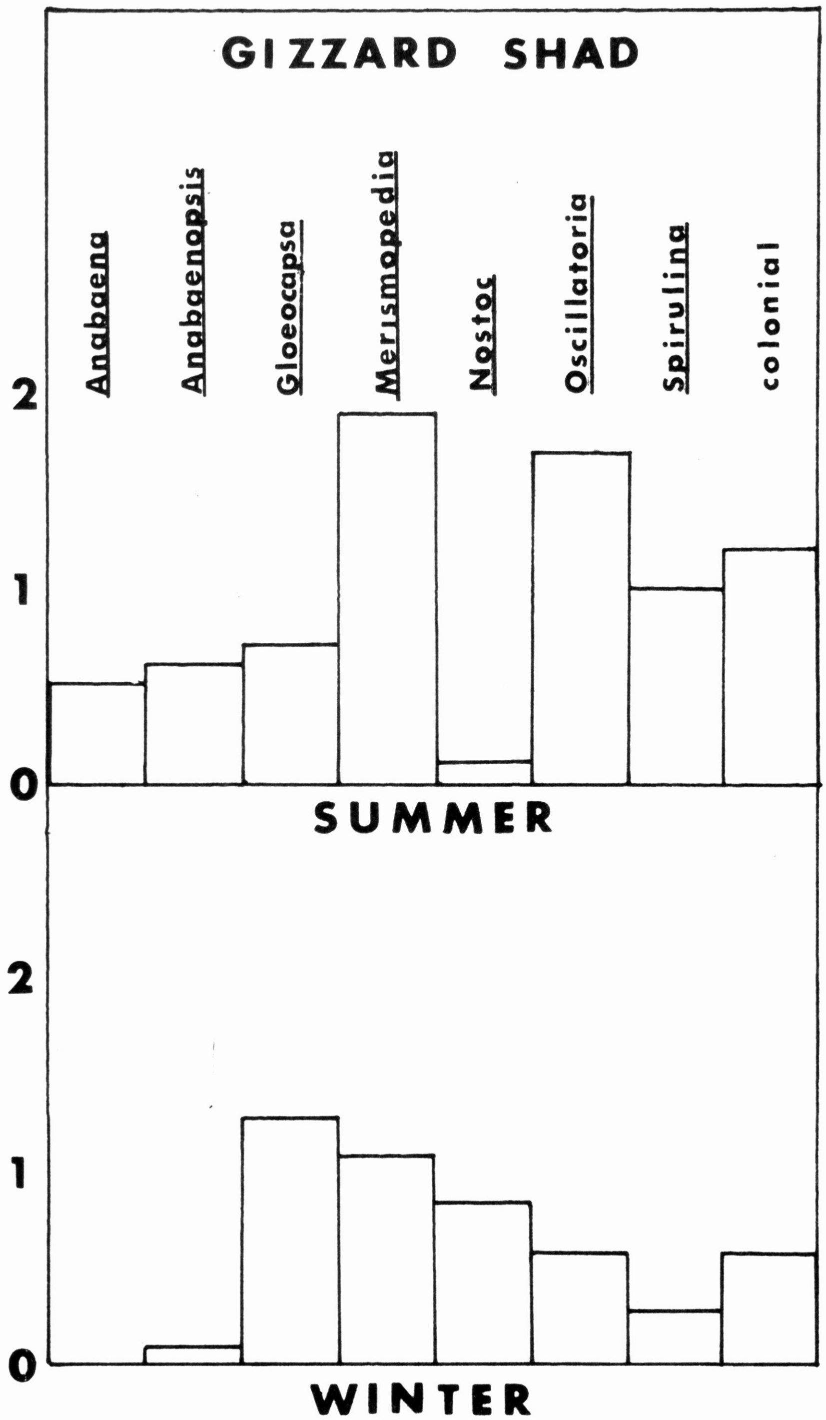

Figure 6. Mean indices of importance for eight blue-green algae common in stomachs of gizzard shad from Trinidad Lake, summer and winter, 1975.

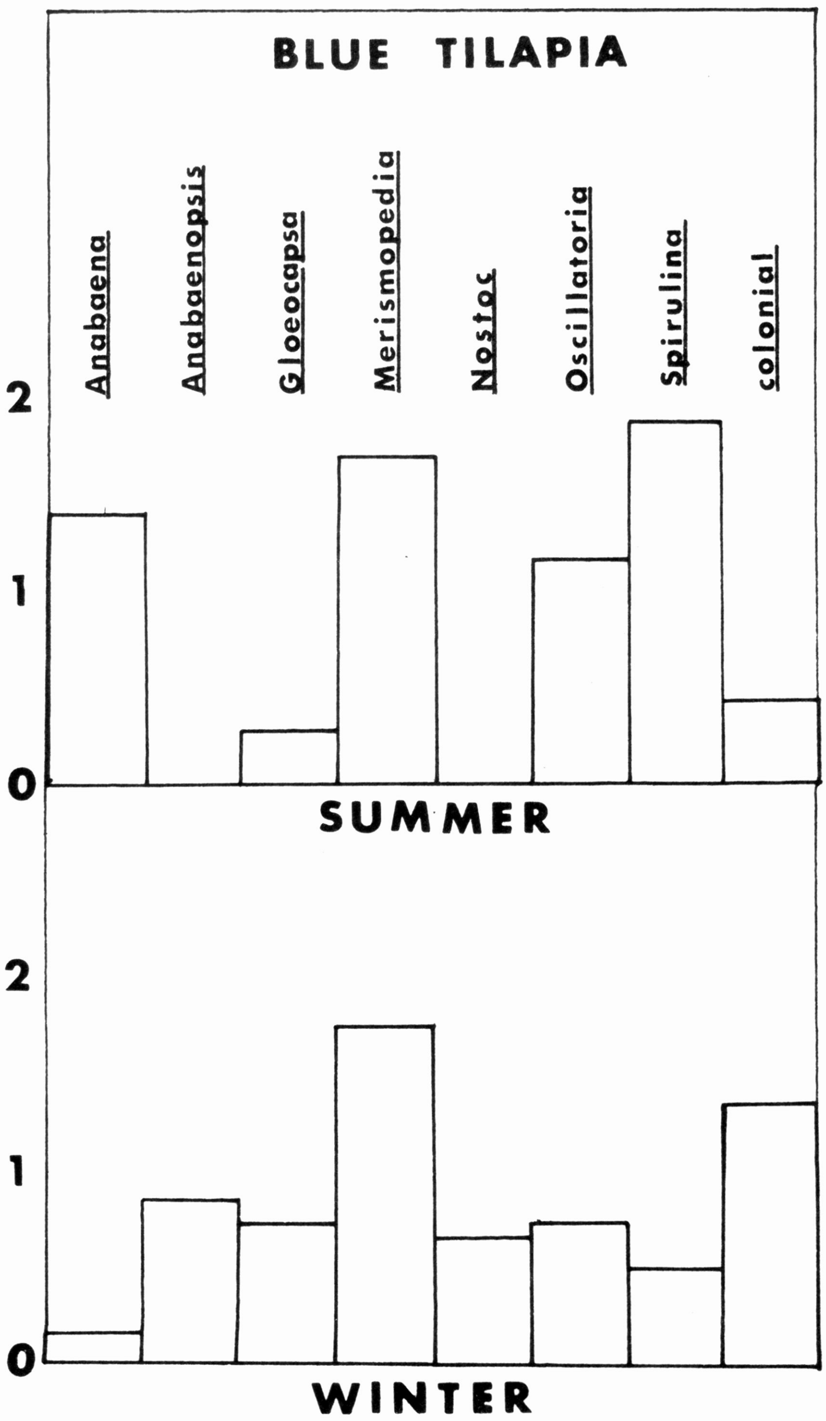

Figure 7. Mean indices of importance for eight blue-green algae common in stomachs of blue tilapia from Trinidad Lake, summer and winter, 1975.

Gloeocapsa and Merismopedia remained important; Gloeocapsa had a 72% frequency of occurrence and an average index of importance of 1.27 while Merismopedia had an 81% frequency of occurrence and an average index of importance of 1.09. For a given sampling period there appeared to be no differences in consumption of blue-greens among the three species (Fig. 5, 6, and 7). Blue-greens were more important in the diets of all three fish species in summer than in winter (Fig. 5, 6, and 7).

Diatoms

Thirteen genera of diatoms were identified in the stomachs examined. Positive identification was difficult, and only the most common and prominent were assigned taxa. Four of these occurred frequently enough to be considered major food items (Fig. 8).

In summer Navicula had 100% frequency of occurrence in blue tilapia and an average index of importance of 1.6. Other forms occurred in less than 15% of the blue tilapia stomachs examined during summer. During winter four genera of diatoms (Cyclotella, Cymbella, Navicula, and Synedra) had frequencies of occurrence ranging from 50 to 66% and indices of importance ranging from 0.50 to 1.00.

Threadfin shad appeared to utilize fewer diatoms than blue tilapia or gizzard shad (Fig. 8). During summer three genera of diatoms (Cymbella, Navicula and Synedra) had frequencies of occurrence ranging from 25 to 38% and average indices of importance of 0.25 to 0.50. During winter four genera of diatoms (Cyclotella, Cymbella, Navicula and Synedra) had frequencies of occurrence ranging from 13 to 46% and average indices of importance of 0.13 to 0.60.

In gizzard shad, during summer, three genera of diatoms (Cyclotella, Cymbella and Navicula) had frequencies of occurrence of 50 to 100% and average indices of importance of 0.50 to 1.40. In winter three genera

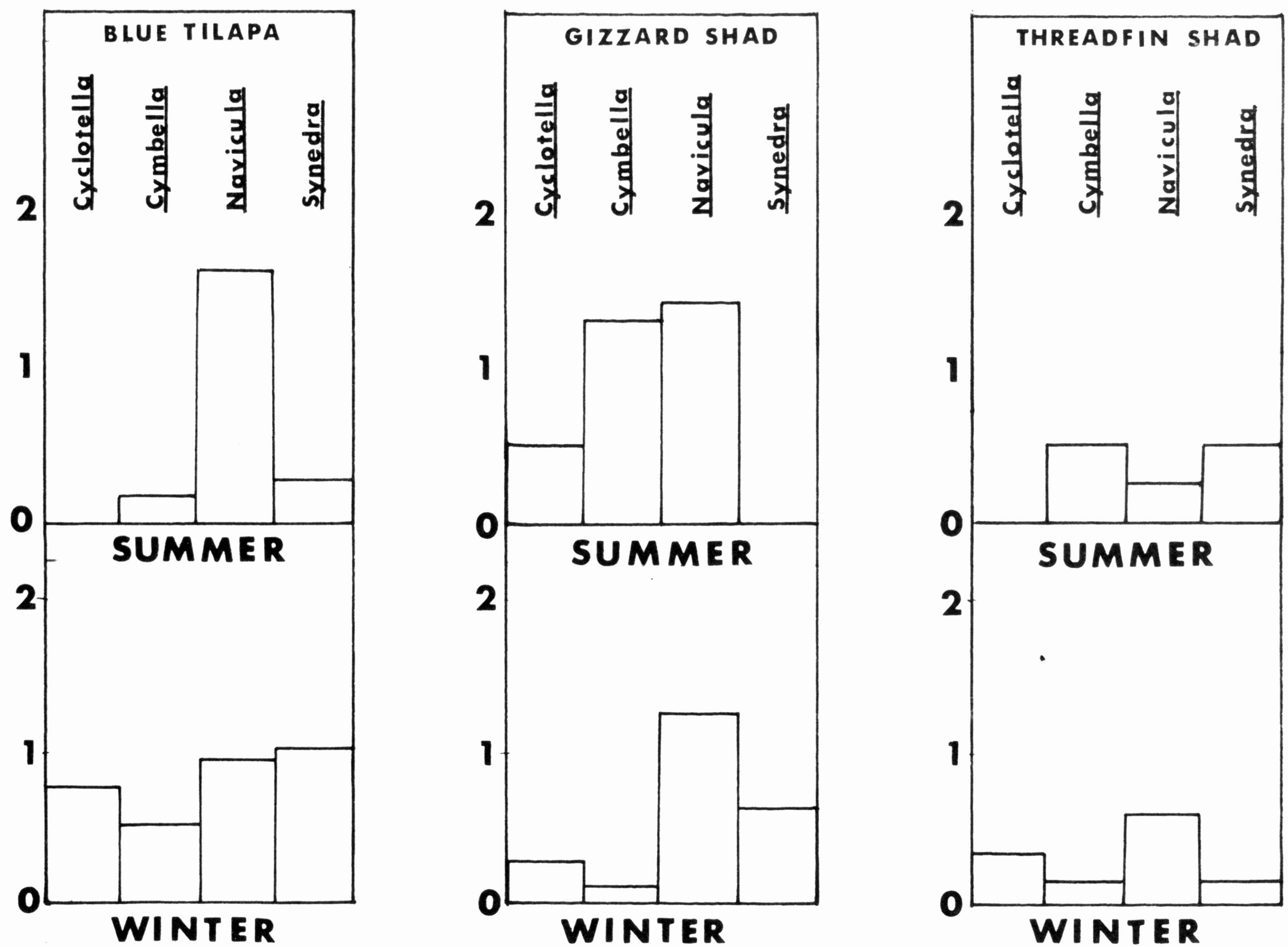

Figure 8. Mean indices of importance for four diatoms common in the stomachs of blue tilapia, gizzard shad, and threadfin shad from Trinidad Lake, summer and winter 1975.

(Cyclotella, Navicula, and Synedra) had frequencies of occurrence ranging from 27 to 81% and average indices of importance of 0.27 to 1.27.

Of the food categories considered, diatoms showed the greatest differences in utilization among the three fish species (Fig. 8). Threadfin shad stomachs examined during December rarely contained diatoms. In all samples examined threadfin shad contained relatively fewer diatoms than gizzard shad or blue tilapia. When partially evacuated stomachs of all three species were examined diatoms were rarely found. Diatoms may be digested quickly and their presence in the stomach could be related to the interval between food consumption and collection of the fish.

Protozoans

Eleven genera of protozoans were identified in fish stomachs examined. Frequency of occurrence of these 11 genera varied with fish species and sampling period (Table 3). The importance of protozoans may have been underestimated due to an inability to distinguish them from other unicellular forms.

Rotifers

Rotifers were identified in the stomachs of all three fish species during both summer and winter sampling periods. Rotifers occurred most frequently in blue tilapia, and least frequently in gizzard shad.

During summer rotifers occurred in 71% of the blue tilapia stomachs examined with an average index of importance of 1.00. During winter rotifers occurred in 50% of the blue tilapia stomachs with an average index of importance of 0.58.

In threadfin shad, during summer, rotifers occurred in 12% of the stomachs examined with an average index of importance of 0.12. During winter rotifers occurred in 50% of the threadfin shad stomachs with an average index ofimportance of 0.53.

In gizzard shad, during summer, rotifers occurred in 20% of the stomachs examined with an index of importance of 0.20. During winter rotifers occurred in 9% of the gizzard shad stomachs with an average index of importance of 0.09.

Copepods

Copepods were identified from blue tilapia and threadfin shad stomachs. Copepods occurred in 28% of the blue tilapia stomachs examined in summer with an average index of importance of 0.28. In winter copepods occurred in 8% of the blue tilapia stomachs with an average index of importance of 0.08.

Copepods were not found in threadfin shad stomachs during summer. In winter copepods occurred in 13% of the threadfin shad stomachs examined with an average index of importance of 0.13.

Cladocerans

Cladocerans occurred in all three species, but most frequently in blue tilapia. During summer cladocerans occurred in 14% of the blue tilapia stomachs examined with an average index of importance of 0.14. During winter cladocerans occurred in 25% of the blue tilapia stomachs examined with an average index of importance of 0.33.

Cladocerans were not found in threadfin shad stomachs during summer. In winter cladocerans occurred in 6% of the stomach examined with an average index of importance of 0.06.

Cladocerans were not found in gizzard shad stomachs examined during summer. In winter cladocerans occurred in 9% of the gizzard shad stomachs examined with an average index of importance of 0.09.

Ostracods

Ostracods were identified from the stomachs of all three species. They occurred in fish stomachs more frequently in winter. During summer ostracods occurred in 14% of the blue tilapia stomachs examined with an average index of importance of 0.14. During winter ostracods occurred in 25% of the blue tilapia stomachs with an average index of importance of 0.25.

Ostracods were not found in threadfin shad stomachs during summer, but in winter occurred in 73% of the threadfin shad stomachs examined with an average index of importance of 1.20. During summer ostracods occurred in 10% of the gizzard shad stomachs examined, with an average index of importance of 0.10. During winter ostracods occurred in 18% of the gizzard shad stomachs examined with an average index of importance of 0.18.

Hydracarina

A single specimen of Hydracarina was found in a blue tilapia stomach.

Nematodes

Nematodes occurred in stomachs of all three fish species, but never had average indices of importance greater than their frequencies of occurrence. In summer nematodes occurred in 71% of the blue tilapia stomachs and 10% of the gizzard shad stomachs but were never found in threadfin shad stomachs. In winter nematodes occurred in 12% of the blue tilapia stomachs, 27% of the gizzard shad stomachs, and 6% of the threadfin shad stomachs. These nematodes were assumed to be free living. They may have been associated with plant materials and ingested accidently.

Diptera Larvae

Diptera larvae were occasionally found in gizzard shad and threadfin shad stomachs, but were not found in blue tilapia. Chironomids occurred in 9% of the gizzard shad stomachs examined during winter. Chironomids and tendipedids occurred in 13% of the threadfin shad stomachs examined during winter.

Bryozoans

Bryozoan statoblasts were identified in stomachs of all three fish species. These free-floating asexual reproductive stages of freshwater bryozoans are easily recognized. Statoblasts were identified as the genus Plumatella. Animal material believed to be bryozoan tissue was also found, but it was broken apart to such an extent that positive identification was impossible.

In blue tilapia during summer bryozoans occurred in 43% of the stomachs examined with an average index of importance of 0.71. During winter bryozoans occurred in 33% of the blue tilapia stomachs with an average index of importance of 0.63.

Bryozoans occurred in 25% of the threadfin shad stomachs examined during summer with an average index of importance of 0.25. During winter bryozoans occurred in 53% of the threadfin shad stomachs examined with an average index of importance of 0.80.

Bryozoans occurred in 20% of the gizzard shad stomachs examined during summer with an average index of importance of 0.20. During winter bryozoans occurred in 27% of the gizzard shad stomachs examined with an index of importance of 0.45.

Sand

Sand grains were present in all threadfin shad and gizzard shad stomachs examined. Sand grains were occassionally found in blue tilapia stomachs.

Discussion

Threadfin shad, gizzard shad, and blue tilapia utilize many of the same food resources in Trinidad Lake. Detritus and organisms of planktonic origin made up most of the material found in the stomachs of all three fish species.

Findings in this study agree with those of Vaas and Hofstede (1952) which indicated that young tilapia feed on diatoms, unicellular algae and small crustaceans. However in this study blue-greens also made up an important portion of the stomach contents of blue tilapia. Bits of plant material which were classified as detritus was estimated to make up at least 50% of the material in blue tilapia stomachs. This is in agreement with the findings of Fryer and Iles (1972) who reported that some tilapia equipped for planktonic feeding may utilize deposit feeding when the plankton of the lake is dominated by unicellular greens and blue-greens. In spite of their short gill rakers blue tilapia stomachs examined contained many small planktonic organisms as frequently as the stomachs of shad did. Small unicellular greens however were found more frequently in threadfin shad and gizzard shad than in tilapia. Blue tilapia appeared to select zooplankton more frequently than either shad species.

Filamentous algae, though it did not comprise an important part of the diet, was found more frequently in blue tilapia than in either shad. Bryozoan statoblasts also appeared to be selected.

Threadfin shad consumed both plant and animal material. Plant material was planktonic in origin and consisted mainly of green algae and blue-greens and some diatoms, small unicellular greens occurred more frequently and in larger amounts in threadfin shad stomachs than in blue tilapia stomachs and in slightly greater amounts than were found in gizzard shad. Threadfin shad appear to be able to concentrate these small unicellular greens efficiently. Animal material found in threadfin shad stomachs consisted of protozoans, bryozoan statoblasts, ostracods and rotifers. Threadfin shad appeared to be selectively feeding on ostracods and bryozoan statoblasts. Smaller organisms appear to be eaten non-selectively. Organic detritus was estimated to make up at least 50% of the material in threadfin shad stomachs. This is in agreement with the findings of Baker and Schmitz (1971) that a significant portion of the diet of threadfin shad is detritus. The presence of sand as well as the occasional occurrence of tendipedid larvae indicate that threadfin shad feed off the bottom as well as pelagically.

Gizzard shad stomachs contained principally plant matter consisting of green algae, blue-greens, and diatoms. Protozoans made up most of the animal material present. Bryozoan statoblasts and occasional rotifers, cladocerans and ostracods were also found in gizzard shad stomachs. Detritus and sand made up the greatest part of the stomach contents. Dalquest (1966) dismissed detritus found in gizzard shad as having little or no food value and reported diatoms to be the main food item. Diatoms were frequently found in gizzard shad stomachs but in smaller amounts than green algae and blue-greens. Diatoms however are easily digested and may be more important than either green algae or blue-greens. The occurrence of sand and occasional tendipedid larvae in gizzard shad suggests that at least some feeding activities are associated with the bottom.

The general food habits of blue tilapia and native gizzard and threadfin shads appear to be very similar. Occurrence of planktonic items in the stomachs of filter feeding fishes, however, does not document the actual utilization of these items, or the contributions made by these items from a nutritional standpoint. This study did not attempt to answer questions pertaining to the actual utilization of detritus, unicellular greens or blue-greens. Since these three categories comprised most of the stomach contents of these three species in Trinidad Lake, it seems likely that some nutrients are derived from these materials.

Food habits of blue tilapia, threadfin shad, and gizzard shad overlap. If food resources are in short supply interspecific competition may occur among these fishes. Trinidad Lake is highly productive in terms of phytoplankton. The major components of the plankton, unicellular green algae and blue-greens are probably never in short supply. Diatoms, protozoans and rotifers are less abundant in the plankton. Production of detritus is difficult to quantify, but the shallow lake has a marshy shoreline and vegetation is abundant. Zooplankton is absent from the plankton samples taken in the limnetic zone. No plankton data were available for the littoral zone. Zooplankton appears to be scarce in Trinidad Lake. Population densities of blue tilapia, threadfin shad, and gizzard shad have been high for several years in Trinidad Lake and competition for zooplankton may be occurring. Blue tilapia appear to select zooplankton to a greater extent than either shad species. The importance of microcrustaceans in postlarval gizzard shad was emphasized by Warner (1940). Gizzard shad examined from Trinidad Lake 47 to 122 mm standard length rarely contained microcrustaceans. Lack of plankton data from previous years makes interpretation of the scarcity of zooplankton in Trinidad Lake difficult.

Blue tilapia, threadfin shad, and gizzard shad co-exist in Trinidad Lake depending upon many of the same food resources. In this highly productive lake, it would seem that there is no shortage of most of the food items the three fish species consumed during July, November and December 1975. However in recent years the blue tilapia population has approached 2000 kg per ha (Noble et al, 1975) which far exceeds average standing crop in most southern reservoirs. Preliminary growth rate analyses (R. Germany pers. com.) indicate that stunting of blue tilapia occurred over the period 1973-1975. Gillnet data from Trinidad Lake show a decrease in numbers of gizzard shad as well as a decrease in their mean lengths, possibly due to reduced growth rates. Since the threadfin shad were not vulnerable to the gillnet sampling, similar data on their size and abundance are not available for comparison. These changes indicate that food may have been in short supply.

The paucity of zooplankton in the plankton samples and in the stomach analyses may be an indication that the fishes were in part limiting their food supply qualitatively. In the absence of such organisms, which other studies have indicated comprise a major portion of the diets of the shad species, greater similarity in food habits could occur. Such reliance on a common food resource, as indicated by the similarity in food habits of these three species, would increase the chances for competition for food to occur.

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Appendix Table 1. Percent frequency of occurrence (% FO) and mean index of importance ($\overline{II}$) for bluegreen algae found in stomachs of three planktivorous fishes in Trinidad Lake, 1975.

	Threadfin Shad						Gizzard Shad						Blue Tilapia					
Month	July		November		December		July		November		December		July		November		December	
Number Examined	8		7		32		10		5		15		7		11		11	
Number containing food	8		7		8		10		4		7		7		8		4	
Standard length (mm)	46-58		47-52		52-75		81-115		98-105		47-122		48-62		61-87		61-100	
Taxon	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$
Anabaena	62	1.12	14	0.28	0	0	40	0.50	0	0	0	0	86	1.4	25	0.25	25	0.50
Anabaenopsis	25	0.25	0	0	62	0.62	60	0.60	25	0.25	0	0	0	0	62	0.75	75	1.00
Dichothrix	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0.12	0	0
Gloeocepsa	50	0.88	71	0.86	38	0.62	70	0.70	100	1.75	57	1.00	28	0.28	38	0.62	75	1.00
Holopedium	0	0	14	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merismopedia	88	1.62	71	1.00	88	1.00	100	1.90	75	0.75	86	1.28	100	1.7	100	1.88	100	1.50
Myxosaxina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microchaeta	0	0	0	0	0	0	0	0	25	0.25	0	0	0	0	0	0	0	0
Nodularia	0	0	0	0	0	0	0	0	25	0.25	0	0	28	0.57	12	0.12	0	0
Nostoc	12	0.12	43	0.43	12	0.12	10	0.10	75	1.25	43	0.57	0	0	25	0.25	75	1.50
Oscillatoria	75	1.38	28	0.28	75	1.13	100	1.70	0	0	57	0.86	71	1.14	50	0.62	50	1.00
Rurilaria	50	0.50	0	0	0	0	20	0.20	0	0	14	0.14	28	0.28	0	0	75	0.75
Spirulina	25	0.50	43	0.71	38	0.38	80	1.00	25	0.25	28	0.28	100	1.86	38	0.50	50	0.50
Trichidesmium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0.25	0	0
Xenococcus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colonial	62	1.25	71	1.14	88	1.62	70	1.20	25	0.25	43	0.71	43	0.43	75	1.12	100	1.75

Appendix. Table 2. Percent frequency of occurrence (% FO) and mean index of importance $\overline{II}$ for diatoms found in stomachs of three planktivorous fishes in Trinidad Lake, 1975.

	Threadfin Shad						Gizzard Shad						Blue Tilapia					
Month	July		November		December		July		November		December		July		November		December	
Number examined	8		7		32		10		5		15		7		11		11	
Number containing food	8		7		8		10		4		7		7		8		4	
Standard length (mm)	46-58		47-52		52-75		81-11		98-105		47-122		48-62		61-87		61-100	
Taxon	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$
Cyclotella	0	0	0	0	62	0.62	50	0.50	50	0.50	14	0.14	0	0	62	0.88	50	0.50
Cymbella	38	0.50	0	0	25	0.25	90	1.30	0	0	14	0.14	14	0.14	62	0.62	25	0.25
Diatoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0.12	0	0
Diatomella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0.25
Fragillaria	0	0	43	0.43	12	0.12	10	0.10	0	0	43	0.43	57	0.57	25	0.25	75	0.75
Fustula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0.25
Gomphonema	0	0	0	0	0	0	0	0	0	0	0	0	14	0.14	0	0	0	0
Gyrosigma	0	0	0	0	12	0.12	10	0.10	0	0	14	0.14	28	0.43	0	0	0	0
Melosina	0	0	0	0	12	0.12	70	0.70	0	0	0	0	0	0	12	0.12	25	0.25
Navicula	25	0.25	0	0	88	1.12	100	1.40	75	1.50	86	1.14	100	1.6	38	0.75	100	1.25
Nitgschia	0	0	0	0	0	0	0	0	0	0	0	0	14	0.14	0	0	0	0
Synedra	25	0.50	0	0	25	0.25	0	0	75	1.00	0	0	14	0.28	88	1.36	25	0.25
Tahellaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Square Diatom	25	0.38	28	0.28	75	1.12	50	0.90	25	0.25	28	0.28	0	0	25	0.25	25	0.50

Appendix Table 3. Continued.

	Threadfin Shad						Gizzard Shad						Blue Tilapia					
Month	July		November		December		July		November		December		July		November		December	
Number examined	8		7		32		10		5		15		7		11		11	
Number containing food	8		7		8		10		4		7		7		8		4	
Standard length (mm)	46-58		47-52		52-75		81-115		98-105		47-122		48-62		61-87		61-100	
Taxon	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$
Scenedesmus	100	2.00	100	2.00	75	1.25	100	1.90	100	2.00	100	1.57	100	1.86	100	2.00	100	2.00
Selenastrum	12	0.12	0	0	0	0	0	0	0	0	0	0	0	0	12	0.25	0	0
Sorastrum	0	0	57	0.57	12	0.12	0	0	0	0	57	0.57	0	0	0	0	25	0.25
Spirogyra	0	0	0	0	12	0.12	10	0.10	0	0	0	0	0	0	0	0	0	0
Stigeoclonium	0	0	0	0	12	0.12	50	0.50	0	0	0	0	14	0.14	0	0	25	0.25
Tetraedron	25	0.38	71	0.71	38	0.38	0	0	50	0.50	14	0.14	43	0.57	88	0.88	75	0.75
Tetrastrum	0	0	0	0	38	0.38	0	0	25	0.25	0	0	0	0	25	0.25	50	0.50
Ulothrix	12	0.12	0	0	0	0	0	0	0	0	0	0	14	0.14	0	0	25	0.50
Unident. filament	38	0.38	28	0.43	25	0.50	30	0.30	75	1.00	14	0.14	43	0.57	38	0.50	75	1.25
round green	88	1.75	86	1.38	100	1.75	100	2.00	75	1.50	57	1.14	28	0.57	62	1.25	100	1.75
oval green	88	1.62	100	2.00	88	1.50	100	1.50	50	1.00	100	1.86	14	0.14	88	1.75	50	1.00

Appendix Table 3. Percent frequency of occurrence (% FO) and mean index of importance ($\overline{II}$) for green algae found in stomachs of three planktivorous fishes in Trinidad Lake, 1975.

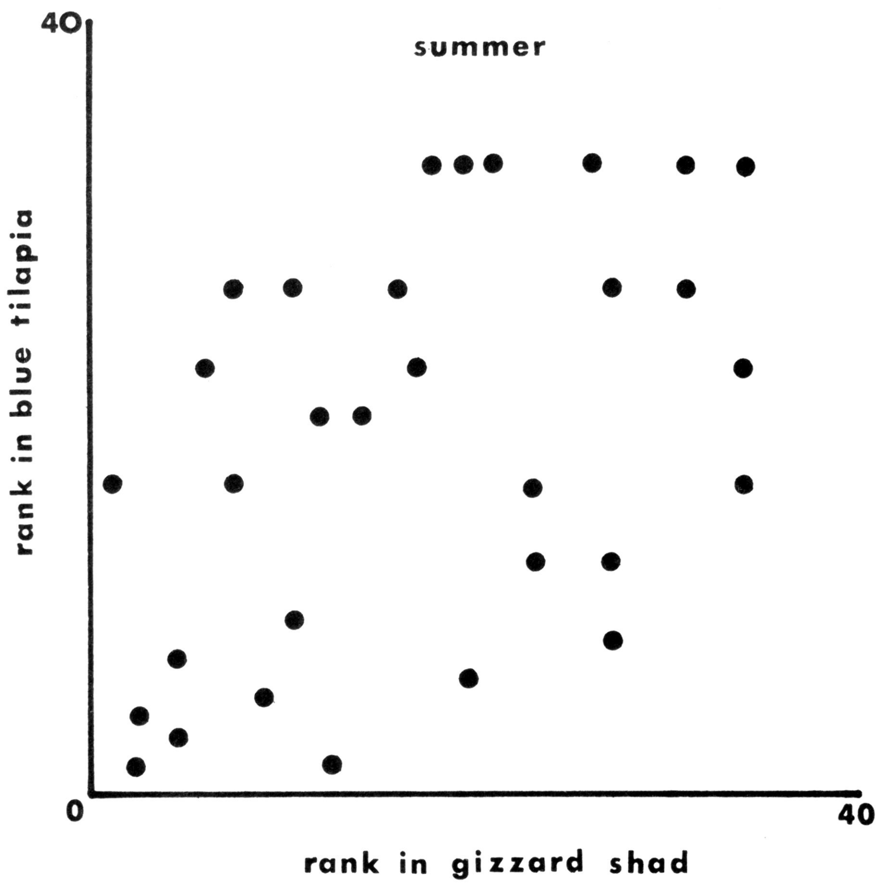
	Threadfin Shad						Gizzard Shad						Blue Tilapia					
Month	July		November		December		July		November		December		July		November		December	
Number examined	8		7		32		10		5		15		7		11		11	
Number containing food	8		7		8		10		4		7		7		8		4	
Standard length (mm)	46-58		57-62		52-75		81-115		98-105		47-122		48=62		61-87		61-100	
Taxon	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$	%FO	$\overline{II}$
Actinastrum	0	0	0	0	0	0	0	0	25	0.25	0	0	14	0.14	0	0	0	0
Ankistrodesmus	0	0	28	0.43	38	0.38	30	0.30	50	1.00	14	0.14	43	0.71	38	0.50	0	0
Arthrodesmus	62	1.00	71	1.43	75	0.88	70	1.30	100	1.50	71	1.14	71	0.86	100	1.86	100	1.25
Cladophora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	1.00
Closteriopsis	12	0.12	28	0.43	50	0.75	30	0.30	75	1.25	14	0.14	28	-.57	50	0.88	50	0.50
Closterium	0	0	0	0	12	0.25	30	0.30	25	0.25	14	0.14	43	0.57	38	0.38	50	0.50
Cosmarium	75	1.25	0	0	88	1.12	100	1.50	75	0.75	28	0.28	43	0.57	75	0.88	75	0.75
Crucigenia	0	0	14	0.14	12	0.12	30	0.30	50	0.50	28	0.28	0	0	38	0.38	25	0.25
Dictyosphaerium	25	0.38	14	0.14	12	0.12	0	0	75	1.25	71	1.28	0	0	38	0.38	25	0.50
Dimophococcus	0	0	14	0.14	0	0	0	0	0	0	0	0	0	0	12	0.12	0	0
Gloeotaenium	0	0	0	0	38	0.50	20	0.20	75	1.50	43	0.43	14	0.14	0	0	75	0.75
Golenkinia	12	0.12	0	0	88	1.5 0	20	0.20	75	1.25	57	0.86	43	0.71	50	0.62	25	0.25
Kirchnella	0	0	14	0.14	0	0	0	0	0	0	0	0	0	0	12	0.12	0	0
Oedogonium	0	0	0	0	12	0.12	20	0.20	0	0	0	0	43	0.71	0	0	25	0.25
Oscystis	0	0	14	0.28	88	1.50	10	0.10	25	0.25	43	0.57	0	0	38	0.50	25	0.50
Pediastrum	75	1.38	86	1.28	88	1.12	100	1.70	100	1.75	100	1.86	100	1.8	100	1.75	100	2.00
Planktiosphaeria	62	0.75	14	0.14	38	0.38	40	0.40	0	0	71	0.71	0	0	0	0	50	0.50
Protococcus	0	0	14	0.14	12	0.12	0	0	0	0	28	0.28	0	0	0	0	0	0
Rhizoclonium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0.50

Appendix. Table 4. Percent frequency of occurrence (% FO) and mean index of importance ($\overline{II}$) for protozoans found in stomachs of three planktivorous fishes in Trinidad Lake, 1975.

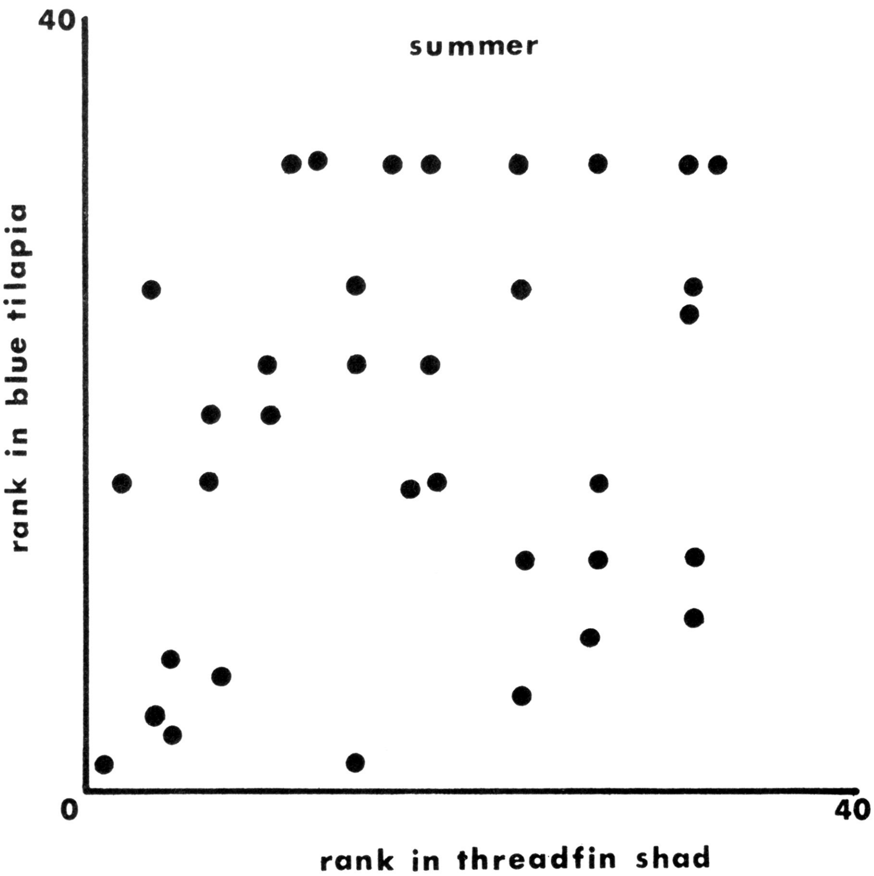
	Threadfin Shad						Gizzard Shad						Blue Tilapia					
Month	July		November		December		July		November		December		July		November		December	
No. examined	8		7		32		10		5		15		7		11		11	
Number containing food	8		7		8		10		4		7		7		8		4	
Standard length (mm)	46-58		47-52		52-75		81-115		98-105		47-122		48-62		61-87		61-100	
Taxon	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$
Chlamydomonas	38	0.62	0	0	62	1.25	20	0.20	0	0	57	1.00	0	0	38	0.75	25	0.50
Chrysidiastrum	0	0	14	0.14	12	0.12	0	0	25	0.25	14	0.14	0	0	38	0.38	50	0.50
Chrysophaerella	0	0	14	0.28	0	0	0	0	25	0.25	0	0	0	0	0	0	0	0
Difflugia	0	0	0	0	25	0.50	10	0.10	0	0	0	0	43	0.57	12	0.25	0	0
Pandorina	0	0	0	0	38	0.38	80	1.60	0	0	0	0	28	0.28	0	0	0	0
Peridinium	0	0	0	0	25	0.25	0	0	0	0	28	0.28	0	0	12	0.12	0	0
Phacus	0	0	0	0	0	0	70	0.80	0	0	0	0	14	0.14	0	0	25	0.25
Platydorina	0	0	0	0	0	0	20	0.20	0	0	0	0	43	0.71	0	0	0	0.25
Trachelomonas	38	0.50	0	0	12	0.12	50	0.80	0	0	14	0.14	0	0	0	0	25	0.50
Volvox	0	0	14	0.14	0	0	60	0.90	0	0	14	0.14	14	0.14	0	0	50	0.50
Vorticella	0	0	0	0	12	0.12	0	0	0	0	14	0.14	0	0	0	0	0	0
Unidentified Colonial	75	0.88	14	0.14	50	0.62	80	0.90	0	0	14	0.14	43	0.43	62	1.12	0	0

Appendix Table 5. Percent frequency of occurrence (% FO) and mean index of importance ($\overline{II}$) for animal material found in stomachs of three planktivorous fishes in Trinidad Lake, 1975.

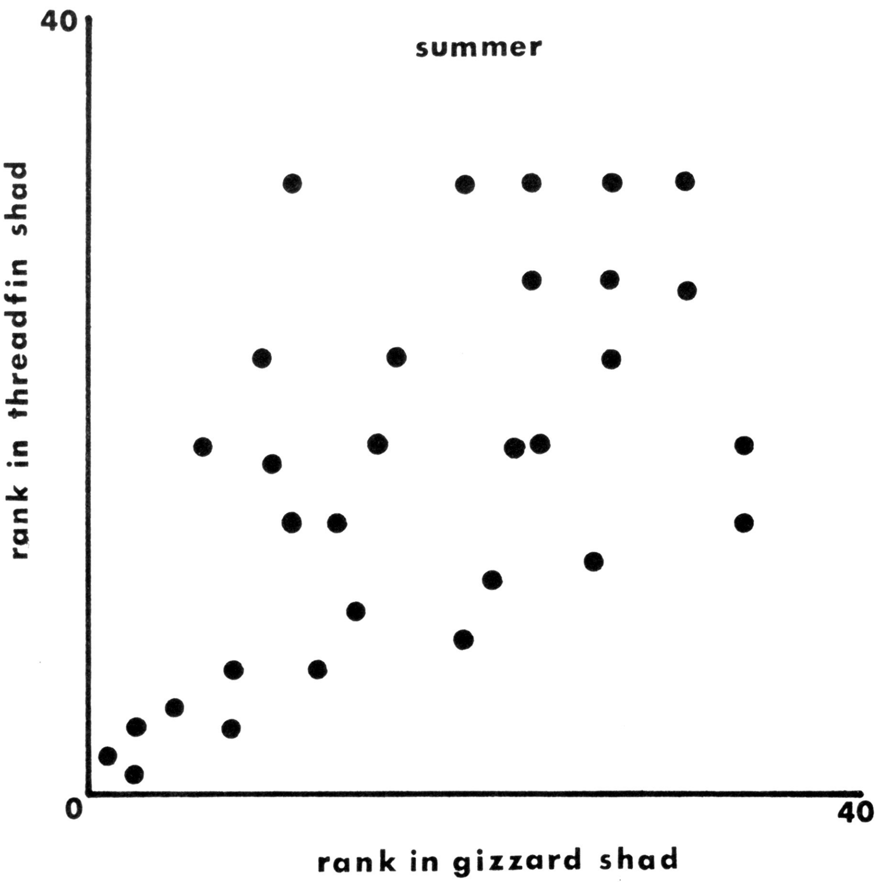
	Threadfin Shad						Gizzard Shad						Blue Tilapia					
Month	July		November		December		July		November		December		July		November		December	
Number examined	8		7		32		10		5		15		7		11		11	
Number containing food	8		7		8		10		4		7		7		8		4	
Standard length (mm)	46-58		47-52		52-75		81-115		98-105		47-122		48-62		61-87		61-100	
Taxon	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$	% FO	$\overline{II}$
Bryozoa	25	0.25	86	1.28	25	0.38	20	0.20	0	0	57	1.00	43	0.71	25	0.50	50	0.75
Rotataria	12	0.12	57	0.57	38	0.50	20	0.20	0	0	14	0.14	71	1.00	50	0.62	50	0.50
Cladocera	0	0	14	0.14	0	0	0	0	0	0	14	0.14	14	0.14	25	0.38	25	0.25
Copepoda	0	0	28	0.28	0	0	0	0	0	0	0	0	28	0.28	0	0	25	0.25
Hydracarina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0.25
Ostracoda	0	0	86	1.43	62	1.00	10	0.10	0	0	28	0.28	14	0.14	25	0.25	25	0.25
Nematoda	0	0	0	0	12	0.12	10	0.10	50	0.50	14	0.14	71	0.71	12	0.12	25	0.25
Diptera																		
Chironomid	0	0	14	0.14	12	0.12	0	0	25	0.25	0	0	0	0	0	0	0	0
Tendipedid	0	0	14	0.14	12	0.12	0	0	0	0	0	0	0	0	0	0	0	0



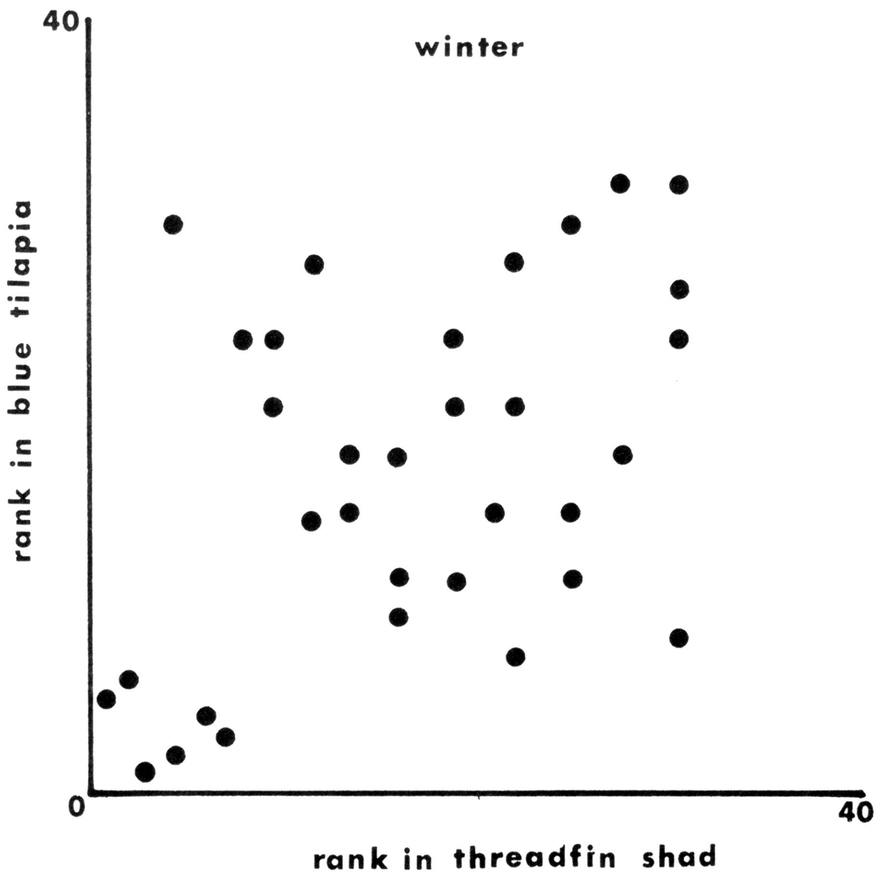
Appendix Figure 1. Relationship between ranks of major food items in blue tilapia and in gizzard shad, Trinidad Lake, summer 1975.



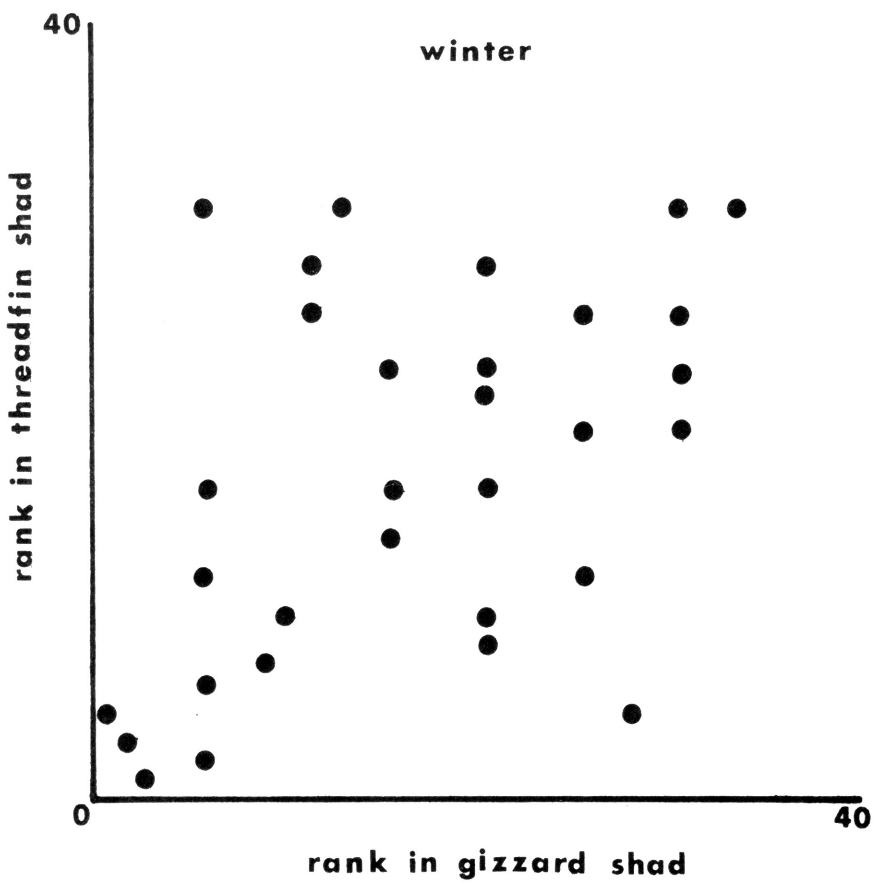
Appendix Figure 2. Relationship between ranks of major food items in blue tilapia and in threadfin shad, Trinidad Lake, summer 1975.



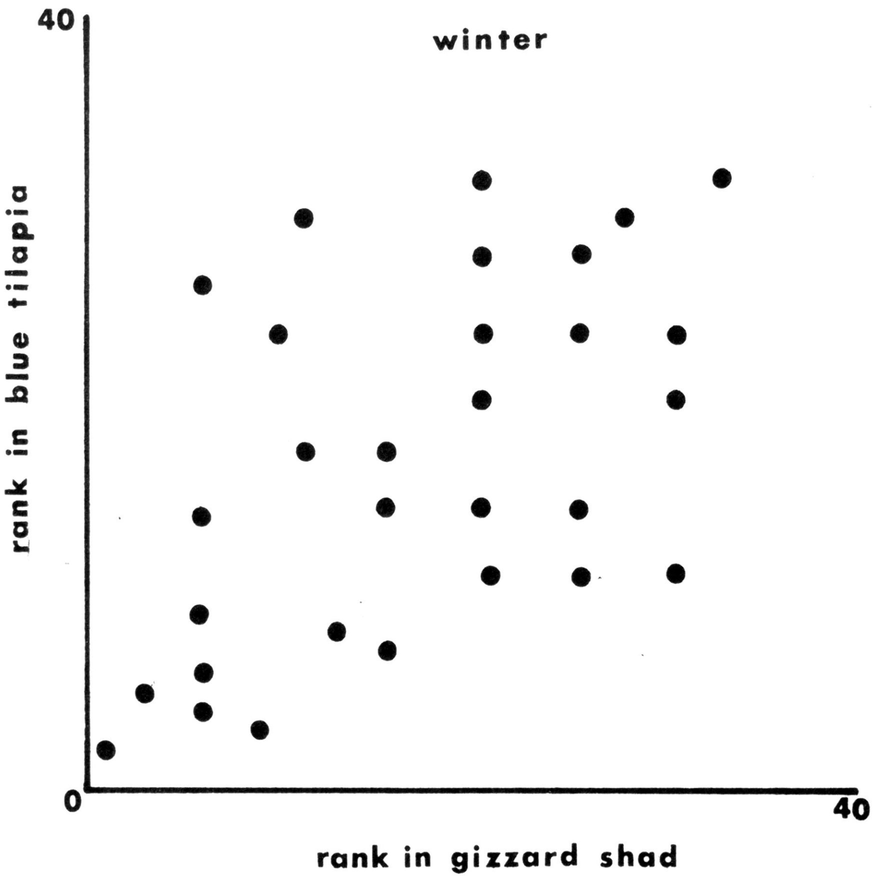
Appendix Figure 3. Relationship between ranks of major food items in threadfin shad and in gizzard shad, Trinidad Lake, summer 1975.



Appendix Figure 4. Relationship between ranks of major food items in blue tilapia and in threadfin shad, Trinidad Lake, winter 1975.



Appendix Figure 5. Relationship between ranks of major food items in threadfin shad and in gizzard shad, Trinidad Lake, winter 1975.



Appendix Figure 6. Relationship between ranks of major food items in blue tilapia and in gizzard shad, Trinidad Lake, winter 1975.