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

By

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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.

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

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.

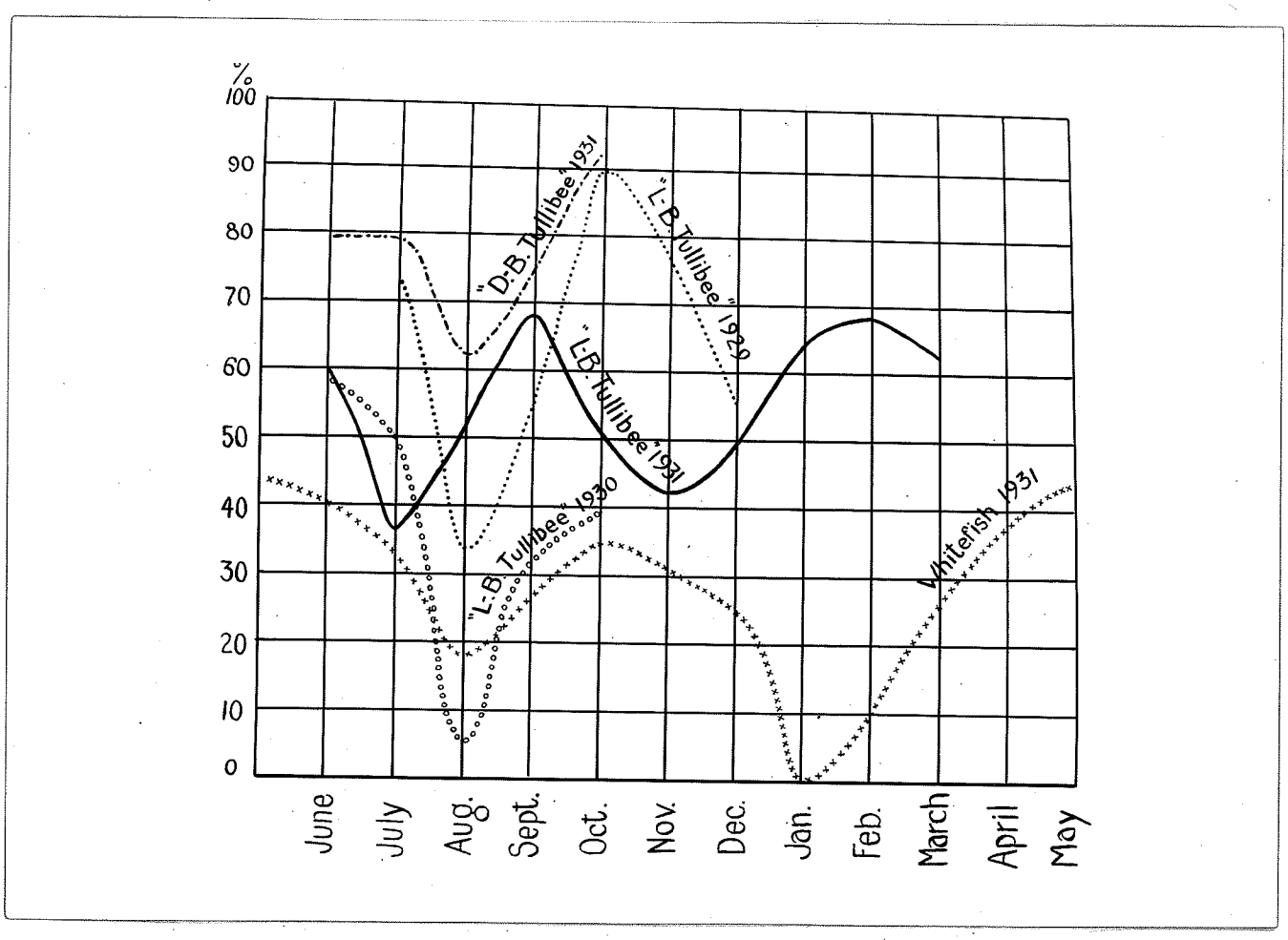
Ninety-six whitefish were examined during the year only three of which were infected, none of the infected fish had more than one parasite.

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

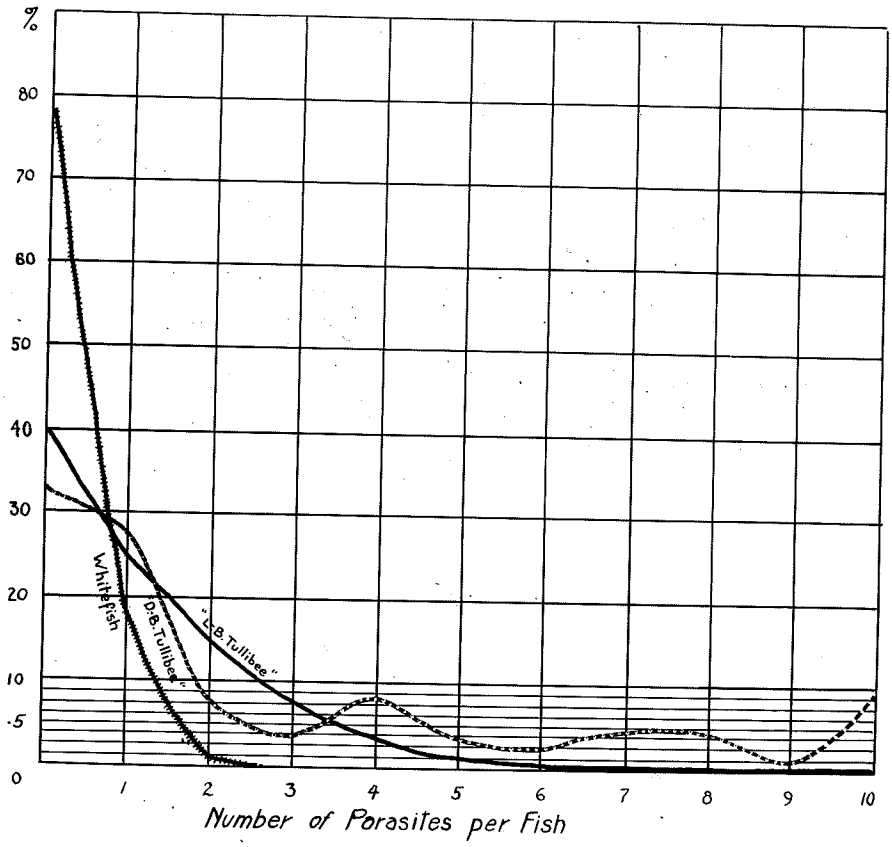
The following graph shows the percentage of infection month by month for 1929, 1930 and 1931 of the white-fish, and "light- and dark-back tullibees." This graph relates only to Lake Winnipeg:

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.

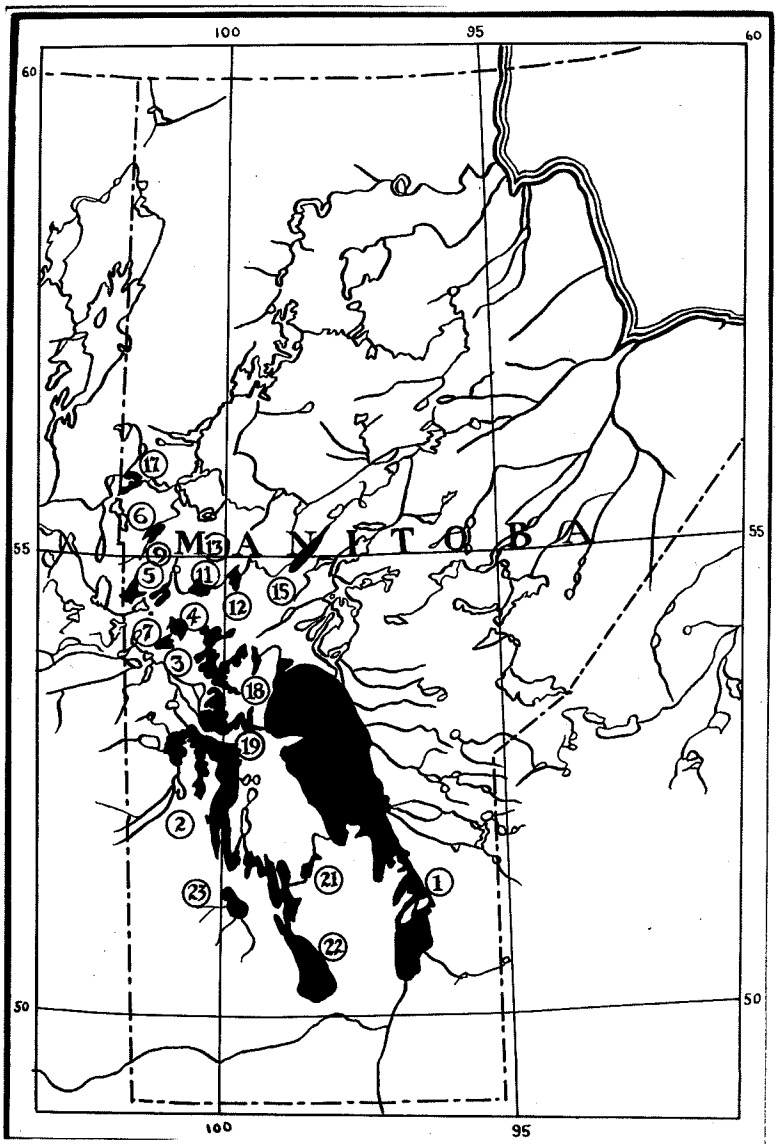
Date 1931	Locality	Number Examined	Number Infected	Percent Infected
August	Moose Lake	6	5	83
Oct. 9	Kississing L.	20	17	85
Oct. 28	Cormorant L.	11	1	9
Oct. 28	Clearwater L.	16	2	13
Nov. 4	Murray Lake	12	0	0
Nov. 4	Jack Lake	14	0	0
Nov. 4	Moose Lake	12	0	0
Nov. 4	Athapapuskow L.	12	0	0
Nov. 5	Rocky Lake	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.

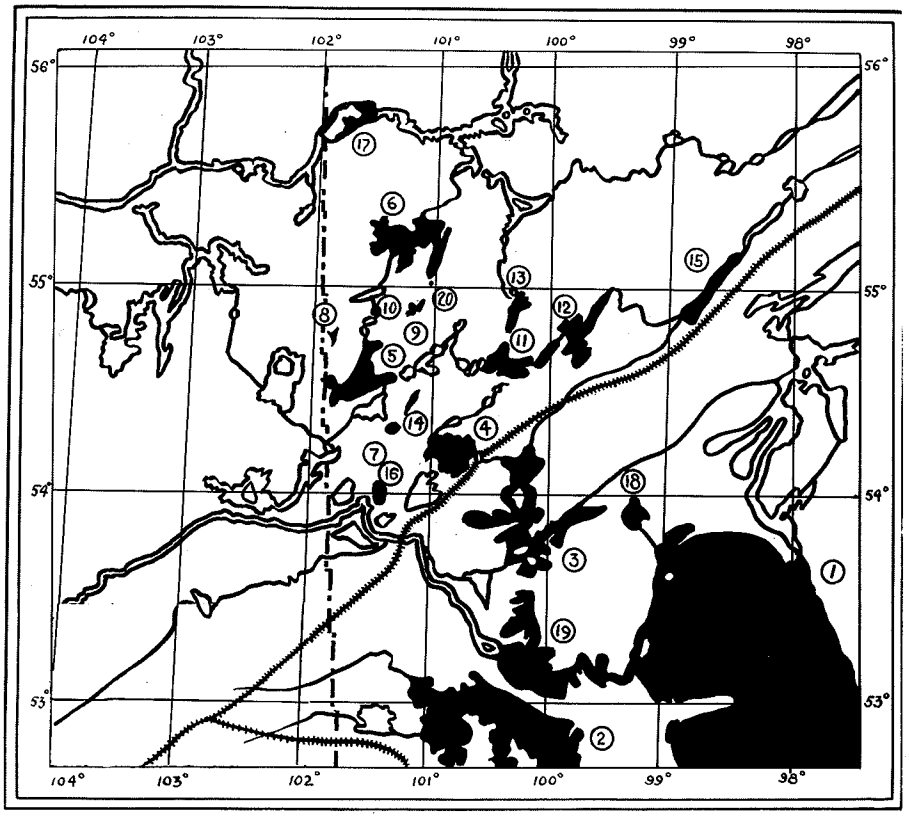


MAP OF MANITOBA

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.

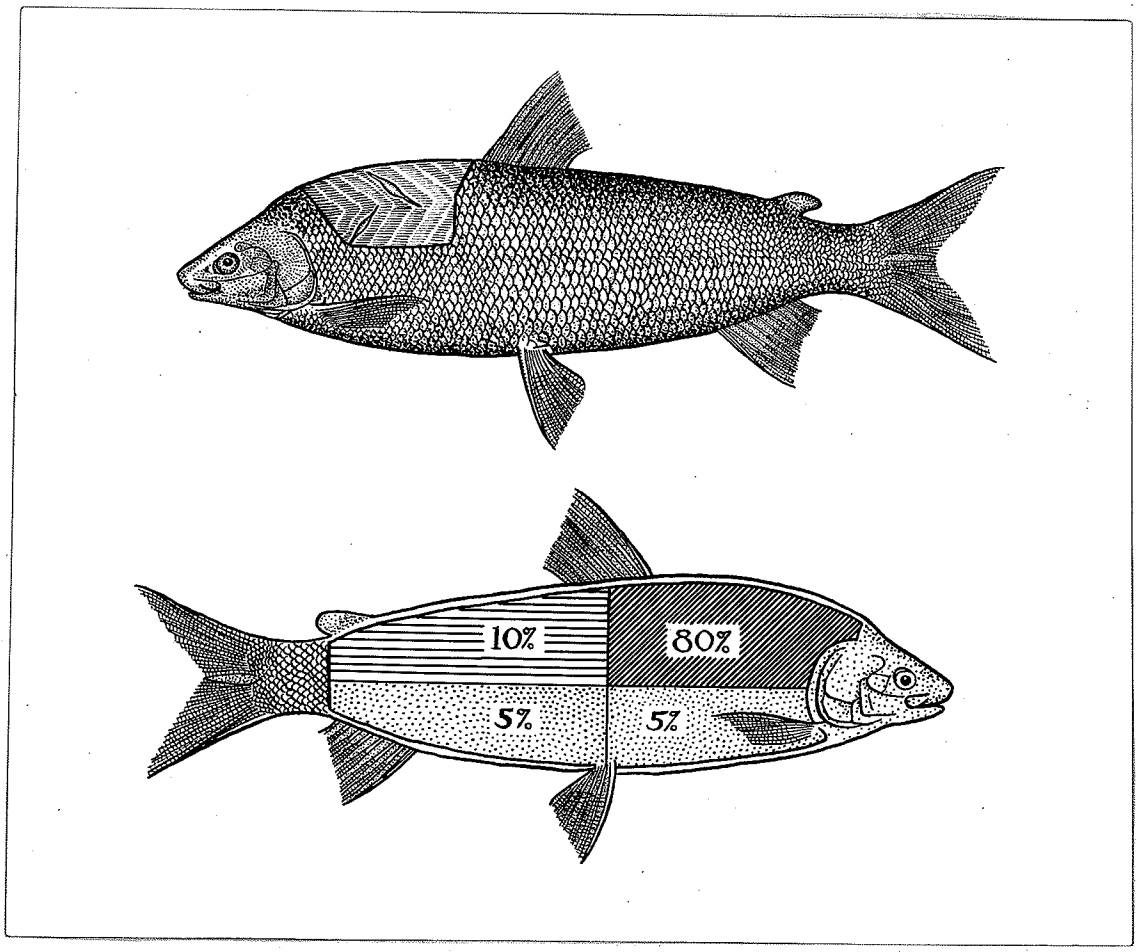
Lakes:
(1) Winnipeg
(2) Winnipegosis
(3) Moose
(4) Cormorant
(5) Athapapuskow
(6) Kississing
(7) Egg
(8) Manistkwan
(9) Naosap
(10) Mikanagan
(11) Reed
(12) Wekusko
(13) File
(14) Simonhouse
(15) Setting
(16) Rocky
(17) Sissipuk
(18) William
(19) Cedar
(20) Fay

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.

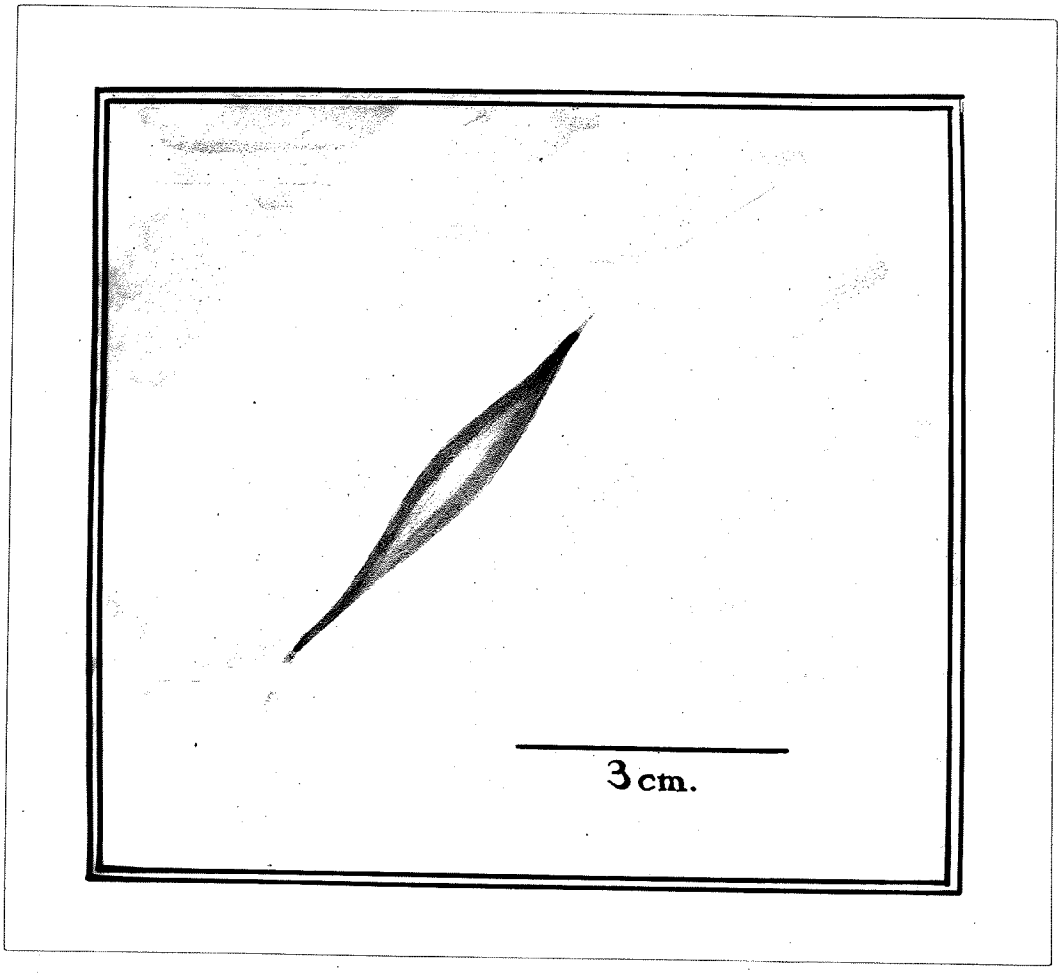
Plate 5.



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.

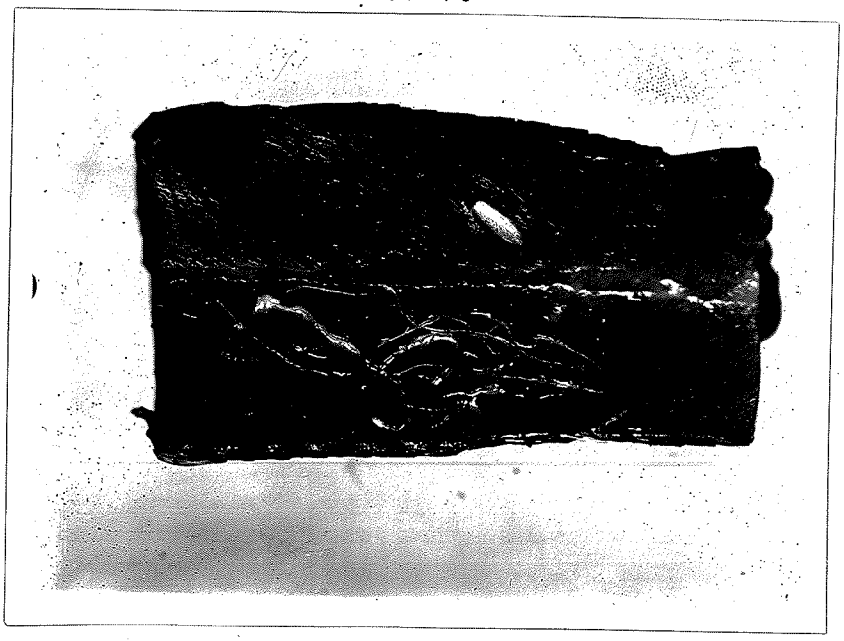
Plate 6.



It may be very much distorted in many cases owing to pressure of other cysts. Many cysts end in a long, hollow, thread-like structure called a cauda. This was referred to by Olsson (1893) and by Cooper (1918) and the suggestion made that it is absorbed as the cyst develops. The size of the cyst bears no relation to the size of the larva within, as in cysts of the same size larvae were extracted varying from 4 to 7 cms. The larvae lie in coils in the cyst surrounded by a yellowish fluid, which appears to be a secretion of the larva. In some cases the fluid appears to have dried up leaving the larvae shrunk and withered, the cyst being then a small sphere about 2 mm. in diameter; in other cases the cyst is found to contain nothing but fluid, no trace of larva being shown.

Plate (7) shows two cysts one unbroken, the other broken to expose the larva and the fluid surrounding it.

Plate 7.



The larval scolex is not definitely orientated with the axis of the cyst; it occurs either at the apex of the cyst or at the centre of the coils. There appears to be no relation between the position of the larvae in the cyst and the stage of larval development. The cyst appears to bring about no pathological lesions upon the surrounding tissue.

The living larva is white in color, the body unsegmented, but deeply wrinkled. The length varies from 10 to 300 mm. and the breadth from .95 to 1.9 mm. The greatest breadth is found to be at the posterior end, which is always indented. The scolex is similar to that of the adult.

Adult Morphology:

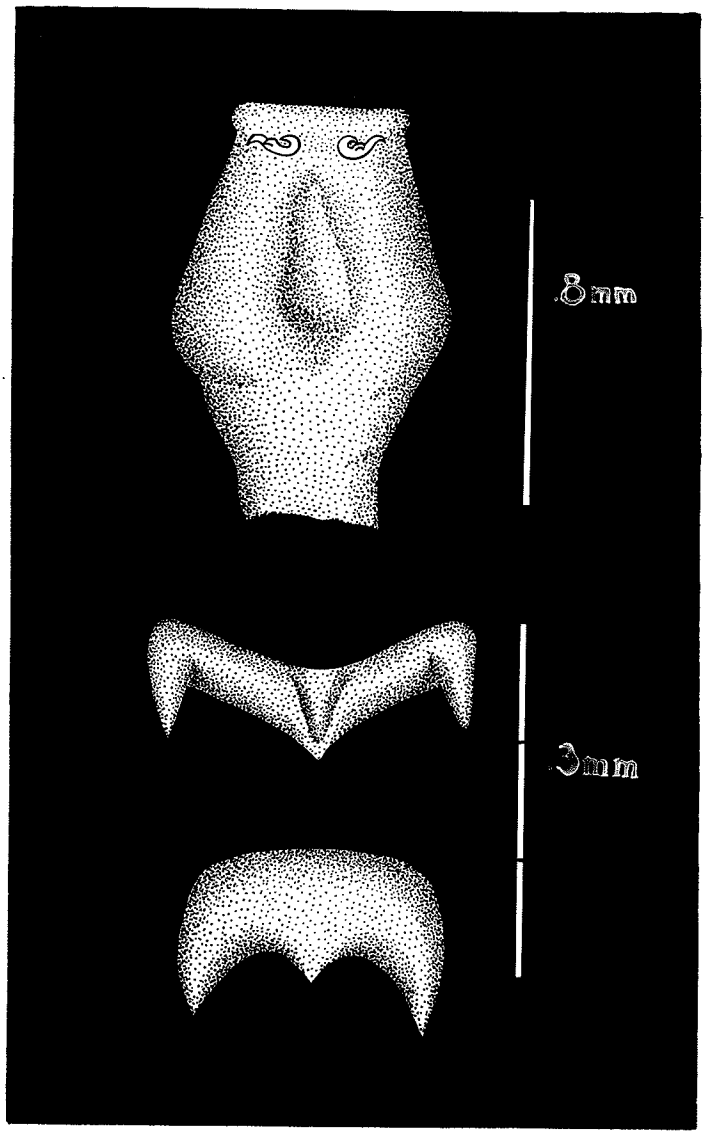
The adult is a medium sized cestode varying in length from 150 to 250 mm. and from 1 to 4 mm. in width. The scolex is in the form of a truncated rectangular pyramid, the terminal disc forming a cap underneath which are the hooks, four in number. In contracted specimens the scolex is demarcated from the strobila by a ring-like thickening; in expanded specimens this does not appear. The bothria are shallow and situated dorsal and ventral, roughly corresponding in outline to that of the scolex. The armature consists of four tricuspidate teeth each at the junction of the terminal disc with the rest of the scolex and at each angle. Each tooth consists of an horizontal bar bearing three curved teeth on its outer surface and a pointed tubercle on its inner surface. The bar and the bases of the teeth are imbedded in the scolex. Two types of armature are present: (a) Bar narrow with a shallow V-curve and the teeth curving outwards, (b) Bar broad without V-curve and teeth not curved. The mean length of the bar is .26 mm. (See plate 8).

The width of the strobila is up to 4 mm. by 1 to 1.25 mm. in thickness, gradually broadening to a maximum width at the posterior end. The cuticle is transversely wrinkled so as to appear pseudo-segmented, acraspedote, an-apolytic, with the posterior segment

extremely indented. The genital pores are marginal, irregularly alternating and separated by a mean distance of .4 mm. The longitudinal muscles are thick and in bundles. The cirrus sac is tubular, one-third the proglottis width, the posterior portion being inclined dorsally. The testes are spherical, 80 to 120 μ in diameter with 200 to 300 per proglottis and are continuous from one proglottis to the next. The vas deferens is strongly coiled, extending to the middle of the proglottis; the withdrawn cirrus is straight. The germarium is irregular in outline, chiefly situated in the poral half of the proglottis. The vagina is dorsal to the cirrus sac but it opens ventral to it. The vitellaria are numerous and situated outside the longitudinal muscle band. They are free dorsally and ventrally by approximately one tenth the proglottis width. They are continuous from one proglottis to the next. The uterus is oval, the uterine pore being surficial and ventral usually median. The eggs are from 60μ in length to 40μ in width. (See plate 9).

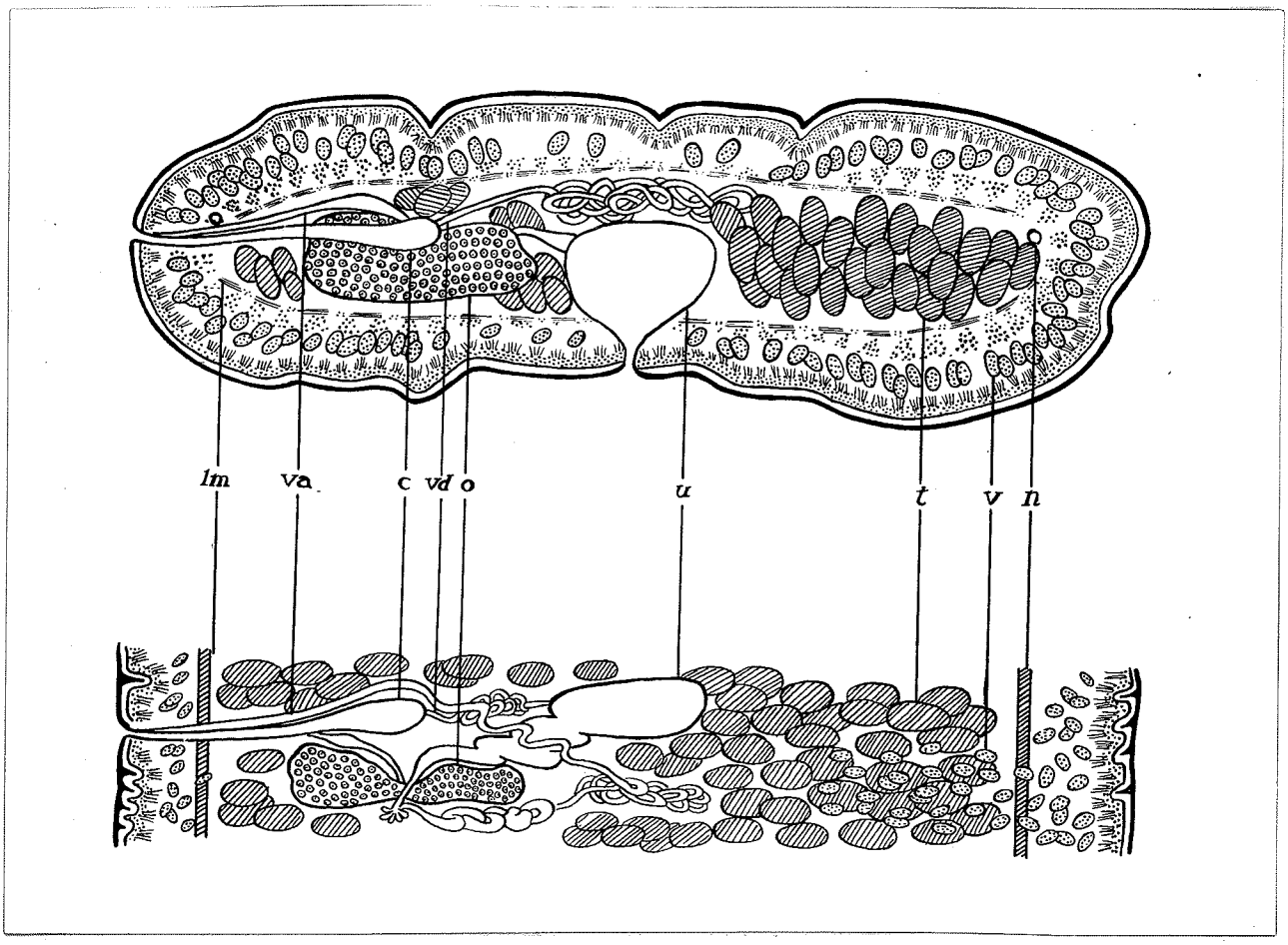
The above description is brief due to the fact that Hjortland (1927) has given a detailed account of both the larval and adult morphology.

Plate 8.



Scolex in upper sketch, types of hooks in lower sketchs.

Plate 9.



lm.: longitudinal muscle.
va.: vagina.
c. : cirrus sac.
vd.: vas deferens.
o. : ovary.
u.: uterus.
t.: testes.
v.: vitellaria.
n.: nerve.

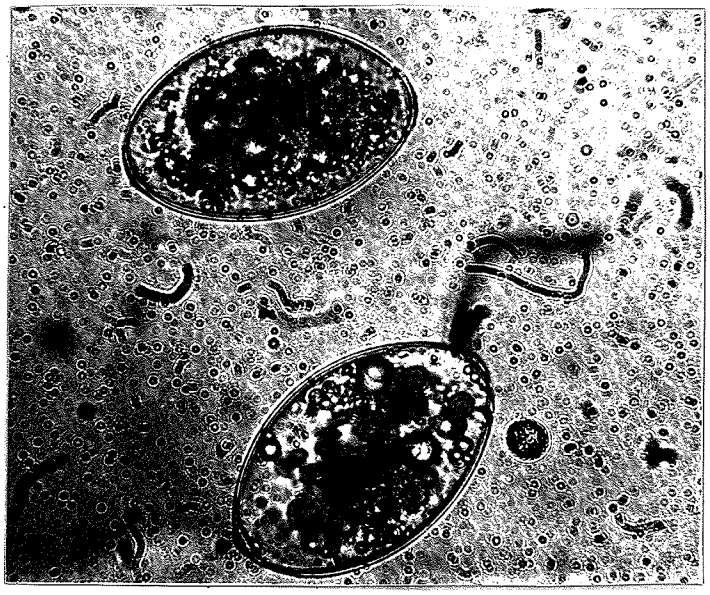
The Life Cycle :

The enteric phase of Triaenophorus tricuspidatus (Bloch) in the intestine of Esox lucius was observed throughout a whole year, weekly samples from Lake Winnipeg fishes being obtained, stained and cleared.

During the period May until August, 1931, no trace of sexual development was apparent, the forms being indistinguishable from the intramuscular plerocercoids. The anlage of the genitalia began to appear in late August and by the middle of November the genitalia were fully developed. Eggs appeared in the uterus in December and mature eggs were finally obtained in early February. These observations do not agree with those of Schauinsland (1886) in Europe, who claims to have found mature specimens of Triaenophorus tricuspidatus (Bloch) in Esox lucius throughout the year. The above observations, however, correspond closely to those of Nybelin (1922).

The eggs are very similar to those of Diphyllobothrium latum but smaller. More opaque yolk is present in the eggs of Triaenophorus tricuspidatus (Bloch) than in those of Diphyllobothrium latum. The lid at the anterior end is quite visible. On the following page is a microphotograph of two eggs, which are 64μ to 65μ in length and 40μ in width.

Plate 10.



Ripe eggs of Triaenophorus tricuspidatus (Bloch). 64μ to 65μ long, 40μ in width.

The ripe eggs were placed in water, along with portions of the mature tapeworm. The coracidia appeared 15 days after the eggs were placed in the water, and continued to appear over a further period of 15 days. These coracidia are extremely small measuring only 6 μ in diameter, they are not globular in shape as in the case of the coracidia of Diphyllobothrium latum, but are more elongated and somewhat pyriform. The posterior portion of the embryo appeared darker but owing to the extremely

small size it was impossible to indentify this darker portion as the hook-bearing region.

Samples of plankton were obtained from Lake Winnipeg on February 20, 1932, and from these Canthocampus sp., Cyclops bicuspidatus Claus, and Limnocalanus macrurus Sars., were obtained. These were placed in small beakers into which numbers of ciliated embryos has been placed. The copepods were examined microscopically daily, yet while both the plankton and the coracidia remained alive for over a month, in no case was an infected copepod found.

Owing to the fact that Limnocalanus macrurus has been found absent in numerous plankton samples taken from Lake Manitoba, and Triaenophorus tricuspidatus (Bloch) absent from the fishes of this lake, it was suspected that this form might prove to be the first intermediate host. For this reason the plankton samples collected for the infection experiment were deep water forms, but as these have proved, so far, to be uninfected, it is doubtful in the author's opinion whether they are the first intermediate host.

It is hoped that further experiments may be conducted with Diaptomus ashlandi Marsh, Diaptomus sicilis Forbes, Epischura lacustris Forbes, Daphnia longispina O. F. Mull, Daphnia longispina O. F. Mull. var. hyalina, Daphnia pulex de Geer and Leptodora kindtii

Focke, all of which are important in the diet of the ciscoes according to an unpublished food survey of ciscoes by Bajkov.

As far as the question of control is concerned, however, the incomplete state of the life cycle, while unfortunate, is not important. It is probable that the first intermediate host is a copepod and it would be impossible to control them in any way.

Discussion:

The wide-spread nature of the distribution of Triaenophorus tricuspidatus (Bloch) in Manitoba is apparent from the survey of the incidence of infection. Very few lakes, from the south of the Province to the extreme north, are free from infection.

The author has talked with Half-breeds and Indians regarding their knowledge of the parasite, and it seems that their acquaintance with the form in Coregonus and Leucichthys sp., extends over many years. They tell of lakes in which their fathers and grandfathers would not fish owing to the presence of the tapeworm. Triaenophorus tricuspidatus (Bloch) thus appears to be long established in Manitoba waters. On the other hand, in 30 years of commercial fishing, there have hitherto been no complaints from the consuming market.

The difficulty of control is intensified by such a well established incidence. The first intermediate host, as previously mentioned, is almost certainly planktonic and crustacean, although as pointed out the four common copepods in the diet of the fishes do not appear to act as hosts. It is probably impossible therefore to control the first intermediate host.

The second intermediate host, Esox lucius is also very common and wide-spread. It is of little commercial value but until recently has been protected during

its spawning season (early spring). This protection was removed upon representation of the investigators. It is practically impossible to eliminate the pike except here and there; a bounty upon the fish would be impracticable.

There is no known method of distinguishing infected ciscoes from uninfected ciscoes without cutting. Unsuccessful experiments were conducted with X-rays and ultraviolet rays; exposed cysts appeared green against a violet background, but unexposed cysts were not visible in the uncut fish.

Numerous experiments with dogs were conducted at the Gimli Biological Station during the summer and fall of 1931. These experiments suggested that mammals cannot act as hosts. Unpublished observations by Wardle indicate that the plerocercoid is killed by temperatures above 25°C and by concentrations of pepsin and hydro chloric acid and of pancreatin and sodium carbonate equivalent to these concentrations in the alimentary tract of the dog. It should be noted that no Triaenophorus tricuspidatus (Bloch) adult has ever been recorded from man or any other mammal, despite the use of ciscoes as food in Western Canada for a long period of time.

The fish are readily sterilised by low temperature exposure (unpublished experiments by Wardle) as when Triaenophorus tricuspidatus (Bloch) encysted larvae were placed in sub zero temperatures between -11° and -2°

Centigrade and exposed for periods varying from a few minutes at -11° to 8 hours at -2°C they were readily killed. The length of exposure, however, required to kill the larvae, is longer when the larvae are imbedded in the uncut fish.

The chief objection to infected fish arises from the fact that in a badly infected fish when smoked, the contents of the cyst may form a white viscous mass over the surface of the fish, but such fish are uaually culled by the smoker, and not placed on the retail market. When infection is not greater than two cysts per fish, in the author's opinion, no objection should be raised to the use of the fish for human consumption.

On the whole, therefore, no definite control measure can be put forward that might be expected seriously to reduce the incidence of infection among the ciscoes.

References:

Bajkov, A. - Fishing Industry and Fisheries Investigations in the Prairie Provinces. Trans. American Fisheries Society, Volume 60. 1930.

Bajkov, A. - Biological Conditions of Manitoba Lakes. Cont. Can. Bio. Fisheries, Vol.V., No. 12. 1929.

Bloch, M.E.- Beschaft. d. Berl. Ges. nat. Frde. Bd. IV. pg. 534-561. Berlin 1779.

Cooper, A.R. - North American Pseudophyllidean Cestodes from Fishes. Ill. Biol. Mon., 4: pg. 369-375. 1918.

Fuhrmann, O. - Triaenophorus robustus Olsson dans les lacs Neuchatel et de Bienne. Bull. Soc. Sc. Nat. Neuchatel, 36: pg. 86-89. 1910.

Hartmannus, Ph. Jac. - Misc. curios sive Ephemeridum Med.-phys. germanicarum Academiae nat. curiosorum. Dec. II. ann. IV, anni 1685. Norimbergaw 1686. Obs. XXIV. pg. 58-59. 1688.

Hjortland, A.L. - On the Structure and Life History of an Adult Triaenophorus robustus. Ill. Biol. Mon. 1927.

Nicholson, D. - Fish tapeworm. Canad. Med. Assoc. J. 1928.

Nybelin, O. - Anatomisch-Systematische Studien uber Pseudophyllideen. 1922.

Olsson, P. - Bidrag till Skandinaviens Helminthfauna. Kongl. sv. Vet. Akad. Handl. Bd. 25 Stockholm. 1893.

Pallas, P.H. - Diss. med. inaug. Lugd. Batav. 1760.

Pallas, P.S. - Neue nord. Beytrage z. physik. und geogr. Erdund Volkerbeschreibung Naturgesch. u. Oeconomie. Petersb. und Lpzg. pg. 39-112. 1781.

Rudolphi, C.A. - Entozoorum sive vermium intestinalium historia naturalis. vol. I. 1808. vol. II. ibid 1809 - 10.

Schauinsland, H. - Die Embryonale Entwicklung der Bothriocephalen, Triaenophorus nodulosus, Zenaische Zeitschrift fur Naturwissenschaft, XIX. 1886.