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OBSERVATIONS ON THE NUMBER OF EGGS AND FEEDING HABITS OF THE CISCO (LEUCICHTHYS ARTEDI) IN SWAINS LAKE, JACKSON COUNTY, MICHIGAN *

by

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While attempting to determine the abundance of cisco in Swains Lake in 1939, the writers secured a number of specimens for stomach examinations and egg counts. Conservation officials first noted spawning activity of ciscoes in Swains Lake about December 1, and on December 5 they made a collection of about 50 fish by means of gill nets. An examination of a dozen fish from this collection showed the females to be mostly "green", i.e. they had not started to spawn. A collection of 87 fish made by us between 7 and 9 P.M. on December 14 contained no males and only 9 females which had not already begun to spawn. Ovaries were saved from these 9 females for egg counts. Age and sex determinations were made on 84 of the 87 ciscoes collected. Three were omitted because of poor scale samples. Stomachs were examined from all 87 fish plus 4 others taken from Browns Lake about the same time.

Swains Lake is fairly well representative of certain small southern Michigan lakes which consistently support populations of ciscoes. It has a surface area of 70 acres and a maximum depth of 64 feet. Marked thermal and chemical stratification exists during the height of the

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* Contribution from the Institute for Fisheries Research, Michigan Department of Conservation.

summer period without a critical reduction in the dissolved oxygen in and immediately below the thermocline. Water suitable for cold-water fish is therefore available at all seasons. Browns Lake is located near by and, although it has not been carefully studied, appears to have characteristics similar to those of Swains Lake.

The surface-water temperature in the late afternoon of December 14, 1939, was practically at the freezing point and thin ice had begun to form near shore. Numerous ciscoes were observed to break water during the early evening when as many as a dozen disturbances were seen at one time. There was no concentration of these fish. Approximately as many were seen over deep water as were observed over the shallows. By 9 P.M. (at the time the gill nets were lifted) the lake had frozen completely over and ice remained on the lake until the following spring "break-up".

Examination of the ciscoes collected indicates that spawning was about at its height. None of the specimens were completely spent and most of the females had just begun egg deposition. It would seem safe to assume, although no subsequent check was made, that spawning may have continued for a period of at least several days after the ice was formed.

Our sample contained 28 males and 56 females (sex ratio of 1-2). This ratio persisted quite consistently in the different age groups (Table I). These data conform to the findings of Hile (1936) on Wisconsin ciscoes in which he reported a preponderance of females in the older fish. It does not agree with the ratio given by Cahn (1927) however, who reports a majority of males. His collections were larger than ours and contained both young and old fish, which fact may account for the difference.

Table I

The age, sex ratio, and size of cisco from Swains Lake

Age	Number of males	Average total length (inches)	Average weight (pounds)	Number of females	Average total length (inches)	Average weight (pounds)
IV	4	15.5	1.32	1	15.0	1.38
V	8	15.8	1.40	14	15.6	1.52
VI	7	15.8	1.43	17	15.7	1.59
VII	9	16.0	1.34	19	15.8	1.54
VIII	...	...	...	1	16.2	1.77
IX	...	...	...	3	16.2	1.58
X	...	...	...	1	16.9	1.75

Ciscoes taken in Swains Lake had an age range of 4-10 years inclusive (number of annuli) with age-groups V, VI, and VII accounting for 85.7 per cent of the entire sample. There was less than 2 inches difference in the lengths of the smallest and largest fish and no great difference in the average weights of the youngest and oldest fish.

Actual egg counts made on nine females are given in Table II. These fish

Table II

Weights, length, size of ovaries and number of eggs for nine female ciscoes. Averages at bottom.

Standard length (mm.)	Total length (inches)	Total weight (pounds)	Weight of ovaries (grams)	Number of eggs	Age
318	15.25	1.48	128.2	23,272	IX
327	15.50	1.65	193.0	30,967	V
331	15.37	1.62	152.8	28,243	V
333	15.50	1.75	174.2	33,641	VI
336	15.67	1.72	178.5	32,505	V
336	15.87	1.86	201.5	35,457	V
340	15.87	1.80	181.7	37,272	VI
343	16.25	1.77	153.7	24,795	VII
343	16.25	1.79	182.9	26,804	VIII
334	15.72	1.72	171.83	30,328	

averaged 30,328 eggs; the largest individual count was 37,272 and the smallest was 23,272. Apparently no correlation exists between the size or age of the fish and the number of eggs produced, although nine fish are not adequate to

give significant information on this point. Stone (1938) made estimated counts of cisco eggs by a volumetric method and found a significant correlation between the number of eggs and the length, weight and age of the fish. He recognizes considerable variation within any age or size group, however.

The usual method of estimating the number of eggs by weighing and counting small samples was tested on three fish. Comparisons were made between the results from partial and total counts (Table III). Samples were taken at random after the ovaries had been broken up and the eggs well mixed.

Table III

Comparison between estimated numbers of eggs, calculated from partial counts and the total counts for three ciscoes.

Total weight of ovaries (grams)	Weight of sample (grams)	Estimated number of eggs	Actual number of eggs	Per cent error
154.65	5	31,023	28,243	+ 9.8
	5	28,425	28,243	+ 0.6
	5	28,138	28,243	- 0.4
	70	29,663	28,243	+ 5.0
	70	26,617	28,243	- 5.7
193.52	10	34,358	30,967	+ 10.9
	10	29,848	30,967	- 3.6
	50	30,643	30,967	- 1.0
173.0	5	39,341	32,505	+ 21.0
	5	31,451	32,505	- 3.2
	5	34,254	32,505	+ 5.3
	70	30,658	32,505	- 5.7

According to these few data the 5 gram samples were nearly as accurate (error 6.7 per cent) as the 70 gram samples (error 5.4 per cent). This method compares favorably with the volumetric method of Stone (1938) who reports an average error of 5.1 per cent.

Stomach examinations were made on a total of 91 ciscoes, 87 from Swains Lake and 4 from Browns Lake. Although most of the fish in Swains Lake were feeding to some degree, only 8 actually had full stomachs. This

scarcity of food in the stomachs may be explained by the fact that most of these fish were spawning. The four fish from Browns Lake, on the other hand, were completely spent and all had full stomachs. A summary of the results of the stomach examinations is given in Table IV. The numbers of organisms present are estimates based on partial counts.

Table IV

Summary of stomach analyses of 87 ciscoes from Swains Lake and 4 from Browns Lake

Number of plankters in stomachs	Number of stomachs
0	5
1 - 10	47
11 - 100	22
101 - 1,000	5
1,001 - 5,000	2
5,001 - 10,000	3
10,001 - 20,000	7

An analysis of the contents of the 12 full stomachs is shown in Table V.

Table V

Analysis of 12 full cisco stomachs

Swains Lake

Total volume (c.c.) by water displacement	Number of organisms			
	Daphnia	Diaptomus	Miscellaneous	Total number
34.2	13,954	205	Cisco eggs	14,159
27.6	19,278	980	...	20,258
27.3	11,630	600	...	12,230
26.2	15,144	550	...	15,694
25.1	15,831	627	...	16,440
25.8	10,036	387	...	10,423
18.3	3,650	64	...	3,714
18.0	2,412	180	...	2,592

Browns Lake

Total volume water displacement	Number of organisms			
	Daphnia	Diaptomus	Rotifera	Total number
16.9	6,160	110	135	6,405
32.0	11,776	112	128	12,016
34.6	8,685	484	242	9,411
14.8	6,949	22	37	7,008

Daphnia, Diaptomus, and rotifers made up the great bulk of the stomach contents. Such miscellaneous items as cisco eggs, Corethra larvae and dragonfly nymphs were found in the stomachs of 6 fish. The staple items of the diet are practically the same as those reported by Stone (1938), Cahn (1927), Clemens and Bigelow (1922) and Langford (1938). Tapeworms of an unknown species were present in the stomachs of 44.4 per cent of the fish studied.

Literature Cited

Cahn, Alvin Robert

1927 An ecological study of southern Wisconsin fishes. Ill. Biol. Monogr. 11(1):1-151.

Clemens, W. A. and H. K. Bigelow

1922 The food of ciscoes (Leucichthys) in Lake Erie. Contrib. Canad. Biol. 1921 : 89-101.

Hile, Ralph

1936 Age and growth of the cisco Leucichthys artedi (Le Sueur), in the lakes of the Northeast Highlands, Wisconsin. Bull. U. S. Bur. Fish. 48:211-317.

Langford, R. R.

1938 The food of the Lake Nipissing cisco, Leucichthys artedi (Le Sueur), with special reference to the utilization of the limnetic crustacea. Univ. Toronto Studies, Biol. Ser. 45:145-190.

Stone, U. B.

1938 Growth habits and fecundity of the ciscoes of Irondequait Bay, New York. Trans. Amer. Fish. Soc. 67:234-245.

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