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THE FOOD OF CISCOES (*Leucichthys*) IN LAKE ERIE

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The results of the examination of the contents of the digestive tracts of 211 ciscoes (fresh-water herring) are presented herein. The bulk of the material was obtained early in June, 1919, and from July to November in 1920, from Lake Erie at various points along the north shore. The species examined were *Leucichthys eriensis*, the jumbo cisco; *L. artedi*, the Lake Erie cisco; *L. sisco huronius*, the Lake Huron cisco; and *L. prognathus*, the Lake Ontario deep water cisco (longjaw). These were taken at Merlin, Rondeau, Port Dover, Nanticoke, McKillop's fishery (near Port Maitland), and Dunnville. In addition 19 individuals of *L. harengus*, the Georgian Bay cisco, from Wiarton, Georgian Bay, and 7 individuals of *L. ontariensis*, the Lake Ontario cisco, from Port Credit, Lake Ontario, have been examined for comparative purposes. The material from Merlin, Rondeau, Nanticoke and McKillop's was obtained in pound nets while the material from all the other points was obtained in gill nets.

The results are given in the following tables. In the table "Unidentified species" are placed those fish whose identity was not determined. The figures indicate the relative abundance, namely: (1) that only a few individuals were noted; (2) that the organisms occurred rather abundantly; (3) very abundantly.

SUMMARY.

1. An examination of the tables shows that the ciscoes are pre-eminently plankton feeders. The study practically covers the fishing season, and during that time at least, the free swimming crustacea form the bulk of the food of these fish. Of Canadian waters, Lake Erie produces more ciscoes than all the other Great Lakes combined. For example, in 1919 Lake Erie produced 7,425,713 lbs., while the remainder of the Great Lakes produced 4,022,711 lbs. It is not improbable that the production of ciscoes is directly dependent upon the amount of plankton Crustacea produced. The numbers of these Crustacea which must abound in Lake Erie in order to support the millions of ciscoes, as well as the great numbers of white fish and young of many other species, is almost beyond the imagination. Comparative quantitative plankton studies in the Great Lakes would, no doubt, afford considerable information as to the fish productive capacities of these lakes.

2. It is doubtful if the various species of ciscoes show any preference among the entomostraca as food material. They doubtless take whatever forms occur in the waters they happen to inhabit.

3. In the great majority of alimentary tracts examined, *Daphnia* formed the great bulk of the contents, while other forms were represented by scattered individuals. In many cases *Daphnia* alone were present. This was particularly true of the jumbo and the Lake Ontario ciscoes. It appears, therefore, that *Daphnia* are very much the most important of the entomostraca as food organisms. *Daphnia longispina* occurred in all the material examined, as variety *hyalina galeata*. *Daphnia* ephippia were abundant in October in Lake Ontario and in November in Lake Erie. Occasional ephippia with three eggs were noted.

4. Of the Copepods *Diaptomus sicilis* and *Limnocalanus macrurus* were perhaps the most abundant forms occurring in the digestive tracts, although *Epischura lacustris* occurred frequently and occasionally in considerable numbers. Very often the oil globules of these forms gave the contents a bright red colour.

5. In the eastern end of Lake Erie one of the most important food organisms was *Mysis relicta*. As far as we are aware this is the first record of the occurrence of this form in Lake Erie. Its presence indicates at least an approach of conditions in the eastern end of this lake to conditions in the other Great Lakes.

6. Three individuals were found to have eaten small fish. In each case digestion had proceeded too far to allow of identification. All three ciscoes were taken in the eastern end of the lake, two were longjaws (*L. prognathus*) and the third, while not definitely identified, was probably also a longjaw. A fisherman near Point Pelee has stated that one winter he found that some ciscoes which he took through the ice, had eaten "minnows."

7. As is shown in the table for the longjaws (*L. prognathus*) these fish in June, 1919, had fed practically entirely upon *Ephemeridae* (*Ephemera simulans*), both adults and subimagoes. The importance of these insects as fish food is thus further demonstrated. Moreover, there is no doubt that the transformation of the nymphs to the subimaginal stage takes place at the surface of the water, as occurs in the closely related genus *Hexagenia* (Needham, 1920).* This means that the subimagoes, as well as the imagoes, were taken at the surface of the water by the ciscoes. The projecting lower jaw of these forms is well suited to such surface feeding.

8. The following table, compiled from the food tables, shows the distribution of the food organisms in the lake.

The outstanding points in the table are:

(*a*) The absence of *Mysis relicta* from the western portion and the absence of *Daphnia pulex* and *D. retrocurva* from the eastern portion. Further investigation, however, may show the presence of these species throughout the lake.

(*b*) Although only 43 gill net fish were examined, and the list of forms is, therefore, incomplete, yet the results are an indication of what would be expected in any large body of water, namely, that the shore waters contain a greater number of species of food organisms than the more open waters. The gill net

*Needham, James G. 1920. Burrowing Mayflies of our Larger Lakes and Streams. *Buli. U.S. Bur. Fish.*, Vol. XXXVI, 1917-18.

	Western Portion	Eastern Portion	
	87 pound net fish from Merlin and Rondeau	55 pound net fish from McKillop's and Nanticoke	43 gill net fish from Port Dover and Dunnville
Epischura lacustris	+	+	+
Diaptomus sicilis	+	+	+
Limnocalanus macrurus	+	+	+
Cyclops sp.	+	+	
Sida crystallina	+	+	
Diaphanosoma brachyurum	+		
Holopedium gibberum	+		
Daphnia pulex	+		
" *retrocurva*	+		
" *longispina*	+	+	+
Bosmina longirostris	+		+
Eurycercus lamellatus	+		
Chydorus sp.	+		
Leptodora kindtii	+	+	
Mysis relicta		+	+
Hyallela knickerbockerii	+		
Ephemeridae	+	+	+
Small fish		+	

fish were taken over 5 miles from shore while the pound net fish were taken within 2 miles of shore.

(*c*) A comparison of the first two columns shows the possibility of there being a greater number of species in the western part of the lake than in the eastern end. There is a possibility also that quantitative differences exist in these regions as well as qualitative.

The results of this study serve to emphasize anew the importance of the plankton fauna of our inland waters, and the necessity for a thorough quantitative, qualitative and distributional investigation of these organisms, including particularly their relations to the production, distribution and movements of fish.

Collection Number.	Date.	Locality.	Length in cms.	Weight in ozs.	Age.	*Epischura lacustris.*	*Diaptomus sicilis.*	*Limnocalanus macrurus.*	*Cyclops* sp.	*Sida crystallina.*	*Daphnia pulex.*	*Daphnia retrocurva.*	*Daphnia longispina.*	*Daphnia* sp.?	*Bosmina longirostris.*	*Leptodora kindtii.*	*Mysis relicta.*	Miscellaneous.
118	June 1/19	Rondeau	25.8	13	5	1		1	1	1	3	3						Insect fragments 1.
101	" "	"	27.0	14½	4				1		3	1						
129	" "	"	31.0	21	5						3							*Ephemeridae* 2; *Chironomidae* 1; *Amphipoda* 1.
127	" "	"	35.5	31	6						3							*Epheremidae* 1.
229	July 6/20	Merlin	23.5	8	4				1	2			3					
15 indiv.	" "	"	24.5	10		1	1		1	1			1			3		
15 "	" "	"	24.5	10		1	1		1	1			2			3		
15 "	July 8/20	"	22.5	6½		1	1		1	2	3		2			1		*Diaphanosoma brachyurum* 1; *Holopedium gibberum* 1.
12 "	July 10/20	"	22.5	6½		1	1						1			3		
299	Aug. 2/20	"	26.4	16	4					1			1			3		*Diaphanosoma brachyurum* 1.

1,206	Nov. 12/20	Rondeau	21.3	7		1	1				3							
1,201	" "	"	21.6	6½			1				3							
1,210	" "	"	21.8	7			1				3				1			*Eucercus lamellatus* 1; Crustacean debris 1; *Volvox* 1.
1,213	" "	"	22.2	7½							3							
1,208	" "	"	22.3	8							3							
1,214	" "	"	23.7	10							3							
1,211	" "	"	24.3	11							3							
1,204	" "	"	27.7	17½							3							
1,203	" "	"	33.3	31							3							
	Nov. 24/20	Merlin	24.5				1				3							
	" "	"	26.5			1	2				3							

L. ARTEDI—LAKE ERIE CISCO OR GRAYBACK IN LAKE ERIE

Collection Number.	Date.	Locality.	Length in cms.	Weight in ozs.	Age.	*Epischura lacustris.*	*Diaptomus sicilis.*	*Limnocalanus macrurus.*	*Cyclops* sp.	*Sida crystallina.*	*Daphnia pulex.*	*Daphnia retrocurva.*	*Daphnia longispina.*	*Daphnia* sp.?	*Bosmina longirostris.*	*Leptodora kindtii.*	*Mysis relicta.*	Miscellaneous.
104	June 1/19	Rondeau	21.4	5¾	4	2	1		1		2	2						*Hyallela knickerbockerii* I.
807	Nov. 10/20	"	21.6	7½			3	2						1				Crustacean debris 2.
1,027	" "	McKillop's	19.6	4½	4		2	2						2				
1,046	" "	"	20.2	5				3					2					
1,045	" "	"	20.5	5	5			3					2					
1,043	" "	"	20.9	6	5			3						2			1	
666	" 24/20	Merlin	23.5	9	6		1				3					1		

L. SISCO HURONIUS—LAKE HURON CISCO IN LAKE ERIE

Collection Number.	Date.	Locality	Length in cms.	Weight in ozs.	Age.	*Epischura lacustris.*	*Diaptomus sicilis.*	*Limnocalanus macrurus.*	*Cyclops* sp.	*Sida crystallina.*	*Daphnia pulex.*	*Daphnia retrocurva.*	*Daphnia longispina.*	*Daphnia* sp.?	*Bosmina longirostris.*	*Leptodora kindtii.*	*Mysis relicta.*	Miscellaneous.
371	Nov. 24/20	Merlin	26.1	11½							2					3		
1,200	" 12/20	Rondeau	26.3	9							3							

L. PROGNATHUS—LAKE ONTARIO DEEP WATER CISCO IN LAKE ERIE

Collection Number.	Date.	Locality.	Length in cms.	Weight in ozs.	Age.	*Epischura lacustris.*	*Diaptomus sicilis.*	*Limnocalanus macrurus.*	*Cyclops* sp.	*Sida crystallina.*	*Daphnia pulex.*	*Daphnia retrocurva.*	*Daphnia longispina.*	*Daphnia* sp.?	*Bosmina longirostris.*	*Leptodora kindtii.*	*Mysis relicta.*	Miscellaneous.
17	June 1/19	Nanticoke	17.8	3	4		1							1				*Ephemera simulans* subimagoes 3; Chironomid adults 1
8	" "	"	18.5	3½	4				1									*Ephemera simulans* subimagoes 3.
7	" "	"	19.3	3½	4	1	1		1									" " 3.
10	" "	"	19.5	4	5		1											" " 3; Dipterous adult 1.
42	" "	"	20.8	6	4	1	1		1									*Ephemera simulans* subimagoes 3; Dipterous adult 1.
1	" "	"	20.9	5	5				1									*Ephemera simulans* subimagoes 3; Dipterous adult 1.
16	" "	"	20.9	4½	5				1									*Ephemera simulans* subimagoes 3.
30	" "	"	21.0	5	4		1		1									" " 3.
2	" "	"	21.3	5	5	1	1		1					1				" " 3.
21	June 1/19	Nanticoke	21.4	4¼	6		1		1									" " 3.
13	" "	"	21.5	4½	4		1		1									" " 3.
38	" "	"	21.8	6	4		1											" " 3.
6	" "	"	22.5	4½	6				1					1		1		" " 3.
120	June 1/19	Rondeau	18.6	4	4	1					3	3						
119	" "	"	21.3	5	4						3	3						
115	" "	"	23.4	7½	5	3	1		1		3	3	1					
111	" "	"	24.6	7	6	1	1				3	3						
716	Nov. 1/20	Dunnville	21.1	8	3	1	1	1					3					
15 indiv.	" "	"				1	2	1					3					
15 "	" "	"				2	2	2					3		1			Insect fragments 1.
837	Nov. 10/20	Nanticoke	20.3	5½	5			3										
843	" "	"	20.7	5½	5		1	1	1				3					Glochidium.
834	" "	"	20.7	5				2					3				1	
845	" "	"	20.7	5	5												3	
841	" "	"	20.9	5½	5												3	
817	Nov. 10/20	"	21.5	6	5	1	1	1									2	Crustacean debris 1.
820	" "	"	21.8	5	4												3	

L. PROGNATHUS—LAKE ONTARIO DEEP WATER CISCO IN LAKE ERIE—Cont.

Collection Number.	Date.	Locality.	Length in cms.	Weight in os.	Age.	*Epischura lacustris.*	*Diaptomus sicilis.*	*Limnocalanus macrurus.*	*Cyclops sp.*	*Sida crystallina.*	*Daphnia pulex*	*Daphnia retrocurva.*	*Daphnia longispina.*	*Daphnia* sp.?	*Bosmina longirostris.*	*Leptodora kindtii.*	*Mysis relicta.*	Miscellaneous.
829	Nov. 10/20	Nanticoke	23.0	7	4													Small fish fragments
816	" "	"	23.0	7½	6			1									3	
826	" "	"	23.2	6½	5			2						1			1	Small fish fragments.
808	" "	"	25.4	9½	6		1						2				2	
1,051	Nov. 10/20	McKillop's	21.4	5½	5		1										3	
1,044	" "	"	21.5	5	5		1	1					2				3	
1.039	" "	"	22.0	5½	5												3	
1,032	" "	"	22.3	5½	5												3	

L. HARENGUS—GEORGIAN BAY CISCO IN GEORGIAN BAY.

Collection Number.	Date.	Locality.	Length in cms.	Weight in ozs.	Age.	*Epischura lacustris.*	*Diaptomus sicilis.*	*Limnocalanus macrurus.*	*Cyclops* sp.	*Sida crystallina.*	*Daphnia pulex.*	*Daphnia retrocurva.*	*Daphnia longispina.*	*Daphnia* sp.?	*Bosmina longirostris.*	*Leptodora kindtii.*	*Mysis relicta.*	Miscellaneous.
23	Nov. 24/20	Wiarton	19.1	3¾	4		3	2					2					
25	" "	"	22.4	6	5	I	2	2					2					
21	" "	"	22.7	5½	6		2	2						2	1			Ostracods 1.
27	" "	"	23.4	7	6	1	2	2					1				1	
15 indiv.	" "	"	simi	lar		1	2	2	1				1		1			

L. ONTARIENSIS—LAKE ONTARIO CISCO IN LAKE ONTARIO

Collection Number.	Date.	Locality.	Length in cms.	Weight in oz.	Age.	*Epischura lacustris.*	*Diaptomus sicilis.*	*Limnocalanus macrurus.*	*Cyclops* sp.	*Sida crystallina.*	*Daphnia pulex.*	*Daphnia retrocurva.*	*Daphnia longispina.*	*Daphnia* sp.?	*Bosmina longostris.*	*Leptodora kindtii.*	*Mysis relicta.*	Miscellaneous.
2	Oct. 21/20	Port Credit	22.0	7½	3								3					
7	" "	"	22.7	8	3		1						3					
6	" "	"	23.9	9¼	3								3					
1	" "	"	24.5	9½	4								3					
5	" "	"	25.9	10½	4								3					

L. PROGNATHUS?—LAKE ONTARIO LONGJAW IN LAKE ONTARIO

11	Nov. 25/20	Port Credit	22.6	8	3						3							
9	" "	"	26.4	12½	4												3	

UNIDENTIFIED SPECIES FROM LAKE ERIE.

123	June 1/19	Rondeau	19.9	4¼	4					1	3	3						
107	" "	"	23.8	8	4	2	1		1		3	3				1		Hydrachnid 1.
15 indiv.	Aug. 5/20	Nanticoke				2		2	1	1			2			1		Insect fragments (*Chironomidae, Trichoptera Ephemeridae*) 3.
1 "	" 9/20	McKillop's																*Ephemeridae* (*Ephemera, Heptagenia,* imagoes and subimagoes) 3.
12 "	Nov. 3/20	Port Dover															3	Insect fragments 1.
809	" 10/20	Nanticoke	21.1	6	4												3	
830	" "	"	22.9	7	5									1			3	
810	" "	"	23.2	11	7		2										2	Small fish.
824	" "	"	21.0	6	5		1	1										Crustacean debris 3.
812	" "	"	23.5	9½	6	2	3	2						1				
819	" "	"	23.6	11	4		1										3	
1,048	" "	McKillop's	24.3	11										1			3	
1,212	Nov. 12/20	Rondeau	23.5	11							3							*Chydorus* sp.? 1.
1,207	" "	"	26.2	11½			1				3							