Pre-Impoundment Studies of the Summer Food Of Three Species of Fishes in Tenkiller And Fort Gibson Reservoirs, Oklahoma[1]

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Little attention has been given to the food of fishes in Oklahoma prior to the pre-impoundment surveys of Tenkiller and Fort Gibson Reservoirs in the summer of 1952. During these surveys studies were made of the food of carnivorous game and food fish, namely: channel catfish, flathead catfish, spotted black bass, white crappie, black crappie, and freshwater drum.[2]

The Illinois River, on which Tenkiller Reservoir is located, has a rubble bottom and rocky riffles which are suitable for high food production. On these riffles, during the summer of 1952, the number of organisms ranged from 100 to 500 per square foot, well above the value given by Lagler (8) for exceptionally productive streams in Michigan. However, organisms in this Oklahoma stream may have been more concentrated than usual during the summer because the water was so low. Moore and Paden (11) stated that, "The Illinois River is probably one of the richest rivers in the United States in regard to the number of fish species," and they pointed out that along the 125 mile course of this river they have found ninety-two species of fishes. The Grand River, on which Fort Gibson Reservoir is located, is some twenty miles to the west of the Illinois, and its properties are between those of the Illinois and the prairie streams to the west. Typical prairie streams of the southwest have low production since flash floods leave a scarcity of brush piles, fallen logs and overhanging trees, and a bottom of shifting sand. Extensive studies on food and feeding relationships have been made in other states on channel catfish (2), drum (4), white crappie (9), and on several species of fish including the above mentioned ones in impounded waters (5, 10, 12).

Materials and Methods

In Tenkiller Reservoir, fish were caught in three nylon nets with six different square mesh sizes ranging from 3/4 to 2 inches, and in two linen nets having 2- and 2½-inch mesh. Stations were scattered along the main river channel for two to three miles upstream from the dam. During the period of study, the water was continually rising at the rate of four inches a day and had risen some ten to fifteen feet by the time the study was terminated.

When the study began, the gates of the Fort Gibson Reservoir had been closed approximately a year and the water had risen about forty-five feet and was being held at this level until the completion of the work on the power plant located on the dam. Rotenone was used to collect the fish. This is not the best method when food studies are to be made, since larger fish have been observed swimming around and feeding upon the already helpless smaller fish. This, of course, results in unnaturally high occurrences of these small fish in the stomachs of the large fish. However, it was believed that the method of capture should have little effect on the consumption of invertebrate items of food.

Total-lengths were taken for all fish, and each stomach was removed and preserved in 10 per cent formalin. The contents were examined under a widefield dissecting microscope and recorded for each fish. The data were analyzed according to the number of stomachs containing each item.

[1] A contribution of the Oklahoma Fisheries Research Laboratory, a cooperative unit of the Oklahoma Game and Fish Department and the University of Oklahoma Biological Survey.

[2] Common names used throughout this paper follow the standardized list of fish names of the American Fisheries Society (1).

This method was adopted when it was found that digestion occurring in the stomachs of fish caught in gill nets had rendered many of the invertebrate items unsuitable for accurate volume analyses. The high summer temperature of the water in these Oklahoma reservoirs had its effect on the rate of digestion despite the fact that gill nets were lifted each morning.

Food of the Channel Catfish

Channel catfish in Tenkiller Reservoir were feeding exclusively on invertebrates during the month of July as revealed by stomach examina-

TABLE I

Food of the Channel Catfish in Fort Gibson and Tenkiller Reservoirs, Summer 1952. The Total Number of Stomachs Containing Each Item is Given.

Channel Catfish	Fort Gibson		Tenkiller	
Total number stomachs with food	85	——	52	——
Total number stomachs containing fish	57	(67.0)*	0	0
Total number stomachs containing invertebrates	66	(77.6)	52	(100.0)
Total number stomachs containing:				
Arthropoda	64	(96.9)	52	(100.0)
Insecta	63	(95.4)	52	(100.0)
Ephemerida	8	(12.1)	40	(78.4)
Hexagenia	7	(10.6)	40	(78.4)
Stenonema	1	(1.5)	—	——
Diptera	41	(62.1)	25	(49.0)
Tendipedidae (Chironomidae)	41	(62.1)	24	(47.1)
Chaoborus	—	——	1	(1.9)
Hemiptera	19	(28.8)	3	(5.9)
Corixidae	18	(27.3)	1	(1.9)
Belostomatidae	—	——	1	(1.9)
Odonata	—	——	4	(7.8)
Dragonfly	—	——	4	(7.8)
Neuroptera	—	——	1	(1.9)
Helgrammite (Dobson fly naiads)	—	——	1	(1.9)
Trichoptera	5	(7.6)	—	——
Coleoptera	6	(9.1)	12	(23.5)
Orthoptera	2	(3.0)	3	(5.9)
Grasshopper	2	(3.0)	3	(5.9)
Unid. insect remains	16	(24.2)	19	(37.3)
Crustacea	8	(12.1)	1	(1.9)
Entomostraca	6	(9.1)	—	——
Cladocera	5	(7.6)	—	——
Bosmina	3	(4.5)	—	——
Daphnia	2	(3.0)	—	——
Ostracoda	1	(1.5)	—	——
Copepoda	3	(4.5)	—	——
Diaptomus	2	(3.0)	—	——
Malacostraca	2	(3.0)	—	——
Decapoda	2	(3.0)	1	(1.9)
Arachnida (spider)	5	(7.6)	1	(1.9)
Myriopoda	—	——	1	(1.9)
Nematomorpha	—	——	1	(1.9)
Gordiaceae	—	——	1	(1.9)
Annelida (*Lumbricus*)	—	——	1	(1.9)
Rotifera	2	(7.6)	—	——
Algae other than diatoms	6	(9.1)	—	——
Diatoms	1	(1.5)	—	——
Other plant material	5	(7.6)	—	——

* percentages of totals in parentheses

tions of 52 fish ranging in length from 7 to 21 inches (Table I). Fish were not found in any of the stomachs examined.

The invertebrates utilized most frequently as food were the burrowing mayfly (*Hexagenia*) and midge larvae (Tendipedidae). These were present in 78.4 per cent and 47.1 per cent of the stomachs containing invertebrates, respectively. The items of lesser importance constituted mostly miscellaneous beetles (23.5 per cent) in addition to other terrestrial forms such as grasshoppers, spiders, myriapods, and earthworms which were available to the catfish as victims of recent innundation. Including dragonflies (7.8 per cent), water boatmen (1.9 per cent), giant water beetles (1.9 per cent), and helgrammites (immature Dobson flies) (1.9 per cent), seven orders of insects were represented in the food of the channel catfish. Unidentifiable insect remains were present in 37.3 per cent of the stomachs. A single crayfish was the only crustacean found.

Channel catfish in Fort Gibson Reservoir were feeding on both invertebrates and fish during the latter part of June as revealed by stomach examinations of 85 fish ranging from 3 to 15 inches in length. While 77.6 per cent of the stomachs contained invertebrates in comparison with the 67.5 per cent in which fish were found, such data cannot be interpreted as evidence that fish constituted a major part of the diet of catfish during the summer since the larger fish might easily have consumed many small helpless fish in waters treated with rotenone. For this reason, the fish items of food are not mentioned and the invertebrate items are evaluated on the basis of the total number of stomachs containing them.

The entire invertebrate diet included arthropods in 96.9 per cent of the stomachs, insects in 95.4 per cent and crustaceans in 12.1 per cent of the stomachs. The non-arthropodan minor portion of the food consisted of rotifers, algae, and miscellaneous other plant material.

Bottom-dwelling immature forms of midges (Tendipedidae) and burrowing mayflies (*Hexagenia*) and adult water boatmen (Corixidae) were major components in the diet. The three most important orders of insects found in the stomachs were: Diptera (48.2 per cent), Hemiptera (22.3 per cent) and Ephermerida (9.4 per cent).

Entomostraca (7.0 per cent) and crayfish (2.4 per cent) constituted the lesser important crustaceans in the diet. The entomostracans, *Bosmina*, *Daphnia*, *Diaptomus*, and Ostracoda, found in stomachs of Fort Gibson catfish were missing in the diet of the Tenkiller fish probably because the latter were larger.

In the two reservoirs, insects were the important part of the diet. While midges and mayflies were frequently found in the stomachs of fish from both impoundments, the relative importance of each food type differed. The burrowing mayfly was found much more frequently than midges in the diet of Tenkiller catfish while the reverse relationship was found in the Fort Gibson catfish.

Water boatmen occurred more frequently than the burrowing mayfly in the stomachs of the Fort Gibson catfish but volume analyses would have enhanced the position of the burrowing mayflies. Terrestrial forms appeared in the diet of catfish from both bodies of water and appeared to have been made available through recent inundation but nevertheless could have fallen into the surface of the water near the bank. Crustaceans with one exception were present only in the stomachs of small catfish from four to six inches long in Fort Gibson Reservoir. This constituted the main qualitative difference among the various length groups. Buck and Cross (3) reported channel catfish in Canton Reservoir, Oklahoma, feeding on crappie, shad, crayfish, insects, and plant material. Bailey and Harrison (2) stated that the channel catfish is omnivorous and that insects and fish serve as staple foods.

Food of the White Crappie

In Tenkiller Reservoir, white crappie were feeding mainly on invertebrates (100 per cent) and to a lesser extent on fish (18 per cent) during the summer of 1952, as revealed by stomach examinations of 50 fish ranging in length from 4 to 12 inches and caught in gill net (Table II).

TABLE II

Food of the White Crappie in Fort Gibson and Tenkiller Reservoirs, Summer 1952. The Total Number of Stomachs Containing Each Item is Given.

White Crappie	Fort Gibson		Tenkiller	
Total number stomachs with food	29	.....	50	.....
Total number stomachs containing fish	23	(79.0)*	9	(18.0)
Total number stomachs containing invertebrates	24	(82.7)	50	(100.0)
Number of stomachs containing:				
Arthropoda	24	(100.0)	50	(100.0)
Insecta	21	(87.5)	50	(100.0)
Ephemerida	6	(25.0)	34	(68.0)
Hexagenia	5	(20.8)	34	(68.0)
Stenonema	1	(4.2)	1	(2.0)
Diptera	14	(58.3)	35	(70.0)
Chironomidae	10	(41.6)	29	(58.0)
Chaoborus	11	(45.8)	15	(30.0)
Hemiptera	6	(25.0)	18	(36.0)
Corixidae	6	(25.0)	18	(36.0)
Odonata	—	——	1	(2.0)
Aeschnidae	—	——	1	——
Trichoptera	2	(8.3)	—	——
Coleoptera	—	——	2	(4.0)
Unid. insect remains	7	(29.2)	—	——
Crustacea	13	(54.2)	—	——
Entomostraca	13	(54.2)	—	——
Cladocera	10	(41.6)	—	——
Daphnia	8	(33.3)	—	——
Diaphanosoma	2	(8.3)	—	——
Copepoda	6	(25.0)	—	——
Diaptomus	1	(4.2)	—	——
Cyclops	6	(25.0)	—	——
Nematomorpha	—	——	15	(30.0)
Gordiaceae	—	——	15	(30.0)
Algae and miscellaneous other plant material	1	(4.2)	—	——

* percentages of totals in parentheses

The invertebrate items of food with exception of horse hair worms (Gordiaceae) constituted in their entirety five orders of insects of which the true flies (Diptera) ,the mayflies (Emphemerida), and the true bugs (Hemiptera) were the most important, being found in 68.0, 70.0 and 86.0 per cent of all stomachs containing food. The burrowing mayfly was the only ephemeridan present but the dipteran forms were composed of larval

midges (58.0 per cent) and phantom midges, *Chaoborus* (30.0 per cent). Beetles (2.0 per cent) and dragonflies (2.0 per cent) were items of incidental occurrence in the summer food of white crappie in Tenkiller Reservoir.

In Fort Gibson Reservoir, stomach examinations of 29 white crappie ranging from 3 to 10 inches and collected by use of rotenone, revealed that 87.0 per cent of the stomachs contained invertebrate items of food while in 79.0 per cent of the stomachs fish were found. As in the case of the catfish, these figures do not necessarily mean that the white crappie were utilizing fish as food to this extent during the summer.

The invertebrate diet of white crappie included both insects (87.5 per cent) and crustaceans (54.2 per cent). Of the four orders of insects in the stomach contents, true flies (Diptera), mayflies (Ephemerida), and true bugs (Hemiptera) were considered important in the summer food of the white crappie since they appeared respectively in 58.3, 25.0 and 25.0 per cent of the stomachs.

As in the food of the Tenkiller crappie, both dipterans, *Chaoborus* (45.8 per cent) and midges (41.6 per cent) were about equally frequent in the diet. The burrowing mayflies (25.0 per cent) and the water boatmen (20.8 per cent) took precedence in the stomach contents in the white crappie over such items of incidental occurrence as caddis flies (8.3 per cent) and *Stenonema* (4.2 per cent). Unidentifiable remains of insects were found in 29.0 per cent of the stomachs.

The crustacean portion of the diet consisted entirely of Entomostraca, cladocerans being present in 41.6 per cent and copepods in 25.0 per cent of the stomachs. *Daphnia* (33.3 per cent) was more frequently a part of the diet than was *Diaphanosoma* (8.3 per cent). The copepodan food items consisted of *Cyclops* (25.0 per cent) and *Diaptomus* (4.2 per cent). Plant material was present in 4.2 per cent of the stomachs.

A comparison of the summer food of the white crappie in both impoundments revealed trends similar to those evident from a comparison of the catfish in the two reservoirs. Invertebrates were the main type of food; the burrowing mayfly was more frequent in the stomachs of Tenkiller specimens than in those from Fort Gibson; and entomostraca were present in the Fort Gibson specimens only. Different trends from such a comparison were: midges were as important as mayflies in Tenkiller; *Chaoborus* was as frequent an item in the diet of Tenkiller specimens as in the Fort Gibson ones; corixids were a fairly important part of the food in both reservoirs; stomachs of Tenkiller specimens contained fish; terrestrial forms were not evident in the stomachs of fish from either reservoir.

In Canton Reservoir, Oklahoma, Buck and Cross(3) made cursory field examinations of 409 stomach contents of white crappie and found that this species relied heavily upon fish since only four stomachs of the 150 with food contained invertebrates. Hall (7) examined the stomachs of 7 white crappie taken from Wister Reservoir, Oklahoma, and reported all stomachs contained fish; one stomach, however, had several chironomids, a *Chaoborus* pupa, and a cicadellid. Lagler and Ricker (9) examined 155 white crappie stomachs and found that the species fed heavily upon fishes as well as upon insects.

Food of the Drum

In Fort Gibson Reservoir, examination of the stomach contents from 95 drum ranging in length from 4 to 11 inches and collected by the use of rotenone revealed that 71.6 per cent of the stomachs contained invertebrates while in 62.1 per cent fish were found, (Table III). As in the case of the catfish and white crappie, these figures do not necessarily mean that the drum were utilizing fish as food to this extent.

TABLE III

Food of the Drum in Fort Gibson and Tenkiller Reservoirs, Summer 1952. The Total Number of Stomachs Containing Each Item is Given.

Drum	Fort Gibson		Tenkiller	
Total number stomachs with food	95	——	13	——
Total number stomachs containing fish	59	(62.1)*	2	(15.4)
Total number stomachs containing invertebrates	58	(71.6)	13	(100.0)
Total number stomachs containing:				
Arthropoda	68	(100.0)	13	(100.0)
Insecta	66	(97.0)	12	(92.3)
Diptera	45	(66.2)	1	(7.7)
Chironomidae	40	(58.8)	—	——
Chaoborus	12	(17.6)	1	(7.7)
Ephemerida	29	(42.6)	12	(92.3)
Hexagenia	26	(38.2)	12	(92.3)
Stenomena	4	(5.9)	—	——
Hemiptera	8	(11.8)	—	——
Corixidae	8	(11.8)	—	——
Trichoptera	7	(10.3)	—	——
Odonata	—	——	1	(7.7)
Aeschnidae	—	——	1	(7.7)
Libellulidae	—	——	1	(7.7)
Coleoptera	1	(1.5)	—	——
Unid. Insect Remains	8	(11.8)	—	——
Crustacea	4	(5.9)	2	(15.4)
Entomostraca	2	(2.9)	1	(7.7)
Copepoda	2	(2.9)	—	——
Cyclops	1	(1.5)	—	——
Diaptomus	1	(1.5)	—	——
Cladocera	—	——	1	(7.7)
Malacostraca	2	(2.9)	1	(7.7)
Decapoda	1	(1.5)	1	(7.7)
Isopoda	1	(1.5)	—	——
Algae and miscellaneous other plant material	2	(2.9)	—	——

* percentages of totals in parentheses

All drum examined had fed on arthropods and 97.0 per cent of the stomachs contained insects while 5.9 per cent crustaceans. Dipteran forms (66.2 per cent) occurred most frequently, followed by mayflies (42.6 per cent), then by bugs (11.8 per cent), caddis flies (10.3 per cent), and beetles (1.5 per cent). Unidentifiable remains of insects were found in 11.8 per cent of the stomachs. Midges (58.8 per cent) and burrowing mayflies (38.2 per cent) were most frequently a part of the diet while other insect items of lesser frequency were: *Chaoborus* (17.6 per cent), corixids (11.8 per cent) and *Stenonema* (5.9 per cent), caddis flies (10.3 per cent), and beetles (1.5 per cent).

Crustacean components (5.9 per cent) of minor importance were: Entomostraca (1.5 per cent) consisting of *Diaptomus* (1.5 per cent) and *Cyclops* (1.5 per cent), and Malacostraca (2.9 per cent) consisting of crayfish (1.5 per cent) and aquatic sowbugs (2.9 per cent). Algae and other plant material were found in 2.9 per cent of the stomachs.

If volume analyses had been undertaken, it appears that the burrowing mayfly would have been the dominant item of food. This form was considerably larger than the midges and generally it occurred in the stomachs in large numbers. This was especially true in the case of the drum examined from Tenkiller Reservoir.

Thirteen drum secured by gill nets in Tenkiller Reservoir were large, ranging in length from 14 to 17 inches and the examination of their stomach contents revealed that 100 per cent of the stomachs contained invertebrates while only 15.4 per cent contained fish. Burrowing mayflies occurred in 92.3 per cent of the stomachs while a single occurrence of *Chaoborus*, dragonflies, cladocerans, and crayfish were found.

A comparison of the summer food of the drum in both impoundments revealed trends similar to those obtained from food studies of the catfish and of the white crappie in the two reservoirs in that invertebrates were the main type of food, mayflies were more frequent in the stomachs of Tenkiller specimens than in those from Fort Gibson, and caddis flies were found only in stomachs of fish from Fort Gibson. Trends similar to those of the white crappie but not to those of the catfish in the two bodies of water were: stomachs of the Tenkiller specimens contained fish; terrestrial forms were not evident in specimens from either reservoir. Trends similar to those of the catfish but not to those of the white crappie were: midges were import food items in the diets of fish from Fort Gibson but not in those from Tenkiller; *Chaoborus* frequented the diet of fish from Fort Gibson but not those from Tenkiller; corixids were found only in the stomach contents of the Fort Gibson specimens.

The drum is an omnivorous fish but is reported to feed extensively on aquatic insects and Crustacea in Lake Erie (4) and in Norris Reservoir (5). The extent that small drum utilize Crustacea (Entomostraca) has been indicated by Ewers (6) and thus larger drum as were analyzed for this present report might be expected to depend more on the larger invertebrates that are available, such as the burrowing mayfly.

Food of Spotted Bass, Black Crappie, and Flathead Catfish

During the course of the study, stomach examinations of spotted bass, black crappie, and flathead catfish were made.

Stomach examinations of nine spotted bass, ranging in length from 6.1 to 12 inches, captured by the use of gill nets in Tenkiller Reservoir, revealed that only one stomach had fish remains and that invertebrate items were found in nine stomachs. Of the invertebrate items, seven contained insect remains, two contained crustacean remains, and one contained a horsehair worm. Of the insect items, four stomachs contained *Hexagenia*, the burrowing mayfly, one stomach contained midges, one stomach contained a dragonfly, one stomach contained a water boatmen and one stomach contained unidentifiable insect remains. Two records of crayfish were the only crustaceans found.

Examination of nineteen stomachs of black crappie, ranging in size from 5.1 to 7 inches and collected by the use of rotenone in Fort Gibson Reservoir, revealed that nine stomachs contained fish while twelve contained invertebrates. Of the invertebrate items, eleven stomachs contained insects, and seven contained crustaceans. Of the insect items, seven contained midges, two contained caddis flies, and two contained beetles. Of the crustacean items, seven contained a water flea, *Diaphanosoma*, and two contained a copepod, *Diaptomus*. Of the fish items, two contained bass, one contained small mouth buffalo, one contained a cyprinid, one contained a log perch, one contained a gizzard shad, one contained an unidentified darter, and seven contained unidentified fish.

Stomach examinations of six flathead catfish, ranging in size from 10.1 to 22 inches revealed that the three flatheads taken by the use of rotenone in Fort Gibson contained only unidentifiable fish remains, while the three taken by gill nets in Tenkiller revealed only an insect diet, namely midges and the burrowing mayfly.

LITERATURE CITED

1. AMERICAN FISHERIES SOCIETY. 1948. A list of common and scientific names of the better known fishes of the United States and Canada. Trans. Am. Fisheries Soc. 75(1945):357-397.
2. BAILEY, REEVE M. AND HARRY M. HARRISON, JR. 1948. Food habits of the southern channel catfish (*Ictalurus lacustris punctatus*) in the Des Moines River, Iowa. Trans. Am. Fisheries Soc. 75(1945):110-138.
3. BUCK, HOMER, AND FRANK CROSS. 1951. Early limnological and fish population conditions of Canton Reservoir and Oklahoma fishery management recommendations. A report to the Oklahoma Fish and Game Council. Research Foundation, Oklahoma A. & M. College, Stillwater.
4. DAIBER, FRANKLIN C. 1952. The food and feeding relationships of the freshwater drum, *Aplodinotus grunniens* Rafinesque in western Lake Erie. Ohio J. Sci. 52(*1*):35-44.
5. DENDY, JACK S. 1946. Food of several species of fish, Norris Reservoir, Tennessee. J. Tennessee Acad. Sci. 21(*1*):105-127.
6. EWERS, LELA A. 1934. Summary report of Crustacea used as food by the fishes of the western end of Lake Erie. Trans. Am. Fisheries Soc. 63(1933):379-390.
7. HALL, GORDON EARL. 1950. A pre-impoundment biological fishery survey of Wister Reservoir, Oklahoma. Unpublished master's thesis, University of Oklahoma.
8. LAGLER, KARL F. 1952. Freshwater fishery biology. Dubuque, Iowa: William C. Brown & Co.
9. LAGLER, KARL F., AND W. E. RICKER. 1942. Biological fisheries investigations of Foots Pond, Gibson County, Indiana. Invest. Indiana Lake and Streams 2(*3*)-47-72.
10. MCCORMICK, E. M. 1940. A study of the food of some Reelfoot Lake fishes. Rep. Reelfoot Lake Biol. Sta. 4:64-75.
11. MOORE, GEORGE A., AND JOHN M. PADEN. 1950. The fishes of the Illinois River in Oklahoma and Arkansas. Am. Midland Naturalist 44(*1*): 76-95.
12. RICE, LUCILLE A. 1942. The food of seventeen Reelfoot Lake fishes in 1941. Rep. Reelfoot Lake Bio. Sta. 6:4-13.