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Abstract. Young yellow bass *Roccus mississippiensis,* ate primarily entomostracans but started taking significant numbers of immature insects when the bass reached 50 mm, total length. Adult yellow bass showed little change in food habits with increase in size from 5 to 7.9 inches with immature insects and crustacea in 60 and 81 per cent of the stomachs, respectively. Forage fish were found in only 2 per cent of the yellow bass in 1960 compared with 24 per cent in 1952 and 86 per cent in 1943 when the yellow bass were larger. Cladocera decreased in frequency in yellow bass stomachs from June to August, 1960. The highest frequencies of copepods, *Hyalella,* and immature insects occurred in July. The daily period of maximum feeding appeared to be 4 to 8 PM with maximum activity, as measured by gill net catches from 6 PM to 2 AM. Black bullheads, *Ictalurus melas,* ate similar foods to the yellow bass except for a greater utilization of forage fish.

DESCRIPTION OF AREA

Clear Lake is a shallow, eutrophic lake located in Cerro Gordo County, north-central Iowa. At outlet level, it covers an area of approximately 3,643 acres, with a maximum depth of about 20 feet (Pearcy, 1953). Since 1956, the water level has been 1 to 3 feet below the outlet (Buchholz, 1960). The bottom in the littoral zone is composed mainly of sand and gravel, while bottom areas in deeper water are silt (Bailey and Harrison, 1945). The giant bulrush, *Scirpus validus,* constitutes the major form of emergent vegetation while *Potamogeton* spp. are the main submergent vegetation (Pearcy, 1953). Yellow bass, *Roccus mississippiensis,* and black bullhead, *Ictalurus melas,* are the two most abundant game fish (McCann, 1960).

METHODS AND MATERIALS

Adult fish were collected from nine selected locations with gill nets and an otter trawl. Two of the areas in shallow water and emergent vegetation also were sampled with an electric shocker. Young fish were collected with a 30-foot bag seine in shallow shore areas during late evening hours. Efforts were made to randomize all sampling.

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Each adult fish in the sample was weighed and measured, and scales or pectoral spines were removed for future age and growth studies. Then the portion of the digestive tract between the esophagus and the pyloric valve was removed, labeled and preserved in 10 percent formalin until studied in the laboratory. Young-of-the-year were put into 10 percent formalin immediately after total length measurements were obtained. Bottom samples were obtained with a ¼-square foot Ekman dredge. The samples were then washed in a pail, with 25-mesh screen in the bottom, before being placed in 10 per cent formalin for later study.

An 18-power dissecting scope was used to identify the stomach contents after they were placed in a petri dish. Organisms were identified to genus if possible and were individually counted when small numbers were present or the number was estimtaed when organisms were abundant. Percentage frequency of occurrence of food items was computed by using the total number of stomachs. After indentification, stomach contents and bottom samples were placed in a calibrated centrifuge tube and centrifuged 2 minutes to determine volumes.

Bottom Fauna

Limited bottom sampling indicated that chironomids were the most abundant organisms at eight of the nine locations. Pearcy (1953) found *Hyalella* sp. the most abundant organism in shallow water bottom samples with chironomids the second most abundant. During 1956, chironomids were the most abundant organism in bottom samples from two shallow-water locations (Ridenhour, 1958). It appears that chironomid larvae have been an important part of Clear Lake bottom fauna during recent years. Other organisms found in the bottom samples included *Chaoborus* and certopagonid larvae. Gastropods, Oligochaetes and flatworms.

Volumes of bottom fauna varied little among the nine locations during 1960, ranging from less than 0.05 cc to 0.2 cc per one-quarter square foot. In general, the volumes of bottom fauna recorded at each location during 1960 were less than those recorded at the same locations by Pearcy (1953) or Rirenhour (1958). Different methods of bottom sampling or laboratory analysis may account for some of this difference, but the decline is believed to have been significant.

Yellow Bass Food Habits

In young-of-the-year yellow bass stomachs (Tables 1 and 2), entomostrancans were the most abundant food items with chironomids and *Hyalella* sp. next in importance. Ridenhour (1960) found the same three food items in stomachs of 75 Clear Lake young-of-the-year collected in 1957, although *Hyalella* sp.

were much more numerous. The August 3rd sample (Table 2) indicates that although all the young fish had eaten entomostracans, insects also were eaten by the majority of those over 50 mm long. Kutkuhn (1955) observed that crustaceans were the most frequent food item of yellow bass under 40 mm in total length in North Twin Lake, Iowa. A change from crustaceans to a predominance of immature insects took place in the 40 to 44 mm length group.

Table 1. Food items of 75 Clear Lake young yellow bass collected from South Bay, July 27, 1961

Food item	Frequency of occurrence	Per cent frequency of occurrence	Frequency ranking by most organisms in each stomach 1st	2nd	3rd	4th	5th
Copepoda	74	99	52	15	5	2	1
Entomostraca							
Leptodora	70	93	8	32	22	8	
Diphnia	57	76	7	11	24	14	1
Sididae	51	68	7	15	14	14	1
Ostracoda	2	3					
Malacostraca							
Hylalella	2	3					
Immature insects							
Chironomidae	53	71		1	6	23	23
Ceratopogonidae	2	3					
Ephemeroptera	7	9					
No. stomachs examined	75						
No. empty	1						

Total length range 31-54 mm

Table 2. Per cent frequency of occurrence of food items from 57 Clear Lake yellow bass young-of-the-year captured near the Island, August 3, 1961

Food item	Total length in millimeters 35-39	40-44	45-49	50-54	55-59	All lengths
Entomostraca	100	100	100	100	100	100
Immature insects	33	20	30	70	100	39
No. with food	15	10	19	10	2	56
No. stomachs examined	15	10	20	10	2	57

There was little evidence of change in food habits with increased sizes after the first summer except for a greater tendency to feed on chironomids (Insert Fig. 1 about here). Total lengths for the yellow bass after the first summer ranged from 3 to 7.9 inches but few fish under 5 inches long were taken. Only four fish, three of which were 7-7.9 inches, had eaten forage fish. Adult Clear Lake yellow bass in previous years have been larger and have shown changes in food habits with increased size. The food studies of 92 yellow bass between 7 and 10.9 inches total length collected from Clear Lake during the summer of 1952 showed an increased utilization of insects and fish and a decrease of crustaceans as the fish got larger (Kutkuhn, 1954). Buchholz (1960) found little difference in frequencies of crustaceans and immature insects among yellow bass between 3.0 and 9.9 inches

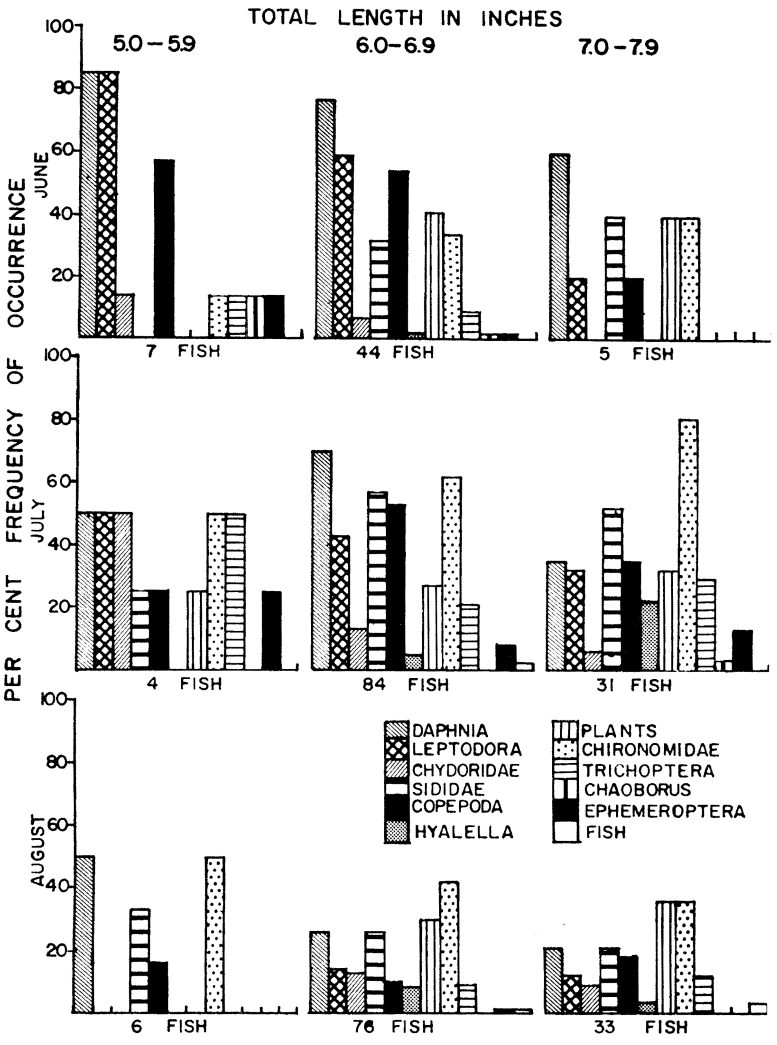

Fig. 1. Per cent frequency of occurrence for twelve food items fro mthe stomachs of three length groups of adult Clear Lake yellow bass during summer, 1960.

total length collected at Clear Lake during 1957 and 1958, but found the larger fish eating more forage fish. At North Twin Lake, Kutkuhn (1955) observed small yearling yellow bass feeding mainly on immature mayflies and chironomids, but between 5 and 5.9 inches total length they began to feed more on forage fish than immature insects. At North Twin Lake during 1953 and 1954, forage fish (young yellow bass and gizzard shad) composed 53.24 per cent of the food volume in yellow bass less than 6 inches long and 88.75 per cent of the food volume in fish over 6 inches long (Kutkuhn, 1955). In 1956, however,

Collier (1959) found forage fish only in stomachs of yellow bass over 10 inches in length.

Immature insects and crustaceans were the most frequent food items for larger yellow bass in Clear Lake during 1960 and were found in 60 per cent and 81 per cent of the stomachs, respectively. Chironomids were the most frequently eaten immature insect with ceratopogonids and *Chaoborus* sp. the only other dipterans observed among the food items. Caddisflies and mayflies were the remaining forms of immature insect food items. Cladocerans, especially *Daphnia* sp., were found in very large numbers in individual yellow bass stomachs indicating selectiveness for these food items. During the diurnal study described later, one 5.4-inch yellow bass collected at 10 a.m. had eaten approximately 3,772 *Daphnia* sp. Six stomachs collected at 6 p.m. contained from 2,396 to 2,888 *Daphnia* sp. Total lengths of these six yellow bass ranged from 5.3 to 5.5 inches. Copecods, ostracods, hydracarinans and amphipods were also found in the larger yellow bass stomachs, although less frequently than cladocerans. Plant materials were observed in 28 per cent of the stomachs but composed little of the food volume. Adult insects and small fish were found in only 2 per cent of the stomachs.

Crustaceans have increased in frequency as a yellow bass food item during recent years and forage fish have decreased (Table 3). The major forms of immature insects also decreased slightly in frequency among yellow bass food items since 1957.

Table 3. Per cent frequency of occurrence of crustacea and forage fish in stomachs of adult yellow bass from Clear Lake in various summers

Year	Crustacae	Forage fish
1943 (Bailey and Harrison, 1945)	7	86
1952 (Kutkuhn, 1954)	38	24
1957 (Buchholz, 1960)	68	3
1958 (Buchholz, 1960)	58	5
1960	81	2

In general, little variation in the food of yellow bass was noted when the nine sampling locations were compared. However, frequency values for cladocerans showed a noticeable change from 64 per cent in deep water to 82 percent in shallow water.

Cladocera decreased in frequency among yellow bass stomachs during June, July and August, 1960 (Insert Fig. 2 about here). Small (1961) found little seasonal variation for mean numbers of cladocerans per liter of water, except for *Daphnia* sp. and *Bosmina* sp. in the main body of Clear Lake during June, July and August, 1960. This indicates that the availability of most cladocerans remained about the same during the summer of 1960, although they were not equally utilized for food by the

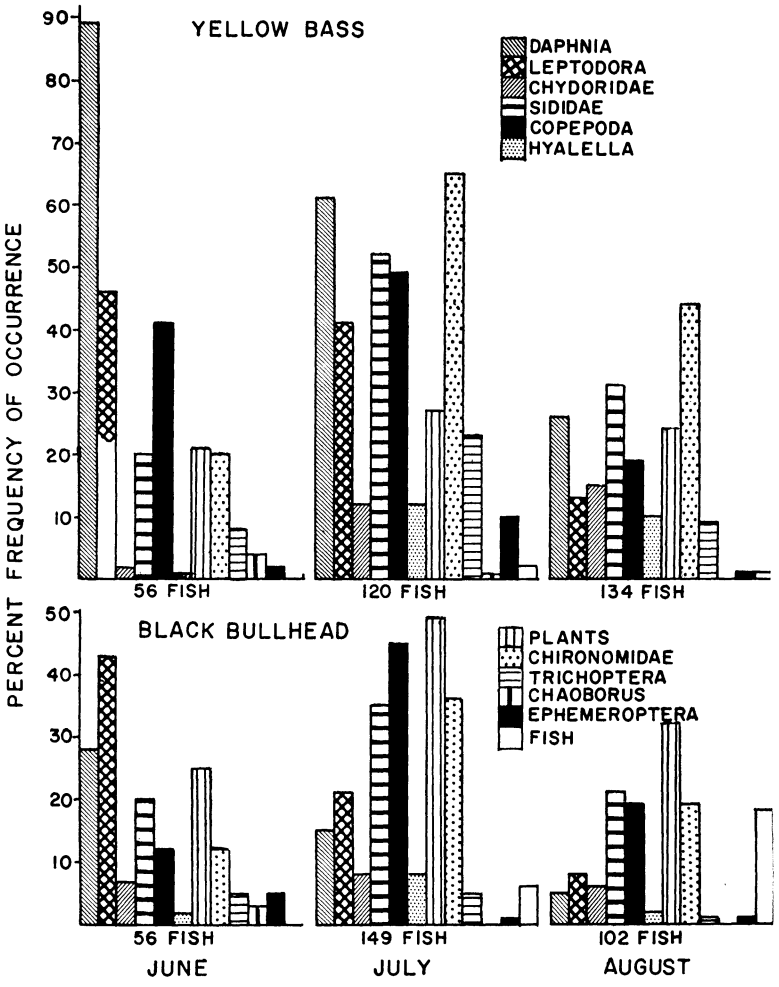

Fig. 2. Per cent frequency of occurrence for twelve food items from the stomachs of Clear Lake yellow bass and black bullheads during summer, 1960.

yellow bass during all three months. Buchholz (1960) showed a decrease in frequency of crustaceans in yellow bass stomachs from July to August, 1957 and 1958, with no data available for June. The frequency of copepods, *Hyalella*, and immature insects among yellow bass stomachs during 1960 was the lowest in June and highest in July. This suggests an increased feeding off the bottom and among aquatic plants. Immature insects also decreased in frequency from July to August in 1957 and 1958. Small fish were not recorded among yellow bass food items in June, 1960 but were found in 2 per cent of the stomachs in July and in 1 per cent during August (Fig. 2). Frequency values

for small fish during July and August 1957-58 were 2 percent and 5 per cent, respectively. There was little monthly variation in the frequency of plant material among yellow bass stomachs during 1960. No plant data were available for 1957 and 1958.

Yellow bass were collected from gill nets at 2-hour intervals through a 24-hour period, June 29-30, 1961 to get at least a limited measure of the diurnal periodicity in feeding (Fig. 3). The

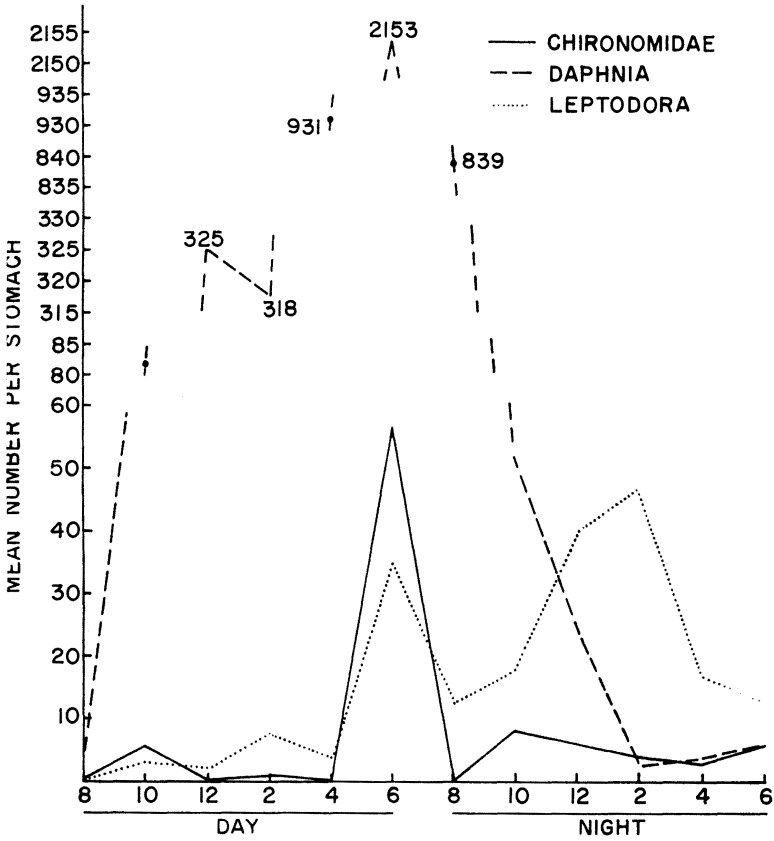

Fig. 3. Mean numbers of some food items taken from yelow bass stomachs collected at various hours of the day and night, Clear Lake, June 29-30, 1961.

period of highest feeding, based on mean food volume per stomach, was from 4 p.m. to 8 p.m. All of the stomachs at 6 p. m. were obviously distended with food, while few stomachs collected at other samplings showed this much fullness. The highest mean number of chironomids and *Daphnia* sp. per stomach was observed at 6 p.m. (Fig. 3). The other important food item, *Leptodora* sp., had the highest mean number at 2 AM Mean numbers of the same three food items during 1957 and 1958

from Buchholz (1960) were plotted in the same manner (Fig. 4) and generally agree with the 1960 data though perhaps peaking a little earlier in the day.

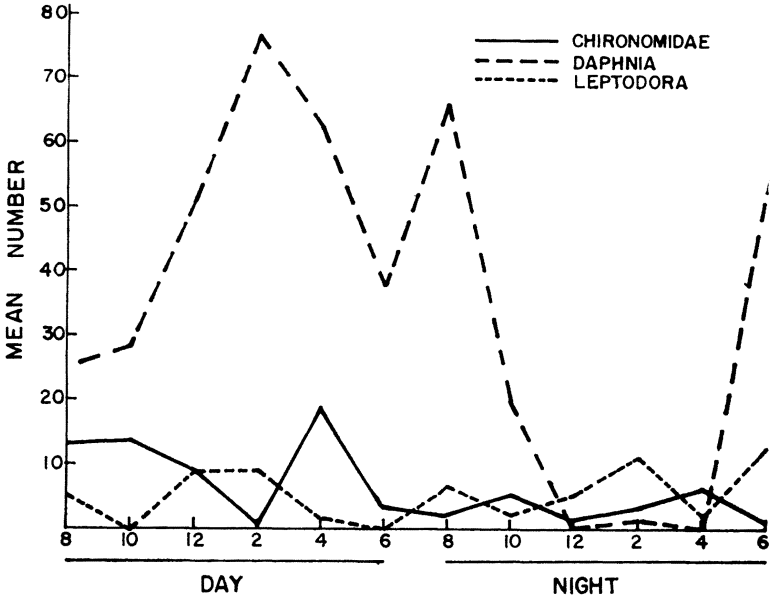

Fig. 4. Mean numbers of some food items taken from yellow bass stomachs collected at various hours of the day and night, Clear Lake, 1957-58.

The numbers of yellow bass caught in the gill nets during each two-hour period, June 29-30, indicated below gives an indication of their diurnal cycle of activity:

	AM					PM					AM		
Hour lifted	8	10	12	2	4	6	8	10	12		2	4	6
Yellow bass	1	6	2	5	5	6	26	22	19		13	10	8

The greatest catches occurred in early evening and were higher at night than during the day. A similar diurnal cycle was evident from the 1957-58 data and also as reported by Carlander and Cleary (1949) and Sieh and Parsons (1950). It is interesting that the period of highest feeding seems to have immediately preceded the period of highest catch in gill nets.

Black Bullhead Food Habits

Crustaceans, plant materials, chironomids and small fish were noted in 57, 42, 28 and 9 per cent of the bullhead stomachs, respectively. Entomostrancans, which composed the major part of crustacean food items, were found in 55 per cent of the stomachs. This represents a considerable increase from the 4 per cent recorded during 1951 (Forney, 1955). Chironomids,

the most important immature insect among black bullhead food items during both studies, were found in 53 per cent of the stomachs collected in 1951 and 28 per cent of those collected in 1960. Although 42 per cent of the stomachs sampled in 1960 contained plant material, this food composed little of the total food volume. Forney (1955) reported that 9 per cent of the bullheads taken in 1951 had eaten plant material. While less than 1 per cent of the bullheads sampled in 1951 had eaten small fish, 9 per cent had eaten them during 1960 indicating increased utilization of this food item by the bullhead. A decrease in total length of the bullhead was aso noted between 1951 and 1960. Total lengths ranged from 8 to 12 inches in 1951 and 7.9 to 9.9 inches in 1960.

Probably one of the more important aspects of monthly bullhead food habits was the increased utilization of small fish during the summer. Small fish were not found among bullhead food items during June but increased in frequency from 6 per cent in July to 18 per cent in August (Fig. 2.)

Few conclusions could be made regarding location differences in bullhead food habits except when the sampling locations were compared on the basis of deep and shallow water. In general, crustaceans and chironomids were eaten more frequently at shallow water locations. Cladocerans, small fish and plant material varied little in frequency between deep and shallow water areas.

Discussion

One of the more important differences between the food habits of adult yellow bass and black and bullheads (Fig. 2) is in the greater utilization of small fish by the bullhead. Seining during the summer of 1960 indicated normal populations of young-of-the-year game fish in Clear Lake. The bullheads foraged on these while the yellow bass did not. Yellow bass appear to feed more on *Daphnia* sp. than the larger *Leptodora* sp. during each of the three months. The opposite feeding preference is indicated by the bullhead during the same period.

The food habits of adult Clear Lake yellow bass are considered an important factor in their reduced growth during recent years. In general, since the early forties, immature insects and especially small fish have decreased in frequency among foods eaten by yellow bass. The very large numbers of certain cladocerans found in the stomachs of many yellow bass indicate selectiveness in feeding for them even when apparently normal populations for forage fish are available.

Since 1951, Clear Lake black bullheads also have decreased

in average size. Chironomids, the most important immature insect have decreased in frequency among bullhead food items during this same period.

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