THE BIOLOGY OF TRIAENOPHORUS TRICUSPIDATUS, (BLOCH 1779), IN WESTERN CANADA

By

Merlin V. B. Newton B.Sc.

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Abstract.

An account is presented of the incidence of infection of *Triaenophorus tricuspidatus* (Bloch 1779) in *Coregonus* and *Leucichthys* species in Manitoba based upon an examination of 7,000 fishes. The survey covers thirty lakes from the southern Manitoba border to mile 200 on the Churchill Railway, a few lakes in north eastern Saskatchewan, and includes the larger lakes of Winnipeg, Winnipegosis and Manitoba. The morphology and biology of the larvae and adult stages are described; and an incomplete description of the life cycle is given. The possibilities of economic control are discussed.

Grateful acknowledgement must be paid to the Department of Mines and Natural Resources, Province of Manitoba, for the provision of facilities: to the Manitoba Cold Storage and to the various commercial fishery companies of Manitoba too numerous to mention individually: to Dr. A. Bajkov for the loan of data and for much advice: to Professor R.A.Wardle of the Department of Zoology, University of Manitoba, for laboratory facilities and much advice.

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Introduction:

The earliest reference to the cestode genus Triaenophorus was probably that of Hartmannus (1688), who described "nidi vermiculorum" occurring in the liver, stomach, intestine and flesh of perch, pike, carp, etc., in Europe. No doubt larval stages of both Bothriocephalus and Triaenophorus were represented, but no attempt at specific nomenclature was made.

Pallas (1760) found, what appears from the description, to be adults of Triaenophorus sp. in the pike and perch, in Europe, and gave to them the name Taenia rugosa. No detailed descriptions or drawings of the parasite, however, were given, so that Bloch (1779), who definitely described and figured the hooks and eggs of Triaenophorus and gave the worm the name Taenia tricuspidata, should have priority of species authorship. Pallas (1781) later suggested the name Taenia nodulosa and described the parasite, and his specific name seems to have gained universal acceptance, even the Index Catalogue of Medical and Veterinary Zoology (Stiles and Hassall 1912) having apparently

overlooked Bloch's earlier description. Rudolphi (1793) changed the generic name Taenia to Triaenophorus.

1893 | In 1892 another species of Triaenophorus was specifically described by Olsson under the name of Triaenophorus robustus.

Triaenophorus tricuspidatus is widespread throughout Europe in fresh-water lakes, but Triaenophorus robustus appears to occur chiefly in the lakes of Scandinavia, although it has been reported as far south as Switzerland. Triaenophorus tricuspidatus has been found in a variety of fresh-water fishes such as, pike, perch, trout, grayling, ling, whitefish, catfish, popefish, salmon, pickerel, etc.

The genus was first reported in Canada by Cooper (1918). He describes "Triaenophorus nodulosus" in the liver of Perca flavescens (Mitch.), the viscera of Micropterus dolomieu (Lacepede), and the intestine of Lucioperca vitreum (Mitch.). He also described "Triaenophorus robustus" in the intestine of Esox lucius (Linne), Lota lota maculosa (Le Sueur). The specimens, which were all larvae, were obtained from the rivers and lakes of Muskoka District, Ontario. Hjortland (1927) described an adult specimen of "Triaenophorus robustus" from the intestine of Esox lucius (Linne), caught in the State of Minnesota.

The occurence of Triaenophorus

tricuspidatus in Manitoba was reported by Nicholson (1928). Until the early months of 1931 the presence of this parasite was not a serious obstacle to the marketing of the fish concerned, but in that year the government of the United States placed a restriction on the importation from Canada of the cisco (Leucichthys sp.).

The degree to which Canadian fishes are infected with this cestode, and particularly with the intermuscular phase, thus became an economic problem of some interest, since the Canadian exportation of ciscoes to the United States amounts to around 10,360,000 lbs. annually.

The aim of the present work, therefore, has been to survey the extent of larval infection in the lakes of Manitoba, to ascertain which species is concerned, and to present all data possible concerning the life cycle of the parasite.

Approximately 7,000 fish have been examined. The following species were included in the examination: pike, Esox lucius (Linne); whitefish, Coregonus clupeaformis (Mitch.); ciscoes, Leucichthys tullibee (Richardson), Leucichthys zenithicus (Jordon and Evermann), Leucichthys nipigon (Koelz), Leucichthys nigripinnis (Gill); perch, Perca flavescens (Mitch.); pickerel, Lucioperca (Stizostedion) vitreum (Mitch.); sauger, Lucioperca (Stizostedion) canadense (Smith);

ling, Lota lota maculosa (Le Sueur); goldeye, Hiodon chrysopsis (Richardson); suckers, Catostomus catostomus (Forster), Catostomus commersonii (Lacepede); and catfishes, Ictalurus punctatus (Rafinesque), Ameiurus nebulosus (Le Sueur).

While the greater portion of the survey has been concerned with lakes Winnipeg, Winnipegosis and Manitoba, a great number of the smaller lakes have been examined in the hope that some would prove to be free from the parasite. The area covered ranges from south of Lake Winnipeg to lakes some distance north of the Churchill Railway, and from the east of the Province to the west.

Owing to the large number of fishes examined - 7,000 being examined altogether - the examination had to be rapid yet accurate. The fish is held in the left hand with the forefinger and thumb placed inside the opercular flap, so that it does not slip. A thin horizontal slice is rapidly removed from the base of the skull to the tail fin, and then vertical incisions on either side divide the musculature in slices about a centimetre thick. In such slices the cysts are readily found. The stomach and liver of each fish was removed and the gut contents examined by the decantation procedure. The species of the fish, the locality, and the date of the year are noted.

Specimens were fixed by stretching on a glass plate and painting with hot water (60°C) followed by immersion in formalin (10%), or in a cold saturated solution of corrosive sublimate, for two hours, the material then being preserved in formalin (5%). The best results were obtained with hot water and formalin. Material was stained with a Delafield or Ehrlich haematoxylin and cleared, or even preserved indefinitely in Beechwood creosote. The cysts were fixed in Bouin's fixative, but the results were not as good as expected, as they became brittle. Sections were made 10μ and 20μ thickness from specimens taken at different periods of the year.

The Incidence of Infection:

The larger lakes, including Winnipeg, Winnipegosis, Manitoba and certain adjacent waters such as Lake Dauphin will be considered first.

The only species of fishes in these lakes which were found to be infected with the encysted larvae of Triaenophorus tricuspidatus were the whitefish, Coregonus clupeaformis (Mitchill) and the various forms of cisco or tullibee as it is termed in Manitoba. Of these the fishermen in Manitoba recognise six different kinds ; Tullibee, Black-backed Tullibee, Light-backed Tullibee, Green-backed Tullibee, Silver-backed and Red-fin Tullibee. There are also several intermediate forms, which are probably hybrids between some of the above mentioned fish. The commonest species are "Black-backed" and "Light-backed", which can be very easily distinguished from each other. Therefore the industry recognises these two distinct species of cisco. Neither of these is a homogeneous group but consists of several species. The dominant species of the "Black-backed" group is Leucichthys tullibee (Richardson), and of the "Light-backed" group, Leucichthys zenithicus (Jordon and Evermann) and Leucichthys nipigon (Koelz). Among the "Black-backed" fish there is also an admixture of other species, such as Leucichthys nigripinnis (Gill) and Leucichthys hoyi (Gill).

In this paper reference will only be made

to the two most important species, namely: "Black-backed Tullibee" meaning Leucichthys tullibee and "Light-backed Tullibee" meaning Leucichthys zenithicus.

Certain gaps will appear in the data of the survey. These were due to weather conditions making it impossible to obtain specimens as the nets could not be lifted, or by the absence of the species concerned from the catches. During the month of June, 1931, for instance, the catch was so light and the whitefish so rare, that it was impossible to obtain sufficient material for a correct average of the month.

For the purpose of completeness and comparison, figures collected by A. Bajkov during his survey of 1929 and 1930 are included. Unfortunately at that time no catches were taken at regular intervals, so that no continuous month by month comparisons are possible.

In Lake Winnipeg it was found that the percentage of infection was fairly high in the early summer, varying from about 45 per cent. in the whitefish in May and 60 per cent. in the "light-backed tullibee" in June to between 30 and 40 per cent. for both in July. A gradual increase in infection followed this in the "light-backed tullibee" until a maximum was reached in August. The whitefish, however, continued at between 15 and 20 per cent. Both showed a decrease in infection from September until January.

The decrease at this season may be accounted for by the fact that Triaenophorus tricuspidatus reaches maturity or the gravid stage in Lake Winnipeg between January and April, while infection must take place in the whitefish and cisco from March to June. The length of life of the larvae in the musculature of the fish is unknown, although they are found throughout the year. The decrease in infection in the late months of the year would suggest, however, that the greater percentage of cysts disappear from their hosts in October or November.

It would, of course follow, that there should be a recognisable decrease in the numbers of the cestodes present in the small intestine of the pike in April and May.

The following table shows the percentages of whitefish parasitised, as well as the numbers of parasites present per fish in Lake Winnipeg. These fish were all caught in gill-nets set at Gimli, Victoria Beach and George Island.

Month 1931	Number Examined	Number Infected	Percent Infected	Number of parasites per fish 1	2	3	4	5	9
May	11	5	45	4	1	-	-	-	-
June	-	-	-	-	-	-	-	-	-
July	6	2	33	1	1	-	-	-	-
August 3	1	1	100	1	-	-	-	-	-
August 4	40	11	28	11	-	-	-	-	-
August 5	39	4	10	3	1	-	-	-	-
August 15	8	0	0	-	-	-	-	-	-
August 16	1	1	100	1	-	-	-	-	-
August 17	5	0	0	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-	-
October	14	7	50	1	2	-	2	1	1
November	6	2	33	2	-	-	-	-	-
December	8	2	25	2	-	-	-	-	-
January 1932	6	0	0	-	-	-	-	-	-

The figures for "light-back tullibee" in Lake Winnipeg are as follows:

Month 1931-32	Number Examined	Number Infected	Percent Infected	Number parasites per fish 1	2	3	4	5	6	7	8	9	10
June 28	5	3	60	-	2	-	-	1	-	-	-	-	-
July 7	37	9	24	5	3	-	1	-	-	-	-	-	-
July 9	76	19	25	12	4	2	1	-	-	-	-	-	-
July 20	100	42	42	31	6	3	1	-	1	-	-	-	-
July 27	5	3	60	-	-	2	-	1	-	-	-	-	-
July 29	116	51	44	18	15	10	5	1	1	1	-	-	-
August 3	1	0	0	-	-	-	-	-	-	-	-	-	-
August 4	1052	545	51	224	159	64	30	41	11	10	12	4	1
August 6	16	7	43	3	2	-	1	-	-	-	1	-	-
August 12	40	20	50	10	5	3	-	1	-	1	-	-	-
August 22	52	42	80	17	16	5	2	1	1	-	-	-	-
August 23	3	1	33	1	-	-	-	-	-	-	-	-	-
August 24	73	41	56	23	5	6	4	-	2	1	-	-	-
September	54	36	67	19	11	3	2	1	-	-	-	-	-
November	23	10	43	3	3	2	-	1	1	-	-	-	-
November	472	318	68	122	95	46	21	11	8	3	4	3	1
December	40	21	50	9	6	2	2	2	-	-	-	-	-
January	827	535	64	257	119	64	36	21	15	7	6	5	4
February	839	571	68	225	136	98	46	26	13	7	6	3	2
March	318	203	63	82	54	27	14	13	3	1	3	1	2

The figures concerning the "dark-back tullibee" in Lake Winnipeg are as follows:

Month 1931	Number Examined	Number Infected	Percent Infected	Number parasites per fish 1	2	3	4	5	6	7	8	9	10
July 7	43	23	53	19	2	1	1	-	-	-	-	-	-
July 7	6	4	66	2	1	-	-	1	-	-	-	-	-
July 20	7	5	71	3	2	-	-	-	-	-	-	-	-
July 29	17	10	59	2	2	2	2	-	1	1	-	-	-
August 3	20	19	95	-	-	-	4	2	-	1	3	1	1
August 20	3	3	100	-	-	-	-	-	1	1	1	-	-

The next figures to be considered will be those of Lake Winnipegosis.

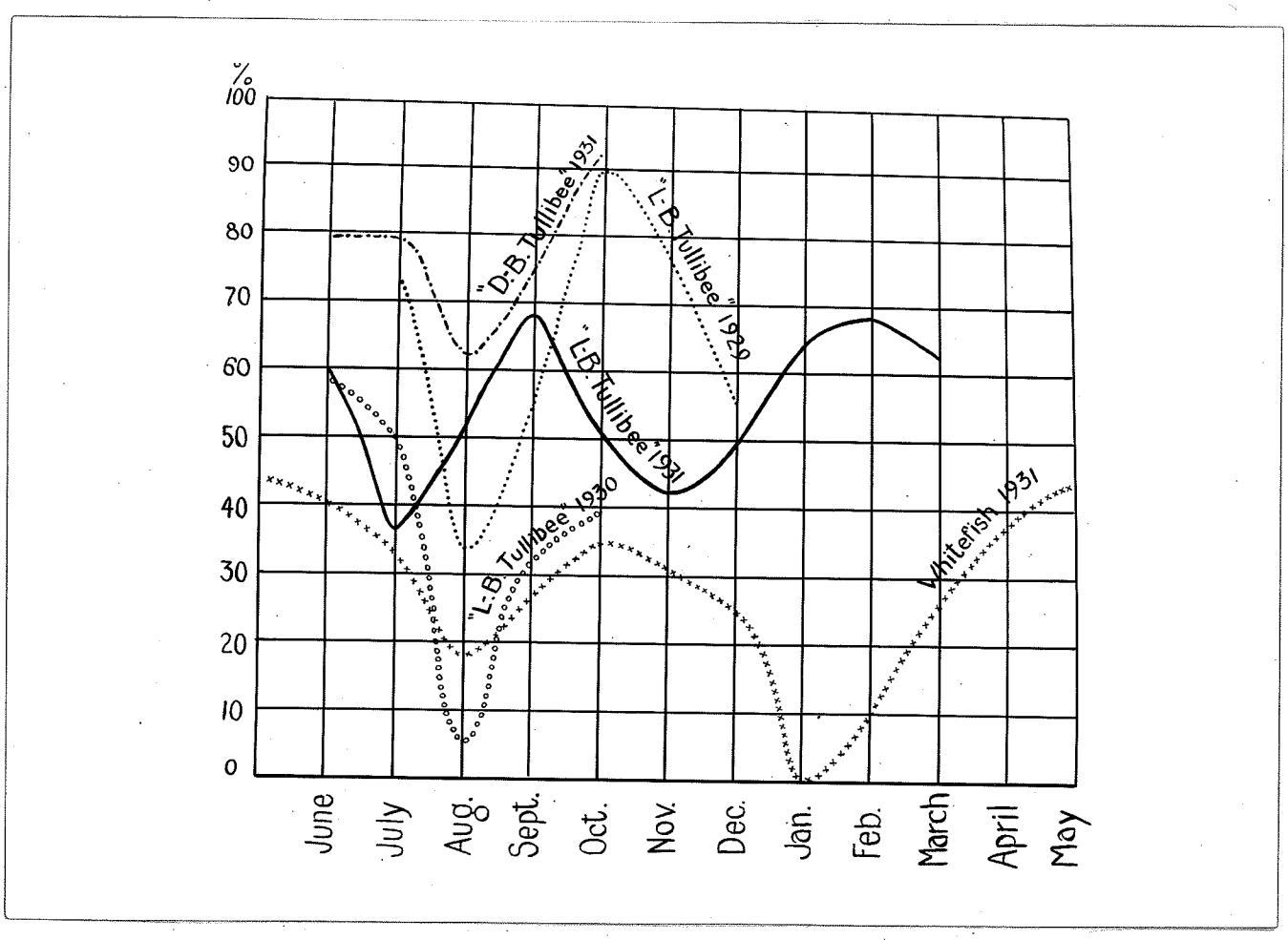
Ninety-six whitefish were examined during the year only three of which were infected, none of the infected fish had more than one parasite.

The cisco infection was as follows:

Month 1931	Number Examined	Number Infected	Infection Percent	Number parasites per fish 1	2	3	4	5	6	7
July	15	15	100	15	-	-	-	-	-	-
August	29	25	89	5	6	4	4	2	-	2
October	1	1	100	1	-	-	-	-	-	-
November	14	11	78	4	1	2	2	-	-	2

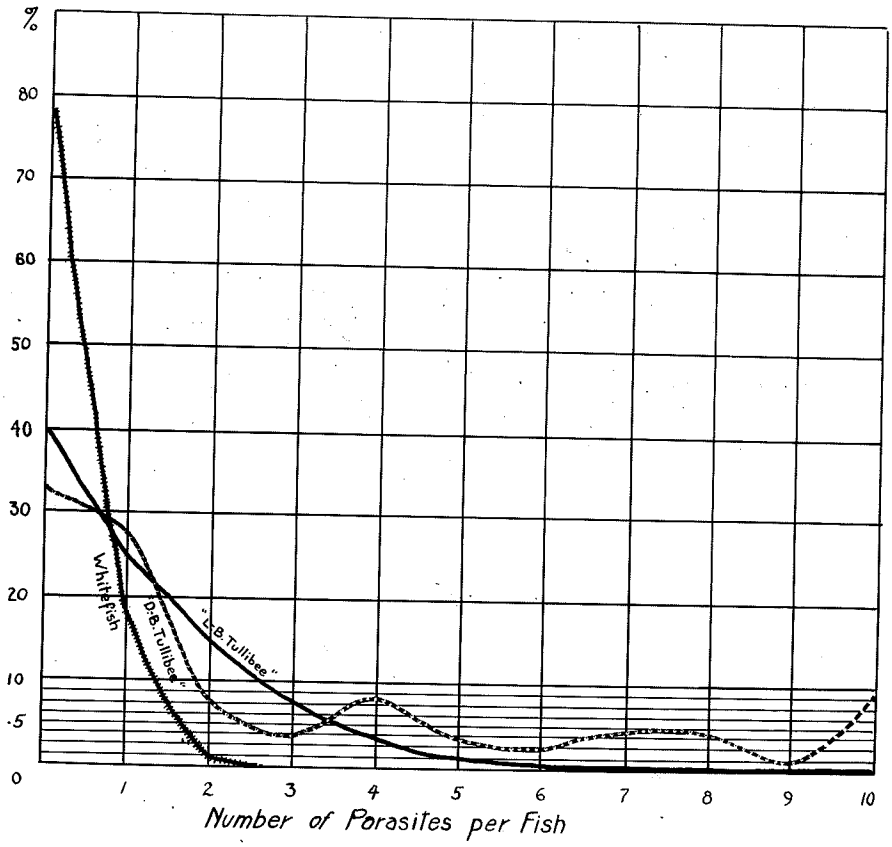
The following graph shows the percentage of infection month by month for 1929, 1930 and 1931 of the white-fish, and "light- and dark-back tullibees." This graph relates only to Lake Winnipeg:

Plate 1.



The following graph shows the percentages of individual infection for the above fishes in Lake Winnipeg :

Plate 2.



It is of interest to note that of all the fish examined from Lake Manitoba none were infected; it is possible that the copepod (1 or organism) which serves as the first intermediate host is absent from this lake.

12 ciscoes were examined from Lake Dauphin in November, all of which were found to be free from infection.

15 whitefish from Lake St. Martin were examined in November, 5 of which proved to be infected; only one parasite was found in each of the individuals infected.

The figures following show the incidence of infection in the lakes which have been grouped together as The Pas District; the location of these specimens are accurate as they were obtained by fish inspectors of the Game and Fisheries Branch, Department of Mines and Natural Resources, Provincial Government; or represent shipments from firms dealing in fish who wished to find out if certain lakes were free from infection, or free enough to permit the exportation of the fish into the United States.

All the specimens, except one shipment from Moose Lake in August, were whitefish; this one shipment contained three ciscoes which were all infected.

LAKES IN THE PAS DISTRICT FROM WHICH FISH WERE EXAMINED.

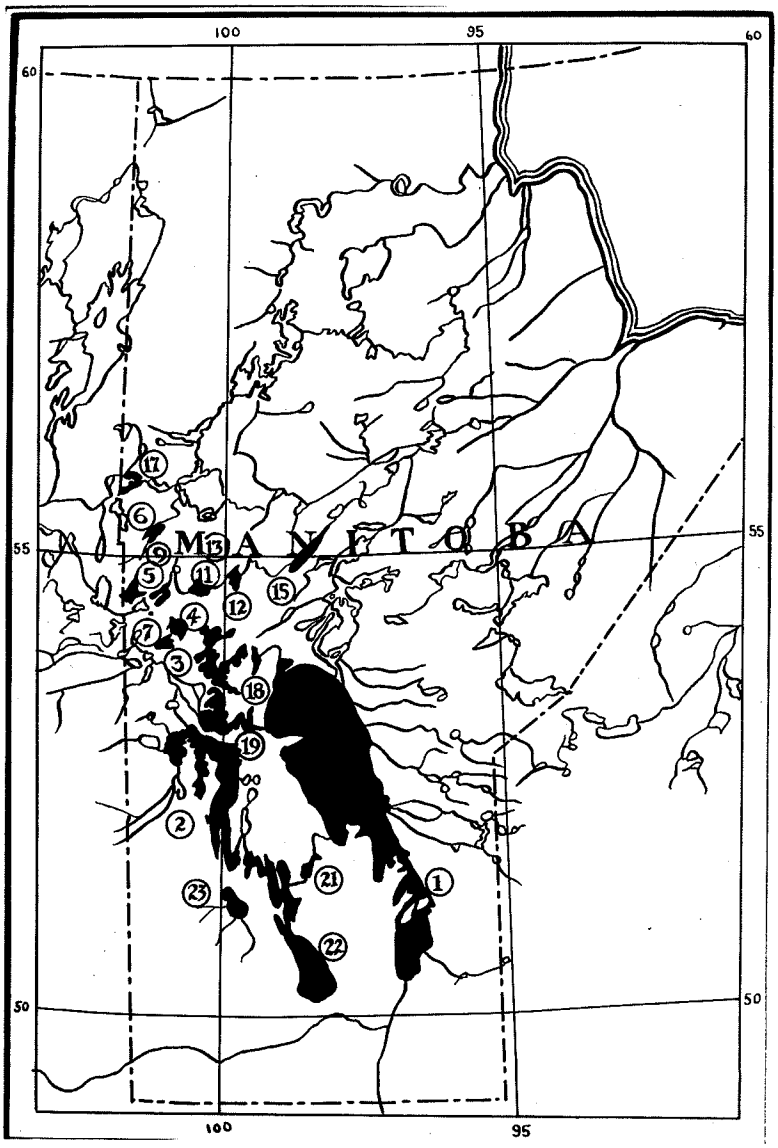
Date 1931	Locality	Number Examined	Number Infected	Percent Infected
August	Moose Lake	6	5	83
Oct. 9	Kississing L.	20	17	85
Oct. 28	Cormorant L.	11	1	9
Oct. 28	Clearwater L.	16	2	13
Nov. 4	Murray Lake	12	0	0
Nov. 4	Jack Lake	14	0	0
Nov. 4	Moose Lake	12	0	0
Nov. 4	Athapapuskow L.	12	0	0
Nov. 5	Rocky Lake	13	0	0
Nov. 5	Setting Lake	12	6	50
Nov. 6	Athapapuskow L.	17	6	35
Nov. 7	Spruce Lake	6	0	0
Nov. 20	Cormorant Lake	35	29	82
Dec. 7	Sissipuk Lake	17	0	0
Dec. 7	William Lake	15	1	6
Dec. 11	Wekusko Lake	14	12	86
Dec. 21	The Pas District	12	8	66
Dec. 21	Egg Lake	15	7	46
Dec. 28	Cedar Lake	28	5	18
Dec. 28	Moose Lake	14	9	64
Dec. 30	Kississing L.	14	13	94
Dec. 30	Moose Nose L.	12	10	83
Jan. 6, 1932	Simonhouse L.	13	10	77
Jan. 6	Manistkwan L.	13	5	38
Jan. 6	Naosap L.	15	7	49
Jan. 7	Wabowden Lake	1	1	100
Jan. 7	Reed Lake	1	1	100
Jan. 20	Mikangan Lake	11	10	99
Jan. 20	File Lake	11	0	0
Jan. 20	Natawanan Lake	10	1	10
Jan. 20	Trout Lake	12	2	16
Jan. 20	Fay Lake	14	2	15

Examination of these figures indicates that in The Pas District the following lakes appear free from the infection: Murray, Jack, Rocky, Spruce, Sissipuk, and File Lake. This may not be entirely correct, however, as it may be noted that both Moose Lake and Athapapuskow Lake were free at one examination, but infected at a later

examination. The samples from these lakes were not so large as might have been desired but at least are an indication. Of the lakes examined, those from which it would appear to be safe from which to catch whitefish for export purposes are: Murray, Jack, Rocky, Spruce, Sissipuk, File and Weskusko Lakes; Winnipeg, Winnipegosis, Manitoba and Dauphin Lakes. Except in the case of Lake Manitoba, however, the ciscoes are heavily infected in all localities.

The larger lakes are shown on the following maps, while those not shown are in the extreme north of Manitoba, where no accurate survey of the Province has been undertaken and the lakes could not be located with any degree of accuracy.

Plate 3.

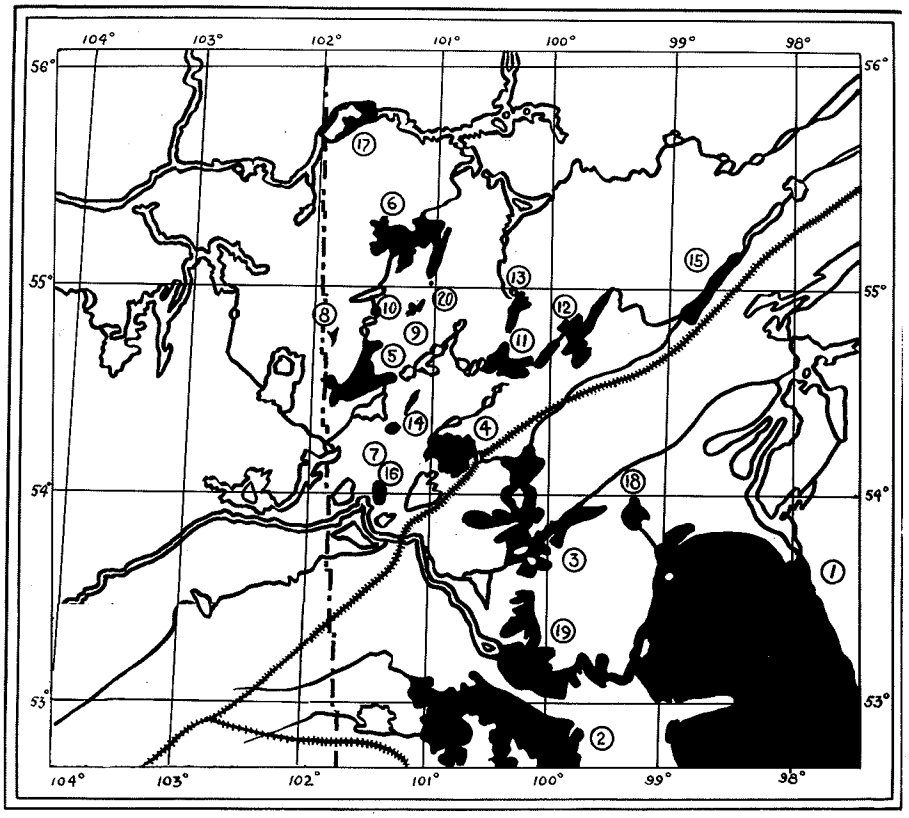


MAP OF MANITOBA

showing lakes from which fish were examined.

Lakes:
(1) Winnipeg
(2) Winnipegosis
(3) Moose
(4) Cormorant
(5) Athapapuskow
(6) Kississing
(7) Egg
(9) Naosap
(11) Reed
(12) Wekusko
(13) File
(15) Setting
(17) Sissipuk
(18) William
(19) Cedar
(20) St.Martin
(21) Manitoba
(23) Dauphin

Plate 4.



THE PAS DISTRICT

showing lakes from which fish were examined.

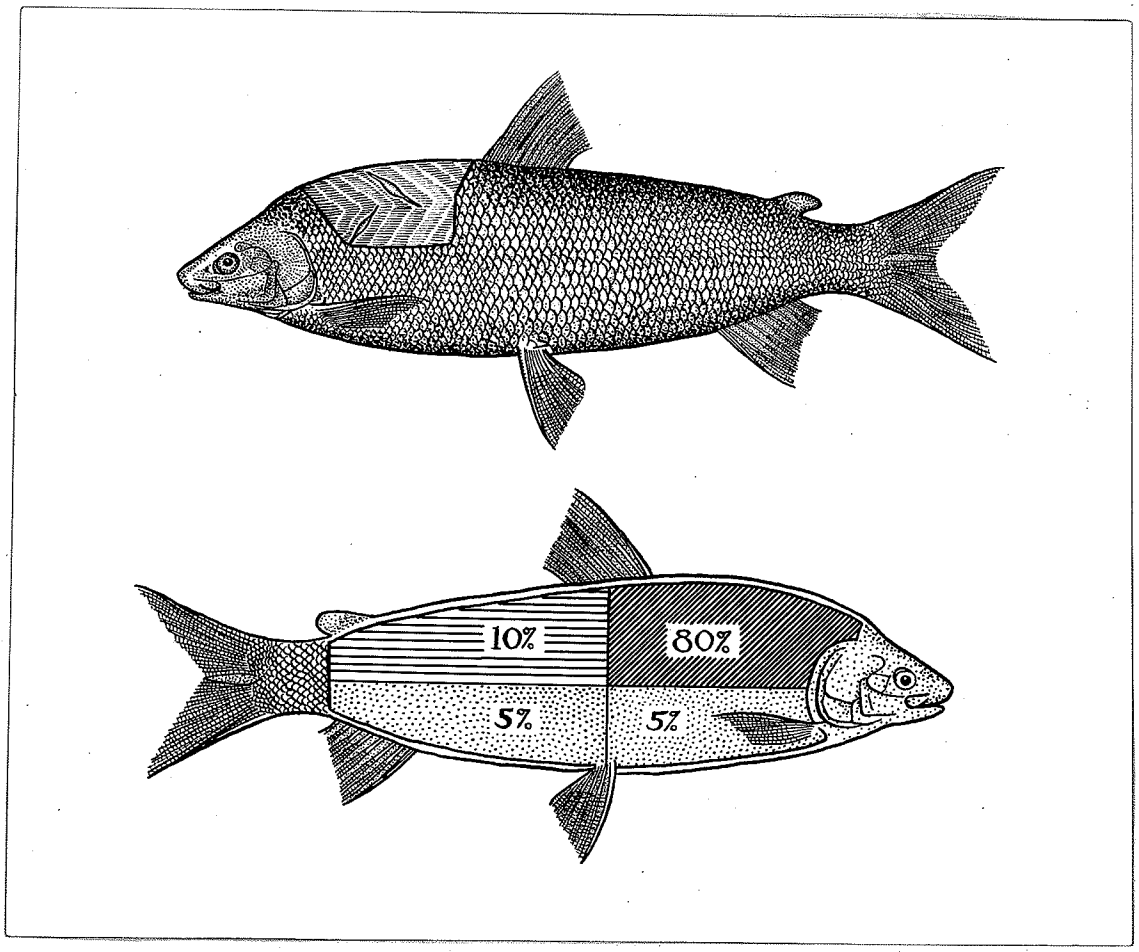
Lakes:
(1) Winnipeg
(2) Winnipegosis
(3) Moose
(4) Cormorant
(5) Athapapuskow
(6) Kississing
(7) Egg
(8) Manistkwan
(9) Naosap
(10) Mikanagan
(11) Reed
(12) Wekusko
(13) File
(14) Simonhouse
(15) Setting
(16) Rocky
(17) Sissipuk
(18) William
(19) Cedar
(20) Fay

Plerocercoid Morphology:

The plerocercoid stage of Triaenophorus tricuspidatus occurs encysted in the musculature of Coregonus clupeaformis and the various species of Leucichthys, and is always found in an area extending from immediately behind the skull to the dorsal fin. The cysts lie parallel to the myomeres, but this orientation is not constant, as specimens have been found lying in various positions. There appears to be no definite correlation, in this respect, between the cyst and host.

Plate (3) shows in the upper sketch the position of the cyst in the host, while the lower diagram shows the areas of infection.

Plate 5.



The number of cysts per host varies from 1 to 35; none of the hundreds of fishes examined showed the high percentage of infection recorded by Hjortland (1927).

The cyst is of a yellowish to a pinkish color, very yellow in frozen fish. It varies in size from .6 to 2.3 cms. in length and from .3 to .6 cms. in breadth. In general, the cyst is elliptical in shape, rounded, and bluntly pointed. Plate (6) shows a cyst in the muscles, the cauda is present.

Plate 6.