THE BIOLOGY OF CERCARIAL DERMATITIS.

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During the past 25 years, medical practitioners in Manitoba have been called upon to diagnose and to prescribe treatment for a severe and unusual type of dermatitis which appears on the body surface in the form of large erythematous intensely itchy papules. Other symptoms such as swelling of the affected limbs, headache and general constitutional symptoms vary with the extent of the affection and the individual idiosyncrasies. Nothing of the nature of a micro-organism can be cultivated from extracts of these papules, and the fact that the condition clears up spontaneously in the course of a few days to two weeks, leaves considerable doubt as to the etiology of the disease. Invariably the case-history shows the disease to appear shortly after the patient has been in contact with lake or slough water.

For this reason, various hypotheses have been advanced as to the origin of the disease. Some observers attribute it to the penetration of the pores of the skin by fine particles of sand. Others are of the opinion that it results from contact with poisonous plants growing on the shore, while others ascribe it to an individual hypersensitivity to toxic plant juices in solution in the water. Because of the failure of the disease to readily respond to treatment, such supposedly susceptible people are advised to refrain from further contact with these waters.

Reported cases were not sufficiently numerous in Manitoba to warrant an extensive investigation until the year 1930 when the area surrounding Clear Lake was converted into a national park. The increased number of campers and tourists visiting this resort resulted in a large number of cases of this type of dermatitis. In the year 1933 over 55,000 people visited Clear Lake and a careful census showed that 50% or more of the bathers contracted the disease. During the three summers that followed, although cases did occur, they were somewhat less abundant, but the summer of 1937 witnessed an outbreak equal to, if not surpassing, that of 1933.

At the present time the prevalence of the disease among bathers endangers the popularity of many lake resorts in both Eastern and Western Canada. The death or permanent incapacitation of a single human being from this cause is as yet unknown, but the morbidity rate is so extremely high as to warrant a thorough investigation with a view to the eradication or efficient control of the disease. Also, the awakening interest in the necessity for the conservation of wild life brings to the fore the influence the causal organisms may have on the health and abundance of other animals.

The purpose of the investigation reported herein, therefore, was that of determining the identity of the causal organism or organisms of this so-called "swimmer's itch", its method of development in the water, source of contamination of the water, identity of the carriers, and the distribution of the organisms in Canada, particularly Manitoba. Also, the mode of infection and the pathological condition produced, as well as its influence on the health of other animals. Such information is considered as essential for the recommendation of an effective method of control or eradication.

CLINICAL NOTES AND PATHOGENICITY.

The majority of the cases are found among people who bathe in water six feet or less in depth. Such cases appear to occur more frequently during or after dull rough weather. The seasonal incidence of infestation corresponds roughly with rise in water temperature as the season advances and the maximum follows closely after the water temperature maximum of the season has been reached. As autumn approaches and the weather becomes cooler, cases occur less frequently until around October first they have mostly disappeared. Early cases are rather sporadic and usually appear early in June. Such an estimate is based, not on the absolute number of cases, but the number of infections relative to the number of bathers.

About one person out of six appears to be immune to the disease. Women and children apparently are more susceptible but the disease is also quite common among men. A good many are reinfected each time they enter the water, since an immunity, if ever acquired, requires considerable time.

Almost immediately upon leaving the water a prickling sensation of the skin in the infected areas is experienced. This continues and develops into a severe itching in about four hours. Pronounced urticaria-like papules appear about this time with whitish centres and reddish inflammed marginal wheals. Infection is usually much heavier on the arms and legs but may occur on any part of the body coming in contact with water as the bathing garments do not afford absolute protection. The papules may be in groups or irregularly dispersed in varying numbers. Their dimensions vary mith the individual but are fairly uniform in size on each person. They are usually from 5 to 15 mm. in diameter and from 1 to 4 mm. high (Plate 1, fig's. 1 and 2). A hair follicle is usually present in the central elevation. In cases of heavy infection the papules may lose their identity and the entire region become enormously swollen. Frequently severe headache and general constitutional symptoms accompany heavy infections.

After 24 hours the papules are highly inflammed, of a uniform reddish colour and the itching is severe. Pus is never present unless secondary bacterial infection has been produced by scratching, but in 36 hours edema is evident and a drop of straw colored exudate may be squeezed from each papule. These continue to "weep" for about five days when the area breaks down and a crust forms at the site of the papule. Regeneration then begins and, in the majority of cases, only red macules remain in two weeks time.

Microscopic examination of serial sections of a typical papule of 36 hours shows a definite ragged passage, usually leading from a hair follicle, in an irregular course around through the tela subcutanea (Plate 1, fig's. 3 and 4). Remains of disintegrated cells surround the passage and for some distance on each side the cells are swollen, nuclei are absent and the cytoplasm has lost its characteristic structure, appearing as a uniform jelly-like mass staining orange with eosin. Keratosis is evident in the vicinity and there is a marked loosening of the connective tissue elements. Large numbers of leucocytes, etc; are aggregated in groups close by. Apparently there is little invasion of the surface layers by fibroblasts as visible scars rarely, if ever, are formed at the site of the papule.

HISTORICAL.

A lengthy search in many countries throughout the world for the causal organisms of the so-called cercarial dermatitis, swimmer's itch, or schistosome dermatitis, has led to the incrimination of larval stages of certain _Platyhelminthes_ or flat worms. Those definitely concerned belong to the Family _Schistosomatidae_ or blood flukes of the Class _Trematoda_. In many cases only the larval stages of the organisms are known and for convenience sake these are designated by the general term "Cercaria" in place of the true generic name which can not be given at this time. It is the custom to assign a specific name also but when the connection of the cercaria with the adult stage has been determined, the first specific name given takes precedence over the other.

The origin of the parasitic habit of life in the Schistosomatidae is lost in antiquity. That some species, in the adult stage, have been inhabitants of the blood vessels of man for at least 30 centuries has been proven beyond doubt by Ruffer (1910). The first schistosomatid species was discovered by Rudolphi in 1819 and was of the so-called non-human type, being a parasite of birds. Schistosoma haematobium, the second species recorded, was a true parasite of man and was first discovered by Bilharz in Egypt in 1852. It was first recorded as Distoma haematobium but received its present name from Weinland in 1858. The second schistosomatid of man, S. japonicum, was described by Katsurada in 1904, and a third, S. mansoni, also well known at the present time, by Sambon in 1907. In the interval of time from 1819 to 1912 thirteen species of Schistosomatidae were recorded but at that time nothing was known of the life-histories of the organisms or their method of gaining entrance to the host. It may be noted, however, that in 1896 Looss suggested it might be by active penetration of the skin.

The species recorded during this interval are as follows:

Ornithobilharzia canaliculata (Rudolphi 1819) Odhner 1912, from birds.

Schistosoma haematobium (Bilharz 1852) Weinland 1858, from man.

Schistosoma bovis (Sonsino 1876) Blanchard 1895, from mammals and man (?).

Bilharziella polonica (Kowalewski 1895) Looss 1899, from birds.

Ornithobilharzia kowalewskii (Parona and Ariola 1896) Odhner 1912, from birds.

Dendritobilharzia pulverulenta (Braun 1901) Skrjabin 1924, from birds.

Schistosoma japonicum Katsurada 1904 (S. cattoi Blanchard 1905), from man.

Schistosoma indicum Montgomery 1906, from mammals.

Schistosoma spindalis Montgomery 1906, from mammals, rarely man.

Ornithobilharzia ~~Schistosoma~~ b~~r~~oumfordi (Montgomery 1906) Price 1929, from mammals.

Schistosoma mansoni Sambon 1907, from man.

Gigantobilharzia acotylea Odhner 1910, from birds.

Ornithobilharzia intermedia Odhner 1912, from birds.

In the years 1913-1914, Miyairi and Suzuki demonstrated that in the case of S. japonicum, an asexual reproductive stage is passed through in a molluscan host and the cercarial larva so produced gains entrance to the appropriate warm-blooded host by an active penetration through the body surface. This cleared the way for further work and the chronology of events from then up to the present time is as follows:

Schistosoma japonicum, life-history by Miyairi and Suzuki 1913.

Ornithobilharzia turkestanicum Skrjabin 1913, from birds.

Schistosoma haematobium and *S. mansoni*, life-histories by Leiper 1915.

Austrobilharzia terrigalensis Johnston 1917, from birds.

Schistosoma spindalis, life-history by Soparkar 1918.

Trichobilharzia ocellata (Skrjabin and Zakharow 1920) Brumpt 1931, from birds.

Schistosomatium pathlocopticum Tanabe 1923, from mammals. Life-history by Tanabe 1923.

Ornithobilharzia macrobilharzia (Travassos 1923) Price 1929, from birds.

Ornithobilharzia odhneri Faust 1924, from birds.

Dendritobilharzia loossi Skrjabin 1924, from birds.

Schistosoma incognitum Chandler 1926, from man.

Schistosoma bovis, life-history (?) by Faust 1926.

Pseudobilharziella yokogawai (Oiso 1927) Ejsmont 1931, from birds. Life-history by Oiso 1927.

Ornithobilharzia, 2 sp. Linton 1928, from birds.

Schistosoma matheii LeRaux 1929, from mammals.

Paraschistosomatium anhingae Price 1929, from birds.

Heterobilharzia americana Price 1929, from birds.

Microbilharzia chapini Price 1929, from birds

Pseudobilharziella kowalewskii Ejsmont 1929, from birds.

Schistosomatium douthitti Price 1929, from mammals.

Ornithobilharzia pricei Wetzel 1930, from birds.

Schistosomatium douthitti, life-history by Price 1931.

Schistosoma rodhaini Brumpt 1931, from mammals.

Schistosoma cucassoni Brumpt 1931, from mammals.

Trichobilharzia ocellata, life-history by Brumpt 1931.

Bilharziella polonica, life-history by Brumpt 1931.

Bilharziella margebowiei LeRaux 1933, from mammals.

Microbilharzia manitobensis McLeod 1936, from birds.

Microbilharzia canadensis McLeod 1936, from birds.

Ornithobilharzia lari McLeod 1937, from birds.

Pseudobilharziella querquedula McLeod 1937, from birds.

Ornithobilharzia sp. Young 1937, from birds.

Exclusive of the species reported for the first time in this thesis, this makes a total of 23 species known to infest birds. Of these only three life-histories have been completed and both larval and adult stages definitely determined. There are also

15 species from man or mammals, of which seven life-histories are known. Thirteen of the above species were first recorded from North America and an additional one, Bilharziella polonica, originally described from Poland, has since been found on this continent by Price (1929). The life-histories of only two species originally described from North America are known. They both spend their adult phase in rats and mice, Tanabe (1923), Price (1931).

The medical interest of the three common species of human schistosomatids requires no recounting here as their wide distribution and pathogenic powers are well known. That they have never become established in the United States or Canada may be due to existing sanitary conditions, absence of suitable molluscan hosts, or unfavorable climatic conditions.

In these two countries, as well as in many others, the occurrence of the transitory skin disease of human beings, popularly known as "swimmer's itch", has attracted the attention of many clinicians and biologists and is now widely recognized to be the result of attacks by schistosomatid larvae. No doubt this disease has been casually known for a good many years, even in Canada, but a true causal organism was first associated with it in Michigan by Cort (1928). Since that time a similar or identical disease has been reported from numerous widely separated places throughout the world.

Following the report of Cort's discovery, numerous authentic cases of cercarial dermatitis, that had, no doubt, previously been attributed to the attacks of chiggoes, larval hookworms, various insects, or put down to unknown causes, were recorded. Further notes by the same author (1928a) state that a similar disease had been encountered in many parts of the United States as well as in Haiti and France. In 1928 Christenson and Greene reported cases of cercarial dermatitis from lakes in the vicinity of Minneapolis, Minnesota. Here the causal organism was found to be a schistosomatid larva whose adult stage is, even yet, unknown and which had been tentatively named <u>Cercaria elvae</u> by Miller (1923, 1926).

Matheson (1930) reported an outbreak among bathers at an artificial lake at Cardiff, Wales. He considered a species of furcocercous cercaria to be the causal organism and identified it as <u>Cercaria elvae</u>. Taylor and Baylis (1930) examined similar material from the same lake a short time later and were able to produce a dermatitis in experimental subjects but identified the organisms as <u>Cercaria ocellata</u> La Val. St. George 1855.

Szidat (1930) reported a large number of cases from near Rossitten in East Prussia in which he suspected the larva of Bilharziella polonica but many experimental exposures of susceptible individuals failed to prove that this organism was a dermatitis provoker or would penetrate human skin. Vogel (1930, 1930a, 1932) observed a good many natural infections of what appeared to be cercarial dermatitis in bathers in the Holstein Lake region south of Kiel, Germany. He was successful in producing experimental infections in volunteers with Cercaria ocellata from snails collected in the lakes where natural infections were known to have occurred. He made a careful study of histological sections of an excised papule and also pointed out the similarity of cercarial dermatitis in Germany to the skin eruptions in human beings reported by Nageli (1923) from the Bodensee region in Switzerland.

It must be noted that none of these observers succeeded in identigying the adult phases of the larval parasites concerned. The work of Brumpt (1931, 1931a) in France, on material collected near Paris, not only confirmed the belief that Cercaria ocellata was a dermatitis provoker but also that it was the larval stage of Trichobilharzia ocellata (Skrjabin and Zakharow 1920) Brumpt 1931.

The etiology and epidemiology of cercarial dermatitis need not be discussed at great length here as several complete and detailed summaries are in existence at the present time. Among the most valuable of these are articles by the following investigators: Fülleborn (1932), Szidat and Wigand (1934), La Rue (1935), and Cort (1936, 1936a).

The writer has additional evidence of the occurrence of outbreaks at the following places in the past three years: Bemidji, Minnesota and Auburn, Alabama, U. S. A., Viking and Sylvan Lake, Alberta and Big Bend, Ontario, Canada.

The disease was first reported from Canada by the writer in 1934 and at that time was thought to be confined to Clear Lake, Manitoba. However, information gathered personally during the past four years demonstrates that the causal organisms and their molluscan hosts are common in the majority of prairie lakes and sloughs in Southern Manitoba (Plate 7).

DERMATITIS PROVOKING CERCARIAE

The number of species of larval trematodes that definitely have the potentiality of provoking human dermatitis, at the present time, is rather uncertain. This is to be understood in view of the great difficulty encountered, even by experienced workers, in identifying species. The larvae show very indefinite physiological characters and the tissues exhibit little differentiation from the primitive stem type. Cercariae from a single snail host show a wide variation in size so that metromorphic characters are not to be entirely relied upon. No doubt, what are considered as single species now, in a good many cases will later be found to represent a complex of several species.

Human susceptibility to the penetration of the organisms must also be taken into account. Probably certain cercariae can penetrate the skins of only a susceptible majority of people and probably only a few of those that do penetrate, provoke a sensible skin reaction. This is particularly true of the schistosomatids of man, concerning whose dermatitis provoking powers there is a division of opinion.

A number of investigators have produced evidence both for and against the hypothesis that the cercariae of S. haematobium, S. mansoni and S. japonicum provoke a dermatitis in man. A number of Japanese workers are of the opinion that "kabure", which resembles cercarial dermatitis of the United States, results from attacks by the cercariae of S. japonicum.

Miyagawa (1913), however, maintains that this is not so as "kabure" occurs in regions where schistosomiasis is not present and also that in endemic areas, "kabure" does not result in infestations with adult *S. japonicum*. Faust and Meleney (1924) state that a skin eruption does not occur among rice farmers in China where schistosomiasis is endemic, and Faust, Jones and Hoffman (1934) working in Puerto Rico state that the cercariae of *S. mansoni* do produce a prickling sensation while penetrating the skin but that a dermatitis does not result.

Vogel (1932) found that the cercariae of *S. mansoni* produced a slight dermatitis on the arm of a white subject but not on two negroes exposed in the same manner. Manson-Bahr and Fairley (1920) saw cases of cercarial dermatitis among Arabs in Egypt, Lee (1925) among gypsies in the Yangtse River area in China and Bettencourt and Borges (1922) on the arm of a woman in Portugal. In each case cercariae of human schistosomatids were known to be present in the water with which the individuals had come into contact or were recovered from snails collected from these waters.

Fülleborn (1932) is of the opinion that "kabure" results from the penetration of human skin by non-human schistosomatid cercariae. Cort (1936) is inclined to the view that the cercariae of the so-called human schistosomatids seldom produce a significant dermatitis and that cercarial dermatitis, in by far the majority of cases, is associated with the reaction of an abnormal host to the penetration of a non-specific cercaria. The writer is of the opinion that individual resistance and susceptibility are important factors as the only apparent positive infection obtained experimentally in birds resulted in a dermatitis so severe that the specimen died. It has also been noticed that some exposures of human beings to non-human schistosomatid cercariae are negative while positive cases vary greatly in extent and severity.

It is improbable that the cercariae of all non-human schistosomatid species can produce a dermatitis in man. The nature of the stimulus to which the organisms respond positively is not well known and the morphological characters which determine certain aspects of their behavior are poorly understood. It is not clear how many may be attracted to the human skin but be unable to penetrate it.

At present there are four types of schistosomatid cercariae as regards tactic behavior towards man,

1. Those that do not respond positively to the presence of a human being in water.

2. Those that respond positively but are unable to penetrate the skin.

3. Those that respond positively and penetrate the skin but, owing to lack of balance between the host and parasite, do not advance deeply and thus provoke merely a localised skin reaction.

4. Those that respond positively, penetrate the skin, and eventually make their way to the portal vein and its branches where sexual maturity is reached. In this case, as already stated, it is thought by many that frequently no skin reaction occurs.

From the information available it can be assumed that only the cercariae of the five schistosomatid species of man belong to group 4. A good many known species may belong to group 1. or 2. but at the present time only six species of the non-human schistosomatid cercariae, with a possible seventh, can definitely be placed in group 3. It is possible that more species of these may, in the future, be classed in group 3. as a schistosomatid dermatitis is known in several localities where the causal organism has not been definitely identified, or the organism erroneously identified as one of the six so-called dermatitis provokers.

Those definitely known to provoke a dermatitis are as follows:

Cercaria elvae Miller 1923.

Cercaria douthitti Cort 1915.

Cercaria stagnicolae Talbot 1936.

Cercaria physellae Talbot 1936.

Cercaria ocellata (La Va. St. George 1855) Ssinitzin 1909.

Cercaria pseudocellata Szidat 1933.

The fact that all known life-histories of *Schistosomatidae* are identical, namely- egg- miracidium- sporocyst- daughter sporocyst- cercaria and adult; and that the intermediate hosts are closely related, also that the differentiation of body tissue is not pronounced, makes possible a great deal of error in their identification. This is particularly true in the case of the cercariae where the most outstanding characters are larval ones, and the anlage of adult structures are not specific. Nor can the phenomena of host specificity and physiological behavior be entirely relied upon as a basis for identification.

The development of the sporocysts or rediae of one species of trematode in the digestive gland of a mollusc lowers the resistance of the host to the invasion of miracidia of other species as shown by

Cort, Brackett and MacMullen (1937). This permits the simultaneous development of two or more species of cercariae in the same host. The constant occurrence of mixed cultures of cercariae, in the case of dermatitis production, increases the difficulty of identifying the true causal organism and has lead to a number of errors. In the description of new species of cercariae, the occurrence of mixed cultures greatly increases the difficulties and accounts for many mistakes.

Such a condition has, in the past, led the writer into the serious error of incorrectly describing a new species, recorded as Cercaria bajkovi McLeod 1934. The difficulty was not that a new species did not exist, but that the characters of two new species were confounded and the description corresponds with neither. Both species have since been described by Cort and Brackett (1937) and hence Cercaria bajkovi becomes an invalid species. Similarly the unnoticed production of small numbers of C. stagnicolae simultaneously with C. wardlei from the same snail, led the writer to assume that C. wardlei was a dermatitis provoker. Although the possibility has not been entirely ruled out by any means, the work has been carefully rechecked a number of times and at present it appears that C. wardlei is not a dermatitis provoker. However, again this work requires confirmation.

All the cercariae definitely known to be schistosomatid larvae were, until 1927, of the apharyngeal brevifurcate type, and a number whose life-histories have been studied since then are also of this type. Consequently all apharyngeal brevifurcate cercariae have been considered as schistosomatid larvae. According to the report of Oiso (1927), another type of cercariae, ie. a longifurcate-pharyngeal cercaria, may occur among the Schistosomatidae. This is in direct contrast to the observations of other workers, and two possibilities are open. Either Oiso was mistaken, though we have little reason to doubt his accuracy, or some of the schistosomatid cercariae are of the longifurcate pharyngeal type.

From our present knowledge of the morphology, behavior, and life-histories of furcocercous cercariae, a number of assumptions can be drawn. In the work reported herein, the writer has followed these but, at the same time, borne in mind the facts as pointed out by La Rue (1926), that although a large number of cercariae show striking morphological resemblances, the legitimacy of a species can only be established definitely when all the life-history stages are known in detail. Further, the absence of pronounced secondary host specificity may result in the production of larval morphae of certain parasites which are sufficiently unlike to appear as distinct species, Wardle (1932).

PROCEDURE

At the outset of the investigation in 1933, nothing was known regarding swimmer's itch in Manitoba except that it was very prevalent at Clear Lake, that a fork-tailed organism had been found in the water, that copper sulphate treatment of the water has been attempted, and that the symptoms of the disease corresponded very closely with those of cercarial dermatitis reported from other regions.

The following lines of investigation were open and, wherever possible, were carried out concurrently in an effort to gain sufficient information that an effective method of control or eradication might be suggested:

1. An identification of the causal organisms and other similar and concurrently occurring organisms, also a survey of their distribution throughout the Province.

2. An identification of molluscan hosts and a study

of their distribution and ecology.

3. An examination of suspected wild mammals in an effort to locate the primary host, and an exposure of laboratory mammals to the cercariae involved to experimentally elucidate the life-cycle and obtain adult stages.

4. An examination of suspected wild birds and exposure of experimental birds to cercarial stages.

5. A study of the pathology, symptomatology, and epidemiology of the disease.

A survey of the pelagic fauna of Clear Lake was first undertaken by using a fine plankton net towed at various depths behind a boat in the vicinity of the bathing beach. The lower layers failed to yield anything of great significance but the upper layer, of about one foot in depth, provided potentially pathogenetic organisms in the form of the furcocercous cercariae that are discussed later. The molluscan fauna of Clear Lake was then surveyed by shore collection and by using an Eckman dredge. The various species of Mollusca thus obtained were examined microscopically for cercarial parasites.

Each species of cercaria was obtained in as pure a culture as possible and susceptible animals and human beings were exposed to them in order to ascertain their dermatitis provocating potentialities.

The search for cercariae and their molluscan hosts was extended to other parts of Manitoba and the incidence of infestation in various localities was recorded from week to week where possible and from year to year. The habitats were roughly studied as regards temperature, vegetation, depth and extent of the water, pH, etc:

Water-frequenting birds and mammals were collected from as many districts as possible and autopsied for adult schistosomatids. Faeces of a number of mammals, not otherwise examined, were examined microscopically for schistosomatid eggs. Young, parasite-free, birds and mammals of several species were exposed in the laboratory to pure cultures of cercariae and later autopsied at intervals, up to six weeks after exposure, in a search for adult Schistosomatidae.

EXPERIMENTAL METHODS

Snails were kept singly in tap water overnight in wide mouthed bottles to determine the extent of infestation and the rate of escape of cercariae. Others were dissected to check the accuracy of the previous method and to obtain sporocyst stages. In the majority of cases cercariae can be detected in the surrounding water if it is examined macroscopically by reflected light against a slightly luminous background. However, if only a few cercariae be present the water should be examined with a binocular microscope before being pronounced negative.

Hot 10% formalin solution or 70% alcohol are suitable fixatives for all larval stages. Specimens so fixed, can then be stained with haematoxylin and eosin stains and mounted in Canada balsm or cleared directly from 70% alcohol in glycerine and mounted unstained in glycerol jelly. Such mounted specimens are only of value in obtaining measurements and with any technique, the dimensional variations are such that large numbers must be measured if the results are to approach a true mean.

The identification of all morphological a nd physiological characters must be made on living material. A study of both undisturbed and agitated jars should be made under a binocular microscope to determine the resting position assumed by the organisms, the length of the resting period, and the tropisms shown when their position, relative to the source of light, etc; has been changed.

For the examination of living material under a monocular microscope, an intra vitam stain is necessary. Neutral red and Nile blue sulphate were found the most suitable for this purpose and gave their best results when a drop of each was added to 20 cc. of a thick infusion of cercariae in a shallow dish and allowed to act for one minute before the mounts were made. In addition to being specific for certain structures, these stains also act as partial anaesthetics and reduce the activities of the organisms considerably. Some of the active swimmers, such as C. wardlei, require an additional anaesthetic substance. One drop of saturated chloretone solution in 30% alcohol was tried with fair results but a similar amount of saturated aqueous solution of urethane was found to be more suitable and did not interfere with the activity of the flame cells.

The examination of mammals and birds for adult schistosomatids should be carried out as soon as possible after death, as blood coagulation greatly increases the probability of overlooking some of the small filamentous forms and, under some conditions, makes their recovery impossible. This is particularly true in the case of birds in late autumn when the coagulation time of the blood appears to be shorter and the small worms can not be extricated intact from the tough coagula.

The usual procedure was to remove the ventral wall of the body and spray the organs lightly from time to time with a warm, 2% aqueous solution of sodium oxalate. This prevented desiccation, excessive lowering of temperature, and clotting of blood when a vessel was opened. The blood vessels of the mesenteries were then examined under a bright light by stretching a small portion at a time, or the larger vessels were ligated and the entire mesentery with vessels, liver and heart were transferred to a shallow dish of warm sodium oxalate solution. These were then examined under a lens.

Bouin's picro-formol or corrosive-acetic solutions were used as fixatives for adult worms with about equal results. A combination of 1 part Delafield's haematoxylin and 3 parts alum-cochineal was the most satisfactory stain. Two to three minutes was sufficient staining time as prolonged destaining ruined the contrast. Dehydration was carried out by means of a series of jars and capillary tubes. Specimens were cleared in wintergreen oil or beechwood creosote and mounted in gum damar. Wintergreen oil clears quite rapidly but makes the specimens very brittle, so that filamentour forms frequently break up in mounting.

An attempt was made to culture *Pseudobilharziella querquedulae* according to the method of Lee and Chu (1935). Sterile sheep serum was the culture medium used but twelve hours was the longest period during which they could be maintained alive. Specimens were removed from the host blood vessels in the field and placed in the culture tubes but at least an hour always elapsed before they could be placed in an incubator. It is not known whether the lowering of the temperature during this interval or the unsuitability of the culture medium was responsible for the poor results obtained.

It was necessary to carry out a good many experiments to prove definitely that "swimmer's itch" is caused by trematode cercariae and not some other organism. Also to establish which so-called species are capable of producing this condition in man and which species are harmless. This was best carried out by taking two portions of a water sample and placing each in a small aquarium or battery jar. To one was added a thick infusion of a single species of cercariae obtained by isolating an infested snail in a jar of water overnight. A portion of the body, such as the fore-arm, of an individual was then immersed in the water of each jar and allowed to remain for a few minutes.

In susceptible individuals, exposure for a period of fifteen minutes or slightly less was sufficient to produce an infection. It was found that penetration is more rapid if the arm is removed from the water periodically and allowed to become almost dry before being returned than if it is exposed continuously for the same length of time. Apparently the cercariae, in the film of water adhering to the arm, are brought into closer contact with the tissue than they would otherwise be and the surface tension of the shrinking film assist them in penetrating the skin. The condition of the two arms was carefully noted for several days following and if a positive infection was obtained on the one exposed to the cercariae, the condition was compared with that found in natural infections. A number of experimental infections were examined by medical authorities and pronounced identical with natural infections.

An alternate method of exposure is to place a drop of water containing a number of cercariae of the desired species on the skin and allow it to dry slowly. In this way the activity of the organisms can be ovserved under a microscope by reflected light. However, because of their small size and lack of colour, the cercariae are difficult to see unless the skin has first been tinged with a stain such as methylene blue.

Exposure of experimental animals was carried out in much the same manner. Specimens were repeatedly placed in a small aquarium jar containing several inches of water with snails and large numbers of freshly produced cercariae of a single species. Normally each specimen drank a quantity of the water and, in the case of ducks, several infested snails were eaten. A number of injections of about 5 cc. of a thick infusion of cercariae were made into both wild and domestic ducklings, either subcutaneously, intravenously, or intraperitoneally. Infusions in both water and physiological saline were used and the injection made by means of a coarse hypodermic needle and syringe. Such injections can be safely carried out because of the remarkably high resistance of ducks to the attacks of any pyogenic bacteria that might be present.

CERCARIAE CONCERNED IN CERCARIAL DERMATITIS IN MANITOBA.

The term cercaria refers more particularly to the free-living stage of a trematode, which in the life-history, follows directly after the sporocyst or redia stages. The sporocyst or redia stages occur almost invariably in the "digestive glands" of gastropod molluscs, there being only one exception known in which a marine annelid is involved. Because of the relative abundance of the cercariae and the ease with which they can be collected along with the molluscan host, in many cases, this is the only stage of the organism that is known.

These various cercariae can be roughly arranged in morphological groups depending on the characters of the body, suckers, tail, exretory system, etc. It has been the custom to carry this practice even farther and where sufficient distinct characters were constantly exhibited, to describe it as a species. In such a case it is impossible to assign the true generic name as the genus is determined by the nature of the adult characters. A tentative specific name is normally given and this, coupled with the term "Cercaria", is used to designate the organism until the adult stage has been found and assigned a generic and specific name. In the case where both larval and adult stages have been named, but the connection between the two not previously known, the first given specific name then takes precedence.

Such a practice, although not strictly in accordance with the rules on nomenclature, does serve a useful purpose in dealing with larval stages and is without any very objectionable feature unless carried to excess. The question of what constitutes a true larval species is still very much open to question. In the discussion of larval stages which follows the general custom regarding names is adhered to.

Key for the identification of Manitoba furcocercous cercariae.

Apharyngeal brevifurcate cercariae--------------1.

Pharyngeal longifurcate cercariae--------------2.

1. Body length about 300 μ, tail stem 400μ, furca 255μ; host, Lymnaea stagnalis---Cercaria elvae.

Body length about 260μ, tail stem 395μ, furca 229μ; host, Stagnicola emarginata----Cercaria stagnicolae.

Body length about 288μ, tail stem 312μ, furca 237μ; host, Stagnicola palustris---Cercaria sp.

2. Oral sucker and acetabulum both present--------3.

Oral sucker present, acetabulum lacking---Cercaria of Crassiphiala amblopitis.

3. Tail stem musculature not exhibiting definite striations, cercaria of medium size----------4.

Tail stem musculature exhibiting definite striations, cercaria of large size; from Stagnicola emarginata, -------------------------------Cercaria wardlei.

4. Tail stem straight when the organism is in the resting position--------------------------------5.

Anterior end of tail stem and body strongly flexed laterally when in resting position---Cercaria of *Diplostomum flexicaudum*.

5. Penetration glands posterior to the acetabulum--6.

Penetration glands anterior to the acetabulum-------------------Cercaria of *Cotylurus flabelliformis*.

6. Cercariae of medium size with elongate bodies--7.

Cercaria of small size with stout oval body and short tail; from *Heliosoma trivolvis*------------ *Cercaria burti*.

7. Intestinal ceca well developed; pigment spots absent-----------------------*Cercaria yogena*.

Intestinal ceca rudimentary; large pigment spots present anterior to acetabulum------*Cercaria dohema*.

Cercaria elvae Miller 1923.

Specific diagnosis. Apharyngeal, furcocercous cercariae with a prominent pair of pigmented eyespots. Entire body and tail uniformly spined. Body fusiform with greatest diameter in the region of the acetabulum. Average measurements are roughly as follows: Body about 300μ by 65μ. The acetabulum is about 35μ in diameter and is located 110μ from the posterior end. Tail stem about 400μ long by 45μ in width. Furcae about 255μ . There is a dorso-ventral furcal fin fold present. Five pairs of penetration glands are present, two being circumacetabular in position and three pairs postacetabular. These open at the anterior end just lateral on the oral sucker by means of five pairs of fine ducts, the openings of which are located on fine spines. Both the oral sucker and acetabulum are quite protrusible. Digestive system consists of a tubular oesophagus which branches in the region of the eye spots into two short caeca. Excretory system is composed of seven pairs of flame cells. In each lateral half there are three anterior to the acetabulum, three posterior and one in the tail stem.

Host: *Lymnaea stagnalis jugularis* Say.

Cercaria stagnicolae Talbot 1936.

Specific diagnosis: Apharyngeal, brevifurcate cercaria with a prominent pair of pigmented eyespots. Entire body and tail uniformly spined. Body fusiform with the greatest lateral diameter in the region of the acetabulum. Average measurements are roughly as follows: Body about 260μ by 60μ . The acetabulum is about 30μ in diameter and is situated 60μ from the posterior end of the body. Tail stem 395μ by 40μ . Furcae about 229μ in length. Dorso-ventral furcal fin fold present. Five paris of penetration glands are present, two being granular and circum-acetabular in position while the other three pairs are post-acetabular in position. These open at the anterior end just lateral on the oral sucker by means of five pairs of fine ducts, the openings of which are located on fine spines. Digestive system consists of a tubular oesophagus which branches in the region of the eyespots into two short caeca. Excretory system is composed of seven pairs of flame cells and their ducts. In each lateral half there are three anterior to the acetabulum, three posterior and one in the tail stem.

Host: Stagnicola emarginata Canadensis Somerby.

The above species, along with C. physellae Talbot 1936, were considered to be cospecific for a good many years until separated by Talbot in 1936. All three are morphologically identical but have different snail hosts and according to Talbot (1936) and Cort and Talbot (1936) show slight differences in metromorphic characters and also in their behavior in the water. All have the same time of emergence from the snail host, namely 4.30 to 8.00 A. M. C. elvae is positively phototactic and in the resting position attaches itself to the wall of the container by means of the suckers and assumes a characteristic shape. The body is arched and the tail is bent at an acute angle over the back in the form of a hook with the furcae turned away from the body, and when in this position the furcae are always crossed.

Cercaria stagnicolae, according to the same authors, is also positively phototactic and hangs suspended from the surface of the water in the region of greatest light intensity. In this case the body and tail stem are extended and rigid and the furcae are widely separated. They do not, however, attach themselves to the side of the glass.

While the original Cercaria elvae Miller 1923, undoubtedly represents a species-complex, the writer has experienced great difficulty in separating these morphologically identical forms. Normally there is a greater variation in size between the specimens from a single snail species than in specimens from different snail hosts. A good many batches of cercariae have been examined from both Lymnaea stagnalis and Stagnicola emarginata and only on three occasions did the writer observe any fundamental difference in behavior. In these cases the characteristic resting position of C. elvae was observed. No doubt variations in water temperature, pH, concentration of dissolved salts, and the age of the organisms will produce slight variations in behavior.

Cercaria sp. Give specific name, R.

In addition to the two above species, what is considered by the writer as a third species of apharyngeal brevifurcate cercaria occurs in Manitoba and the molluscan host is *Stagnicola palustris elodes*. It is morphologically identical with the other three species described by Talbot and is approximately the same size but differs somewhat in relative body measurements. It resembles more closely *C. stagnicolae* Talbot but the body is longer being on the average 288μ, and the tail stem is shorter being only 312μ. In its behavior it resembles *C. stagnicolae* but is a slow sluggish swimmer and some minor differences can be detected when the two are compared either in the fixed or living condition. It has less tendency to bend the body ventrad so that very frequently dorso-ventral mounts can be obtained. To the author's knowledge no other schistosomatid type of cercaria has been recorded from *S. palustris* except *C. douthitti* and, in view of the fact that at least six species of adult schistosomatids occur here in Manitoba, this might reasonably belong to a separate species. However, the completion of more life-history work will clear up the doubt regarding both this and the other species.

In Manitoba, the above organism is the most common, the most widely distributed and also the most potent of the dermatitis producers. Larger numbers of these can penetrate the human skin in a given time than either of the other species, articles of clothing such as bathing suits or woollen socks offer less resistance to it and it is more virulent once entrance to the skin has been affected.

The sporocysts in which the cercariae are produced are small motile tubules of fairly uniform diameter and have a small sub-terminal birth pore at one end. These are usually found in large numbers in the digestive gland of the snail host (Plate 3, Figure 1 & 2) and have the general appearance of fungus hyphae. When the shell has been dissected from the snail the free ends of the sporocysts constantly wave to and fro, apparently due to the mass movement of the cercariae back and forth.

The greatest number of cercariae escape during the early morning hours as previously stated, but agitation materially increases the rate of liberation. This, along with increased light no doubt accounts for their super-normal abundance following dull rough weather. Under ordinary conditions the extent of infestation of the snail is quite heavy and, in the case of specimens observed in the laboratory, the output is quite high.

Eight specimens of <u>Stagnicolia emarginata</u> placed in 500 c.c. of pure water over night liberated 15,875 cercariae. Escape from snails that have recently died is common and the numbers so liberated frequently equal or surpass the normal maximum.

<u>Other Furcocercous Cercariae Occurring in Manitoba.</u>

In addition to the three species mentioned, there occur in Manitoba several species of longifurcate cercariae of the pharyngeal type. They are widely distributed and quite abundant. A good many utilize the same snail host as the brevifurcate forms and are frequently found in conjunction with them. Double or even quadruple infestation being occassionally encountered. The ones definitely identified are as follows:

Cercaria of <u>Dipolostomum flexicaudum</u> Van Haitsma 1931 (<u>Cercaria flexicauda</u> Cort and Brooks 1928)

A longifurcate pharyngeal distome cercaria of medium size, the average measurements being as follows: body length 170 μ, and width 54 μ; length of tail stem 254 and width 36 μ; length of furcae 226 μ; the body is elliptical in shape and is always somewhat shorter than the tail-stem. There is a well developed anterior organ with an average length of about 50 μ. It is surrounded by a prominent band of spines and in the circumoral spineless area there is a group of about ten anteriorly directed spines dorsal to the mouth aperture. The body spines are arranged in definite separate rows about eighteen in number encircling the body. The ventral sucker is just posterior to the mid-body region and measures about 35μ in diameter, it bears two rings of minute spine. A distinct pharynx is present and the esophagus branches in front of the ventral sucker into two blind ceca which terminate near the hinder end.

Four comparatively large penetration glands are located back of the ventral sucker and fill the spaces between the intestinal ceca back to the group of cells which form the primordium of the genital organs. The tail-stem has extending from it a number of long fine hair-like filaments. It contains numerous caudal bodies which vary considerably in size, shape, and number. The excretory system consists of eight pairs of flame cells with their tubules. In each lateral half there are three anterior to the ventral sucker, three posterior, and two in the tail-stem behind the mid-region.

This species can be easily identified in the water. The resting periods are long, during which time the organism hangs suspended from the surface with the furcae widely spread and with the anterior fourth of the tail-stem bent sharply so that this portion and the body form an angle with the remainder. The swimming periods are short and motion rapid, spiral, and in a vertical direction.

Hosts: Lymnaea stagnalis jugularis; Stagnicola emarginata canadensis.

Cercaria of Cotylurus flabelliformis (Faust 1917) Van Haitsma 1931 (Cerdaria douglasi(Cort 1917) Cort and Brooks 1928.)

A rather large longifurcate pharyngeal distome cercaria. The average measurements being as follows: body about 170μ long by 58μ wide: tail-stem about 220μ by 38μ and the furcae about 235μ in length. The anterior organ has a length of about 40μ and a width of 30μ . The acetabulum is situated just posterior to the mid-body region and measures about 30μ in diameter. The body is elliptical in shape and bears a ring-like mass of spines around the anterior end. In the circumoral spineless area, dorsal to the mouth, is a group of about 18 forwardly directed spines. The remainder of the body and furcae are lightly spined. The tail-stem bears about six pairs of long lateral filaments. On the dorsal surface, anterior to the mid-body region is a pair of unpigmented eyespots. The mouth aperture is sub-terminal and the esophagus branches in front of the acetabulum into two indistinct ceca which terminate near the genital primordium. Two pairs of small penetration glands are situated anterior and lateral to the acetabulum and connect by means of fine ducts with openings lateral to the mouth. The excretory system is composed of ten pairs of flame cells and their ducts. In each lateral half they are disposed in groups, four being anterior to the acetabulum, four posterior to the acetabulum and two in the tail-stem close to its junction with the body. There is a commissural connecting vessel between the two collecting tubules just posterior to the acetabulum. Definite caudal bodies are absent in the tail-stem.

The free organisms are almost constant swimmers in the water and follow a spiral course, being capable of swimming backward or forward. They have a tendency to remain near the bottom of the water but during short resting periods near the surface they hang with the body straight down and the furcae widely separated.

Host: Stagnicola emarginata canadensis. Stagnicola palustris elodes.

Cercaria yogena Cort and Brackett 1937

A small longifurcate distome cercaria with the body shorter than the tail stem and furcae almost equal in length to the tail stem. The average measurements are approximately as follows: body about 170 μ long by about 41 μ wide, tail stem 236 μ long by 36 μ wide, furcae 220 μ long. The ventral sucker is situated just back of the midbody region and is about 23 μ in diameter. The anterior end bears a band of about seven rings of prominent spines, posterior to this down to the hinder margin of the ventral sucker spination is in the form of nine rather definite rings. In the hinder body region the spination is uniformly dispersed. In the circumoral spineless area, dorsal to the mouth aperture is located a group of about twelve anteriorly directed spines. The pharynx is prominent and the esophagus branches just anterior to the ventral sucker into two ceca of moderate length. Two pairs of penetration glands are situated posterior to the ventral sucker and their ducts open lateral and dorsal to the mouth. The excretory system is composed of eight pairs of flame cells and their tubules. In each half of the body they are disposed into two groups. The anterior group of three has two flame cells in the pharyngeal region and one posterior to the ventral sucker. The posterior group of three is situated close to the hinder end. There are two pairs in the tail stem being uniformly spaced in the second and third quarters. Eyespots are absent but a variable number of yellow pigment granules are found between the ventral sucker and the anterior end, usually being more abundant near the ventral sucker.

These cercariae are active swimmers, the swimming periods being relatively long and during which time they migrate in all directions through the water. The resting periods are moderately short and the organisms hang from the surface at different angles. The furcae are moderately diverged and the preacetabular region of the body is bent slightly ventrad. Normally in the resting position or frequently under a cover glass there is a prominent constriction behind the acetabulum and the preacetabular portion shows annulations.

Host: Stagnicola emarginata canadensis, and Stagnicola plaustris elodes.

Cercaria dohema Cort and Brackett 1937.

Longifurcate pharyngeal distome cercariae with the body length and width about equal to that of the tail stem, and the furcae longer than the tail stem. The average measurements are as follows: body length about 155μ, width about 40μ. The tail stem is about 180μ with a width equal to that of body. The furcae measured 195μ in length. The anterior organ has a length of 40μ and a width of 29μ. The acetabulum is posterior to the middle of the body and is about 20μ in diameter. The circumoral spineless area bears a group of twelve anteriorly directed spines dorsal to the mouth. This area is surrounded by a band of several rows of prominent spines and posterior to this is a wider band which is less densely spined. The remainder of the body is naked. The esophagus is short and branches at the junction of the first and second thirds of the body into two rudimentary globular ceca. There are three pairs of small penetration glands posterior to the acetabulum. The excretory system is composed of five pairs of flame cells and their collecting tubules. In each lateral half there is an anterior group of two, a posterior group of two and one in the tail stem close to its anterior end. The main collecting tubules in the body have a transverse commissural connection just posterior to the acetabulum. Eyespots are absent but two large irregular bodies are present anterior to the acetabulum. The tail stem contains six pairs of prominent caudal bodies.

The organisms swim almost constantly in the water and are rather erratic, travelling in almost any direction. Resting periods are infrequent but during this time the organisms may be found in any stratum and hanging with the furcae widely diverged.

Host: Lymnaea stagnalis jugularis, Stagnicola emarginata canadensis.

Cercaria of <u>Crassiphiala ambloplitis</u> Hunter 1927 (<u>Cercaria bessiae</u> Cort and Brooks 1928.)

A longifurcate monostome pharyngeal cercaria with unpigmented eyespots and a very short rudimentary digestive system. In a free condition in the water the organisms are seen in greatest numbers in the resting position just below the surface with the furcae uppermost and diverged at an angle of slightly over 90 degrees. The tail stem is well extended and straight while the body, which is somewhat broader, has its anterior one-third flexed tightly ventrad. The active swimming periods are short, in which time the organism, by rapid vibrations of the tail, travels upward a short distance to the surface following a spiral course.

The average measurements of ten specimens fixed in hot 70% alcohol and mounted in glycerol jelly are as follows: Body 216μ by 41μ ; tail-stem 248μ by 31μ ; furcae 213μ . The anterior organ measures about 49μ in length and 30μ in width. The sides of the body are almost parallel. The following differences in measurements were noted between the smallest and the largest specimens examined:- body length 32μ , width 4μ , tail-stem length 15μ but of constant width, furcae length 10μ .

The anterior one-third of the body is lightly spined and a pair of unpigmented eyespots is present, one on either side just in front of the middle of the body. An acetabulum is absent but the oral sucker is well developed and heavily spined. A group of about twelve forward pointing spines is present dorsal to the mouth in the circumoral spineless area. There is a short prepharynx opening into a well defined pharynx but the digestive canal terminates as an unbranched tube a short distance posterior to the pharynx. Three pairs of penetration glands are present, arranged in two longitudinal rows in the posterior part of the body with their ducts running forward to open lateral to the mouth.

The flame cells of the excretory system of the body consists of six pairs, disposed in each lateral half into an anterior group of two and a posterior group of four. The anterior two lie just anterio-lateral and posterio-lateral to the pharynx while the posterior four are evenly spaced in the posterior half of the body. Two pairs are present in the tail-stem a short distance from its anterior end. The tail-stem bears 7-8 pairs of fine lateral filaments but caudal bodies are absent.

The above species resembles in many respects both C. hamata Miller 1923 and C. bessiae Cort and Brooks 1928. It differs from C. hamata in having only six pairs of flame cells in the body; in the presence of unpigmented eyespots and the absence of caudal bodies. It is identical with *C. bessiae* as described by Cort and Brooks except for minor differences in metromorphic characters. These differences may easily be due to the different fixing and mounting techniques employed and the writer feels justified in assuming this species to be *C. bessiae*. Since the time this cercaria was first recorded the entire life-history of the organism has been worked out by Hunter (1935) and it is now more correctly known as the cercarial stage of the strigeid trematode, *Crassiphiala ambloplitis* Hunter 1927, of the subfamily *Polycotylinae* Monticelli 1892.

Host: *Heliosoma (Planorbis) trivolvis*.

Cercaria burti Miller 1923.

A very small pharyngeal longifurcate cercaria with an elliptical body somewhat broader than the tail-stem. In the free condition in the water these cercariae are not very active and are usually found suspended body downward and the furcae widely diverged just below the water surface. However, they may also be found resting horizontally on the substratum. The swimming periods are short and in these the motion is rapid and in a short spiral, the tail always preceding the body.

The average measurements of ten specimens fixed in hot 70% alcohol and mounted in glycerol jelly are as follows: Body 122μ by 43μ ; tail-stem 114μ by 30μ ;

furcae 118μ. The anterior organ has a length of 30μ while the acetabulum is 22μ in diameter and has a distance of 43μ between its posterior margin and posterior end of the body. The specimens were very uniform in size and the variation between the largest and smallest was only 18μ in body length, 4μ in width; 4μ in tail-stem length and 7μ in furcal length.

The acetabulum is well developed and almost circular in outline but is not protrusible. The unpigmented eyespots lie slightly anterior to the acetabulum and the anterior half of the body surface is lightly spined. The oral sucker is moderately well developed and there is a short prepharynx, a muscular pharynx and a short esophagus. The intestinal ceca are not large and end just posterior to the acetabulum. The two transverse rows of penetration glands of four each lie just posterior to the acetabulum, their ducts passing forward and opening dorsal and lateral to the mouth.

The tail-stem is broad and straight and has about six pairs of fine hair-like lateral filaments. About eight pairs of well-defined caudal bodies are present and there are 30-35 nuclei in a row along each side. The excretory system consists of seven pairs of flame cells, disposed in each lateral half into two anterior ones in the vicinity of the pharynx, two lateral to the penetration glands, two lateral to the genital primordium, and one pair in the tail-stem near its anterior end.

This species corresponds identically with C. burti Miller, in every respect except body measurements. Again, however, this variation is likely due to different technical treatment and the similarities are sufficient to warrant the two being considered as the same species.

Host: Lymnaea stagnalis jugularis.

Cercaria wardlei McLeod 1934. (Plate 2, Plate 3, fig. 3)

The above organism was recorded from Clear Lake, Manitoba during the summer of 1934 but the description, while correct in all major points, is incorrect in one minor point and also is not sufficiently detailed to be of the greatest value in identification. For this reason, it is considered advisable to revise and extend the description.

Specific diagnosis: A large longifurcate pharyngeal distome cercaria with a rather stout rectangular body. The furcae are long and approximately the same length as the tail stem. Body is shorter than the tail stem. The body bears nine definite rings of spines in the pre-acetabular portion, while the post-acetabular portion is uniformly and fairly densely spined. There are about 10 pairs of lateral filaments on the tail stem. The cecal branches are long and reach almost to the hinder end of the body. Three pairs of penetration glands are present in the post-acetabular region between the ceca. Eight pairs of flame cells are present. In each lateral half is an anterior group of three, a posterior group of three, and two well back in the tail stem. The organism is a powerful swimmer but resting periods are long and during which time it hangs usually straight downward. From <u>Stagnicola emarginata canadensis</u>.

A large cercaria with a stout rectangular body that is somewhat pointed at the anterior end but the sides are almost parallel. The tail stem and furcae are about equal in length but each is longer than the body. Body measurements vary greatly between the largest and smallest specimens but the average measurements of a wide range of material fixed in hot 10% formalin is as follows: Body 194μ long by 45μ wide. The anterior organ measures 39μ in length and the acetabulum which is 41μ in diameter gives an average distance of 95μ between its anterior margin and the anterior end. The tail stem is about 298μ in length by 32μ in width and the furcae are 295μ in length. The oral region is surrounded by a dense band of about six rows of spines and in the circum-oral spineless area, dorsal to the mouth is located a group of about twelve anteriorly directed spines. The preacetabular body region bears nine definite rings of spines and the postacetabular region is uniformly spined. The tail stem bears about ten pairs of long lateral filaments. The pharynx is prominent and the long esophagus branches just anterior to the acetabulum into two well defined ceca which terminate near the excretory bladder. Three pairs of penetration glands are located posterior to the acetabulum and their ducts open lateral and posterior to the mouth. The excretory system is made up of eight pairs of flame cells and their tubules, etc: Two of the anterior group of three, in each lateral half, are located in the pharyngeal region and the third lateral to the acetabulum. The posterior group of three are directed mesad and are fairly uniformly spaced. Two pairs are present in the tail stem and are equally spaced in the second and third fourths of the tail. The lateral collecting tubule has a definite convolution near its anterior end and in each arm of this there appears to be a patch of long filaments. The excretory bladder is large and has a definite constriction near its middle, at which point contraction takes place during the constant pulsations of the bladder. Caudal bodies are absent in the tail stem but there are lateral rows of about fifty musculo-epithelial cells. These have distinct nuclei and the inner muscular portion is directed obliquely backward and shows rather definite transverse striations (Plate 3, fig. 3). Such a type of cell has previously been reported from cercariae by Ssintzin (1926). However, they are absent or much less prominent in other local cercariae and thus form an easy and reliable means of identifying C. wardlei.

Cercaria wardlei is a powerful swimmer but the swimming periods are normally short and the organism rotates as it passes along. When agitated it will swim back and forth for a considerable time before becoming quiescent. The resting periods are long when undisturbed and the organism hangs body downward from the water surface with the long furcae widely spread forming almost a straight line. The preacetabular portion of the body may be flexed ventrad or the tail-stem may be flexed near its anterior end, throwing the body sharply either to the right or left.

Host: Stagnicola emarginata canadensis.

MOLLUSCAN HOSTS IN MANITOBA.

Manitoba lakes and sloughs may be divided roughly into three general ecological groups as regards geographic position, temperature, type of bottom, vegetation, and hydrogen ion concentration. The first, or what may be classed as the oligotrophic type, occurs in the eastern part of the Province, involving the Manitoba portion of the Pre-Cambrian shield and commonly known as the eastern region (Adams 1926). Here the lakes are numerous, are usually very deep with rocky bottoms and very little vegetation. The temperature is low throughout the summer, the oxygen concentration is high and the hydrogen ion concentration is on the acid side of neutrality. Because of these factors, snails are scarce, if present at all, and cercarial dermatitis has never been reported from this region so that it has not been included to any extent in the surveys.

The second or eutrophic type includes the vast majority of Manitoba waters of the prairie region such as lakes, sloughs and ponds. Here the water is shallow, somewhat turbid, and the summer temperature is relatively high. The inwash of material is large, the bottom is of clay or sand and the hydrogen ion concentration is on the alkaline side of neutrality. The essential difference between the prairie lake and slough is one of size and also in the amount of vegetation present in the littoral regions owing to differences in water currents.

The typical prairie slough is usually fairly shallow with a gradually sloping bottom from the water's edge to the deepest portions (Plate 5). The bottom is of loose organic ooze varying in depth and overlying more solid gravel or clay. Plant zonation of the littoral region is fairly distinct. Farthest from the shore may be found such submerged or floating plants as filamentous and other algae, <u>Elodea sp.</u>, <u>Potamogeton sp.</u>, <u>Chara</u>, <u>Nitella</u>, and <u>Utricularia</u>. Toward the end of the warm season these may become extremely dense and reach right to the water surface. Emergent vegetation near the shore usually shows more or less definite rings of Typha, Scirpus, and Phragmites.

The protection offered by the tall marginal plants does not allow strong air currents to come into contact with the water surface for a considerable distance from the shore. This absence of disturbance of the water permits of a dense growth of submerged and floating plants. Here there is usually a great abundance of rotifers, nematode worms, crustaceans, snails, and larval insects.

Bays and protected bits of shore line of the larger bodies of water such as Lake Winnipeg, Lake Manitoba and Lake Dauphin, in general, show much the same flora and fauna as the common slough. In many cases a definite shore has not yet been formed in these recent lakes and the body of water shades off into typical marsh or muskeg (Plate 7; No. 11, 12, 14, 20, 21.). In a few cases typical bog with a definite marginal sedge mat is found.

Clear Lake (Plate 7, No. 2) represents a type intermediate between the ologotrophic and the eutrophic lakes. It is situated at a relatively high altitude in an outcropping of the coniferous forest near the ecotone with the deciduous forest. There is little inwash of organic material as sizable inflowing streams are absent, as is an outlet. The turbidity of the water is low and currents are strong. The temperature is low, oxygen concentration high and the hydrogen ion concentration is on the alkaline side of neutrality. It is a small body of water about eight miles in length by three miles in maximum width and has a greatest known depth of 180 feet.

The bottom near the shore is of fine white sand and coarse stones(Plate 4). The shore is rugged, and cold water springs, either with or without definite channels, seep out of the bank into the lake in numerous places. Emergent vegetation, such as reeds and rushes, is sparse and confined to localized patches but a growth of fine moss and algae is found over the surface of submerged stones near the shore.

Killarney Lake (Plate 7, No. 8) represents a type approximately intermediate between Clear Lake and the prairie slough, both as regards depth, temperature, bottom, and aquatic vegetation. Birds Hill area (Plate 7, No. 19) represents an early stage of succession in rain and snow water pools in large gravel pits.

The molluscan fauna of Manitoba is moderately rich in species of gastropoda but a good many of these are few in number of individuals and restricted in distribution. No doubt, in future, some of these may be found to act as intermediate hosts to schistosomatid trematodes, but up to the present time, only those that occur where cercarial dermatitis has been reported, have been studied to any extent. They are briefly as follows: Lymnaea stagnalis jugularis Say, Lymnaea stagnalis perampla Walker, Stagnicola palustris elodes Say, Stagnicola emarginata canadensis Sowerby, Heliosoma trivolvis Say, Heliosoma campanulata Say, Physella gyrina Say, Fossaria obrussa Say, Valvata tricarinata Say, Amnicola sp.

Lymnaea stagnalis jugularis (Plate 6, No. 1) is the largest and one of the most widely distributed snails of Manitoba. It occurs in large numbers in practically all the prairie lakes and permanent sloughs where the summer temperature is high and the vegetation dense. It was obtained from all districts studied (Plate 7.) with the exception of 3, 8, 13, 19, and 25, and in every case a number was found to be infested with the sporocysts and liberating the cercariae of the dermatitis-provoking type.

Stagnicola palustris elodes (Plate 6, No. 2) is a smaller but extremely abundant form found coincidently with L. stagnalis in all districts excepting 9. In addition it has been found in 19, Plate 7, and many other small or temporary bodies of water such as ditches, etc. Like L. stagnalis, wherever it occurs a sufficient distance away from disturbance or human habitation, it is found to be host to the larval stages of schistosomatid and other types of trematodes.

Stagnicola emarginata canadensis, Lymnaea stagnalis perampla, and Fossaria obrussa were found only at Clear Lake. S. emarginata is very abundant along the shore of almost the entire lake from a depth of eight feet to the waters edge. Here they are found on the sand and rocks feeding on the algae and mosses. It is also a common host to the larval stages of a schistosomatid. Only three specimens of Lymnaea stagnalis perampla were found on one occasion and these were uninfested. Fossaria obrussa occurs in small numbers in the seepage water from springs around the lake edge. Only a few of these were examined but all were free from trematode infestation.

Heliosoma campanulata, Valvata tricarinata, and Amnicola sp. occur in the deeper waters of Clear Lake and were obtained by the use of an Eckman dredge but all three species were parasitic free.

Heliosoma trivolvis and Physella gyrina occur in a wide range of situations and were particularly abundant in Killarney Lake (Plate 7, No. 8) but here both were uninfested. On one occasion specimens of H. trivolvis from Pelican Lake were found to be infested with Cercaria burti and the cercariae of Crassiphiala ambloplites Hunter. An unidentified longifurcate cercaria, possibly C. multicellulata Miller was obtained from P. gyrina on two occasions at Clear Lake.

AVIAN HOSTS IN MANITOBA.

Many species of wild mammals are found in the vicinity of Manitoba lakes and sloughs and any one or more of these might reasonably act as host to adult schistosomatids. In recent years, parasitological surveys of 460 snowshoe rabbits (Lepus americanus) and 240 gophers (Citellus sp.) have been carried out in the Zoological Laboratories at The University of Manitoba (Boughton 1932) (McLeod 1933) but all were negative for schistosomatids. Other specimens examined include one short-tailed shrew (Balarina brevicauda talpoides) and four specimens of muskrat (Fiber zibethicus). Five laboratory mice and three kittens were experimentally exposed to cercariae but post-mortem examination one month later showed them to be free from blood trematodes.

Representatives of the majority of Manitoba wild mammals have been examined in the laboratories of the Provincial Game and Fisheries Branch during the past eight years by Dr. J. A. Allan, Pathologist, but as yet no schistosomatids have been found.

Manitoba is visited annually by large numbers of water-fowl either as migrants or summer residents. The ordinary prairie marsh and slough is the feeding and breeding ground of a good many ducks, coots, grebes, as well as a number of shore birds and waders. Gulls and terns are fairly common around the larger lakes, breeding either in neighboring marshes or on rocky islands. Loons and mergarnser ducks nest around some of the deep colder lakes but never occur in great numbers. Migrating pelicans, cormorants and geese as well as a number of others remain for varying lengths of time in the spring and fall.

The fact that schistosomatid cercariae were widespread in Manitoba and that their occurrence coincided with that of the snail hosts except in certain small areas very close to human habitations, indicated that the definitive hosts quite probably would be water-birds.

The above condition coupled with the fact that over half of the known schistosomatids have water-birds as definitive hosts led to the examination of all possible local species. However, insufficient numbers of some species were examined to give significant results.

All material with the exception of the viscerae of eight Herring Gulls from the vicinity of Yarmouth, Nova Scotia, was collected in Manitoba. Three of the eight specimens from Yarmouth were infested with both males and females of Ornithobilharzia lari McLeod 1937. The same species was later recovered from local gulls from Lake Winnipeg (Plate 7, 25). Other specimens of Herring Gulls and also Ring-billed Gulls from the same point yielded two additional species of schistosomatids, namely-----

BIRDS EXAMINED

Specific name	Common name	No. exam.	No. inf.
Larus franklini	Franklin's Gull	7	0
Larus argentatus	Herring Gull	20	5
Larus delewarensis	Ring-billed Gull	9	1
Sterna forsteri	Forster's Tern	5	0
Dafila acuta	Pintail Duck	12	0
Querquedula discors	Blue-winged Teal	36	21
Nettion carolinense	Green-winged Teal	4	0
Anas platyrhynchos	Mallard Duck	8	0
Nyroca valisneria	Canvas-back Duck	3	1
Spatula clypeata	Spoonbill Duck	12	0
Mareca americana	Baldpate Duck	1	0
Marila marila	Bluebill Duck	2	0
Nyroca americana	Redhead Duck	30	0
Marila collaris	Ringneck Duck	1	0
Erismatura jamaicensis	Ruddy Duck	2	0
Branta canadensis	Canada Goose	1	0
Fulica americana	Coot	7	0
Colymbus nigricollis	Eared Grebe	3	0
Limosa fedoa	Marbled Godwit	1	0
Phalacrocorax auritus	Crested Cormorant	1	0
Bartramia longicauda	Upland Plover	1	0
Botaurus lentignosus	American Bittern	1	0
Gavia stellata	Red-throated Loon	3	0
Ceryle alcyon	Belted Kingfisher	1	0

Total no. of species 24. Total no. of specimens 171.

Ornithobilharzia aviani sp. nov. and *Ornithobilharzia* sp. Several juvenile specimens were examined but they were uninfested.

Both species of gulls occur in moderate numbers around Lake Manitoba, usually a single individual being seen at a time. They also occur at Clear Lake in moderate numbers, flocks constantly having been seen feeding around the bathing beach, especially in rough weather. Specimens from either place have not been examined so it is not known if, and to what extent, they are infested. A few Loons and Merganser Ducks are found at Clear Lake but ordinary pond or diving ducks are not found there during the breeding season and late summer.

The Blue-winged Teal is the commonest duck nesting around prairie lakes and sloughs. They are very numerous and widely distributed, a few usually being found nesting around almost every pond or pasture field slough. Over 60% of all specimens both adult and juvenile, were infested with males of *Pseudobilharziella querquedulae* McLeod 1937. These were collected from a good many localities and infested birds were encountered in every case regardless of the season.

The Canvas-back duck is found in Southern Manitoba only during the seasonal migrations. It nests on the western margin of Lake Winnipegosis and from there northward. A single specimen infested with *Microbilharzia* manitobensis McLeod 1936 and Microbilharzia canadensis McLeod 1936 was collected in late fall at Lake Frances.

Following the first discovery of adult schistosomatids in local birds it was decided to expose a number of parasite-free wild ducks experimentally to various cercariae in an effort to complete the life-histories. Hatchery reared birds of from one to six weeks of age were obtained and some of each species were exposed repeatedly in the laboratory for from 15 to 45 minute intervals to water containing the cercariae. In other cases thick infusions of cercariae were injected intravenously, intraperitoneally, or subcutaneously by means of a hypodermic needle.

BIRDS EXPOSED EXPERIMENTALLY

Specific name	Common name	Number
Anas platyrhynchos	Mallard Duck	5
Dafila acuta	Pintail Duck	5
Nyroca valisneria	Canvas-back Duck	5
Nyroca americana	Redhead Duck	4
Anas boschas demestica	Domestic Duck	6
Querquedulae discors	Blue-winged Teal	10

Control birds were kept in each case in order to check the accuracy of the experiment. In the case of one domestic duck, exposed to Cercaria stagnicolae from Clear Lake, a severe inflammation of the skin occurred two days after exposure. This became more acute and the bird picked its skin and feathers so that by the fifth day there was complete depinnation of the body except the neck and wing tips. The skin was much inflammed and on the sixth day the bird died.

Post-mortem examination of all birds were conducted from two to six weeks after exposure, if they survived that time, but a positive infestation was never obtained.

CLASSIFICATION OF SCHISTOSOMATIDAE.

The discovery of several new species of Schistosomatidae in the past few years, particularly those recorded by Ejsmont (1929), Wetzel (1930) and the writer (1936, 1937), necessitates a revision of the classification and keys for the identification of various members of the family. The classification suggested by Price (1929) was adequate at the time of its appearance but is not sufficiently broad to include some of the more recent forms. In the following keys, Price's classification is used as a basis but the writer suggests a number of minor changes. The Genus Ornithobilharzia should be amended, as suggested by Wetzel, to include forms in which the female is shorter or longer than the male, having 28 or more testes in the male and also having the spiral ovary of the female confined to the anterior one-third of the body. This would also necessitate the amending of the Genus Microbilharzia as follows: Suckers present in male, present or absent in the female. Testes 18-26 in number in the male, ovary pre-equatorial in the female. The species Ornithobilharzia lari McLeod 1937 would then be transferred to the Genus Microbilharzia. The creation of the new Genus Pseudobilharziella by Ejsmont 1931 calls for a revision of the Generic diagnosis of the old Genus Bilharziella and he suggests the following changes: Anterior region narrow and one-half the body length; posterior region broader and lanceolate. Genus Pseudobilharziella: Anterior portion of body wide and one-fifth of body length; posterior portion narrow and strap-like.

A modification of Price's classification in accordance with the above suggestions would consequently be as follows:

Key to the Sub-families of Schistosomatidae.

Females slender, more or less cylindrical in cross-section; males larger than females, flattened, and with the lateral edges infolded, forming a gynaecophoric canal; intestinal ceca usually unite caudad of the equator of the body; testes situated cephalad of the cecal union-------------------------------------Schistosominae.

Females similar to males in shape; males without well developed gynaecophoric canal; cecal branches unite cephalad of the equator of the body; testes situated caudad of the cecal union----------<u>Bilharziellinae</u>.

Key to the Genera of <u>Schistosominae</u> Stiles and Hassal 1898.

1. Either males or females unknown--------------------2.

   Males and females both known----------------------3.

2. Males unknown. Females slender, flattened; ovary spiral, in posterior third of body; intestinal ceca unite near the posterior end of body; vitellaria consists of a few scattered follicles between the cecal branches; in birds.---------<u>Paraschistosomatium</u>.

Female unknown. Gynaecophoric canal well developed; testes numerous, in posterior third of body and cephalad of the cecal union; in mammals---<u>Heterobilharzia</u>.

3. Testes 28 to over 60 in number; female shorter or longer than male; ovary spiral, in the anterior one-third of body--------------<u>Ornithobilharzia</u>.

   Testes 26 or less in number; ovary from just pre- to post-equatorial in position; suckers present in male, present or absent in female-------------4.

4. Anterior end of gynaecophoric canal near equator of body; testes in two rows, at anterior end of

gynaecophoric canal; genital pore immediately in front of anterior testes; intestinal ceca with short lateral diverticula; common cecum in both sexes short; ovary pre-equatorial.-------------

Schistosomatium.

Anterior end of gynaecophoric canal near acetabulum; genital pore of male a short distance caudad of acetabulum; intestinal ceca with diverticula reduced or absent; common cecum usually long; ovary pre-equatorial or post-equatorial in position---5.

5. Testes less than ten in number; ovary oval--Schistosoma.

Testes 18-26 in number; ovary spiral---------------6.

6. Anterior end of gynaecophoric canal slightly caudad of acetabulum; oral sucker lacking in female; ovary about one-third of body length from posterior extremity-------------------------Austrobilharzia.

Anterior end of gynaecophoric canal cephalad of acetabulum; suckers present or absent in female; ovary pre-equatorial----------------Microbilharzia.

Key to the genera of Bilharziellinae Price 1929.

1. Body cylindrical or nearly so---------------------2.

Body flattened-----------------------------------3.

2. Female unknown; posterior end of body threadlike, middle portion wider than either the anterior or posterior portions; no gynaecophoric canal; suckers

present----------------------------------Trichobilharzia.

Male and female very long and slender; gynaecophoric canal reduced to a short groove in the anterior part of the body; suckers absent---Gigantobilharzia.

3. Suckers present; common cecum without lateral dendritic branches-------------------------------------4.

Suckers absent; common cecum with short, lateral dendritic branches------------------Dendritobilharzia.

4. Body divided into narrow anterior and broad lanceolate posterior portions, point of union being at junction of second a nd third fifths of body---Bilharziella.

Body divided into broad anterior and narrow strap-like posterior portions, the point of union being at the junction of the first and second fourths of body------------------------------------Pseudobilharziella.

Key to the species of the Genus Microbilharzia

1. Testes in male reaching into post-equatorial region--2.

Testes in male confined to pre-equatorial region-----3.

2. Body fairly stout in male; cecal branches slightly convoluted and without diverticulae; female known---M. pricei.

Body slender in male; cecal branches convoluted and with small diverticulae-----------M. manitobensis.

3. Cecal branches in male uniting at about junction of middle and hinder thirds body; common cecum long;

acetabulum wanting in female----------*M. canadensis*.

Cecal branches in male uniting near hinder end of body; common cecum short; acetabulum present in female---*M. lari*.

ADULT SCHISTOSOMATIDAE OCCURRING IN MANITOBA

Microbilharzia manitobensis McLeod 1937. (Plate 8, fig. 3)

Generic diagnosis: *Microbilharzia*

Male: Slender bodied worms of 4.5-4.9 mm. in length by .47-.48 mm. in maximum breadth. Suckers well developed; oral sucker oblique and almost terminal, acetabulum pedunculate and 560 μ from the anterior end. Cuticle smooth and gynaecophoric canal well developed, beginning in front of acetabulum. Cecal branches progressively more sinuous toward hinder end where they bend at angles of about 90 degrees. They have numerous small diverticula and unite close to posterior body termination. Common cecum short. Testes 18-20 in number, arranged in two irregular rows reaching into post-equatorial region.

Female: Unknown.

Cercaria: Unknown or unrecognised.

Type host: Primary, birds (*Nyroca valisneria*); secondary, unknown.

Location: Hepatic portal vein.

Type locality: Lake Frances, Manitoba, Canada.

Microbilharzia canadensis McLeod 1937. (Plate 8, fig's. 1 and 2.)

Generic diagnosis: Microbilharzia

Male: Stout bodied Schistosominae measuring 4.-4.5 mm. in length by .48 mm. in maximum width. Suckers well developed; oral sucker terminal and oblique, acetabulum pedunculate and .32 mm. from the base of oral sucker. Cuticle finely tuberculate; gynaecophoric canal deep and begins cephalad of acetabulum. Cecal branches slightly convoluted and unite at about junction of the middle and hinder body thirds. Common cecum long, reaching to near posterior end of body. Testes 18-20 in number, arranged in an irregular double row between acetabulum and equator.

Female: 3.2 mm. in length by .27mm in maximum width. Anterior portion cylindrical and filamentous, posterior portion broader and flattened. Cuticle smooth; oral sucker poorly developed and subterminal, acetabulum absent. Ovary spiral, tightly coiled, about 450-470 μ long and pre-equatorial in position. Uterus long and moderately straight. Vitellaria occupy most of the posterior half of the body and are made up transverse follicles.

Type host: Primary, birds (Nyroca valesneria); secondary, unknown.

Cercaria: Unknown.

Location: Hepatic portal vein.

Type locality: Lake Frances, Manitoba, Canada.

Microbilharzia lari New combination. (Plate 10, fig's 1 and 2; Plate 12, fig. 3.)

Syn. *Ornithobilharzia lari* McLeod 1937.

Specific diagnosis; *Microbilharzia*

Male: Stout sickle-shaped worms measuring about 3.7 mm. in length by 490 μ in maximum width. Oral sucker terminal with mouth ventral; acetabulum well developed, pedunculate and .44 mm. from the anterior end. Cuticle thick and smooth; gynaecophoric canal well developed, deep, and beginning cephalad of the acetabulum. Cecal branches large and follow a sinuous course to near the hinder end where they unite. The common cecum is short. Testes 18-26 in number, arranged in an irregular row in the pre-equatorial region. Seminal vesicle present.

Female: Filamentous and flattened with a maximum length of 2.75 mm. and width of 180μ. Oral sucker and acetabulum present, the acetabulum being about 247μ from the anterior end. The ovary is spiral, of considerable length, and pre-equatorial in position. A receptaculum seminis is present; the oviduct is long and the genital pore is close to the acetabulum. Vitellaria are in the form of transverse follicles and occupy most of the posterior half of the body.

Type host: Primary, birds (Larus argentatus), secondary, unknown.

Cercaria: Unknown or unrecognised.

Location: Portal vein, intestinal veins and liver.

Locality: Yarmouth, N. S. and Lake Winnipeg, Manitoba, Canada.

Ornithobilharzia aviani, sp. nov. (Plate 11, fig's 1, 2 & 3. Plate 12, fig. 2)

Generic diagnosis: Ornithobilharzia

Male: Large straight bodied worms of an average length, in fixed specimens, of 12 to 15 mm. and of a fairly uniform diameter reaching a maximum of .63 mm. The lateral edges of the body are infolded to form a well developed gynaecophoric canal which begins just caudad of the acetabulum and gradually becomes more pronounced. It is only moderately deep throughout most of its length and gradually disappears near the caudal end. The edges normally do not meet in the mid-line. The cuticle is thick and without tubercles or spines. The oral sucker is terminal and in the form of a shallow funnel the aperture of which is directed oblique ventrad. It is circular and has an average diameter of about 250 μ. The anterior body portion is elliptical in cross-section and the acetabulum is pedunculate. Its anterior margin is .82 mm. from the anterior end of the body and the average diameter is 400 μ. The mouth is situated in the centre of the oral sucker and leads into a narrow straight tube. A short distance back it passes through a mass of tissue, partly muscular, partly glandular in nature. Cephalad of the acetabulum it passes into a squarish cavity of considerable size. The cecal branches arise from the posterior-lateral margins of this and follow a slightly convoluted course caudad. Farther back the ceca become progressively larger and more convoluted and later anastomosis occurs. There are some individual variations near the posterior end where there may be one or two anastomosing branches. Following this the ceca may be of unequal length and end singly or may unite, the common cecum ending close to the posterior end of the body. A small but distinct Y shaped excretory bladder opens at the posterior tip of the body. The testes are arranged in a row which at the anterior end is convoluted, while toward the hinder part, it is made up of a compact mass about two testes in width. The row begins about .68 mm. caudad of the acetabulum and extends into the post-equatorial region. In mature specimens the testes are spherial, about 95 μ in diameter, and vary from 54 to 74 in number. The vas deferens is narrow and moderately straight. It opens into a transversely elongated seminal vesicle. The genital pore is considerably to the left of the median line and is about .28 mm. caudad of of the acetabulum. A prostate or cirrus pouch is absent. Female: Filamentous worms considerably shorter than the males and usually completely enclosed in the gynaecophoric canal. The average length in fixed specimens is 7.2 mm. by .23 mm. in width. The portion anterior to the ovary is cylindrical and finely attenuated while the hinder portion is flattened and bluntly pointed. The cuticle is finely tuberculate. The oral sucker is terminal and has an average diameter of 50 μ. The acetabulum is well developed, pedunculate with a diameter of 62 μ. The digestive canal branches into two fine ceca just cephalad of the acetabulum. These pass ~~past~~ caudad to just behind the ovary where they may unite permanently or separate and reunite once or twice. The common cecum follows a straight course to near the hinder end of the body. The ovary is a spiral consisting of about eight loops and begins 1 mm. from the acetabulum. Its length, disregarding the total length of the spiral, is .78 mm. A small receptaculum seminis is present at the posterior end of the ovary and Laurer's canal is also present. An oviduct of moderate size passes forward to the ootype which is distinct and located .81 mm. caudad of the acetabulum. The vitellaria are in the form of numerous small oval follicles which occupy most of the region caudad of the ovary. The vitelline duct passes forward in company with the oviduct to the ootype.

The uterus is narrow, moderately straight and the genital pore opens close behind the acetabulum. Eggs are produced singly.

Cercaria: unknown or unrocognised.

Type host: Primary, birds (Larus argentatus), secondary, unknown.

Type locality: Lake Winnipeg, Manitoba, Canada.

Location: Portal and intestinal veins.

The above description is based on the examination of a few pairs of males and females in a good state of preservation taken in copula from the intestinal veins of an adult specimen of Larus argentatus. Both males and females closely resemble those of O. canaliculata (Rudolphi 1819) Odhner 1912. The male also resembles that of O. kowalewskii (Parona and Ariola 1896) Odhner 1912, in so far as the brief descriptions of these two species go. Dr. Price suggests that there is a strong possibility of the two being cospecific but because of the brevity of the published descriptions it is impossible to definitely establish the point. The writer considers it advisable to regard the above as a new species until such time as specimens of both O. canaliculata and O. kowalewskii can be examined in detail and the differences or similarities determined for all three.

Ornithobilharzia sp. (Plate 12, fig. 1.)

Specific diagnosis: Ornithobilharzia.

Male: Identical with O. aviani in every respect except the number of testes, which varies from 88 to 108 in different individuals.

Female: Extremely long and filamentous with a length of 15 to 20 mm. and a maximum width of .1 mm. the anterior end is cylindrical and finely attenuated while the posterior portion is somewhat flattened and ends bluntly. The ovary is a elongated tubular body in the first eighth of the body and the vitellaria are in the form of a single row of large follicles each of which is almost as wide as the body. They occupy the posterior seven-eighths of the body. Suckers are absent and the cuticle is smooth. Details of the digestive and reproductive systems could not be determined due to the poor state of preservation of the females.

The writer feels that the above organisms represent an undescribed species but more favorable material must be obtained before a detailed specific description can be given. The general structure and arrangement of the body organs in both males and females resemble those of O. odhneri but the great difference in size would eliminate the possibility of the two being cospecific. Specimens were obtained from both Larus argentatus and

Larus delewarensis collected in the vicinity of Lake Winnipeg, and all were found in the intestinal veins. Several specimens were found in *Larus argentatus* also infested with *O. aviani*. For this reason only male specimens found in copula with the different types of females were considered in making the separation. The males are decidedly similar but from the information obtained from the examinations it is thought that they can be readily separated on the basis of the number of testes present.

Pseudobilharziella querquedulae McLeod 1937. (Plate 9)

Specific diagnosis: *Pseudobilharziella*.

Male: Filamentous worms of 3.7 mm. in maximum length and .15 mm. in breadth. Anterior portion broader and flattened, being about one-quarter of the total body length. Posterior portion narrow and strap-like. Gynaecophoric canal short and poorly developed, just cephalad of the junction of the two body regions. Suckers well developed and close to-gether. Cuticle thin and finely tuberculate. Seminal vesicle long and just caudad of the acetabulum. Cirrus sac and prostate present; genital pore to the left side of the median line at the beginning of the gynaecophoric canal. Testes 210 to 240 in number, occupying the posterior body portion.

Female: Unknown.

Cercaria: Unknown or unrecognised.

Host: Primary, birds (Querquedula discors), secondary, unknown.

Locality: Southern Manitoba.

Location: Portal and mesenteric veins.

DISCUSSION

Up to the present time there have been reported from the world, what are thought to be, 39 distinct species of Schistosomatidae distributed among twelve genera. Fifteen of the species occur in North America but only one species, definitely known to occur elsewhere (Europe), is among these. Thirteen of the North American forms spend their adult phases in birds and none of their other life cycle stages are known. Two occur as adults in mammals (rodents) and their life-histories are known. At least six distinct schistosomatid cercariae are thought to be present in North Amerida, and no doubt a number more will be discovered in future or are at present being mistaken for one or more of the recorded species.

Six species of adult Schistosomatidae have been found in Canada by the writer and all of these occur in birds in the southern half of Manitoba. Two species are rare, having been found only once in the canvas-back duck, a bird that occurs here only as a migrant.

Pseudobilharziella querquedulae is the commonest of the adult schistosomes found. It occurred in 60% of all the specimens of Querquedula discors examined, regardless of the season or the place from which the birds were collected. Birds from a good many widely separated localities were examined and the usual number of positive cases was always found. P. querquedulae undoubtedly is the adult of one of the local dermatitis-provoking cercariae, as immature worms have been recovered from fledgling birds that were, as yet, unable to fly but had frequented the waters of prairie lakes where both Cercaria elvae and Cercaria sp. were abundant.

That no females of this species have been found in such a large number of examinations where males were plentiful is remarkable. There is the possibility that they have been overlooked on account of their small size. A more logical explanation, perhaps, is that Q. discors is an unnatural host and only the male Schistosomatids develop in it. This was found to be the case by Faust (1926) in infections of human schistosomatids in unnatural hosts, such as the rabbit and sheep.

Microbilharzia lari and Ornithobilharzia aviani are found in local adult herring gulls in fairly large numbers. It is not known where the infection is contracted, there being no more evidence to favor the winter feeding ground than the summer habitat. Diplostomum flexicaudum is carried in the adult stage by the herring gull and the larvae occur coincidently with schistosomatid cercariae at Clear Lake. This might indicate that C. stagnicolae is the larva of one of the gull schistosomatids as the herring gull is the only common host of D. flexicaudum in the vicinity of Clear Lake. Immature male worms of both species were obtained from birds collected in late autumn and as the time required for maturation in most schistosomatids is two months or less, this would strengthen the theory that the infection occurred in local waters.

Ornithobilharzia sp. was found in both herring gulls and ring-billed gulls from Lake Winnipeg in late autumn. Mature and immature males and females were recovered and the above argument in favor of local infection would apply equally to these.

Consistent failure to produce adult worms by exposure of experimental animals may be due to a number of causes. In addition to the experimental work by the writer, Talbot (1936) exposed young domestic ducklings, herring gulls, and a pigeon to three species of schistosomatid cercariae from Douglas Lake, Michigan, but the results were negative in every case. Differences in the temperature, the pH or the salt concentration of water used in the laboratory may be responsible for the production of cercariae so inviable that they are unable to penetrate the skins of experimental animals or these changes may interfere with their normal responses to the presence of a host.

Effective treatment of the disease once it has been contracted by human beings is very difficult. The intense itching and annoyance are the most serious aspects and treatment is usually directed to relieve these. Application of various lotions or ointments is usually recommended but the writer has found these to be of little or no value in either reducing the irritation or killing the organisms. The most effective treatment tried was that of scrubbing the affected parts with a stiff brush until the papules bled freely, using a solution of soap and some antiseptic in hot water. Such treatment gives temporary relief and appears to reduce the course of the disease by one or two days.

A generous application of grease to the skin before entering the water or an antiseptic bath directly after leaving might be of some value but has not been tried extensively enough for an opinion to be given.

The control of cercariae through snail destruction has been successfully effected in small bodies of water in other countries (Annual Report for 1929 of the Medical Officer of Health, etc. City and Port of Cardiff). Here a concentration of 1-500.000 copper sulphate was used and no further cases of dermatitis were reported for about three months. Water treatment with copper sulphate would be futile in the case of Clear Lake unless enormous quantities were used, because of the extent of the beach and the depth of the water. This treatment has been attempted at Clear Lake annually, beginning in 1932, and even though considerable quantities have been used, there has apparently been no resultant change in the number of cases of dermatitis. The common procedure was to tow a sack of the chemical back and forth behind a power boat and it is doubtful if a lethal concentration was ever reached at any time. A drop in the incidence of the disease following 1933 was thought by some to be due to the treatment of the water but the recurrence of a severe outbreak in 1937, even with continued water treatment, indicates that the variation was due purely to biological causes. Had the entire supply of copper sulphate been applied at one time or a denser substance that would have remained as a layer over the bottom been employed, better results might have been obtained. Hand picking of snails, also suggested by Swails (1936) is not particularly applicable and practically without value as a preventative measure at Clear Lake.

A less expensive and, no doubt, more effective method would be to examine gulls from the region and, if found to be harbouring adult schistosomatids, eradicate them entirely.

The direct pathological effect of adult schistosomes on the bird hosts is not known but invariably infected birds are lighter and much more emaciated than uninfected ones. The intestines, livers, etc; of a good many infected birds have been examined but a definite lesion due to the presence of eggs has never been found.

SUMMARY

The foregoing report on the biology of "swimmer's itch" is based on the results of investigations carried on over a period of four years, in the field and in the Zoology Laboratories of the University of Manitoba. New information is added and old information is brought together and correlated. In the main, it is concerned with the following points:

1. "Swimmer's itch" in Manitoba and cercarial dermatitis in other parts of the world are shown to be identical.
2. The disease is proven to be the result of attacks by trematode cercariae.
3. Clinical and pathological notes on cercarial dermatitis are given.
4. An outline is given of the distribution of the disease in other parts of the world, in North America, and in Manitoba.

5. A history of previous work done on schistosomatid cercariae and cercarial dermatitis is included.

6. The records of known adult Schistosomatidae are summarized.

7. The results of a survey of dermatitis-provoking cercariae and their distribution in Manitoba are given.

8. The results of a survey of other furcocercous cercariae in Manitoba are given, also a rivised description of Cercaria wardlei McLeod 1937.

9. Molluscan hosts are listed and their ecology and distribution discussed.

10. Six new species of Schistosomatidae occurring in Manitoba are described.

11. Bird hosts and the numbers found to be infested are listed, also the number of other birds examined.

12. Notes on the experimental exposure of a number of animal species to schistosomatid cercariae are given.

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Plate 1.

Figure 1. Human fore-arm 24 hours after experimental exposure to _Cercaria stagnicolae_, showing size and distribution of papules.

Figure 2. Natural infection by _Cercaria stagnicolae_ on the legs of a bather.

Figure 3. Photomicrograph of histological section of a papule 26 hours after infection showing aggregations of leucocytes and loosening of the connective tissue elements, x 100.

Figure 4. Photomicrograph of a section of the same papule showing canal made by the cercaria and keratosis in the surrounding tissue, x 100.

Figure 1.

Figure 2.

Figure 3.

Figure 4.

Plate 2.

Semidiagrammatic sketch of *Cercaria wardlei*; body and anterior portion of tail stem, x about 1400.

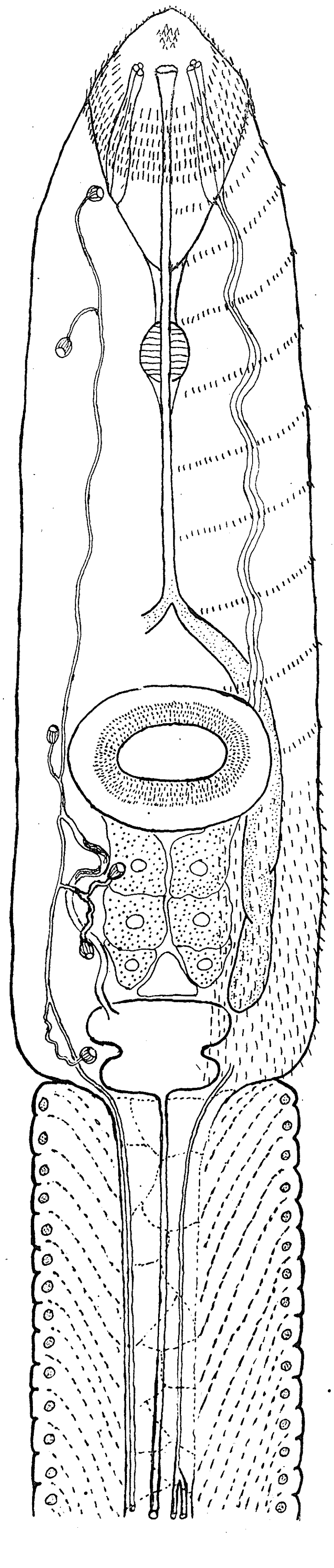


Plate 3.

Figure 1. Photomicrograph of portions of sporocysts teased from the "digestive gland" of an infested snail, x 100.

Figure 2. Photomicrograph of section of "digestive gland" of *Lymnaea stagnalis* infested with sporocysts of *Cercaria elvae*, x 100.

Figure 3. Photomicrograph using oil immersion showing tail-stem musculature of *Cercaria wardlei*, x 940.

Figure 1.

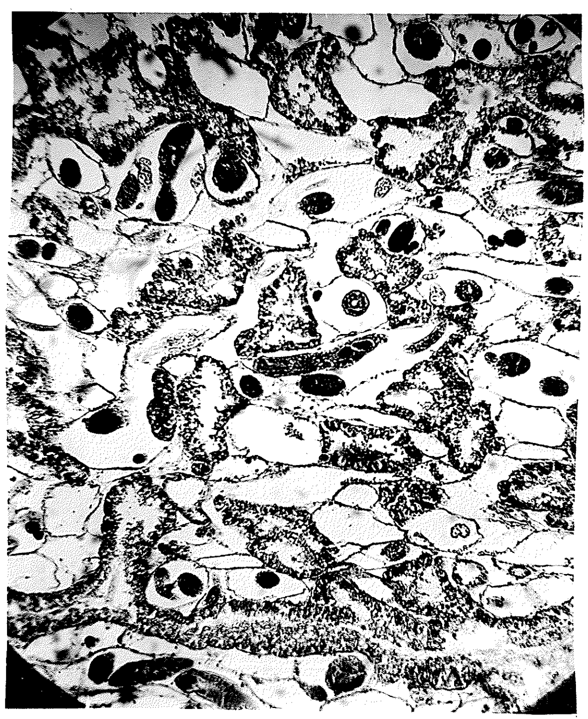


Figure 2.

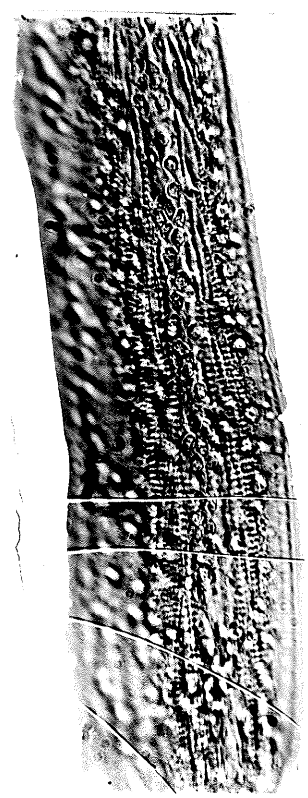


Figure 3.

Plate 4.

Figure 1. Northern margin of Clear Lake showing steep rocky shore.

Figure 2. Aeroplane Point, Clear Lake showing narrow beach of fine sand.

Figure 3. Eastern margin of Clear Lake showing narrow beach of coarse gravel and absence of macroscopic aquatic vegetation.

Figure 1.

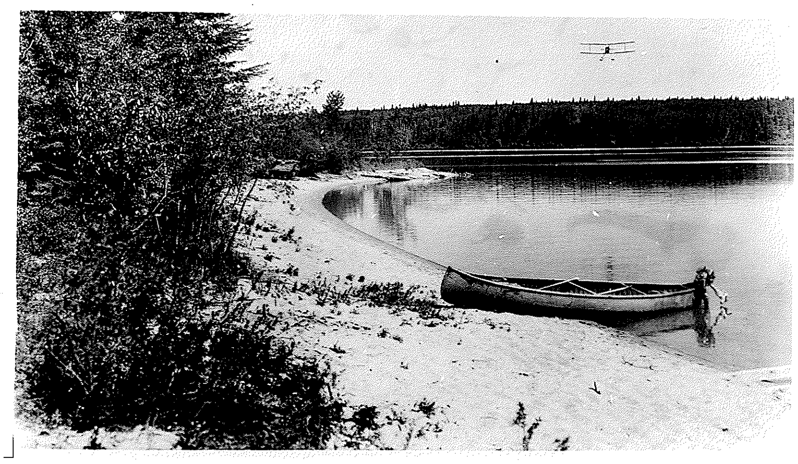


Figure 2.

Figure 3.

Plate 5.

Figure 1. Late autumn scene of Portage Creek near Delta, Manitoba. Phragmites in the foreground, _Scirpus_ and _Typha_ in the distance.

Figure 2. Portage Creek showing an emergent marginal ring of _Typha_.

Figure 3. A typical Manitoba slough showing dense growth of _Scirpus_.

Figure 1.

Figure 2.

Figure 3.

Plate 6.

Molluscan hosts of furcocercous cercariae in Manitoba.

No. 1. *Lymnaea stagnalis jugularis* Say.

No. 2. *Stagnicola palustris elodes* Say.

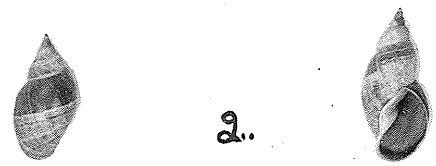
No. 3. *Heliosoma trivolvis* Say.

No. 4. *Physella gyrina* Say.

No. 5. *Fossaria obrussa* Say.

No. 6. *Stagnicola emarginata canadensis* Sowerby.

1.



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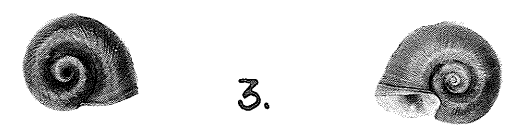

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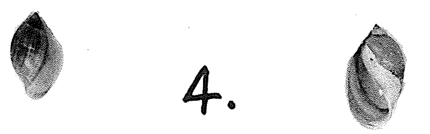

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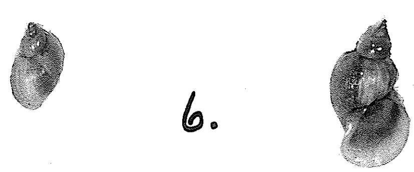

6.

Plate 7.

Map of Southern Manitoba showing districts studied.

Legend.

Cercarial dermatitis known to occur.

Molluscs found infected with schistosomatid cercariae and sporocysts.

Districts from which birds have been examined.

Birds found infested with adult Schistosomatidae.

1. Lake Dauphin.
2. Clear Lake.
3. Shoal Lake.
4. Gilmour Lake near Kelwood.
5. Pelican Lake, Ninette.
6. Pasture field slough near Ninette.
7. Lake Louise, Neelin.
8. Killarney Lake.
9. Artificial dam near Austin.
10. River lagoon, Portage La Prairie.
11. Delta marsh.
12. Portage Creek.
13. Black's Lake, High Bluff.
14. Lake Frances.
15. Long Lake, Raeburn.
16. Pasture field slough near Marquette.
17. Pigeon Lake.
18. River lagoon, St. Andrews.
19. Gravel pits, Birds Hill.
20. Libau marsh.
21. Netley marsh.
22. Whitewold.
23. Ponemah.
24. Gimli.
25. Catfish Creek.

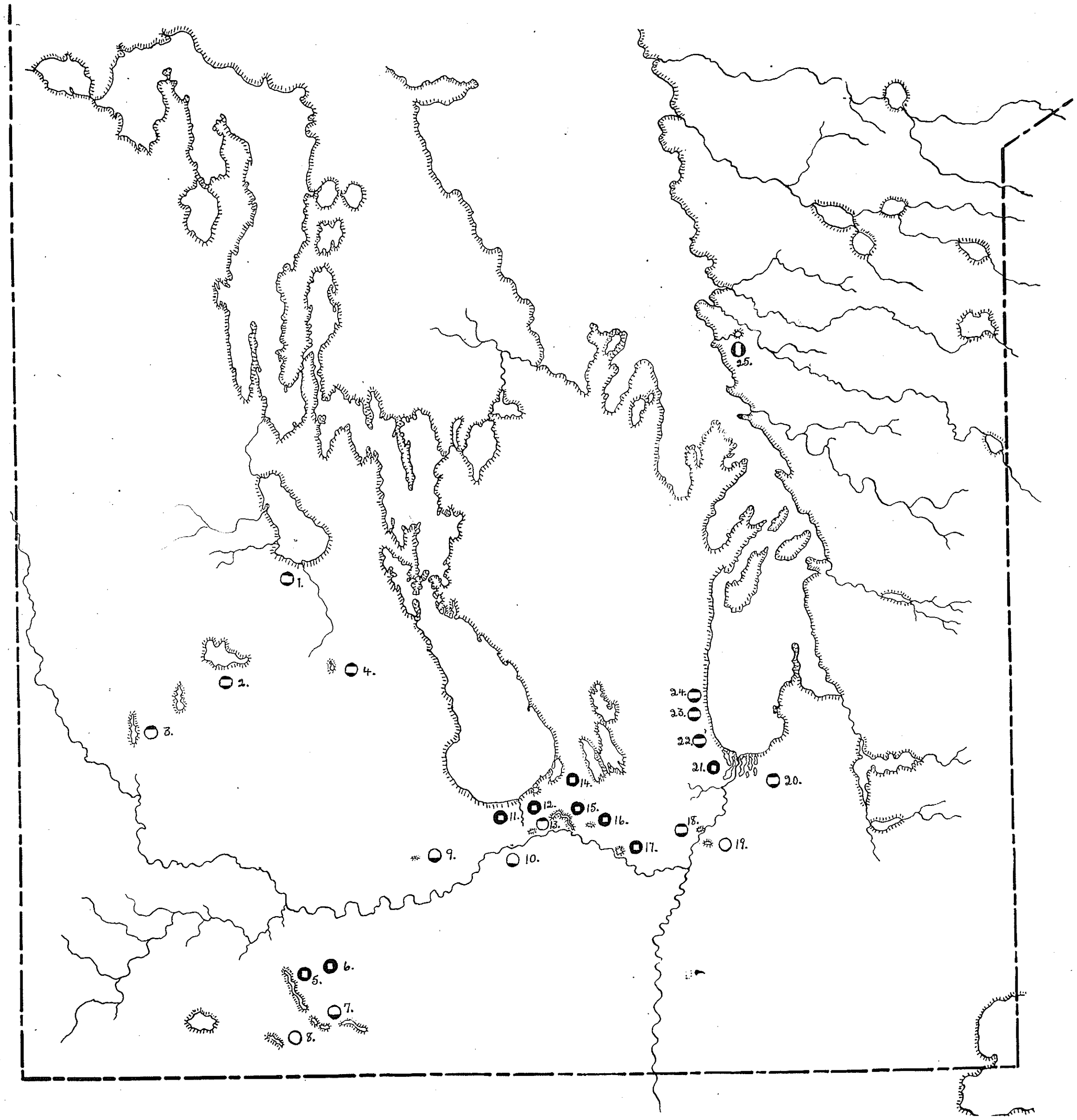

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Plate 8.

Figure 1. *Microbilharzia canadensis*, female, x 40.

Figure 2. *Microbilharzia canadensis*, male, x 40.

Figure 3. *Microbilharzia manitobensis*, male, x 40.

Legend.

ac.	Acetabulum.
c.	Common cecum.
cb.	Cecal branch.
exd.	Excretory duct.
gy.	Gynaecophoric canal.
oes.	Oesophagus.
o.	Ovary.
os.	Oral sucker.
t.	Testes.
u.	Uterus.
v.	Vitellaria.
vas.	Vas deferens.
ph.	Pharynx.(?)

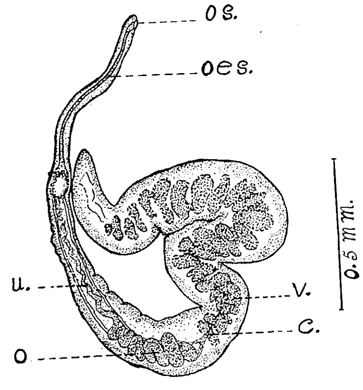

Figure 1.

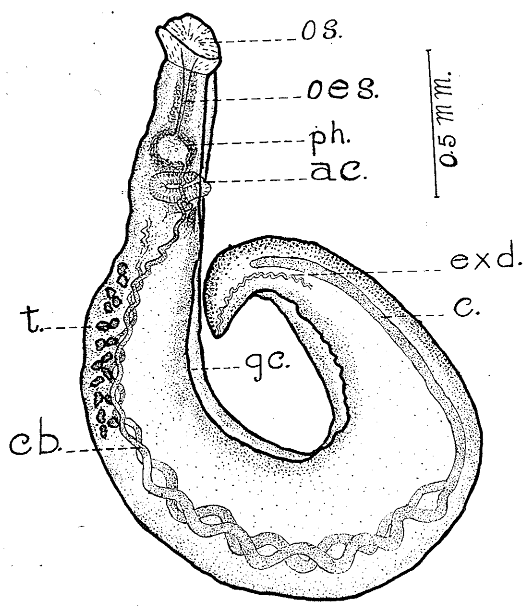

Figure 2.

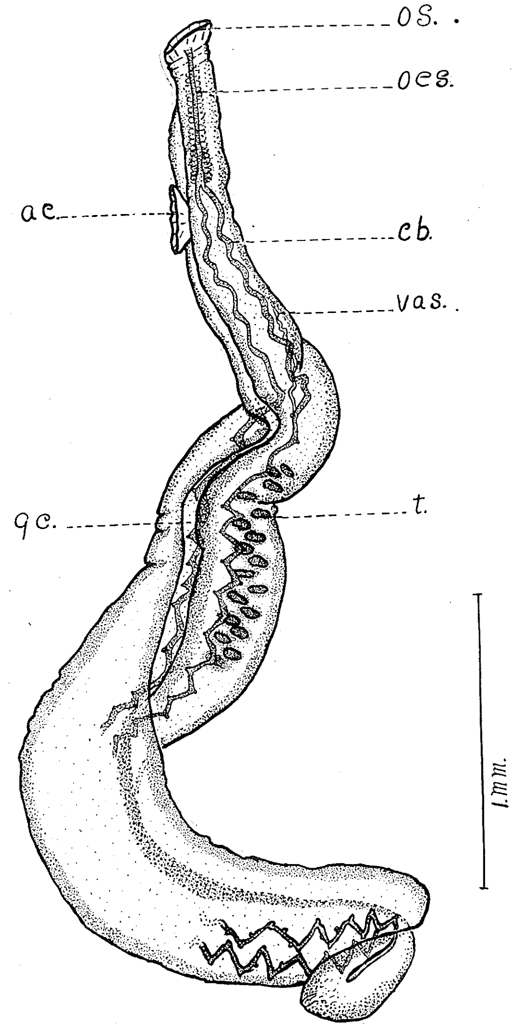

Figure 3.

Plate 9.

Pseudobilharziella querquedulae, x 140.

Figure 1. Anterior portion of young male.
Figure 2. Posterior portion of male.
Figure 3. Anterior portion of older male.

Legend.

ac. Acetabulum.
cb. Cecal branch.
cc. Common cecum.
gc. Gynaecophoric canal.
gp. Genital pore.
os. Oral sucker.
p. Prostate.
s. Spermatozoa.
sv. Seminal receptacle.
t. Testes.
vd. Vas deferens.

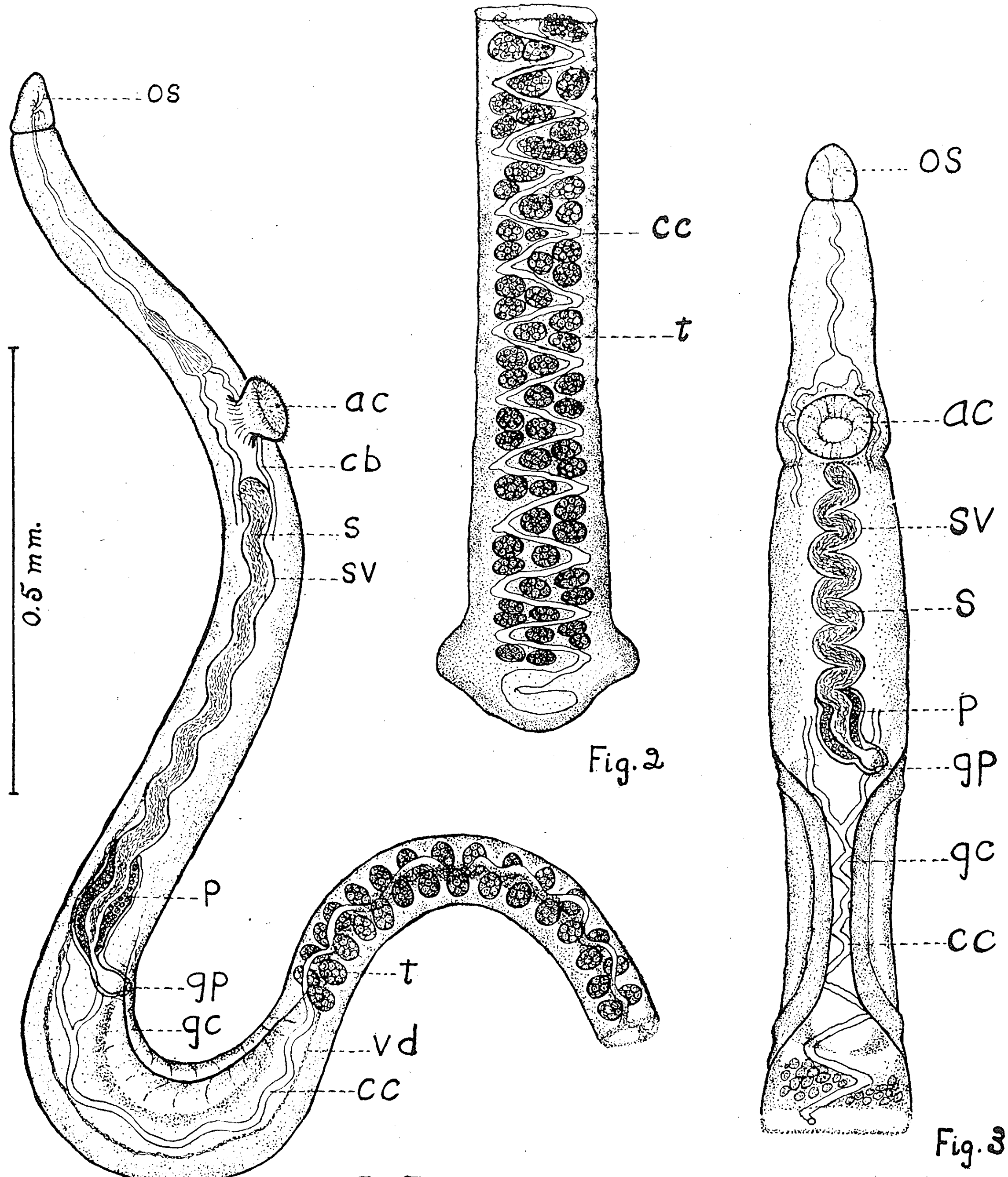

Fig. I

Fig. 2

Fig. 3

Plate 10.

Microbilharzia lari.

Figure 1. Adult male, x 56.

Figure 2. Adult female, x 70.

Legend

ac. Acetabulum.
cc. Common cecum.
e. Egg.
gc. Gynaecophoric canal.
gp. Genital pore.
o. Ovary.
od. Oviduct.
os. Oral sucker.
rs. Receptaculum seminis.
sv. Seminal vesicle.
t. Testes.
v. Vitellaria.

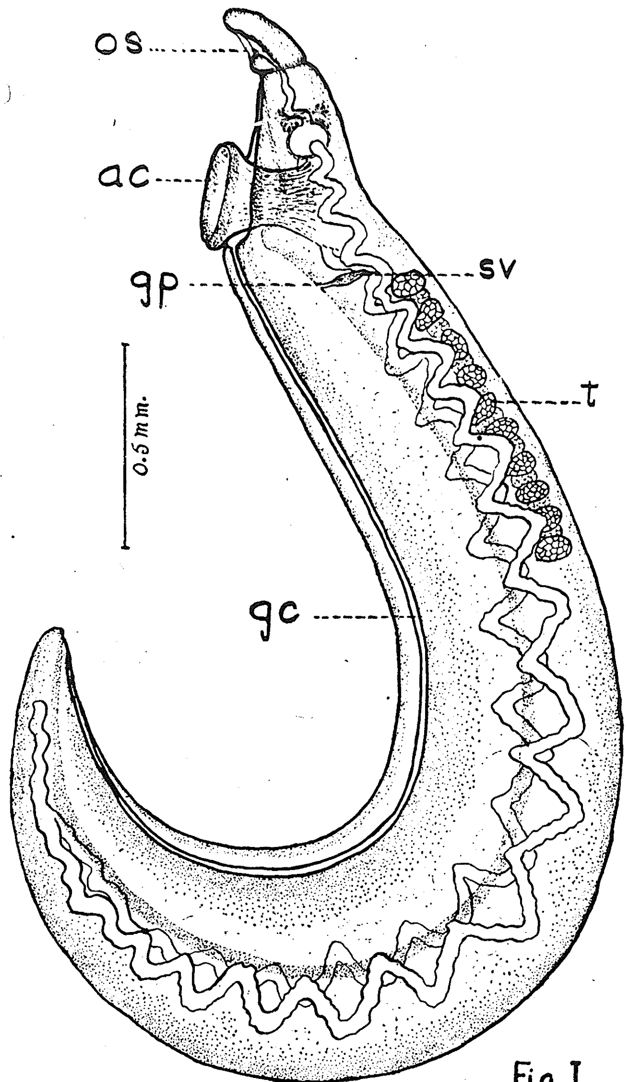

Fig. 1

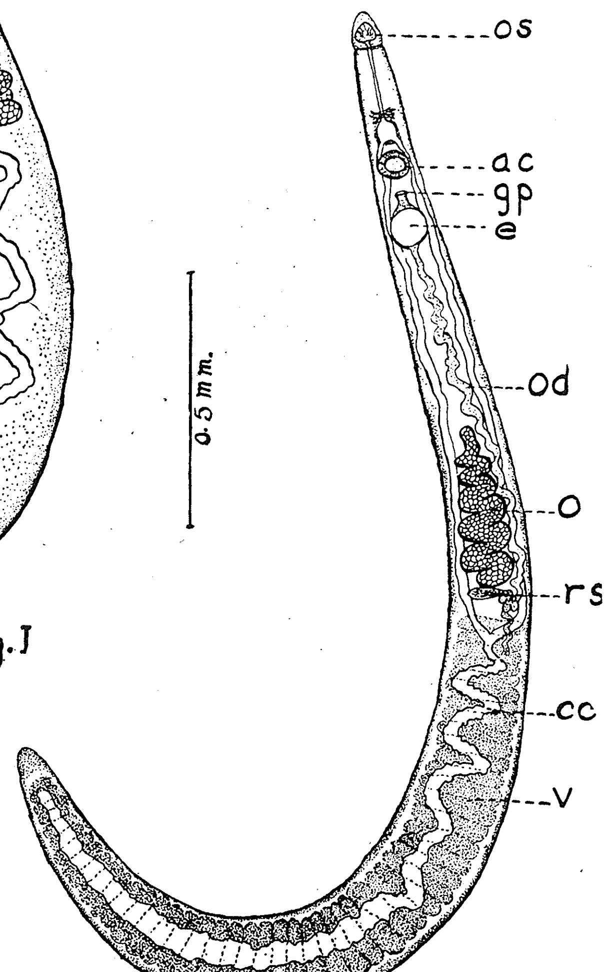

Fig. 2

Plate 11.

Ornithobilharzia aviani. sp. nov., x 50.

Figure 1. Anterior portion of male.

Figure 2. Anterior portion of female.

Figure 3. Posterior portion of male.

Legend

cb. cecal branch.
cc. common cecum.
eb. excretory bladder.
d. vitelline duct.
gp. genital pore.
lc. Laurer's canal.
o. ovary.
rs. receptaculum seminis.
sg. shell gland.
sv. seminal vesicle.
t. testes.
u. uterus.
v. vagina.
vd. vas deferens.
vt. vitellaria.

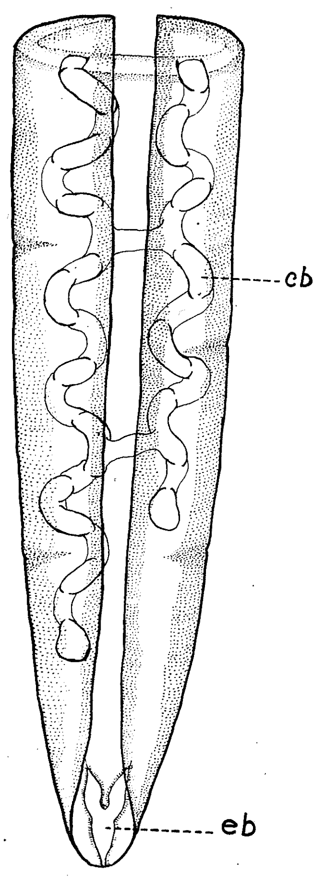

Figure 3.

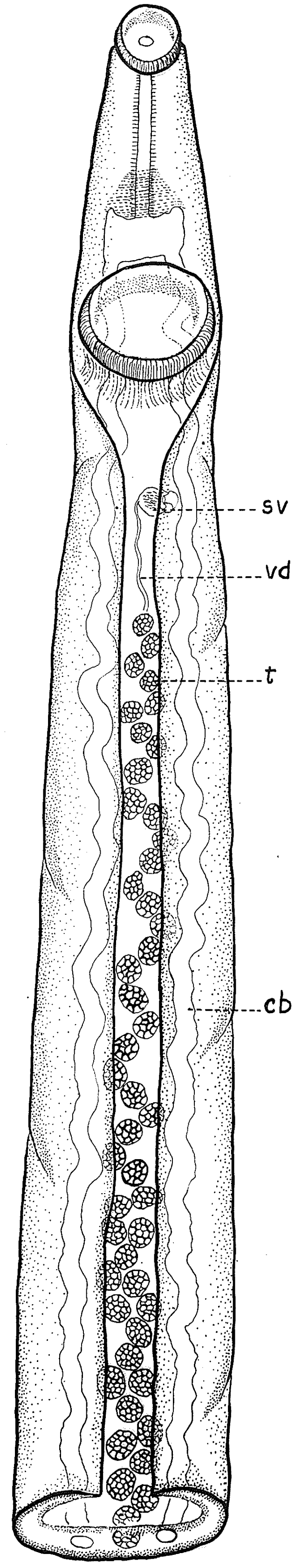

Figure 1.

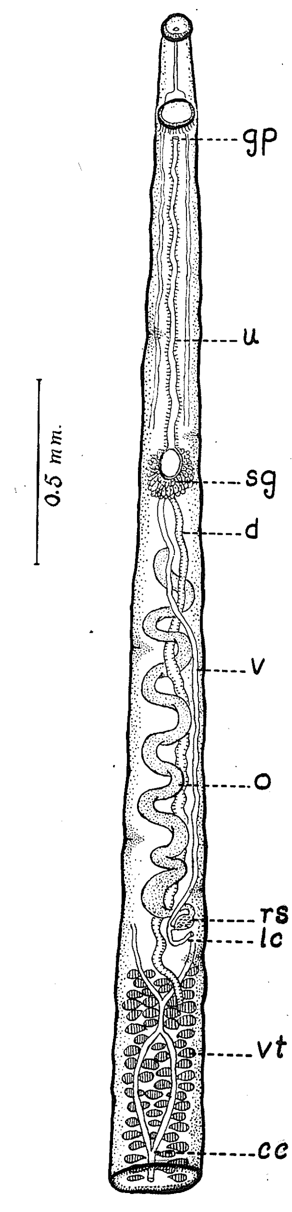

Figure 2.

Plate 12.

Figure 1. Photomicrograph of mid-body region of *Ornithobilharzia sp.* showing single row of large vitellaria, x 60.

Figure 2. Photomicrograph of genital region of female *Ornithobilharzia aviani*, showing spiral ovary, seminal receptacle, cecal union, oviduct and shell gland and vitellaria, x 60.

Figure 3. Photomicrograph of genital region of female *Ornithobilharzia lari*, showing stout spiral ovary, seminal receptacle and vitellaria, x 60.

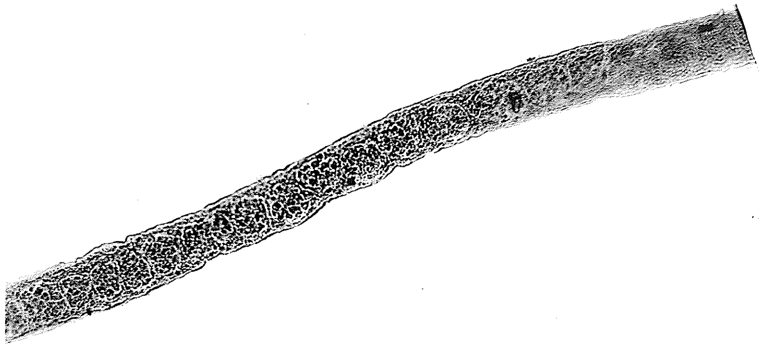

Figure 1.

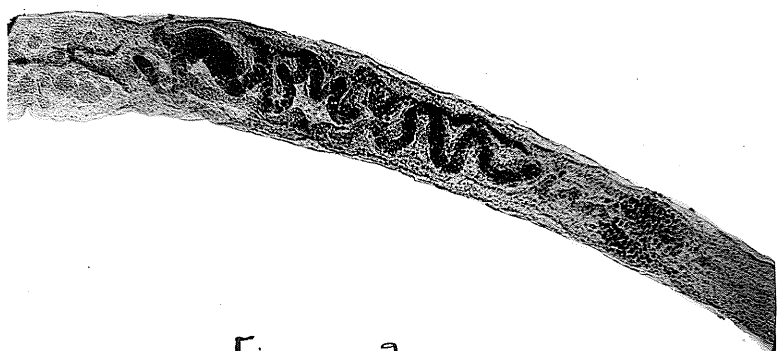

Figure 2.

Figure 3.

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