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WINTER FEEDING HABITS OF BLUEGILLS AND PERCH IN CEDAR LAKE, WASHTENAW COUNTY, MICHIGAN

by

James W. Moffett and Burton P. Hunt

The winter feeding habits of warm-water fishes are not very well known. Some studies have been made during other seasons of the year but their scope did not cover winter feeding habits. It is the purpose of this report to present data secured during a study of bluegill and perch winter feeding habits as they were found in Cedar Lake, Washtenaw County, Michigan. Pumpkinseed sunfish, black crappie and largemouth bass were also taken during this investigation but were so rare in the catches that they are not considered in this report.

All fish were taken by hook and line. They were allowed to freeze on the ice until each day's collecting was completed. They were then weighed and measured. Scale samples were taken from some. Stomachs removed from these fish were identified by a number which was written on good quality museum label paper and inserted into the stomach. The same number was recorded opposite the length and weight of that fish from which the stomach was removed. This method proved very satisfactory. It was rapid and convenient. Not one of the inserted labels was lost from any stomach.

Fish collections were made by various members of the Institute for Fisheries Research staff as well as by the senior author and his wife. To these hardy individuals goes grateful thanks. Mr. Burton P. Hunt assisted materially in the laboratory, sorting, measuring and counting organisms recovered from the stomachs.

General Features of Cedar Lake

Cedar Lake is a body of water 73 acres in extent. It lies in the Waterloo Recreational Area in Section 9 of T. 1 S., R. 3 E., of Washtenaw County. Its basin is regular, being shallow in the east portion and sloping gradually on all sides to a simple depression 27 feet deep. This depression is in the west third of the lake. Most of the lake is about 12 feet deep. No inlets or outlets are present on Cedar Lake. All waters are supplied to the lake by seepage and surface run-off which is very

limited. This lake is connected by a narrow channel to Little Cedar Lake which occupies the northwest portion of a continuous basin.

Bottom materials are predominately pulpy peat. Some marl and fibrous peat occur sparingly around the shoals. The contributing drainage around the lake is small and the soil comprising it is poor in quality.

Cedar Lake water is colorless and quite clear. A Secchi disc disappears from view at a depth of 10 feet. During summer, a thermocline occurs in the lake. In early June, 1941, it was present from a water depth of 12.5 feet to the lake bottom. Oxygen is probably depleted in the deeper portion of the lake by midsummer but in early June 3.2 parts per million were found near the bottom. Chemical conditions in Cedar Lake during winter were not investigated. It is quite probable that oxygen in water near the bottom becomes depleted in late winter, especially when that season is severe. Water in this lake is highly alkaline. Its pH ranges between 7.4 and 8.6. The water is moderately hard, containing 112-130 parts per million of Methyl Orange Alkalinity.

Biologically, Cedar Lake is considered fairly productive. Many extensive weed beds around the shoals produce large quantities of invertebrate fish food and offer considerable shelter for young fish. Bottom food samples taken in the winter (March 1, 1941) were quite rich. Mayfly nymphs, freshwater shrimps, dragonfly and damselfly nymphs were abundant, especially in the plant zone. Snails (Helisoma and Gyraulus) and fingernail clams (Sphaeriidae) were common in the same area. Midge larvae and aquatic earthworms were relatively abundant in the bottom material in this zone and to water depths of 12-15 feet. In the deepest portion of Cedar Lake very few bottom organisms were found despite repeated sampling. It was noted that most of the insects and snails consumed by the fish were the same kinds which inhabited beds of recumbent vegetation.

Cedar Lake yields fish to the angler in goodly numbers. Bluegills, perch, pumpkinseed sunfish, largemouth bass, black crappie, green sunfish, mud pickerel, and yellow bullheads are most often taken. During a creel census study of summer fishing in the Waterloo area, Cedar Lake showed the highest catch per hour of all lakes included in the area studied.

Winter fishing in this lake was quite exceptional. Good catches were made on practically all collection dates. Usually, the best fishing time was between the hours of 4:00 and 6:00 P.M. The total catch for the winter season was 1,428 fish. The catch was composed of 1,064 bluegills, 211 perch, 94 pumpkinseed sunfish, 52 black crappie and 7 largemouth bass. Approximately 313 hours of fishing effort were expended by the contributors to this study. The catch rate, based on this number of hours, was 4.56 fish per hour. This catch rate is not confined to legal-sized fish. All sizes were kept for stomach analysis. Approximately 70 per cent of the fish taken were legal-size or over.

Winter Conditions During the Study

The winter of 1940-41 was comparatively mild in Michigan. Ice did not cover Cedar Lake until late December and then only for a few days. A subsequent warm spell opened the lake and it didn't freeze over permanently

until January 5-10, 1941. The ice cover became about 10 inches thick during the course of the winter. It was clear and of good quality early in the season but successive thaws and freezes covered the original layer with about 4-5 inches of clouded ice. Snowfall was light as is shown in Figure 1. A continuous snow cover was present only during the last half of February. On Cedar Lake this snow was, for the most part, drifted into patches by the wind. Meteorological conditions as recorded by the senior author on each collection date are given in Table 1. Additional weather data, snow cover records and barometric pressures are shown in Figure 1. The additional weather data were secured from the records of the University of Michigan weather station at Ann Arbor. Snow records, in part, were supplied by Mr. John Greenbank.

Figure 1

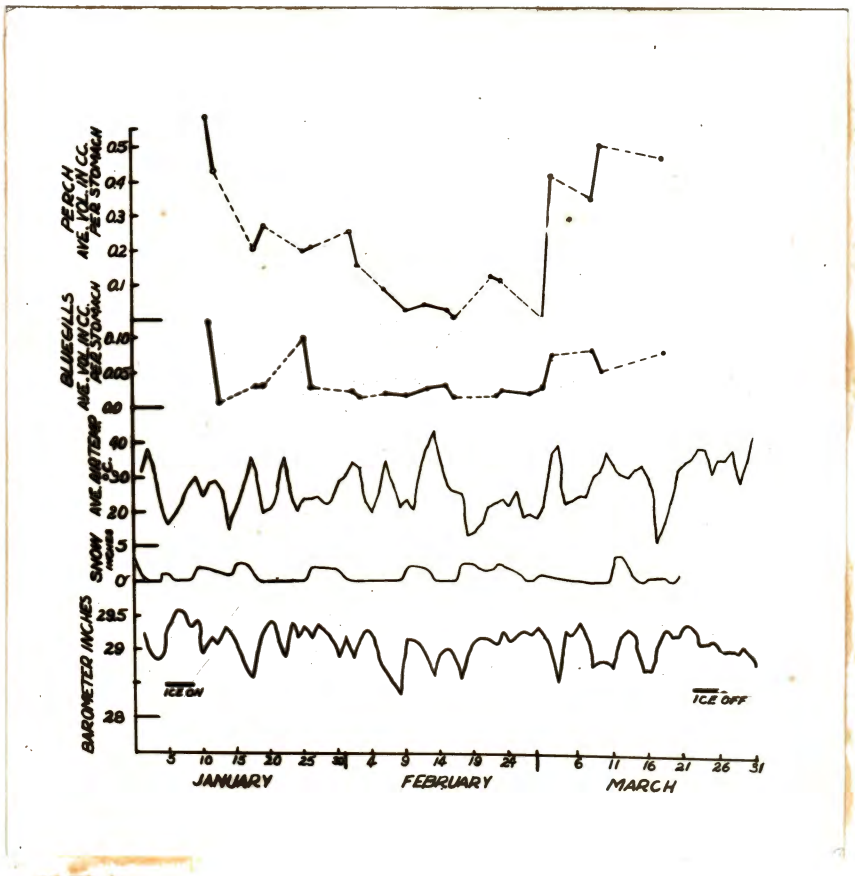


Table 1

Meteorological conditions as found on Cedar Lake at each collection date.

Collection date	Time fished	Inches of snow on ice	Weather	Air temp. range °F.	Wind	Preceding weather
Jan. 11	2-5 P.M.	1	Clear-cloudy	30	NW	...
Jan. 12	2-6 P.M.	½	Cloudy	...	...	Clear-cloudy
Jan. 18	2-6 P.M.	None	Snow-increasing cold	...	NW	Warm rain
Jan. 19	3-6 P.M.	None	Cloudy	23	NW	Snow
Jan. 25	2:30-6 P.M.	None	Clear-sun	32	NW	Clear-cold
Jan. 26	2:45-6:15 P.M.	2	Blizzard	23	NE	Clear-cold
Feb. 1	2:15-6:15 P.M.	None	Clear-thaw	37-41	SW	Thaw
Feb. 2	3:25-6:15 P.M.	None	Cloudy-cold	27-28	NW	Thaw
Feb. 6	3-6:15 P.M.	None	Thaw-clear	31-35	WSW	Thaw
Feb. 9	3:30-6:15 P.M.	2	Clear-cold	12-21	None	Blizzard
Feb. 12	4-6 P.M.	Trace	Warm-sun	...	S	Thaw
Feb. 15	3:15-6:20 P.M.	Trace	Snow	27	NW	Thaw-warm
Feb. 16	3:30-6:15 P.M.	Trace	Cloudy-snow	25-31	NW	Clear-cold
Feb. 22	3-6:30 P.M.	1	Cloudy	28	NW	...
Feb. 23	3:15-6:30 P.M.	Spotty 1	Clear-cold	17-23	NW	Cloudy
Feb. 27		No information				
Mar. 1		No information				
Mar. 2	3:15-5:45 P.M.	Trace	Warm-hazy	43	SW	...
Mar. 8	3:15-7 P.M.	None	Clear	36	None	...
Mar. 9	3:30-7 P.M.	None	Clear	30-38	NW	Clear
Mar. 18	3-6:45 P.M.	Trace	Overcast	...	NW	Warm spell

Growth Rates of Bluegills and Perch

Growth rates for the two most numerous species, the bluegill and yellow perch, are given in Tables 2 and 3. These results are determined from fish caught solely with hook and line and, therefore, none of the younger age groups are represented. It should be pointed out that bluegills younger than the III-year group are not represented and perch younger than the II-year group are lacking.

Bluegills in Cedar Lake reach legal size (6 inches total length) during their sixth year of life. They grow rather slowly throughout life as the figures in Table 2 show. Their length increment is approximately 15 millimeters each year and they gain about 16 grams in weight. It is quite evident that the bluegill population of Cedar Lake is stunted. It should be further noted in Table 2 that the male bluegills grow a little faster and gain a little more weight than do the females.

Perch reach the 6-inch legal size limit somewhat earlier than do the bluegills. This size is attained sometime during their 5th year of life (Table 3). In this species the females average somewhat larger than the

males. It appears from Table 3 that the perch in Cedar Lake are also stunted. The series of samples in the case of these fish is not great enough to make definitely sure that stunting is evidenced. These fish do grow somewhat erratically and slower than do perch from other lakes in which they are known to prosper.

Table 2

Growth rate of bluegills from Cedar Lake.
Lengths in millimeters, weights in grams.
All lengths and weights are averages.

Age group	Females				Males				No sex recorded				Total			
	No.	S.L.	T.L.	Wt.	No.	S.L.	T.L.	Wt.	No.	S.L.	T.L.	Wt.	No.	S.L.	T.L.	Wt.
III	...	...	...	...	...	...	...	...	1	77	97	13	1	77	97	13
IV	8	105	134	35	10	107	136	34	1	100	129	30	19	106	135	34
V	30	115	147	42	26	120	153	48	6	114	145	40	62	117	149	45
VI	67	127	162	58	58	131	168	67	14	136	158	64	139	129	164	62
VII	20	140	178	82	12	149	188	98	2	141	174	...	34	143	181	90
VIII	7	139	176	81	...	...	...	...	1	158	185	...	8	141	177	81

* Ages were determined by Dr. W. C. Beckman.

Table 3

Growth rate of perch from Cedar Lake.
Lengths in millimeters, weights in grams.
All lengths and weights are averages.

Age group	Females				Males				Total			
	No.	S.L.	T.L.	Wt.	No.	S.L.	T.L.	Wt.	No.	S.L.	T.L.	Wt.
II	1	120	142	34	1	100	119	...	2	110	130	34
III	9	102	121	18	8	94	114	15	17	98	118	17
IV	12	99	127	15	5	106	121	13	17	99	126	15
V	9	148	171	61	10	122	150	31	19	136	160	46
VI	6	153	181	66	9	132	156	40	15	141	166	52
VII	3	163	185	78	6	148	175	58	9	152	176	64
VIII	4	184	214	96	3	134	171	47	7	167	195	76
IX	1	160	187	77	...	...	...	...	1	160	187	77

* Ages were determined by Dr. W. C. Beckman.

Feeding Habits of the Bluegill

During the period covered by this study the bluegills in Cedar Lake consumed a rather large variety of organisms. Their main diet, numerically speaking, consisted mainly of planktonic forms of life with Daphnia predominating. Mayflies were usually common and in both early and late winter their abundance was greater than that of Daphnia or any other single group of organisms eaten.

Tables 4 to 22*/ present the results of stomach analyses for each collection date. Organisms were grouped in the most easily identified categories. In most instances, genera were identifiable and are presented as such. A summary table (#23) and graph (Figure 2) follow.

Table 23

Summary of per cent of total volume of major food groups of bluegills, Cedar Lake, 1941.

	Jan.18	Jan.19	Jan.25	Jan.26	Feb.1	Feb.2	Feb.6	Feb.9	Feb.12	Feb.15
Ephemeroptera	26.11	62.14	85.91	40.44	26.43	36.71	4.82	0.00	0.00	0.00
Odonata	8.92	3.57	2.82	16.54	0.00	12.66	0.00	2.27	0.00	0.00
Trichoptera	38.22	10.71	1.41	1.84	25.72	14.76	2.41	2.27	0.00	2.61
Total	73.25	76.42	90.14	58.82	52.15	64.13	7.23	4.54	0.00	2.61
Diptera	13.38	5.72	1.41	5.51	10.71	8.44	7.22	20.46	36.96	17.83
Total	86.63	82.14	91.55	64.33	62.86	72.57	14.45	25.00	36.96	19.44

	Feb.16	Feb.22	Feb.23	Feb.27	Mar.1	Mar.2	Mar.8	Mar.9	Mar.18
Ephemeroptera	12.50	0.69	7.36	7.10	17.60	40.64	23.87	6.62	63.08
Odonata	0.00	0.00	0.00	4.40	4.00	11.83	1.14	13.22	14.38
Trichoptera	0.00	0.00	0.00	7.10	28.00	9.78	25.00	19.86	10.00
Total	12.50	0.69	7.36	18.60	49.60	62.25	50.01	39.70	87.46
Diptera	6.25	15.51	7.37	14.30	16.00	10.73	3.97	12.50	2.31
Total	18.75	16.20	14.73	32.90	65.60	72.98	53.98	52.20	89.77

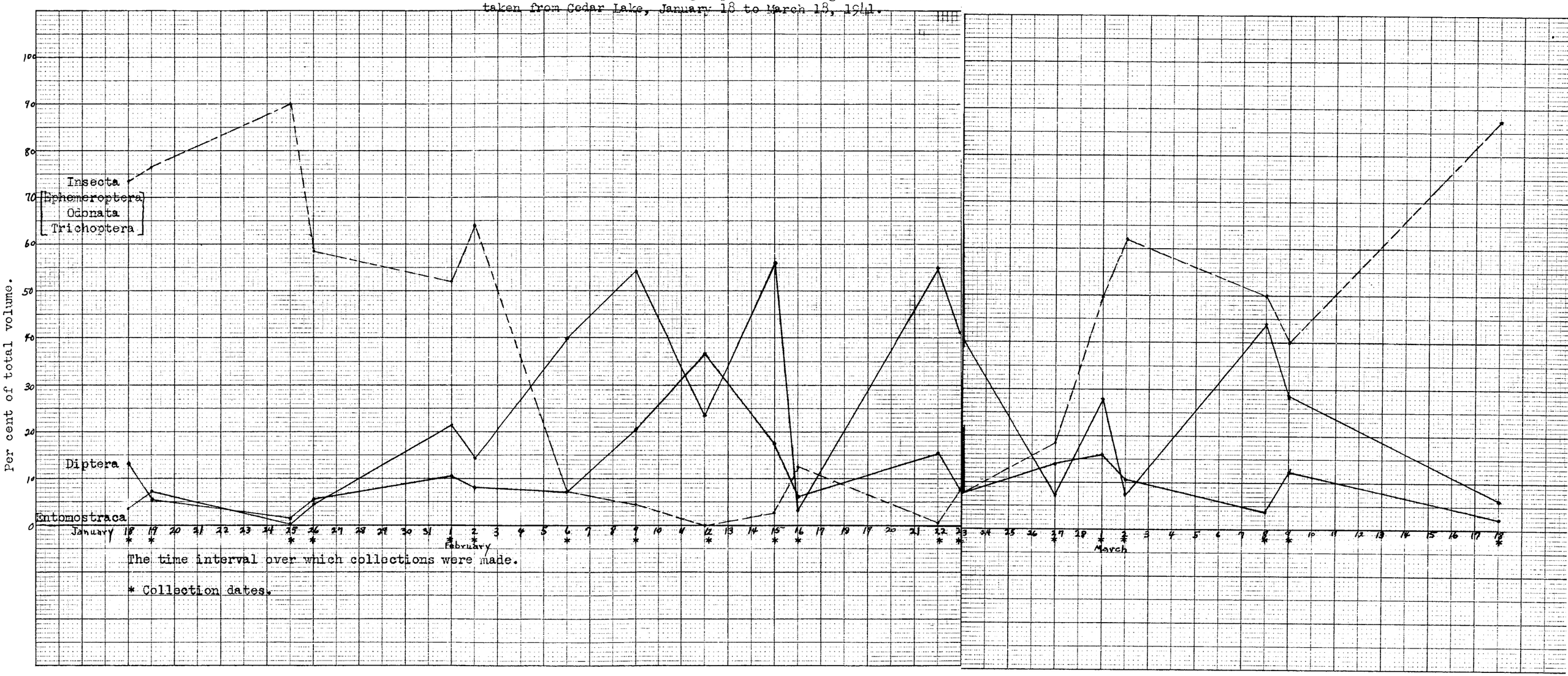
It is noteworthy from these tables that as far as numbers are concerned, insect components of the bluegill diet are relatively unimportant and become increasingly so during the winter until the advent of early spring and disintegration of the ice cover has begun. Daphnia are the most numerous organisms eaten during early winter, become subordinate to Ostracoda during mid-winter and increase to a highly dominant position in late winter. Of the insect foods, mayfly nymphs of the genus Elasturus are the most often eaten. They are followed rather closely by Chironomus and Chaoborus larvae. Chironomus larvae are more consistently numerous in the diet than are the Chaoborus larvae.

Volumetric comparisons of the various components of bluegill diets in winter present a somewhat different story. At no time do planktonic forms constitute more than 56.5 per cent of the volume of the stomach contents. During the first 3 weeks of the winter, invertebrate forms other than planktonic groups constituted over 90 per cent of the volume in the stomachs.

*/ Original tables are not included but are filed with the Institute for Fisheries Research copy of report in the Ann Arbor office.

Figure 2

The occurrence of the major food groups in the bluegill stomachs taken from Cedar Lake, January 18 to March 18, 1941.



As the winter progressed, plankton became increasingly important only to decrease to a relatively unimportant position by the time the ice began to yield to spring weather (Figure 2). Daphnia were the predominant plankton group. They were less in volume than Ostracoda during two weeks of mid-winter but quickly assumed their dominant position following that time. Mayfly nymphs, chiefly Blasturus, were the dominant insect group. They were exceeded in volume by Trichoptera during the first week of this study, by Chironomus larvae during two weeks in mid-winter and by Odonata during the week of March 9-15. Mayfly nymphs became the most important group during the last week of this study. In the bluegill diet there is a decrease in the volume of insect life consumed, Diptera excepted, during mid-winter and an increase as spring approaches (Figure 2). However, this trend is accompanied by a general decrease in the average total volume per stomach during mid-winter and an increase toward spring. The converse is true when numbers are considered. The greatest average numerical content per stomach occurs during mid-winter when plankton constitutes the main component of the bluegill diet.

Unusual items eaten by bluegills during winter are Bryozoa (moss animalcules) which occur too often to be considered chance bits taken into the stomach while feeding on other organisms. Fish remains were found in 11 stomachs. These remains were, for the most part, young bluegills. It is worthy of note that although fish were infrequently eaten, they comprised a considerable part of the volume of the total food of the larger bluegills.

It is interesting to note, when the feeding habits of different size groups of bluegills are considered, that there is very little difference in the dietary constituents. Only when these fish approach a total length of 200 mm. do they tend to leave off plankton and feed on insect foods and fish. The percentages of total numbers and volumes which each major group of food organisms constitutes in the diets of the various size groups are presented in Table 24. The average volume per stomach for each size group is also given. The latter figures indicate a trend toward a larger volume per stomach as the fish increase in size. This increase is probably due to the greater volume per single organism which the larger fish eat.

Feeding Habits of Perch

Perch taken during this study were caught with "wigglers" (Hexagenia nymphs). Some, especially the larger individuals, were taken with minnows. The number of perch involved in the work was not great enough to be considered by individual collection dates. Consequently, results of stomach analysis have been grouped into weekly periods. These consolidated findings are presented in Tables 25-34.*

At the beginning of the ice cover, the numerical composition of the perch diet was dominated by insects. Dragonfly nymphs were most numerous during the first week. They were replaced by mayfly nymphs, the bulk of which were Blasturus, during the second week. Mayfly nymphs were the most prevalent component of the diet of the perch taken in the third week but they were almost equaled by Ostracoda, the first plankton organisms to be eaten. During February and the first two weeks of March, plankton

* Not included in this report but filed with the Institute for Fisheries Research copy at Ann Arbor.

Table 24

Organisms eaten by the various size groups of bluegills during winter in Cedar Lake.

Size range Total length in mm.	100-119		120-139		140-159		160-179		180-199		200-219	
No. of stomachs	24		79		212		210		72		14	
Organisms	Per cent of no.	Per cent of vol.	Per cent of no.	Per cent of vol.	Per cent of no.	Per cent of vol.	Per cent of no.	Per cent of vol.	Per cent of no.	Per cent of vol.	Per cent of no.	Per cent of vol.
Bryozoa	0.05	...	Tr.	...	0.01	...	0.11	0.67	0.15	...	1.59	...
Mollusca	0.52	10.00	0.17	4.27	1.04	24.23	0.63	7.53	0.92	3.74	0.27	...
Cladocera	85.73	16.67	89.10	53.52	56.59	25.51	69.47	21.00	81.18	6.38	13.52	...
Copepoda	0.86	...	0.86	...	2.69	0.75	12.38	5.67	0.78	...	...	...
Ostracoda	6.74	3.33	7.70	5.02	36.37	15.47	11.37	2.00	0.03	...	...	...
Amphipoda	0.12	...	0.09	...	0.09	...	0.06	...	0.17	...	...	...
Hydracarina	0.07	...	0.03	...	0.17	0.75	0.13	...	0.08	...	1.59	...
Ephemeroptera	3.32	46.67	0.58	9.30	0.97	11.77	3.21	36.80	11.49	43.07	53.84	23.64
Odonata	0.05	...	0.02	2.01	0.02	4.91	0.02	2.33	0.08	6.38	0.27	...
Neuroptera	...	...	Tr.	2.51	...	...	Tr.	2.00	...	...	...	...
Trichoptera	0.42	11.33	0.31	10.05	0.32	7.93	0.30	5.33	0.89	24.18	0.53	21.82
Coleoptera	...	...	...	...	...	...	Tr.	0.67	...	...	0.54	...
Diptera	2.12	12.00	1.13	13.32	1.39	8.68	2.31	10.67	4.21	7.12	27.32	7.27
Pisces	...	...	...	...	...	...	Tr.	5.33	0.02	9.13	0.53	47.27
Total number	4,066		21,468		48,451		32,491		6,516		377	
Total volume in cc.		0.750		2.090		6.625		7.500		5.480		1.575
Ave. vol./stomach		0.031		0.026		0.031		0.036		0.076		0.112

dominated the entire numerical picture. Ostracoda were by far the most abundant during the first three weeks of February. They were superseded by Copepoda in the last week of February and the first week of March. However, they regained numerical dominance the second week in March. Only three perch were collected during the third week in March. Their stomachs contained insects and fish. Plankton was entirely absent. Mayfly nymphs were most numerous.

The average number of organisms per stomach was naturally highest during the middle of the winter when plankton constituted the main diet of the perch. In contrast, the average volume per stomach was greatest during early and late winter, descending to a broad low during the period when the numerical average was highest. This was due to the small volume of individual plankton organisms when compared with insects and fish.

Fish constituted over 90 per cent of the volume of the perch winter diet during every week of this study except February 9-15 when they represented 62 per cent, being displaced from their dominant position somewhat by plankton, especially Ostracoda. Most of the fish eaten were small bluegills. Their average length ranged between 30 and 40 millimeters. Undoubtedly, they were the young of the previous spring spawning. There were usually two and often three bluegills in each stomach containing fish.

When the results of stomach analyses of the perch from Cedar Lake are tabulated according to size groups with no regard for date of collection, there seems to be a definite segregation of feeding habits among the groups as is shown in Table 35. Perch smaller than 119 mm. in total length feed almost entirely on invertebrates. In this particular study, plankton forms were most often eaten by fish in this size range. Plankton constituted about 74 per cent of the volume of food eaten. The next larger size (120-139 mm. T.L.) perch ate many invertebrate organisms. In fact, 95.7 per cent of the number of organisms eaten were Ostracoda. However, volumetrically, fish, mostly bluegills, made up 67 per cent of the diet while plankton accounted for only 28 per cent. Perch, in size groups above the two just discussed, tended more and more toward a solid diet of fish. Mayfly nymphs (Blasturus) and midge larvae (Chironomus) were eaten quite often by perch of medium size. Perch over 179 mm. in total length ate fish almost exclusively.

Table 35

The diets of various sized yellow perch during winter in Cedar Lake

Size range T.L. in mm.	100-119		120-139		140-159		160-179		180-199		200-219		220-239		240 --	
No. of stomachs in group	50		17		15		14		6		6		3		1	
Organisms	Per cent of total no.	Per cent of total vol.	Per cent of total no.	Per cent of total vol.	Per cent of total no.	Per cent of total vol.	Per cent of total no.	Per cent of total vol.	Per cent of total no.	Per cent of total vol.	Per cent of total no.	Per cent of total vol.	Per cent of total no.	Per cent of total vol.	Per cent of total no.	Per cent of total vol.
Daphnia	4.55	2.38	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cyclops	7.19	2.38	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Diaptomus	10.77	6.19	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ostracoda	76.36	62.86	95.68	10.29	...	...	...	...	26.92	...	...	...	...	...	...	...
Amphipoda	0.03	...	0.24	...	...	...	2.69	...	...	...	...	...	...	...	...	...
Ephemeroptera																
Blasturus	0.33	7.14	2.42	17.65	8.00	...	69.13	5.48	...	...	...	...	...	...	...	...
Ephemerella	0.10	...	...	...	...	...	4.70	...	...	...	...	...	...	...	...	...
Callibaetis	0.05	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Caenis	0.02	...	0.03	...	...	...	...	...	...	...	...	...	...	...	...	...
Odonata																
Enallagma	0.01	...	0.03	...	...	...	2.01	0.99	...	...	...	...	...	...	...	...
Ischnura	0.08	9.53	...	...	...	...	1.34	0.99	...	...	...	...	...	...	...	...
Trichoptera																
Leptoceridae	0.006	...	...	...	...	...	0.67	...	...	...	...	...	...	...	...	...
Diptera																
Procladius	0.05	...	0.06	...	...	...	...	...	...	...	...	...	...	...	...	...
Pentaneura	0.08	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chironomus	0.19	4.76	0.73	2.94	4.00	...	8.05	...	3.85	...	...	...	...	...	...	...
Clinotanypus	0.05	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chaoborus	0.13	...	0.45	1.47	...	...	...	...	...	...	...	...	...	...	...	...
Ceratopogonidae	...	...	0.12	...	...	...	...	...	...	...	...	...	...	...	...	...
Vertebrata																
Pisces																
Unident. fish	0.006	...	0.09	16.18	12.00	3.83	1.34	3.98	11.54	17.86	14.29	4.35	...	...	...	...
Lepomis sp.	...	...	0.03	1.47	4.00	2.36	...	...	...	...	7.14	4.35	...	...	...	...
Bluegills	0.006	4.76	0.12	50.00	68.00	79.65	10.07	88.56	57.69	82.14	78.57	91.30	100.0	100.0	100.0	100.0
Common shiner	...	...	...	...	4.00	14.16	...	...	...	...	...	...	...	...	...	...
Total no. and vol. in cc.	15,420	1.050	3,312	1.700	25	8.475	149	5.025	26	5.600	14	4.600	5	2.100	1	0.500

INSTITUTE FOR FISHERIES RESEARCH

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