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FOOD HABITS AND FEEDING CHRONOLOGY OF CHANNEL CATFISH *ICTALURUS PUNCTATUS* (RAFINESQUE), IN CONOWINGO RESERVOIR

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The single 24-hour feeding chronology study indicated that subadult and adult catfish fed heavily during the daylight hours although some feeding also occurred in the night. The major foods eaten by subadults and adults differed over the 24-hour period. Fishes formed the bulk of the diet at 0600 and 0900 hours and insects at 0400 and 2400 hours; whereas the zooplankton was the principal food at other periods. The presence of large amounts of detritus (sand and mud) during the times of heavy feeding indicated near-bottom feeding habits.

Stomach contents of 798 subadult and adult channel catfish (122 to 270 mm fork length) collected from July to November, 1966 in Conowingo Reservoir were examined. Stomachs of 183 young catfish (35 to 83 mm) collected in August and September were also analyzed. By weight and on the basis of percentage frequency of occurrence zooplankton was the principal food of catfish of all sizes. Fishes were important in the diet of subadults and adults only in August and October. Amphipods comprised an important segment of the diet of subadults and adults only in November. Insects and algae were less important.

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INTRODUCTION

Previous studies of food of the channel catfish, *Ictalurus punctatus* (Rafinesque) by Boesel 1938; Darnell, 1958; Davis, 1959; Dendy, 1946; Dill, 1944; Ewers and Boesel, 1935; Forbes, 1888; McAtee and Weed, 1915; McCormick, 1940; Menzel, 1945; Parks, 1949; Rice, 1941; Shira, 1917; and Ware, 1966 were based on few specimens collected over a short period. Bailey and Harrison (1945) reported its detailed seasonal food habits based on a large sample in Des Moines River, Iowa. Busbee (1968) noted its piscivorous food habits in High Falls Lake, Georgia. None of the investigators, however, reported on the feeding chronology (hours of active feeding) of the channel catfish over a 24-hour period.

The importance and method of determining the amount of food consumption by fishes in a natural habitat in a given 24-hour period has been discussed by Darnell and Meierotto (1962), Keast and Welsh (1968), and Surber (1930). The objectives of the present investigation on channel catfish in Conowingo Reservoir were to determine 1) the 24-hour feeding chronology (hours of active feeding) and 2) the qualitative and quantitative composition of the food eaten in the various months.

Conowingo Reservoir is located on the lower Susquehanna river in Pennsylvania and Maryland. It is 14 miles long and averages one mile in width. The total surface area is about 9,000 acres. Moyer and Raney (1969), Whaley (1960), and Whitney (1961) have reported on its biological, physical, and chemical characteristics.

This study is one of a series completed as part of an ecological study of the Conowingo Reservoir by Ichthyological Associates for the Philadelphia Company in reference to the Muddy Run Pumped Storage and the Peach Bottom Atomic Stations.

METHODS

Fish used for the feeding chronology study were taken at 3-hour intervals over a 24-hour period on 19-20 August 1966. They were captured between the mouth of Fishing Creek and Mt. Johnson Island in 10-minute hauls of a 16-foot semi-balloon trawl. Specimens for monthly food study were taken in 10-minute trawl hauls from several localities during July through November 1966. Preliminary examination of the stomachs collected from the several localities did not show any qualitative or quantitative differences and the data were combined to reveal monthly trends in feeding.

Fish were preserved in 10 per cent formalin and later transferred to 40 per cent isopropyl alcohol. All specimens taken in a single collection were used for food study. The stomach of each fish was removed and its contents examined and a note made on relative degree of digestion. The contents were identified and their frequency occurrence noted. Later they were sorted into major taxonomie groups and the damp weight (after blotting) was recorded for each. Blue-green algae could not be separated easily from the detritus (fine sand and mud) and their percentage by weight was visually estimated.

The quantitative data are given in two forms: percentage frequency of occurrence and percentage damp weight. The 183 young studied ranged from 35 to 83 mm fork length and the 798 subadults and adults were from 122 to 270 mm.

RESULTS AND DISCUSSION

Feeding chronology of subadults and adults — Bailey and Harrison (1945) stated that the channel catfish collected at dusk frequently had empty stomachs but those taken later in the night usually had eaten. They also reported that those taken later in the night usually had eaten. They also reported that those

seined in the forenoon usually contained food in early stage of digestion; whereas, those taken in the afternoon most often were empty or had food in an advanced stage of digestion. They did not give any quantitative data on these findings.

In the present study the feeding activity over a single 24-hour period was determined by the mean weight of stomach contents per fish. These data (Table 1) indicate that feeding started sometime around 0400 hours and continued throughout the daytime. However, the maximum feeding occurred between 1500-1800 hours. In general, the weight of the stomach contents was higher during the daylight hours than in the dark. The presence of freshly eaten organisms (although their actual percentages were not noted) in each 3-hour collection indicated that the channel catfish fed throughout the 24-hour period.

The relative importance by weight of major components in the stomachs of catfish differed during the 24-hour period (Figure 1). Zooplankton was most abundant in the diet at 1200 and 2100 hours when they formed 88 to 91 per cent of the total food. At other periods they contributed 8 to 37 per cent to the total food. Insects composed 1 to 28 per cent of the total food at various times of the day. Fishes comprised a significant portion of the diet only in the morning (0600-0900 hours) when they formed 55 to 57 per cent of the food. Detritus was taken in large quantities at 0400, 1500, and 1800 hours when it comprised 82, 56, and 42 per cent of the food respectively. The large amounts of detritus during the times of heavy feeding activity suggest a near bottom feeding habits. Algae formed only a negligible portion of the diet (1 to 5 per cent) throughout the 24-hour period.

The percentage frequency occurrence of several food items also differed during the 24-hour period (Table 2). *Daphnia* spp. occurred in 100 per cent of the stomachs at 1200, 1800, and 2100 hours and at other periods it appeared in 52 to 86 per cent of the stomachs. *Bosmina* sp. occurred in 2, 4, 23, and 4 per cent at 0600, 0900, 1800, and 2400 hours respectively. *Cyclops* spp. appeared in 26 to 100 per cent at various times of the day. *Leptodora* sp. was found in 100 per cent at 2100 hours and at other periods it occured in 7 to 74 per cent. *Latona* sp. occurred in 4 to 70 per cent except at 1500 and 2100 hours when it was not eaten. *Alona* spp. occurred in 4 to 21 per cent except at 1200 and 2100 hours when they were absent.

Among the insects, dipteran larvae and pupae occurred in 22 to 93 per cent of the stomachs at various times of the day (Table 2). Trichoptera larvae occurred only at midnight and appeared in 19 per cent. Most of the fish were eaten in the daylight hours but occurred in low frequencies. Algae were not found at 1200 and 2100 hours but occurred in 7 to 67 per cent at other periods.

The data in Table 2 also indicate that the diet of the channel catfish was most diverse at 0600, 1800, and 2400 hours when 13 to 16 kinds of forage organisms were recorded whereas at other periods only 5 to 11 species of food items were observed.

The differential consumption of many items at different hours is probably due to the fact that certain organisms are accessible only at certain hours. The shift in the diet over the 24-hour period demonstrated herein also emphasize the possible short-commings of basing general food studies on specimens collected at one time of day. Keast and Welsh (1968) reported similar findings for bluegill and pumpkinseed sunfishes in Lake Opinicon, Ontario. Ide (1942) noted that brook trout in Algonquin Park contained no *Simulium* in the morning prior to their emergence, but large numbers at the height of their emergence during the forenoon.

Food of subadults and adults by month — Ninety (11.3 per cent) of the 798 stomachs examined from July through November were empty. As the water temperatures decreased (from 82° F in July to 53° F in November) an increase in the percentage of empty stomachs was noted (Table 3). It suggests a lower level of feeding at lower temperatures. Bailey and Harrison (1945) reported that the catfish rarely feed in winter.

Zooplankton and detritus consisted of a large percentage by weight (Figure 2). Zooplankton comprised 91 per cent of the food in July and contributed 14 to 38 per cent of the total food in other months. Fishes contributed 3, 13, and 15 per cent in the diet in July, August, and October respectively; none were found in September and November. Detritus formed only 3 per cent of the contents in July and constituted 58 to 69 per cent of the contents in August through October. Algae were consumed in small quantities in August through October and comprised 4 to 7 per cent of the total food. Insects were not important in the diet and formed 2 to 7 per cent of the contents. Amphipods formed a significant portion (32 per cent) of the food only in November.

Detritus (fine sand and mud) is not an organic food material and if it is excluded from the food analysis the contribution of the other organic food items to the total food by weight in the various months become as follows: Zooplankton 36 to 93 per cent; fishes 35 to 38 per cent; insects 2 to 16 per cent; amphipods 44 per cent; and algae 4 to 18 per cent.

As measured by percentage frequency of occurrence among the zooplankters, *Daphnia* spp. were most important (Table 3). They appeared in 100, 82, 79, 50, and 78 per cent of the stomachs by months from July through November, respectively. *Leptodora* sp. the largest plankter consumed, occurred in 86, 41, and 47 per cent in July, August, and September, respectively. The near-bottom dwelling *Latona* sp. occurred in 39 and 8 per cent in August and October. *Bosmina* sp. was important food item only in October when it occurred in 32 per cent. *Cyclosp* spp. were the only important copepods eaten and appeared in 50, 52, 61, 37, and 22 per cent from July through November respectively. Other zooplankters which were rarely eaten included *Alona* spp., *Ceriodaphnia* sp., *Moina* sp., *Diaptomus* sp., and *Cypris* sp.

Of the insects the dipteran larvae and pupae were most important and occurred in 65, 34, and 35 per cent of the stomachs in August, September, and October, respectively (Table 3); in July and November they appeared in 5 and 14 per cent. Other insects which also appeared in a few stomachs included the larvae of Odonata, Trichoptera, and terrestrial Coleoptera, Homoptera, and Hymenoptera.

Amphipods *(Hyallela* sp) occurred in 1 and 16 per cent of the stomachs in October and November. The mollusc)*Sphaerium* sp.) and Acari were rarely eaten. Algae occurred frequently in the stomachs (24 to 49 per cent) in all the months except July when none were found. Detritus occurred frequently (50 to 73 per cent) in the stomachs in August through October.

Among the fishes, pumpkinseed, *Lepomis gibbosus,* and johnny darter, *Etheostoma olmstedi* were common. The spotfin shiner, *Notropis spilopterus,* and bluegill, *L. macrochirus* were also eaten occasionally. However, none of these species occurred in more than 3.1 per cent of the stomachs in any month (Table 3).

The results of this study indicate that the principal food of channel catfish in Conowingo Reservoir was zooplankton. Fishes were important in the diet in August and October only when the data on detritus (fine sand and mud) were excluded from the analysis. These findings are not in complete accord with the findings of Bailey and Harrison (1945), Forbes (1888), Hoopes (1960), Rice (1941), and Ware (1966). The results of these investigators indicate that insects, crustaceans (Isopoda, Amphipoda, and Decapoda), molluscs, and plant seed dominate the food of subadult and adult channel catfish. These differences are probably due to the differences in the food supplies of the bodies of water studied.

Food of Young — Zooplankton was the primary food and comprised 68 to 76 per cent of the total food by weight in August and September. Insects composed 25 per cent of the diet in August and 3 per cent in September while detritus formed 5 per cent in August and 18 per cent in September. Bailey and Harrison (1945) found that young had fed exclusively on insects in Des Moines

River, Iowa. Shira (1917) found midge larvae and mayfly nymphs to be important in the diet of young reared in ponds at Fairport, Iowa. Boesel (1938) reported that midge larvae and pupae and mayflies made up 53 per cent of the food of young in Lake Erie and crustaceans (mainly cladocerans) constituted 33 per cent of the diet.

Among the food items as measured by percentage frequency of occurrence, the zooplankter, *Daphnia* spp. were most important and appeared in 97 and 84 per cent of the stomachs in August and September. *Latona* sp., *Alona* spp., *Leptodora* sp., and *Diaphanosoma* sp., were important in the diet in August and occurred in 98, 78, 24, and 24 per cent respectively. There plankters were less important in September. *Bosmina* sp. was important in the diet in September and occurred in 47 per cent of the stomachs. *Cyclops* spp were important in both months and occurred in 39 and 49 per cent. Other plankters which were rarely eaten included *Ceriodaphnia* sp., *Diaptomus* sp., and *Cypris* sp.

Most of the insects consumed were midge larvae and pupae. They appeared in 84 and 55 per cent of the stomachs in August and September. Algae occurred in 24 per cent of the stomachs in each month and comprised less than 3 per cent of total food by weight. Little plant material was found in the diet of Des Moines River catfish by Bailey and Harrison (1945), but McCormack (1940) reported that filamentous algae comprised 28 per cent by volume in Reelfoot Lake, Tennessee. Menzel (1945) found that during August they fed principally on filamentous algae in the Chickahominy River, Virginia. Dill (1944) found the plants of importance in the diet in West Main Ditch, California.

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Table 1. Feeding periodicity in subadult and adult channel catfish based on mean weight of stomach contents per fish during a 24-hour period on 19-20 August 1966 in Conowingo Reservoir.

Time	Number of Fish	Number of Empty Stomachs	Mean Weight of Stomach Contents per Fish (gram)
0600	58	9	0.072
0900	30	3	0.081
1200	3	1	0.080
1500	10	3	0.298
1800	40	1	0.485
2100	3	0	0.007
2400	28	1	0.037
0400	34	6	0.018

Table 2. —Percentage frequency of occurrence of food items in the diet of sub-adult and adult channel catfish during a 24-hour period on 19-20 August 1966 in Conowingo Reservoir.

Time	0400	0600	0900	1200	1500	1800	2100	2400
Food Item								
Cladocera								
Daphnia	82.1	79.6	51.9	100.0	85.7	100.0	100.0	85.2
Bosmina	-	2.0	3.7	-	-	23.1	-	3.7
Leptodora	60.7	36.7	7.4	50.0	28.6	30.8	100.0	74.1
Alona	21.4	16.3	3.7	-	14.3	5.1	-	18.5
Latona	53.6	22.4	3.7	50.0	-	64.1	-	70.4
Diaphanosoma	3.6	6.1	-	-	-	5.1	-	18.5
Ceriodaphnia	-	-	-	-	-	7.7	-	3.7
Copepoda								
Cyclops	53.6	40.8	44.4	100.0	85.7	79.9	66.6	25.9
Diaptomus	-	-	-	-	-	2.6	-	-
Ostracoda								
Cypris	-	-	-	-	-	-	-	3.7
Insecta								
Diptera	92.9	79.6	22.2	50.0	57.1	46.2	33.3	88.9
Coleoptera	3.6	6.1	3.7	-	-	-	-	-
Trichoptera	-	-	-	-	-	-	-	18.5
Hymenoptera	-	4.1	-	-	-	-	-	-
Unidentified	-	2.0	-	-	-	5.1	-	3.7
Mollusca								
Sphaerium	-	-	-	-	-	5.1	-	-
Pisces								
Notropis spilopterus	-	2.0	-	-	-	-	-	-
Lepomis gibbosus	-	2.0	7.4	-	7.3	-	-	-
L. macrochirus	-	2.0	3.7	-	7.3	-	-	3.7
Etheostoma olmstedi	-	2.0	-	-	-	-	-	-
Detritus	82.1	67.3	55.6	50.0	57.1	87.2	-	81.5
Algae								
Oscillatoria	7.1	22.4	7.4	-	28.6	66.7	-	3.7

Table 3. —Percentage frequency of occurrence of food items in the diet of sub-adult and adult channel catfish collected from Conowingo Reservoir in July-November, 1966.

Date	19	19-20	10	13	9,17
Month	July	August	September	October	November
No. of stomachs examined	260	206	174	94	64
No. of empty stomachs	0	24	19	20	27
Food Item					
Cladocera					
Daphnia	100.0	81.9	78.7	50.0	78.4
Bosmina	0.4	6.6	2.6	32.4	5.4
Leptodora	85.8	41.2	46.5	-	-
Alona	-	12.6	-	-	-
Latona	-	39.0	-	8.1	-
Ceriodaphnia	2.3	2.2	5.2	-	-
Diaphanosoma	88.5	6.6	41.3	-	-
Moina	1.2	-	-	-	-
Copepoda					
Cyclops	50.0	52.2	60.6	36.5	21.6
Ciaptomus	0.4	0.5	-	-	-
Ostracoda					
Cypris	-	0.5	2.6	-	-
Insecta					
Diptera	5.0	65.4	34.2	35.1	13.5
Coleoptera	0.8	2.7	-	9.5	-
Trichoptera	-	2.7	-	-	-
Odonata	0.4	-	-	-	-
Homoptera	0.8	-	1.3	-	-
Hymenoptera	2.7	1.1	-	4.1	-
Unidentified	0.8	2.2	3.2	31.1	8.1
Acari	-	-	0.6	-	-
Mollusca					
Sphaerium	-	1.1	0.6	-	-
Amphipoda					
Hyallela	-	-	-	1.4	16.2
Pisces					
Notropis spiloterus	-	0.5	-	-	-
Lepomis gibbosus	3.1	2.2	-	1.4	-
L. macrochirus	-	2.2	-	-	-
Etheostoma olmstedi	-	0.5	-	1.4	-
Detritus	11.9	72.5	50.3	64.9	-
Algae					
Oscillatoria	-	24.2	43.9	48.6	32.4

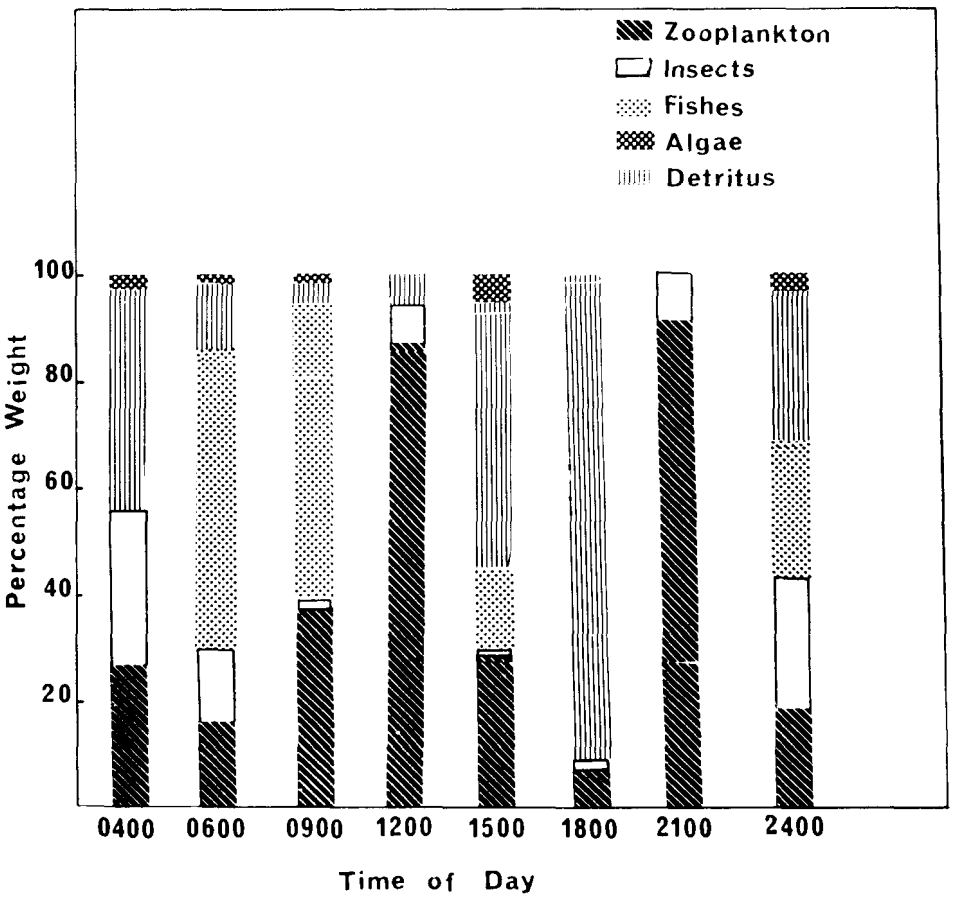

FIGURE 1. Percentage by weight of major food groups in stomachs of sub-adult and adult channel catfish collected in Conowingo Reservoir during a 24-hour period on 19-20 August 1966.

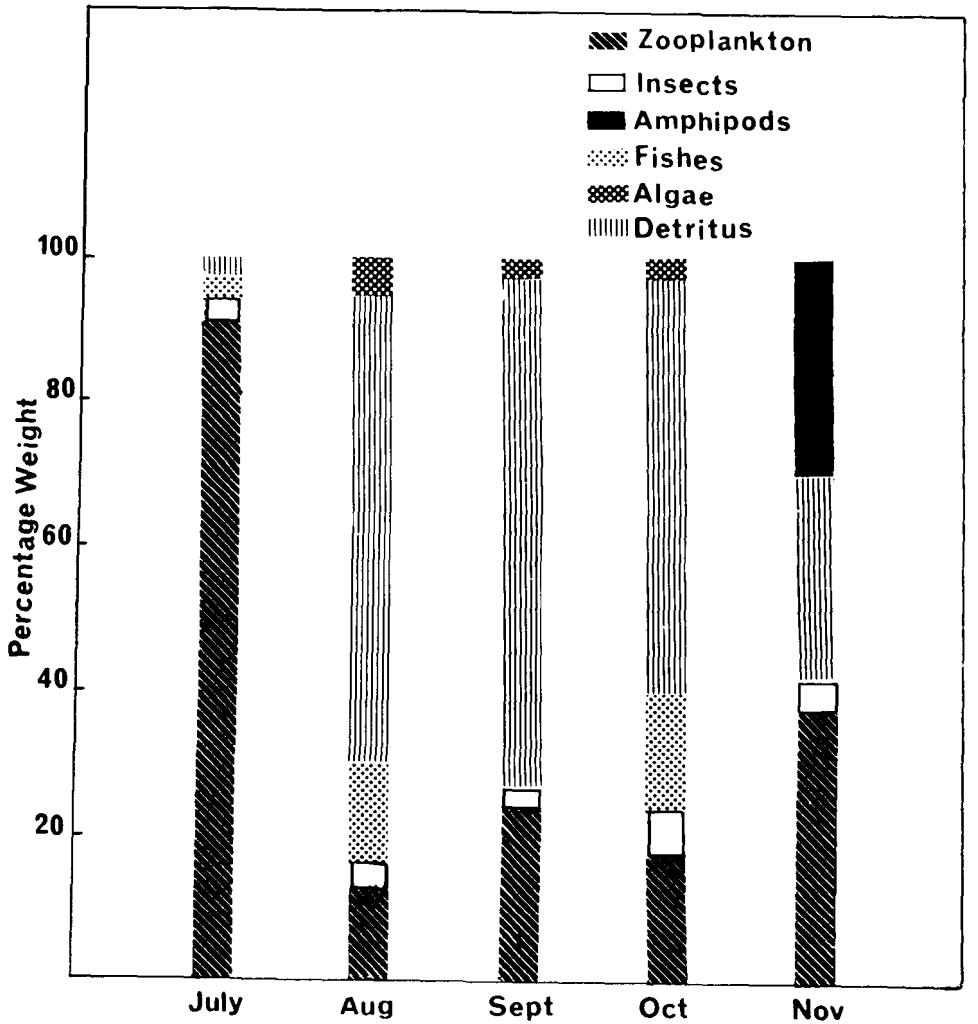

FIGURE 2. Percentage by weight of major food groups in stomachs of subadult and adult channel catfish collected in Conowingo Reservoir from July-November 1966.