A SURVEY OF THE SCHISTOSOME FAUNA OF SOUTHERN MANITOBA AND A MONOGRAPH ON THE SCHISTOSOMATIDAE OF THE WORLD.

A Thesis

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the Faculty of Graduate Studies and Research

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In Partial Fulfilment

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Doctor of Philosophy.

by

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ABSTRACT

Seven adult schistosome species were recovered in Manitoba from 431 birds and 34 mammals examined. Seven species of schistosome cercariae were also found. One new adult species, one new larval species and two new larval varieties were described. A number of new host and locality records were reported.

The seasonal incidence of two cercarial species and the growth pattern of their host were determined.

A monograph on the known schistosomes of the world was prepared. This includes the complete systematics of the Family together with the descriptions of all known species and taxonomic keys.

TABLE OF CONTENTS.

LIST OF TABLES

PART ONE

PART TWO

PAGE

LIST OF FIGURES

PART ONE

FIGURE PAGE

PART TWO

EXPLANATION OF FIGURES

In all figures 'a' refers to the male and 'b' to the female of the species.

Abbreviations used:

CC. Common caecum.
CP. Cirrus pouch.
CR. Cirrus.

ED. Ejaculatory duct.
ES. Oesophagus.
ESV. External seminal vesicle

GC. Gynaecophoric canal.
GP. Genital pore.

ISV. Internal seminal vesicle

LC. Laurer's canal.

MG. Mehlis gland.

O. Ootype.
OD. Oviduct.
OV. Ovary.

P. Prostate.
PC. Paired caeca.

SR. Seminal receptacle.
SV. Seminal vesicle.

T. Testes.
TC. Transverse canals.

U. Uterus.

V. Vitellaria.
VD. Vitelline duct.
VS.D. Vas deferens.

INTRODUCTION

The Schistosomatidae of the class Trematoda are of particular interest for two reasons: firstly they are unique in being dioecious, in contrast to the almost universal occurrence of hermaphroditism in the remaining Trematoda; and secondly they are of extreme medical importance.

The life-cycle of this family is relatively simple, having only a single gastropod intermediate host and a final host into which the cercariae actively penetrate. The adult schistosomes are found in the blood vessels of mammals and birds, and include species which infect man, causing the very serious scourge of Bilharziasis endemic to South America, Africa, the Near East and the Orient.

The group is also of importance in Canada and particularly Manitoba in that the cercariae of non-human schistosomes may accidently penetrate the skin of man causing the onset of 'swimmers itch' or 'cercarial dermatitis'. With the rapid development of the province and the added emphasis on the tourist 'business' much potential revenue is no doubt lost through it. Since some of the wild life of this province are hosts to the schistosomes, particularly game-birds and fur-bearing mammals,there can be little doubt that the schistosomes also play an important role in the picture of wild-life diseases.

At the commencement of this study, it was realized that before any further work could be attempted on the epidemiology of the schistosomes, some attempt had to be made to classify the known schistosomes of the world. Over the years a vast amount of literature had accumulated, and partly because of this and also because to date no attempt had been made to assemble and organize these data, the classification of the group was in quite a considerable chaos.

The whole point is that until now it has been impossible to view the group as a unit. New species have been erected without a critical analysis of the situation and with only a cursory glance at the literature. Confusion has been intensified by an almost pathological fear of arriving at any decision regarding synonymy of species, the situation being avoided by the usual expedient of erecting new species based on minute structural differences.

For these reasons a monograph on the schistosomes of the world has been included in this thesis. The author makes no apologies for the fact that much of the monograph is a review and interpretation of the literature. When possible type material was examined, but it was never possible to improve on the original descriptions, except of course where fresh material was available locally.

The view is often expressed that such a monograph as this is impossible without a more thorough knowledge of the schistosome life-cycles, and that without such knowledge no conclusion is possible regarding the identity of certain species. Such a view is perfectly justifiable and correct. A final classification of the schistosomes based on either morphology or phylogeny is as yet impossible and will remain so for many years hence. This monograph, however, has no pretence to be the final solution to the problems that exist; rather it functions to clarify the situation; a beginning not an end. Rome, we are told, was not built in a day and neither can the writing of such a monograph be delayed *ad infinitum* until, with all problems solved, the final classification is attained. Without some attempt being made at this time to clarify the situation, however wrong it may prove to be, the present chaos will multiply.

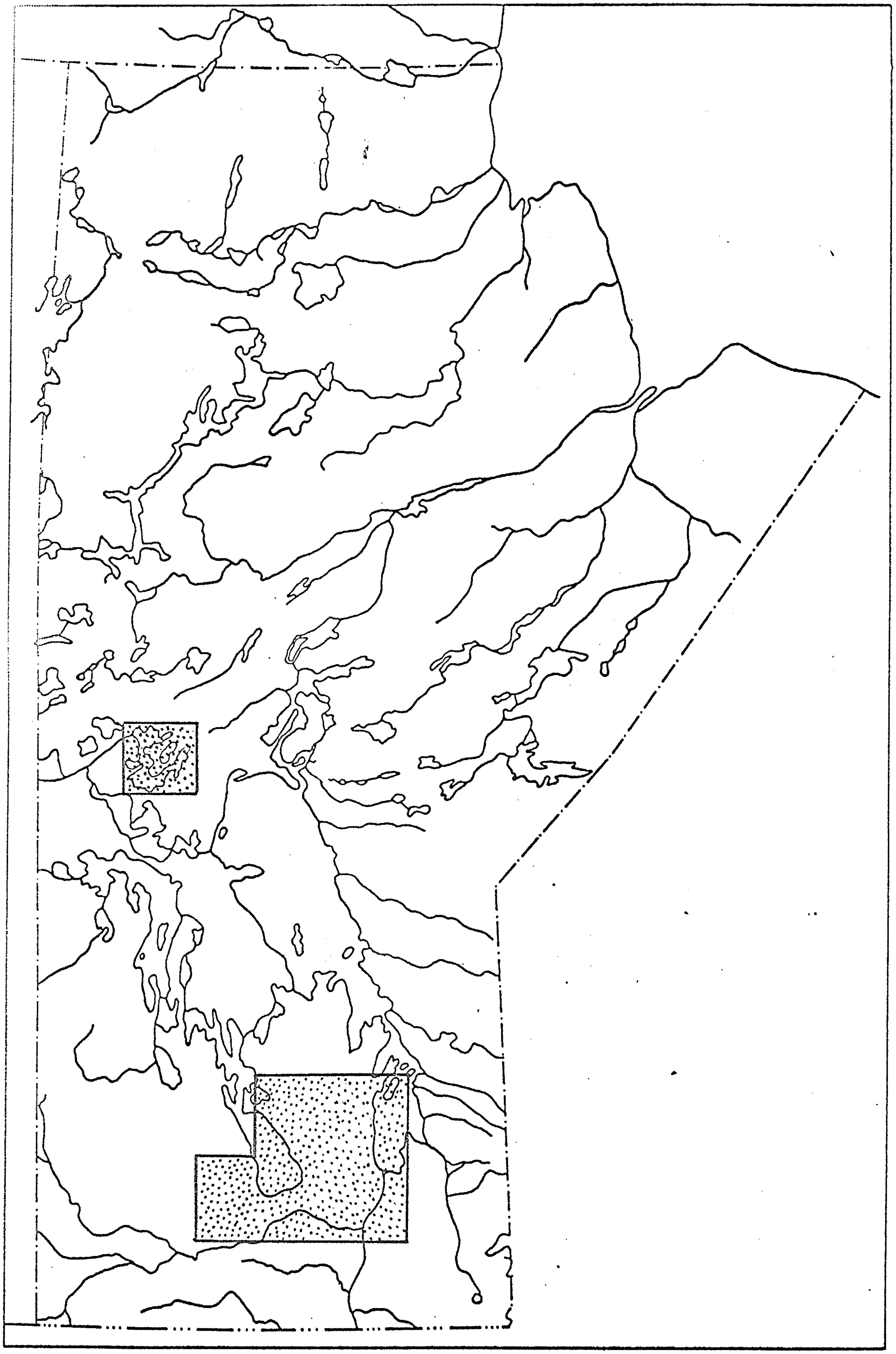
The thesis has been divided into two parts:

PART I. A SURVEY OF THE LOCAL SCHISTOSOME FAUNA.

PART II. A MONOGRAPH ON THE SCHISTOSOMATIDAE OF THE WORLD.

The survey was carried out over the summers of 1961, 1962 and 1963. It includes examination of bird and mammal hosts for adult schistosomes and snails for their larval stages, together with life-cycle studies in the laboratory. The areas covered by the survey are shown (Fig 1), the distribution maps used throughout this thesis being a composite of the two shaded areas.

FIGURE I. Areas covered by survey.



HISTORICAL

Following the realization that the schistosomes are of immense importance to the health of man, the amount of research undertaken has been astronomical, so much so that to attempt a detailed historical account would require a volume to itself. The historical account given below will therefore only include discoveries pertinent to a classification of the group, and to a survey of the region.

The first species of schistosome was recorded by Rudolphi (1819) under the name of *Distoma canaliculatum*; whilst the second, *Distoma haematobium*, was described from man by Bilharz (1852).

Much confusion exists as to the early naming of the group. Weinland (1858) placed them in the genus *Schistosoma*, type species *Distoma haematobium*, and erected the family *Gynaecophora*. Later in the same year Diesing proposed the generic name *Gynaecophorus*, and Cobbold (1859) erected the genus *Bilharzia* in honour of Bilharz. In 1860, Moquin-Tandon renamed the genus *Thecosoma* on the grounds that a term *Schistosomus* had been used as far back as 1837 by G. St. Hilaire and used in teratology. By a decision of the International Commission on Zoological Nomenclature (1954), the generic name of the group became *Schistosoma*; whilst at the same time it was recommended that the term 'Bilharziasis' be used to designate the disease.

Stiles and Hassall (1898) placed the schistosomes in the sub-family *Schistosominae* of the family *Fasciolidae*, whilst in 1899 Looss raised the group to the rank of family, the *Schistosomidae*. At the same time he erected a second genus, *Bilharziella*, to include *Bilharziella polonica*, previously described by Kowalewski (1895) as *Bilharzia polonica*.

Poche (1907) correctly pointed out that the family name *Schistosomidae* is grammatically incorrect, and should be replaced by the term *Schistosomatidae*. Similarly the sub-family name should read *Schistosomatinae* as actually used by Stiles and Hassall (1926).

Katsurada (1904) and Sambon (1907) described the two remaining common schistosomes of man, *S. japonicum* and *S. mansoni* respectively.

In 1910 Odhner erected a third genus, *Gigantobilharzia*, to include a new species *G. acotylea*. Later in 1912, the same author erected the genus *Ornithobilharzia* when describing *O. intermedia*, including within this genus *O. canaliculata* (Rudolphi), the first schistosome described, and also *O. kowalewski* originally described by Parona and Ariola in 1896 ~~in~~ as a member of the genus *Bilharzia*, and later placed in the genus *Bilharziella* by Looss.

The first breakthrough to a complete understanding of this group occurred in 1913 when Miyairi and Suzuki demonstrated that the larval stages of *S. japonicum* occur in a mollusc and that the cercariae so produced actively penetrate the body surface of their final host. Prior to this other workers had suspected the mollusc as being an intermediate host but had failed to provide proof. As early as 1864, for example, Harley suspected snails as being intermediate hosts. The impetus of the discovery by Miyairi and Suzuki lead to the life-histories of both S. haematobium and S. mansoni being described by Leiper in 1915.

Johnston in 1917 erected the fifth genus of the schistosomes, Austrobilharzia, to be followed by the genus Schistosomatium (Tanabe, 1923) and Dendritobilharzia (Skrjabin et Zakharrow, 1920). Travassos (1923) proposed the genus Macrobilharzia to include a very large male fluke, M. macrobilharzia. This group has disappeared and reappeared at intervals since that time. Skrjabin and Zakharrow in 1920 also erected the genus Trichobilharzia on the basis of an inadequate description of a new species T. kossarewi, considered to be lacking a gynaecophoric canal.

Price therefore in 1929 was faced with a group containing nine genera and 24 species. On the basis of the relative length of the gynaecophoric canal he divided the group into two sub-families: Schistosominae and Bilharziellinae. The former included the genera Schistosoma, Ornithobilharzia, Schistosomatium, and Austrobilharzia, whilst the latter contained the genera Trichobilharzia, Gigantobilharzia, Bilharziella and Dendritobilharzia. He also expanded the Schistosominae to include three new genera: Paraschistosomatium, Heterobilharzia and Microbilharzia. Later, in 1931, the same author discovered that the female worm Paraschistosomatium anhinga, the type species of the genus, was in fact the female of

Macrobilharzia macrobilharzia (Travassos) only the male of which had previously been known. This genus Price had earlier suppressed as being synonymous to Ornithobilharzia. He therefore suppressed the genus Paraschistosomatium and reerected the genus Macrobilharzia.

In 1929 Ejsmont erected a new genus Pseudobilharziella of the sub-family Bilharziellinae to include P. kowalewski first described by Kowalewski in 1896, and considered by him to be the immature stage of Bilharziella polonica. The genus differed from the description given for Trichobilharzia only in the possession of a gynaecophoric canal. Much later, McMullen and Beaver (1945)recognized that Trichobilharzia and Pseudobilharzia were identical and that the genus Trichobilharzia did in fact bear a gynaecophoric canal. The genus Pseudobilharziella was therefore suppressed as being synonymous to Trichobilharzia.

With various modifications the above classification remains. Mehra in 1940 raised both Gigantobilharzia and Dendritobilharzia to sub-family rank: the Gigantobilharzinae and Dendritobilharzinae, a classification accepted both by Skrjabin and Yamaguti in their volumes on the trematodes. Lal (1937) created a new genus Chinhuta for a worm which closely resembled Bilharziella polonica except that a gynaecophoric canal was considered to be present. This has since been considered as a case of mistaken identity and the genus suppressed as synonymous to Bilharziella. Finally Penner (1953b) suppressed the genus Microbilharzia as being identical to

Austrobilharzia.

Although the classification was gradually becoming stabilized much dissatisfaction remained particularly re the genera *Schistosoma* and *Ornithobilharzia*. In 1961 Dutt and Srivastava attempted a revision of the genus *Ornithobilharzia*. They removed the three mammalian species included in this genus and on rather shaky morphological grounds included them in a new genus the *Orientobilharzia*. The species *O. odhneri* (Faust,1924) was also removed and placed in a separate genus *Sinobilharzia* (nec Le Roux, 1958).

A tremendous amount of work has been done over the years on the African schistosome complex and to date no agreement has been reached on the relationships between the various forms. For a detailed account of this problem the reader is referred to the work of Fisher (1934), Van den Berghe (1937), Schwetz (1951), Amberson et Schwarz (1953), Kuntz (1955), Nelson (1960), etc. Le Roux (1958) proposed a completely new classification of these African schistosomes when he broke up the large genus *Schistosoma* into three genera: *Schistosoma*, *Afrobilharzia*, and *Rhodobilharzia*. He also placed *S. japonicum* from the orient into a new genus *Sinobilharzia*, and *Ornithobilharzia bomfordi* from India into the *Eurobilharzia*. Unlike Dutt (1961) he did not place *Ornithobilharzia dattai* in the same genus as *bomfordi* although he did agree that it should not be retained in *Ornithobilharzia*. Unfortunately Le Roux did not attempt to classify the remaining *Schistosoma* from India. This scheme of classification has not been accepted by other workers, not one feels because of a critical rejection of Le Roux's views, but rather because of a natural disinclination to change the generic names of the three human flukes.

As a final note to this extremely brief history it must be mentioned that hybridization may well be rather common among the schistosomes, and that many of the perplexing problems of species identification may well be a result of this phenomenon. Unfortunately since the schistosomes are extremely difficult to cultivate in the laboratory - especially the avian forms, it may be many years until the extent and result of hybridization will be understood.

Survey Work.

Since migratory birds are the most important hosts of schistosomes in Manitoba, a survey of the literature relative to this topic would not be complete without reference to work carried out in the U.S.A.

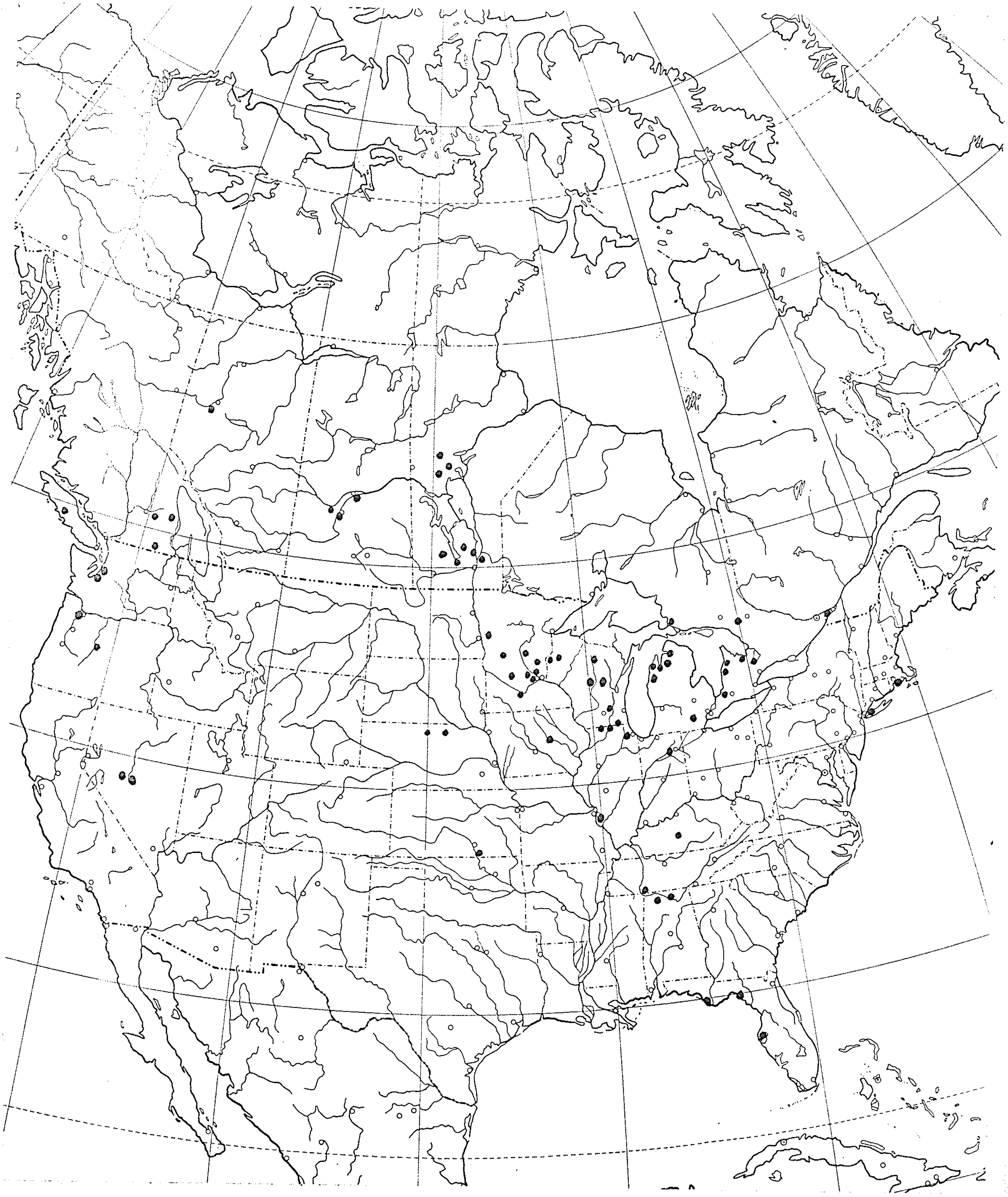
Interest in the non-human schistosomes of North America first arose when Cort (1928) showed that "swimmers itch' was caused by the penetration into human skin of schistosome cercariae for which man is not the definitive host.

Schistosome dermatitis, characterized by highly irritable papular eruptions, of up to two weeks duration is distributed round the world although naturally in areas where Bilharziasis is endemic the problem is too trivial to warrant much study. For this reason there has been no definite record of the itch in Africa, although Porter (1938) reported the presence of non-human schistosome cercariae in South Africa. The itch has been reported from Asia. In Malaya the so-called 'sawah' disease of man has been shown to be caused by Schistosoma spindales, normally parasitic in cattle (Buckley, 1938). The 'kabure' and 'Koganbyo' diseases of Japan are associated with workers in the rice paddies, the latter being caused by the cercariae of Gigantobilharzia sturniae. Schistosome dermatitis also occurs in Australia, New Zealand, and in Europe, particularly in France and in Lake Constance where the disease in termed 'Hundsblattern'. In Wales a very severe outbreak took place in an artificial lake in Cardiff (Matheson,1930).

Canada and the U.S.A. can boast of the worst incidence of schistosome dermatitis, Figure II showing its distribution along bird flyways throughout this region. In Canada outbreaks occur over the prairies, British Columbia and Quebec and in the U.S.A., Oregon, Wisconsin, Minnesota and Michigan appear to be the most heavily infested regions.

Following the discovery by Cort, quite an extensive series of investigations were carried out by such people as Cort, McMullen and Penner in the U.S.A. and McLeod in

FIGURE II. Map showing the distribution of schistosome dermatitis in North America.



Canada, most of which took place between 1930 and 1950. The majority of this work was concerned with the four common schistosome cercariae found in the northern regions of the United States: *C. elvae* Miller, 1923; *C. stagnicolae* and *C. physellae* Talbot, 1936 and *C. douthitti* Cort, 1914. Price (1931) showed the latter cercariae to be the larval stage of *Schistosomatium douthitti*, parasitic in small rodents. Later Penner (1942) showed fairly conclusively that it was identical to *Schistosomatium pathlocopticum* described by Tanabe (1923) from Massachusetts.

Much confusion exists as to the identity of the three remaining cercariae. All are similar, being members of the 'ocellata' group of schistosome cercariae. Talbot (1936) was able to show morphological criteria for distinguishing them and Cort and Talbot (1936) were able to show that all three differed quite considerably in their behaviour. Despite their common occurence however, their definitive hosts have not been positively identified, although McMullen et Beaver (1945) showed them to be members of the genus *Trichobilharzia* after experimental infections of pigeons, canaries and ducklings.

A similar complex of schistosome cercariae exists in Europe, where Szidati (1942) showed that *Cercariae ocellata*, originally described by La Valette St. George (1855), was in fact a compound of at least three separate species: *Cercariae pseudocellata* Szidat et Wigand, 1934; *C. neocellata* and *C. parocellata* Szidat, 1942. Earlier

Brumpt (1931) obtained adults from experimentally infecting ducklings with '*C. ocellata*' and on the basis of rather sparse material and egg dimensions synonymized the adults with *Trichobilharzia kossarewi* Skrjabin et Zakharrow, 1920. On the grounds of priority the name was changed to *T. ocellata*. McMullen et Beaver considered the adults from *C. elvae* identical to those obtained by Brumpt, and thus *Trichobilharzia elvae* to be synonymous with *T. ocellata*. Since however the exact species of the cercariae used by Brumpt cannot be ascertained, the name 'ocellata' must be surpressed as a specific name and only used to denote the general group of schistosome cercariae.

Many other species of larval and adult schistosomes have been reported from the U.S.A., a complete record of which is available in Part II. It is of interest that only three species of mammalian schistosomes have been reported from the Western hemisphere and one of these is probably a fairly recent immigrant: *Afrobilharzia mansoni*, parasitic in man and rodents of South America; *Schistosomatium douthitti* from rodents of the northern latitudes and *Heterobilharzia americana* from bobcats, racoons, etc. in the southern States.

Work has been carried out on the life cycles of snails in relation to the seasonal incidence of some schistosome cercariae, but very little in respect to *C. elvae*. Cort *et al* (1940) carried out investigations on the life cycle of Stagnicola emarginata angulata which is the molluscan host of C. stagnicolae in the Douglas Lake region of northern Michigan. They found the peak of the breeding season to be early July after which the adults began to die off, being greatly reduced by the end of August. None of them appeared to live over a second winter. The juveniles hatched and some reached almost adult size by September, sexual maturity and full size being reached in the early part of the second summer.

Cort et al (1941) studied the life-cycle of Physa parkeri, host of C. physellae in the same location as above. They found the eggs to be laid in the late spring and early summer after which the adults die, very few remaining by the end of July. The young snails appeared to reach full size by late fall.

Brackett (1940a) studied the life-cycle of Lymnaea stagnalis lillianae host of C. elvae at Rush Lake, Wisconsin. The snails reached maturity and bred in July and August after which they began to die and were completely gone by October. The juveniles overwintered and grew rapidly the following spring to become mature adults by the summer. In another location the same species of snail was found to resemble S. emarginata in that almost full grown juveniles were present in the fall.

The seasonal incidence of C. stagnicolae in Stagnicola emarginata was examined by Cort et al (1940). Early in the summer numerous immature infections were present in the near adult snails, the first cercariae being liberated in late June and early July. They found very little infection of juveniles and no evidence that any infection took place in the summer months, the majority being in the spring and fall. Such results point to the infection being acquired from a migrant bird species not nesting in the area.

McMullen et Beaver (1945) found two periods of infection of *Physa sp.* with *C. physellae*. The early summer was marked by an infection of adult snails and the late summer by infections of juveniles.

Very little has been done on the seasonal infection with *C. elvae* or *C. douthitti*. Brackett (1940a) found the incidence of *C. elvae* in *Lymnaea stagnalis lillianae* to increase from 3% in early July to 6% in mid-September, suggesting that the definitive host nested in the area.

The great majority of investigations on schistosomes in Canada has taken place in Manitoba. Clear Lake, Riding Mountain National Park, was a particularly important spot since a high incidence of 'swimmers itch' occurred there in 1930's. McLeod (1934) reported the presence of *C. elvae* and Swales (1936) found the lake to be heavily infested with *Cercariae stagnicolae* from *Stagnicola emarginata canadensis*. The first attempt to locate adult schistosomes in Canada was carried out by McLeod (1936) and two new species *Microbilharzia* (*Austrobilharzia*) *canadensis* and *M. manitobensis* were recovered from the canvas-back duck.

In 1937 McLeod found 18 of 30 blue-winged teal infected with Pseudobilharziella (Trichobilharzia) querquedulae; and 3 of 8 herring gulls with Ornithobilharzia lari, which he later (1940) transferred to the genus Microbilharzia. McLeod (1940) reviewed the situation in Manitoba up to that time and reported a new species of schistosome cercaria from Lymnaea palustris (C. dermolestes) and two new adult species: Ornithobilharzia aviani and O. filamenta from gulls.

Continued studies on the schistosomes of Manitoba were carried out by McLeod and Little (1942). They established the life-cycle of Trichobilharzia querquedulae and found the larval stage to be C. physellae, thus surpressing the name T. querquedulae on grounds of priority. They also exposed pigeons to C. dermolestes and located small worms in the fine veins of the intestine wall. They suggested that this species was identical with a species of Trichobilharzia observed in, but not recovered from the mesenteric veins of the pectoral sandpiper and the lesser yellow-legs. Trichobilharzia querquedulae was also recovered from Pintail and Shoveller ducks.

Wu (1953) carried out investigations on schistosomes at Ste. Anne de Bellevue Quebec where 'swimmers itch' had been known to occur sporadically along the Ottawa river. She found cercariae in Physa gyrina and by experimentally infecting canaries and ducklings described a new schistosome, Trichobilharzia cameroni. Edwards et Jansch (1955) described two new cercariae from Cultus Lake, B.C., and experimentally infected ducklings with them. One immature adult, of the genus Trichobilharzia, was located from exposure to C. adamsi. Bourns (1961) reported the first occurrence of C. douthitti in Canada, being present in various lakes to the north of Toronto. He also reported the seasonal incidence of the cercariae in the area. Schistosome dermatitis is also known to be very widespread in Saskatchewan and Alberta although the literature on the occurrence in these two provinces is quite small.

It is an unfortunate truism that unless one is specifically looking for schistosome adults one never sees them. This fact accounts for the near absence of any reference to schistosomes in the many surveys of water-fowl parasites carried out throughout the world. For this reason it is as yet quite impossible to come to any conclusion regarding host specificity in the group. It is hoped that the monograph included in this thesis will focus more attention on the group, and promote some workers to take a glance at the blood vessels before delving into the inner sanctities of the alimentary canal.

PART I.

A SURVEY OF THE LOCAL SCHISTOSOME FAUNA

MATERIALS AND METHODS.

A survey of this type necessitates examination of adult schistosomes and cercariae, the maintenance of life-cycles in the laboratory and a survey of the snail hosts.

Examination of adult schistosomes.

The great majority of material was collected from birds during the summers of 1962 and 1963. The birds were shot in the field and identified by means of Peterson's 'Field Guide to the Birds'.

The very best conditions of lighting are needed for the location and removal of schistosomes from the blood vessels, so that examination of the birds in the field is not recommended. On the other hand once the blood has coagulated it is quite impossible to locate any of the worms. For this reason the birds were eviscerated immediately after killing and the gut, liver and heart stored in bottles containing physiological saline with heparin, and kept in a portable ice-box.

The guts were examined under a stereoscopic microscope using 15X magnification. Particular emphasis was placed on the larger veins by examing them under strong transmitted light, and to the surface venules by using direct light. By this method it was possible to locate at least one sex of the worm, if present.

Worms present in the larger veins were removed by cutting the vein and gently pressing out the worm. To remove the worms in the small plexi and to complete the examination of the gut it was necessary to slit open the gut, remove the contents and scrape away much of the mucosa. The gut wall was then examined under strong transmitted light. Removal of the minute worms in the small blood vessels is an extremely tedious and difficult process. It was found necessary to use No: 00 insect pins fused into glass handles some of which were bent over at one end to form a minute hook.

A piece of venule wall was gently torn away with the hooked pin and the rear end of the worm pulled out of the blood vessel. Gradually working towards the anterior end of the worm the same process was repeated, continually pulling the posterior part of the worm free from the blood vessel. In many cases however the worms were of the same colour and texture as the surrounding tissue and were practically indistinquishable when the blood was expelled from the vessels. In this case the author found it possible only to remove fragments.

In many cases the eggs were located in the mucosa underlying the worms and in large clusters within the gut contents. Such eggs presented no problem in removal and hatching. In other cases the location of eggs was extremely difficult and in the case of _T._ _querquedulae_ it was necessary to remove the eggs singly, since they were embedded within the sub-mucosa of the gut wall.

After removal the worms were relaxed in 2%

chloral hydrate for a few hours, then fixed in Gilson's fixative for 12 hours, stained in Gower's carmine and mounted in permamount.

The formulae and procedures were as follows:

Gilson's Fixative.

Nitric Acid (80%)........................15ccs
Glacial Acetic Acid...................... 4ccs
Mercuric Chloride........................20gms
Ethyl Alcohol (60%)......................100ccs
Distilled Water.........................880ccs

1. Take up to 70% alcohol.
2. Leave overnight in 70% alcohol, coloured 'port red' with iodine.
3. Take down to distilled water.
4. Leave for 2 mins. in approximately 2% Sodium Thiosulphate, to remove any iodine discolouration.
5. Stain 12 hours in Gower's carmine.

Gower's Carmine.

Acidified Carmine........................ 1gm.
Potash Alum..............................10gm.
Distilled Water.........................200ccs

Plus Thymol crystals to prevent mould growth.

6. Wash in distilled water
7. Dehydrate to 95% alcohol
8. Gradually transfer to Terpineol.
9. Mount in permamount.

Fixing in Bouin's proved to be unsatisfactory. Despite washings in lithium carbonate the yellow colour of the fixative was often retained and interfered with the staining.

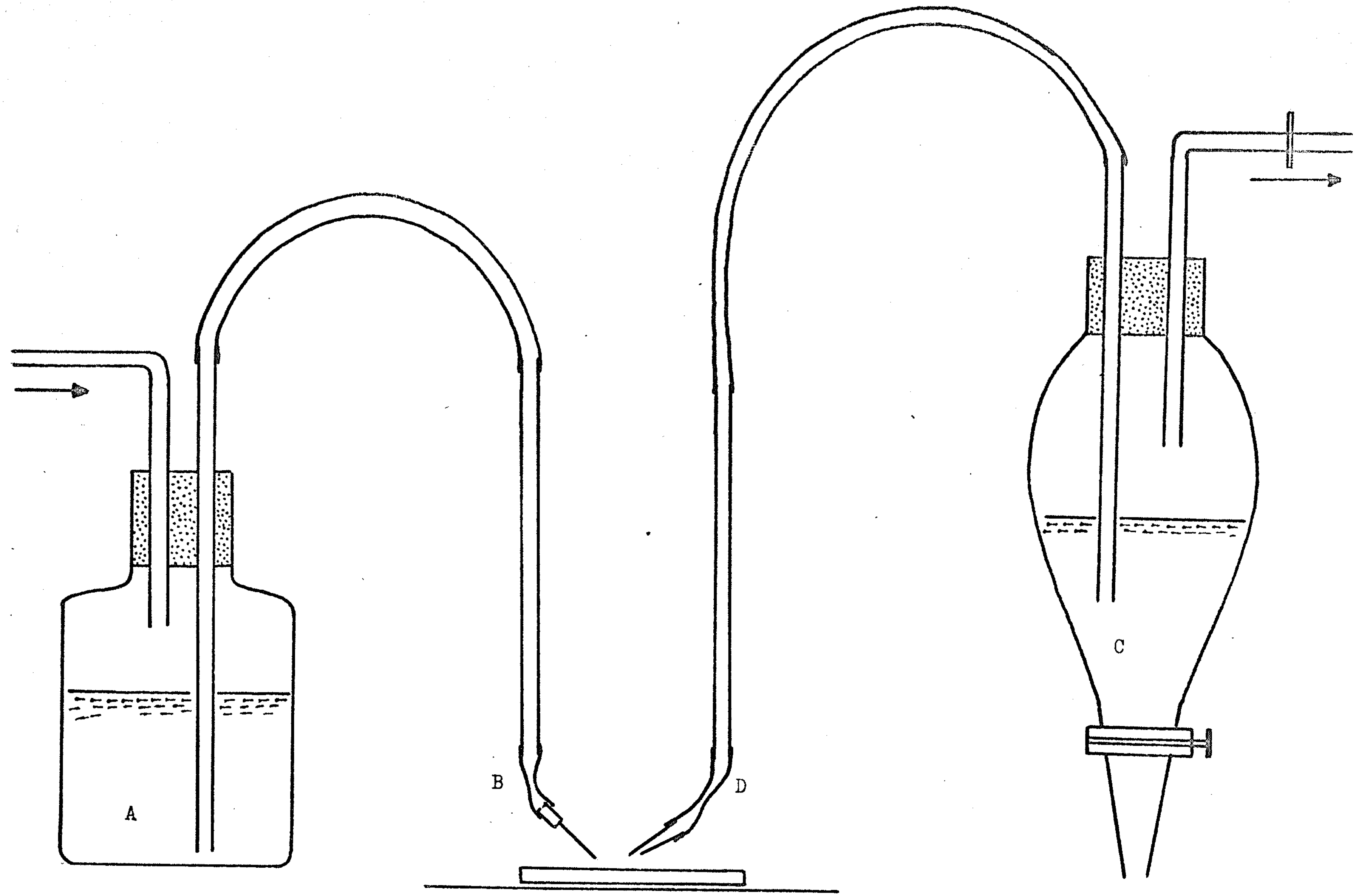
Gower's carmine gave excellent results, expecially in the more delicate worms. It is a purely nuclear stain, thus the important organs stand out clearly against a transparent body. It was found impossible to prevent mould growth completely so that only small batches of the stain were made up at one time.

Specimens were drawn by means of the camera lucida. Photographs were not taken as the minuteness of the worms prevented much detail being visible on photographic plates.

Adults of Schistosomatium douthitti were removed from laboratory infected mice by a perfusion technique. The vessel A (Fig.III), containing physiological saline and heparin, was attached to a force pump and a hypodermic needle attached to the outlet B. The suction apparatus C was attached to a vacuum pump and the inlet D fitted with a glass tube. The mouse was clamped to a board and the ventral abdominal wall removed. The hypodermic needle was inserted into the dorsal aorta through the wall of the left ventricle and the hepatic portal vein severed. Saline was perfused through the gut and collected from the severed blood vessel by the suction apparatus, the worms collecting in the vessel C.

Miracidia were collected from eggs occurring in the liver of the mouse following the side-arm technique

FIGURE III. Perfusion apparatus for the removal of *Schistosomatium douthitti* adults.



A
B
D
C

of McMullen et Beaver (1945). The liver was ground into small pieces with wet, coarse sand in a mortar and pestle and transferred to the main vessel of the side arm flask (Fig.lV) which was then filled to the mark A with water. The flask was then topped by adding water to the side-arm, and placed in a light-proof container with the side-arm illuminated by a lamp.

The miracidia, which are positively phototactic and negatively geotactic, appeared in the side arm after about 10 minutes where they could be seen against a darkened background. From this position they were collected by means of a small pipette and used to infect snails.

A few rodents were examined for S. douthitti by trapping in the field and examination on the spot.

Examination of Cercariae.

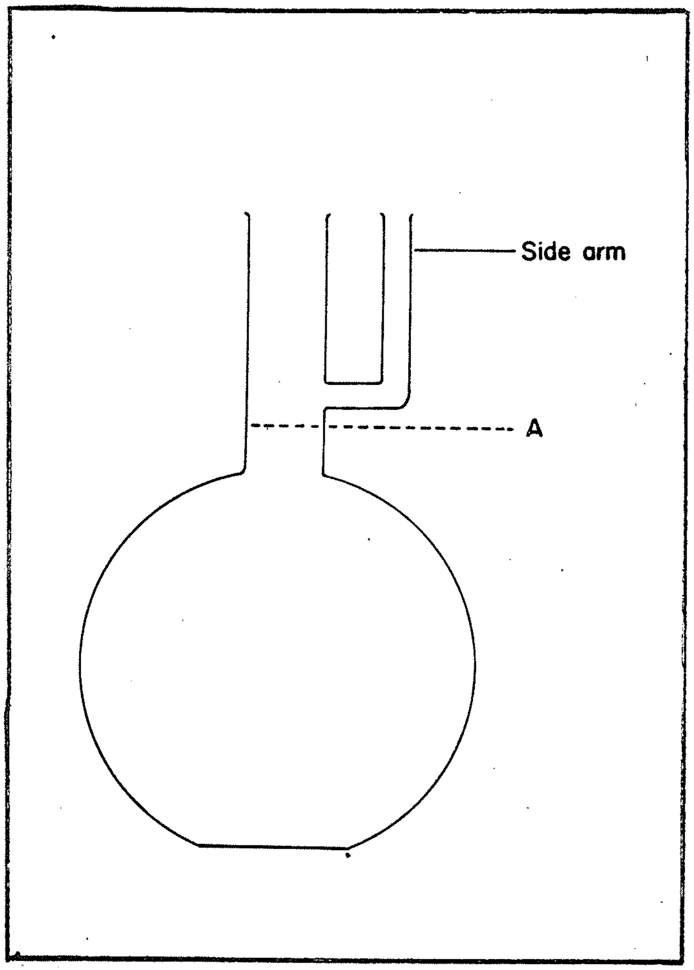
Cercariae were obtained by placing naturally infected snails overnight in jars containing pond-water. It was also possible to 'forcibly' obtain cercariae by altering the light cycle: illuminating overnight and placing in a dark container for a few hours during the day. The latter method was utilized when exposing possible primary hosts since it guaranteed a supply of fresh cercariae in the afternoon.

Morphological studies of the cercariae were made following the method of Talbot (1936). Cercariae to be fixed and measured were placed in a very dilute solution of neutral red for a few minutes and fixed by pouring into boiling 10% formalin. The neutral red caused the cercariae to relax although prolonged exposure caused some to lose their tails.

Morphological studies must be carried out on living cercariae. The practice of fixing, staining and mounting them serves no useful purpose and was not attempted. The following method was used:

1. A series of outline drawings of the cercariae were made from the fixed material.
2. The living cercariae were placed in the dilute neutral red solution and after a few minutes a little nile blue sulphate was added, just sufficient to give a faint blue tinge.
3. The cercariae were then examined under the microscope and particular emphasis was placed on the head organ and penetration glands. The information gained was then incorporated into the drawings.
4. Fresh cercariae were then placed under a cover-slip and a drop of neutral red introduced under it, so that gradually the cercariae became bathed in a concentrated stain solution. Using this method it was possible to see the flame cells, and immediately prior to death the ducts became visible.

FIGURE lV. Side-arm flask for the collection of schistosome miracidia.


Side arm
A

Maintenance of schistosome life-cycles in the laboratory.

Snails of the common Manitoban species were maintained in the laboratory. The bottoms of the aquaria were covered with about one inch of coarse sand in which aquarium plants were grown. The aquaria were filled initially with clear pond water which ensured a good supply of fresh water crustaceans etc., so necessary in preventing the growth of micro-organisms. Throughout the summer however the aquaria could be topped with tap-water, although whenever possible fresh water was brought from the field.

The aquaria plants and algae provided an adequate diet for the young snails, although for mature individuals fresh lettuce leaves were necessary. Powdered calcium carbonate was added at intervals to provide the necessary calcium for shell development.

Snails to be exposed were placed in small glass vials by species and eggs or miracidia added to the water. The snails and miracidia were left in contact for about 5 hours. Commencing at about 30 days after exposure the snails were examined for cercariae following the method already outlined.

Animals to be exposed to the cercariae were allowed to wade in infested water for about one hour. Water, deep enough to cover the legs, most of the breast and the anal region is necessary when exposing birds to the cercariae. When exposing mice the water must be shallow which necessites transferring the cercariae from the jar containing the snails to the exposure vessel. Since the cercariae of S.douthitti, the rodent schistosome, clings to the surface of the water the transfer was made by drawing a wire loop across the surface, and trapping the cercariae in the film so produced. Birds and mammals were examined for adult schistosomes at least one month after exposure.

Examination of snails

Throughout the summers of 1961,'62 and '63 snails were collected to determine the incidence of infection with schistosome cercariae. At the same time samples of Lymnaea stagnalis jugularis were collected from St.Andrew's Lagoon, near Lockport and measured to determine the growth pattern of the species. The data collected from St. Andrew's was used to estimate the age of snails from other areas. St. Andrews was chosen for this work since it was readily accessible at all times, particularly in the early spring when other lakes were inaccessible.

The identification of snails presented great difficulty. Reference was made to the works of Baker (1911, 1928); Mozley (1938) and Goodrich (1932).

Snails were dissected and their internal organs examined. The radulae were removed and left overnight in a 10% KOH solution. After washing in water the radula was placed between two microscope slides with a strip of paper each side to prevent crushing. The slides were then bound together and in this position dehydrated and cleared in xylol. One slide was then removed and the radula mounted under a coverslip.

RESULTS

SECTION A. ADULT SCHISTOSOMES

A total of 431 birds representing 47 species, and 34 mammals representing 3 species were examined for schistosome adults during the summers of 1962 and 1963.

Twelve species of birds were found infected with schistosome adults (Table 1) whilst 35 species were negative (Table 2). The following six species of avian schistosomes were recovered from these birds:

1. *Gigantobilharzia lawayi* (Brackett, 1942) Farley, 1963.
2. *Gigantobilharzia gyrauli* (Brackett, 1940) Brackett, 1942.
3. *Gigantobilharzia totani* n.sp..
4. *Trichobilharzia querquedulae* (McLeod, 1940) McMullen et Beaver, 1945
5. *Austrobilharzia lari* (McLeod, 1937) Penner, 1953b.
6. *Ornithobilharzia canaliculata* (Rudolphi, 1819) Odhner, 1912.

One mammalian species was found infected with a single species of mammalian schistosome:

7. *Schistosomatium douthitti* (Cort, 1914) Price, 1931.

Since the monograph included in this thesis contains the descriptive details of the above species, much of it is omitted in this section.

TABLE 1. INFECTED BIRDS EXAMINED

SCIENTIFIC NAME	COMMON NAME	NO. EXAMINED	NO. INFECTED	SPECIES PRESENT
Order: Anseriformes				
Anas discors (Linnaeus)	Blue-winged teal	25	9	*Trichobilharzia querquedulae*
Spatula clypeata (Linnaeus)	Shoveller	2	1	*Trichobilharzia querquedulae*
Aythya valisineria (Wilson)	Canvas-backed duck	1	1	Un-identified
Order: Charadiformes				
Totanus melanoleucus et *T. flavipes* (Gmelin)	Greater et Lesser Yellow Legs	24	7	*Gigantobilharzia totani* n.sp
Larus argentatus (Pontoppidan)	Herring-Gull	Adult 4	1	*Gigantobilharzia lawayi*
		2nd year 7	2	*Gigantobilharzia lawayi*
		Juvenile 3	-	
Larus delawarensis (Ord)	Ring-billed Gull	Adult 1	1	*Gigantobilharzia lawayi*
		Juvenile 11	3	*Gigantobilharzia lawayi*
Larus philadelphia (Ord)	Bonaparte's Gull	Adult 12	2	*Austrobilharzia lari*
			1	*Ornithobilharzia canaliculata*
			4	*Gigantobilharzia lawayi*
		Juvenile 8	1	*Austrobilharzia lari*

TABLE 1 (Continued)

INFECTED BIRDS EXAMINED

SCIENTIFIC NAME	COMMON NAME	NO. EXAMINED	NO. INFECTED	SPECIES PRESENT
Larus philadelphia (Ord)	Bonaparte's Gull		3	*Gigantobilharzia lawayi*
Order: *Passeriformes*				
Agelaius phoeniceus (Linnaeus)	Red-winged Blackbird	73	12	*Gigantobilharzia gyrauli*
Xanthocephalus xanthocephalus (Bonaparte)	Yellow-headed Blackbird	28	9	*Gigantobilharzia gyrauli*
Molothrus ater (Boddaert)	Brown-headed Cowbird	3	1	*Gigantobilharzia gyrauli*
Quiscalus quiscula (Linnaeus)	Common Grackle	16	2	*Gigantobilharzia gyrauli*

TABLE 2. NON-INFECTED BIRDS EXAMINED.

Scientific Name.	Common Name.	No: examined.
ORDER. PODICIPEDIFORMES		
Aechmorphorus occidentalis (Lawrence)	Western Grebe	2
Podilymbus podiceps (Linn)	Pied-billed Grebe	5
Podiceps auritus (Linn)	Horned-Grebe	3
Podiceps grisegena (Boddaert)	Red-necked Grebe	1
ORDER. CICONIFORMES		
Botaurus lentiginosus ((Rackett)	American Bittern	5
ORDER. ANSERIFORMES		
Branta canadensis (Linn)	Canada Goose	1
Anas platyrhynchos (Linn)	Mallard	14
Anas strepera (Linn)	Gadwall	6
Anas acuta (Linn)	Pintail	21
Anas carolinensis (Gmelin)	Green-winged teal	1
Mareca americana (Gmelin)	Baldpate	3
Aythya americana (Eyton)	Redhead	2
Aythya affinis (Eyton)	Lesser Scaup	4
Lophodytes Cucullatus (Linn)	Hooded Merganser	4

TABLE 2. (Continued) NON-INFECTED BIRDS EXAMINED

Scientific Name.	Common Name.	No: examined
ORDER. GRUIFORMES		
Rallus limicola (Vieillot)	Virginia rail	1
Porzana carolina (Linn)	Sora rail	4
Fulica americana (Gmelin)	Coot	17
ORDER. CHARADIFORMES		
Charadrius vociferus (Linn)	Killdeer	16
Erolia minutilla (Vieillot)	Least sandpiper	16
Catoptrophorus semipalmatus	Willet	2
Limosa fedoa (Linn)	Marbled Godwit	1
Limosa haemastica (Linn)	Hudsonian Godwit	1
Steganopus tricolor (Vieillot)	Wilson's phalarope	11
Sterna hirundo (Linn)	Common Tern	27
Chlidonias niger (Linn)	Black Tern	13
Larus pipixcan (Wagler)	Franklin's Gull	7
ORDER. PASSERIFORMES		
Icterus galbula (Linn)	Baltimore Oriole	1
Turdus migratorius (Linn)	Robin	7
Dumetella carolinensis (Linn)	Catbird	2
Pipilo erythrophthalamus (Linn)	Towhee	1
Melospiza melodia (Wilson)	Song-sparrow	3

TABLE 2. (Continued) NON-INFECTED BIRDS EXAMIMED

Scientific Name.	Common Name	No: examined.
ORDER. PASSERIFORMES		
Tyrannus tyrannus (Linn)	Eastern Kingbird	7
Telmatodytes palustris (Wilson)	Long-billed Marsh Wren	1
Dendroica coronata (Linn)	Myrtle warbler	1
Passerculus sandwichensis (Gmelin)	Savannah Sparrow	2

FAMILY: SCHISTOSOMATIDAE (Looss, 1899) Poche, 1907

SUB-FAMILY: GIGANTOBILHARZIINAE (Mehra, 1940) Amend.

GENUS: GIGANTOBILHARZIA (Odhner, 1910). Amend.

(Key to Genus: Part II, page 195)

GIGANTOBILHARZIA LAWAYI (Brackett, 1940) Farley, 1963.

Seven complete males, two complete females and many fragments of both sexes were recovered from one adult herring gull, one adult ring-billed gull, 4 adult bonaparte gulls, 2 second-year herring gulls, 3 juvenile ring-billed gulls and 3 juvenile Bonaparte gulls. A total of 14 infected gulls were found from the 53 examined.

Description of Species.

Fig. V

Specific diagnosis: Gigantobilharzia Odhner,1910.

Male: Extremely long and thin with a distinct gynaecophoric canal. Suckers absent. Body 21.25 to 38.5 mm (avg. 28.9) in length by 0.06 to 0.1 mm wide anterior to the gynaecophoric canal, 0.15 to 0.22 mm at the canal and 0.1 to 0.15 mm posterior to the canal. Posterior end of the body swollen but not spatulate. Gynaecophoric canal with distinct anterior end 0.86 to 1.25 mm (avg. 1.06) from the anterior end of body, 1.75 to 2.7 mm (avg 2.16) in length with the posterior part ending obscurely. Floor of the canal with numerous (up to 50) thickened bands at right angles to axis of body, sharply defined anteriorly, becoming less pronounced posteriorly. Oesophagus 0.3 to 0.44 mm long, paired caeca short, reuniting in the region of the anterior part of seminal vesicle. Common caecum extending to posterior end of body. Testes 345 to 545 (avg. 460) extending from the posterior end of the gynaecophoric canal to the posterior end of body, tandemly arranged, and reaching a diameter of about 0.09 mm. Seminal vesicle elongate and spiral, lying anterior to the gynaecophoric canal, and divisible into two portions: the anterior part or external seminal vesicle lying outside the cirrus pouch, and the posterior part of internal seminal vesicle lying enclosed within the cirrus pouch. External seminal vesicle 0.23 to 0.44 mm (avg.0.32) in length, commencing 0.38 to 0.54 mm (avg. 0.43) from the anterior end of body. Internal seminal vesicle 0.2 to 0.38 mm (avg. 0.31) in length. Ejaculatory duct opens on papilla at the anterior end of the gynaecophoric canal.

Female: Filamentous worm about 20 mm in length, with a constant width of 0.075 mm. Suckers absent. Oesophagus 0.38 to 0.46 mm long; paired caeca reuniting immediatedly posterior to the seminal receptacle. Ovary coiled, 0.46 to 0.6 mm (avg.0.57) long, commencing 1.45 to 1.9 mm (avg 1.64) from anterior end of body. Seminal receptacle 0.18 to 0.2 mm in length, situated immediately behind the ovary. Oviduct from posterior end of ovary, receives a branch from the seminal receptacle, and immediately turns forward giving off a Laurer's canal.

Oviduct receives vitelline duct and opens into ootype 0.23 to 0.28 mm in front of ovary. Uterus long, opening at anterior end of body. No eggs seen in uterus. Vitellaria of small follicles along each side of the common caecum.

Eggs: Oval without spine. Mature eggs in gut mucosa measured 94.12 ($\pm$ 9.38) by 76.23 ($\pm$ 7.54) micra. 100 eggs examined.

Cercariae: Unknown

Location: Intestinal veins.

Distribution: Manitoba, Canada (Fig. VI)

Identity of Species

To date the genus *Gigantobilharzia* contains 12 species, eight of which resemble the above in lacking an oral sucker: *G. acotylea* Odhner, 1910; *G. adami*, *G. nettapi*, *G. plectropteri* Fain, 1960; *G. ardeola* Fain, 1955; *G. huronesis* Najim, 1950; *G. huttoni* Leigh, 1955 and *G. lawayi* Brackett, 1942.

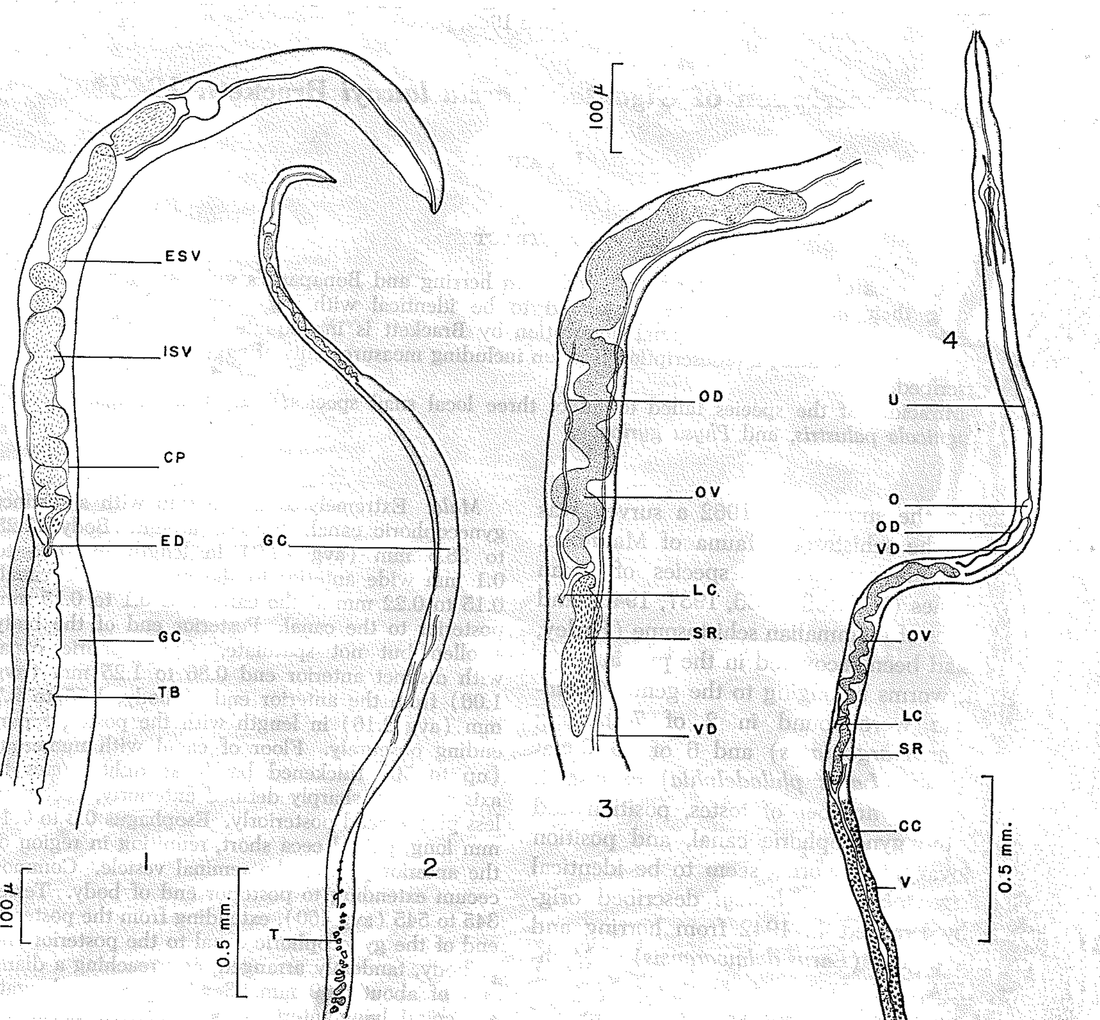
G. acotylea clearly differs from the species described above, both in body shape and size, position of various organs, and length of gynaecophoric canal. Fain only described the males of the four species found in Africa; nevertheless, they all differ from the above in the size and position of the gynaecophoric canal and the number of testes. *G. huronensis*, fully described by Najim (1956) from goldfinches and cardinals of Michigan, U.S.A., differs from the above in having a shorter gynaecophoric canal and

FIGURE V. Gigantobilharzia lawayi.

(After Farley, 1963)

1. Male showing anterior end.
2. Male showing extent of gynaecophoric canal.
3. Female at level of ovary.
4. Female showing anterior end.

Figures drawn with the aid of a camera lucida. Abbreviations as page XII .


ESV
ISV
CP
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100 μ
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GC
T
0.5 mm.
2
100 μ
OD
OV
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4
U
O
OD
VD
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LC
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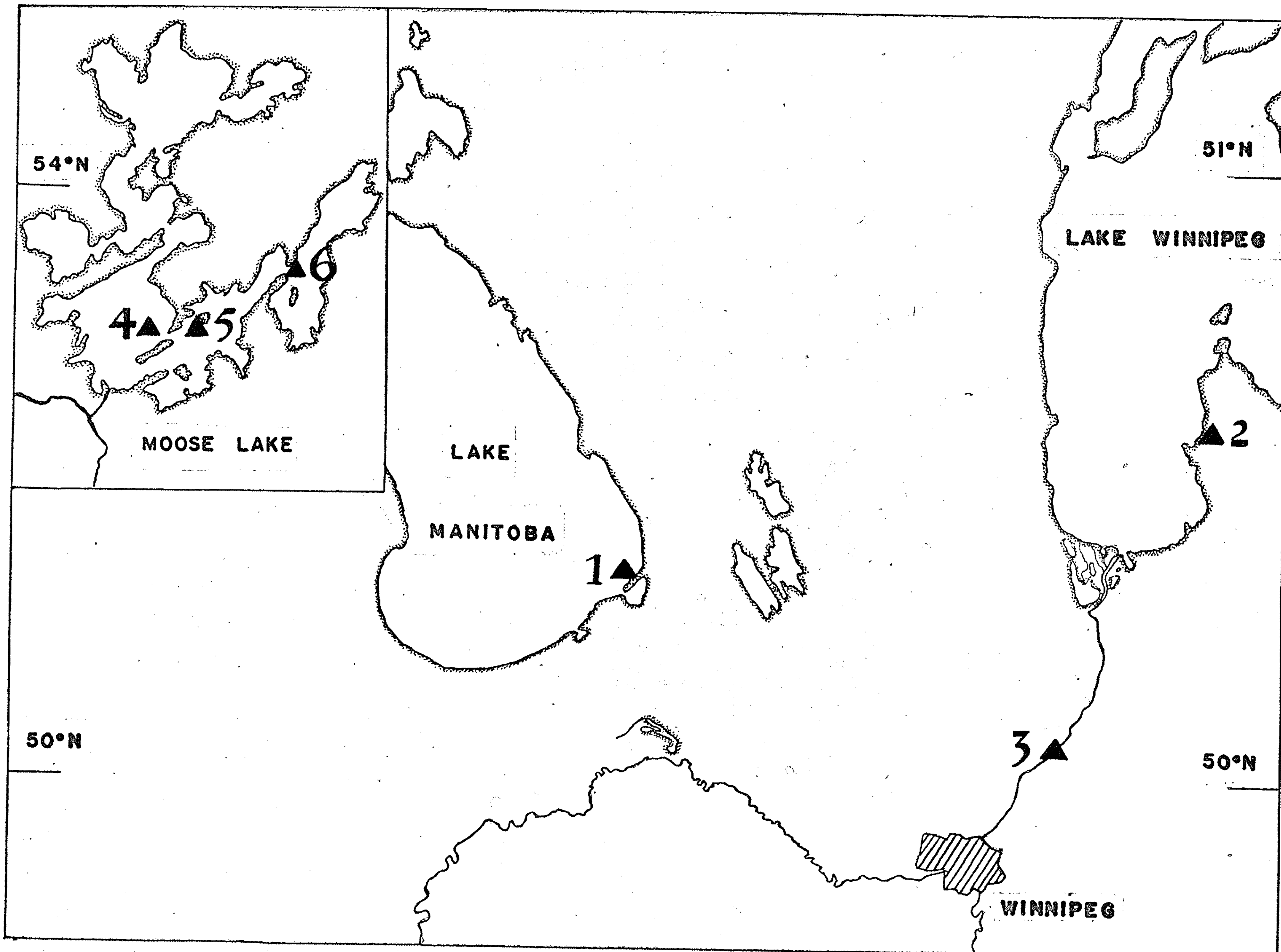
0.5 mm.

FIGURE VI. Areas of gull infestation with *Gigantobilharzia lawayi*

1. Twin Beaches, Lake Manitoba.
2. Grand Beach, Lake Winnipeg.
3. Red River, St. Andrews.

4,5,6. Moose Lake.

UNIVERSITY OF LIBRARY MANITOBA


54°N
4
5
6
MOOSE LAKE
LAKE
MANITOBA
1
51°N
LAKE WINNIPEG
2
50°N
3
50°N
WINNIPEG

a cirrus containing many prostate cells. It also differs considerably in size. Although the female closely resembles the above, the differences in the males and the different host point to them being considered as separate species. Although _G. huttoni_ has only been described from experimentally infected parakeets, it differs considerably in gross size and dimensions of the gynaecophoric canal. The intermediate host of this species is a marine gastropod whilst that of the local species has been shown to be a snail from local fresh waters.

Brackett (1942) described a new species _G. lawayi_ as follows:

"_Specific diagnosis_: _Gigantobilharzia_: Extremely filamentous. Female as long as or longer than male and similar in shape but more slender."

"_Male_: About 7.3 mm in length and 0.15 mm in diameter at gynaecophoric canal and 0.105 mm elsewhere. Gynaecophoric canal present, anterior end distinct but posterior end terminates obscurely; 0.63 to 0.85 mm from anterior end and may be as long as 2.25 mm or may be shorter. Testes over 500 in number, wider than long, and arranged in tandem and usually close together. Testes extend from posterior tip of body to a point further forward than the posterior end of gynaecophoric canal but not beyond its equator. Vas deferens leads forward as a fine tubule to a point 0.37 to 0.52 mm from the anterior and where it bends posteriorly and expands into the seminal vesicle. Seminal vesicle 0.30 to 0.37 mm in length and coiled in about six or seven loops. Cirrus and cirrus sac present. Genital pore situated at anterior end of gynaecophoric canal. Intestine bifurcates from 0.22 to 0.30 mm from anterior end. Point of caecal reunion not seen."

"**Female**: About 10 mm in length and a maximum width of 0.060 mm. Ovary coiled in 8 to 10 loops; 0.22 mm in length and situated 0.71 mm from anterior end. Posterior end of ovary opens almost directly into seminal receptacle which is 0.075 mm in length. Oviduct arises from the posterior end of the seminal receptacle and immediately turns anteriorly and proceeds to a point 0.60 mm from anterior end where it expands into a large thin-walled ootype. The uterus runs forward from the ootype and the genital pore is probably just behind the oral opening. Vitellaria small and numerous and start a short distance posterior to the seminal receptacle and fill the body caudad of this point. Vitelline duct not observed. No eggs seen in the uterus of the worms or the intestinal mucosa of the host. Digestive system not observed."

" Hosts: *Larus argentatus* and *Larus delawarensis*."

" Distribution: Michigan, U.S.A."

The above description differs in many respects from that of the local species. (Table 3). In the male the position and length of the gynaecophoric canal and the number of testes are nearly identical, although according to Brackett the testes appear to commence rather more anteriorly. The only major difference between the two descriptions is the length of body, the specimens from Manitoba being about five times as long. Examination of the type males showed them to be incomplete specimens which resemble the corresponding portions of the males from Manitoba. Thus the discrepancies in size between the two are a result of the original description being based on incomplete worms.

Comparison of the females is rather more difficult as Brackett fails to mention the occurrence of a Laurer's canal and also states that the oviduct arises from the posterior end of the seminal receptacle. The writer feels that Brackett may have been mistaken as in all other members of the genus the oviduct arises from the posterior end of the ovary, and if present a Laurer's canal is given off in this vicinity. Examination of type females provided no clue to this since the reproductive organs were impossible to distinquish. As in the male, the specimens were incomplete.

The writer feels confident that the local species is identical to that described as *Gigantobilharzia lawayi*, and for this reason the species has been redescribed (Farley, 1963).

Life-cycle studies.

As expected on ecological grounds specimens of *Lymnaea stagnalis jugularis*, *Lymnaea palustris*, *Aplexa*

TABLE 3. Comparison of local species with that described as *G. lawayi* (Brackett)

	Farley, 1963	Brackett, 1940
MALE.		
Length of body	21.25 - 38.5 mm	About 7.3 mm
Width of body at canal	0.15 - 0.22	0.15
Gynaecophoric canal:		
Length	1.75 - 2.7	About 2.25
Distance from ant. end.	0.86 - 1.25	0.63 - 0.85
Testes	345 - 545	over 500
Seminal Vesicle:		
Length	0.43 - 0.82	0.30 - 0.37
Distance from ant. end.	0.38 - 0.54	0.37 - 0.52
FEMALE.		
Length of body	About 20 mm	About 10 mm
Width of body	0.075	0.060
Ovary:		
Length	0.46 - 0.6	0.22
Distance ant. end	1.45 - 1.9	0.71
Seminal receptacle:		
Length	0.18 - 0.2	0.075

hypnorum and Physa gyrina were exposed to miracidia of G. lawayi without success.

Similarly, repeated exposure and examination of Lymnaea catascopium and Gyraulus sp (parvus) from the rocky shore of Lake Manitoba where infected gulls were obtained, proved negative.

During the summer of 1963 juvenile ring-billed and Bonaparte's gulls at Moose Lake were found infected with G. lawayi. Since these birds had not commenced their autumn migration it may safely be assumed that the infection was gained in local waters. A collection of snails from the rocky islands of Moose Lake abounding in gulls and terns included the following species:

1. Lymnaea stagnalis lillianae
2. Physa ancillaria
3. Gyraulus hirsutus
4. Gyraulus sp.
5. Helisoma campanulatum
6. Helisoma antrosum
7. Amnicola sp.

Physa ancillaria, both gyraulid species and H. campanulatum were especially plentiful clinging to the rocks along the shore line, whilst the other species had a very spotty distribution.

Specimens of the above snails were exposed to the miracidia of G. lawayi and these, together with a sample of collected snails were returned to the laboratory and maintained in the aquaria. In no case were infected snails found either in Moose Lake or in the laboratory collection so the molluscan host is as yet unknown.

The finding of G. lawayi in Manitoba represents a new locality record for this parasite, both in Canada and the province. Bonaparte's gull also constitutes a new host record.

<u>GIGANTOBILHARZIA</u> <u>GYRAULI</u> (Brackett, 1940) Brackett, 1942.

Fragments of this species were recovered from 12 red-winged blackbirds, 9 yellow-headed blackbirds, one brown-headed cowbird and two common grackles. A total of 24 infected birds from 120 examined.

This species was found inhabiting the minute veins surrounding the intestinal wall and is virtually impossible to remove. The females stand out readily since their intestines are filled with black pigment - breakdown blood products. The males however lack this pigment and are the same colour and texture as the background rendering them even more difficult to obtain. For this reason the description of the species is very inadequate.

<u>Description of species.</u>

<u>Gigantobilharzia</u> <u>gyrauli</u> was first described by Brackett (1942)from blackbirds of Wisconsin, U.S.A. He was unable to obtain any complete worms, the description being based on four fragments of both sexes:

<u>Specific</u> <u>diagnosis</u>: <u>Gigantobilharzia</u>. Extremely filamentous. Sexes similar in size and shape. Body cylindrical, about 10 mm in length with posterior tip bluntly rounded. Body width uniformly about 0.045 to 0.05 mm. Oral sucker well developed and 0.03 mm long. Ventral sucker absent.

<u>Male</u>: Gynaecophoric canal present; 0.8 mm in length and 1.38 mm from anterior tip of body. Body 0.054 mm wide

at gynaecophoric canal. Testes very numerous; distance between each testis equal to or greater then diameter of each follicle. They extend from a point about 0.26 mm back of the gynaecophoric canal to posterior tip of body. Vas deferens leads forward from testis as a very fine tubule to a point about 0.28 mm from anterior end of body where it bends posteriorly and expands into a seminal vesicle. Seminal vesicle about 0.26 mm long and coiled in 8 to 10 loops. Sperm duct leads directly as a plain tubule to the genital pore which is situated on a small papilla at anterior end of gynaecophoric canal.

Female: Ovary coiled in about 10 loops; 0.45 mm in length extending posteriorly from a point 1.4 mm from anterior tip of body. Posterior end of ovary narrows into a tubule 0.018 mm in length which leads into a seminal receptacle 0.15 mm in length. Oviduct arises at the posterior end of seminal receptacle and immediately turns anteriorly and continues to a point 1.115 mm from anterior end of body where it expands into a thin walled ootype. The uterus extends forward from the ootype to the genital pore which is situated immediately behind the oral sucker. Vitellaria in numerous follicles closely arranged and practically filling the entire body from a point a short distance caudad of the seminal receptacle to the posterior tip of the body. Vitelline duct leads forward and joins the oviduct just before it enters the ootype. No eggs observed *in utero*. Eggs only slightly elongate, about 0.060 mm long, thin shelled and without spine. Oesophagus bifurcates 0.54 mm from anterior end and caeca reunite just caudad of seminal receptacle.

A comparison of the local material with the above description is shown (Table 4). Numerous differences exist between the two descriptions.

In the male the length and position of the seminal vesicle are markedly different. Brackett describes it lying in a very anterior position and terminating 0.84 mm from the gynaecophoric canal. In the local species (Fig. VII and VIII) an internal seminal vesicle, lying within the cirrus pouch was readily visible proceeding forward from the genital pore and terminating 0.94 mm from the anterior end of the body. An external seminal vesicle extended forward from this point but immediately became invisible so that its length was unknown.

In the female Brackett again describes the oviduct arising from the posterior end of the seminal receptacle whilst in the local species it arises from the posterior end of the ovary. The writer feels confident that Brackett was mistaken in his observations.

<u>Incidence of Infection</u>.

Figure IX shows the areas where infected birds were recovered. Table 5 shows the incidence of infection of <u>G. gyrauli</u> in red-winged and yellow-headed blackbirds from four areas during the summers of 1962 and 1963.

The most notable result was the general drop in intensity of infection from 1962 to 1963. Nineteen of 48

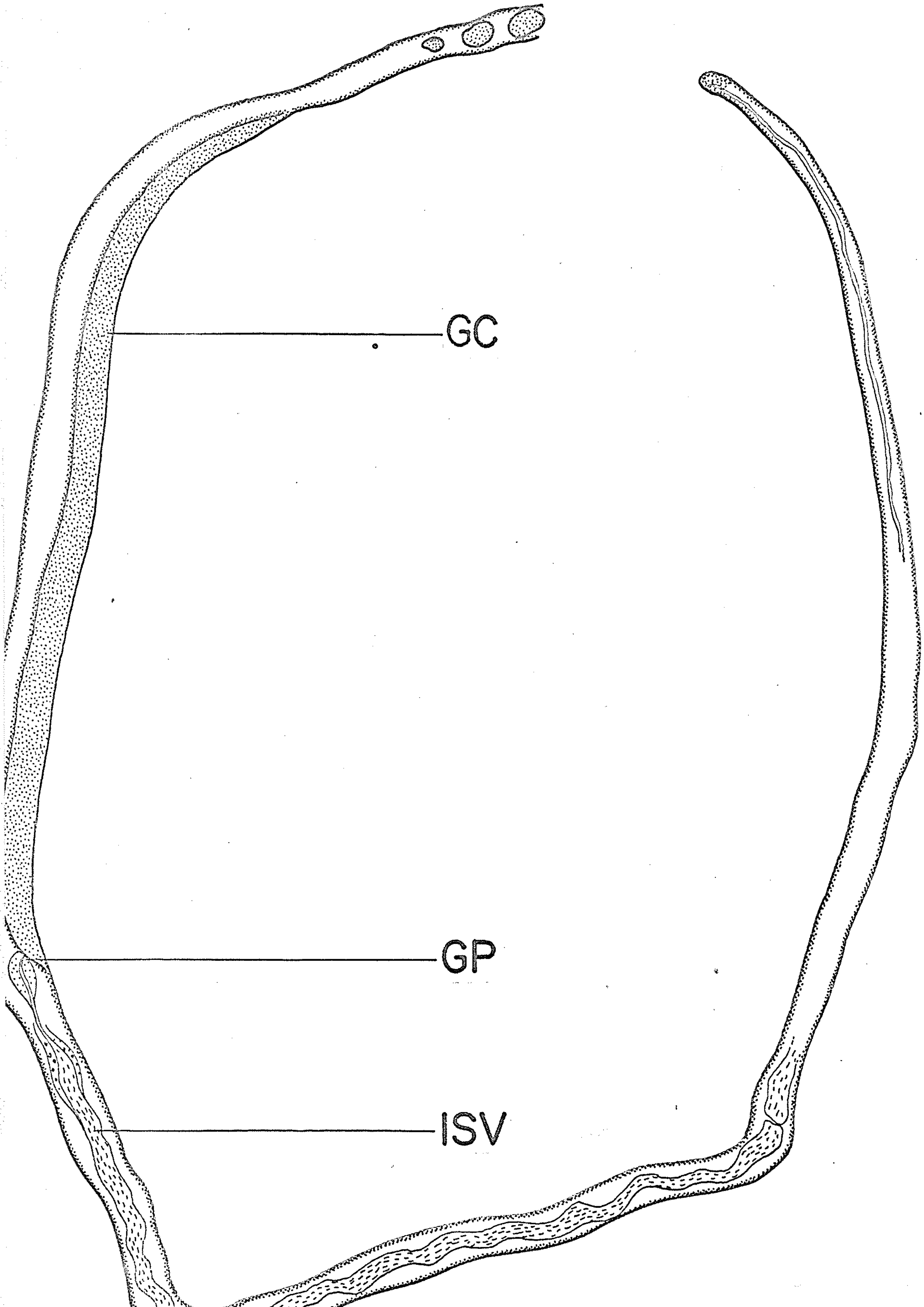
TABLE 4. Comparison of data for *Gigantobilharzia gyrauli*.

	Present findings	Brackett 1942
MALE.		
Length of body.	Unknown Approx 10 mm	Approx 10 mm
Width of body	0.03 - 0.05	0.045 - 0.05
Gynaecophoric canal:		
Length	0.937	0.80
Distance from ant. end	1.875	1.38
Seminal vesicle:		
Length	0.875 (I.S.V)	0.26
Distance from ant. end.	0.94 (I.S.V)	0.28
Testes	Unknown	Unknown
FEMALE.		
Length of body	As male	As male
Width of body	0.025 - 0.05	As male
Ovary:		
Length	0.40 - 0.58	0.45
Distance from ant. end.	1.40 - 1.86	1.40
Seminal receptacle:		
Length	0.10 - 0.125	0.15
Ootype:		
Distance from ovary	0.13 - 0.25	0.29
Egg	Oval	Oval
	63.9 by 62.5 micra	60

FIGURE VII. <u>GIGANTOBILHARZIA GYRAULI</u> MALE

Figure drawn with the aid of a camera lucida.

Abbreviations as page ..XII.....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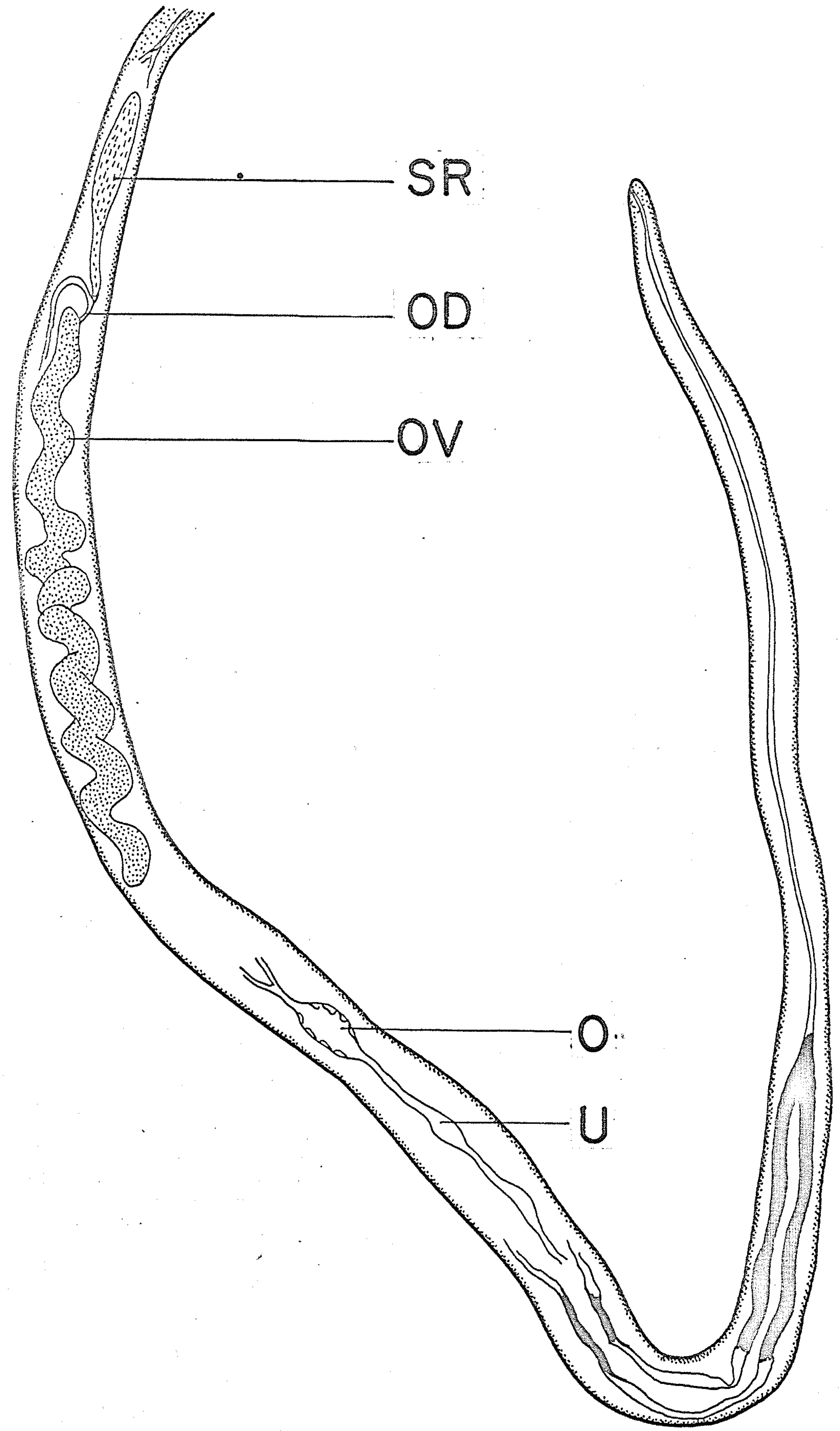
ISV

FIGURE VIII. GIGANTOBILHARZIA GYRAULI FEMALE

Figure drawn with the aid of a camera lucida.

Abbreviations as page XII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(40%) birds were infected in 1962, compared with only 2 of 53 (3.8%) in 1963. This drop was particularly marked at Long Lake, an excellent nest site for both blackbird species, where the level of parasitaemia dropped from 66% in 1962 to only 7% the following year.

Life-cycle studies.

Cercariae gyrauli (Brackett, 1940) were recovered from experimentally infected specimens of *Physa gyrina* with the miracidia from the blackbirds and cowbird. This proved conclusively the identity of the adult schistosomes.

Repeated attempts to infect the reported natural hosts, *Gyraulus parvus* and *Menetus exacuous* (V. page .102..) failed.

This is the first report of this species in Manitoba and Canada. The finding of infected cowbirds and grackles represent new host records.

Figure IX. Areas of Infestation with *Gigantobilharzia gyrauli*.

1. Long Lake, Reaburn.
2. Meadows
3. St Andrew's
4. Norris Lake
5. North Shoal Lake
6. Twin Beaches, Lake Manitoba.

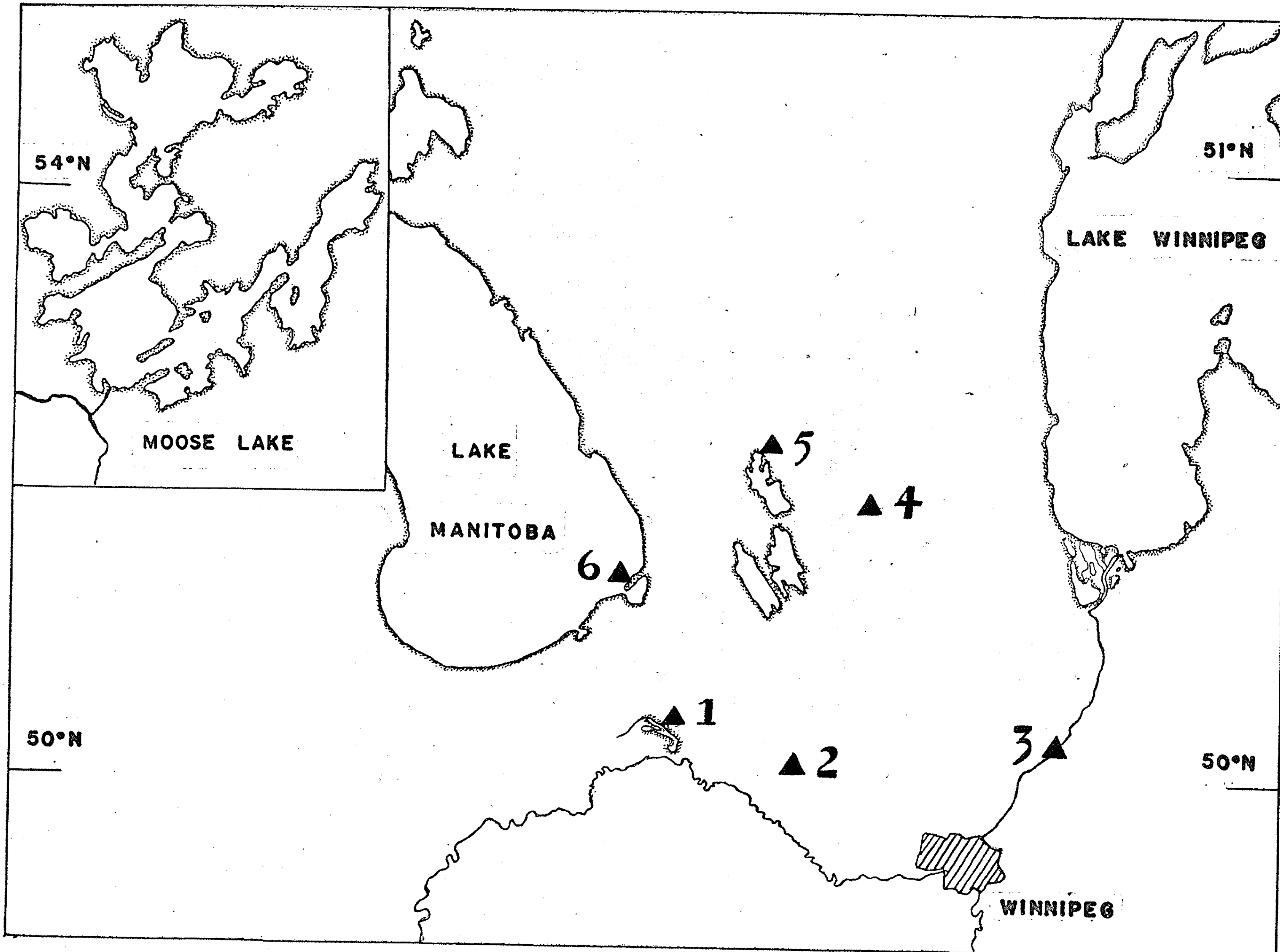

54°N
MOOSE LAKE
LAKE
MANITOBA
51°N
LAKE WINNIPEG
5
4
6
1
2
3
50°N
50°N
WINNIPEG

TABLE 5 INCIDENCE OF G. GYRAULI IN RED-WINGED AND YELLOWHEADED BLACKBIRDS, 1962 & 1963

Locality	1962						1963					
	Red-Wing		Yellowhead		Total		Red-Wing		Yellowhead		Total	
	Exam.	Inf.	Exam.	Inf.	Exam.	Inf.	Exam.	Inf.	Exam.	Inf.	Exam.	Inf.
Long Lake Reaburn	8	6	10	6	18	12	18	0	10	2	28	2
Norris Lake & Shoal Lake	5	4	2	1	7	5	4	0	6	0	10	0
Lake Manitoba	10	1	-	-	10	1	6	0	-	-	6	0
Meadows	13	1	-	-	13	1	9	0	-	-	9	0
	36	12	12	7	48	19	37	0	16	2	53	2

GIGANTOBILHARZIA TOTANI n.sp.

(Figs. X and XI)

Seven of twenty-four yellow-legs were found infected with a species of Gigantobilharzia, which although very similar to G. gyrauli may well be a new species. Like the latter parasite, G. totani is found in the veins surrounding the intestine and proved impossible to remove, thus the somewhat inadequate description is based only upon fragments.

It is presumed that both greater and lesser yellow-legs act as the host. Unfortunately many of the birds identified as lesser-yellow-legs may well have been greater yellow-legs, thus the exact identification of the birds is not known.

Description of Species

Specific diagnosis: Gigantobilharzia. Odhner, 1910

FEMALE: Body long and filamentous, length of body unknown. Width of body 0.025 to 0.031 mm anterior to the ovary; 0.038 to 0.056 mm at the ovary; and 0.025 to 0.037 mm posterior to the ovary. Suckers absent, cuticle smooth. Oesophagus 0.475 mm long, paired caeca reuniting immediately posterior to the seminal receptacle. Ovary situated 1.625 to 2.012 posterior to the anterior end of body, 0.575 to 0.687 mm long, with oviduct from the posterior end receiving branch from the seminal receptacle before turning anteriorly. Laurer's canal present.

Oviduct runs forward to join with the vitelline duct immediately posterior to a well marked ootype, situated 0.212 to 0.225 mm anterior to the ovary. Seminal receptacle 0.11 to 0.21 mm long, situated 0.05 mm posterior to the ovary.

MALE: Body dimensions as female. Anterior end not seen. Gynaecophoric canal 0.375 mm long with the genital opening at the anterior end. Seminal vesicle very elongate, divided into two portions, the most anterior or external seminal vesicle lying outside the cirrus pouch and the posterior or internal seminal vesicle enclosed within the pouch. External seminal vesicle 0.325 mm in length, internal seminal vesicle 0.546 mm long, with posterior 0.05 mm narrow and surrounded by many prostate cells. Ejaculatory duct leading to the genital pore, 0.08 mm long.

Eggs: Oval, spineless. 55.8 by 55.7 micra.

Cercariae: Unknown

Hosts: Primary: *Totanus melanoleucus* (Greater Yellow-legs); *Totanus flavipes* (Lesser Yellow-Legs)

Distribution: Manitoba, Canada (Fig. XII)

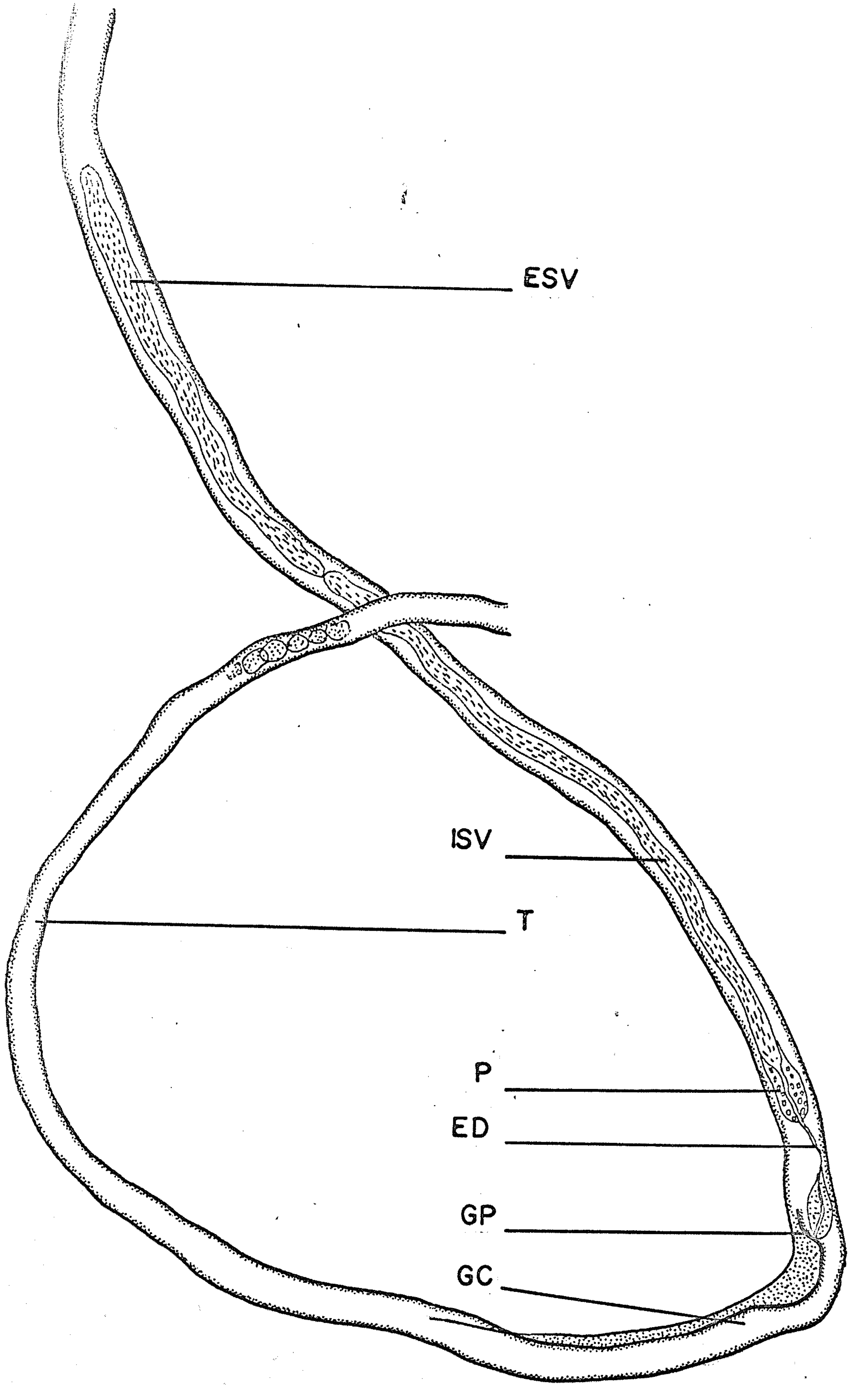
Locality: Small intestinal veins.

Identity of Species

The above species closely resembles three other species of the genus *Gigantobilharzia*: *G. gyrauli* Brackett, 1942; *G. huttoni* Leigh, 1955; and *G. plectropteri* Fain, 1960. A comparison of these species

FIGURE X MALE. GIGANTOBILHARZIA TOTANI n.sp.

Figures drawn with the aid of a camera lucida.
Abbreviations as page XII .


ESV
ISV
T
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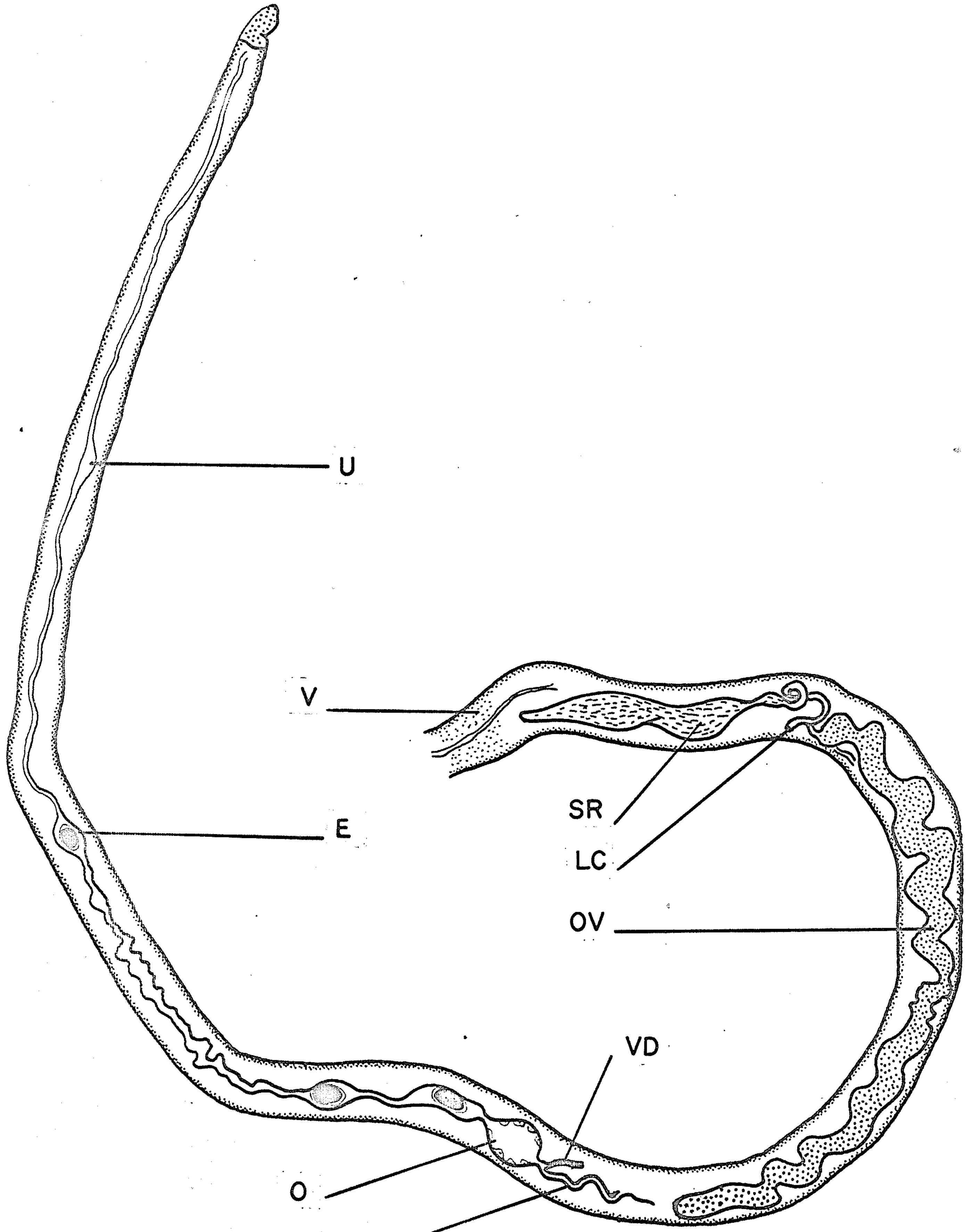
ED
GP
GC

FIGURE XI Female. GIGANTOBILHARZIA TOTANI n.sp.

Figure drawn with the aid of a camera lucida. Abbreviations as page XII .


U
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OD

is shown (Table 6).

G. totani, *G. gyrauli* and *G. huttoni* clearly represent three distinct species, differing in body length, length of gynaecophoric canal, length and position of ovary and egg dimensions.

Comparison of *G. totani* and *G. plectropteri* from the spur-winged Goose of Central Africa is more difficult, not only were the worms recovered in different continents, but also their life-cycles are unknown. It is as yet impossible to come to any conclusion regarding their identity. The different egg dimensions given for *G. plectropteri* are not reliable since eggs in the uterus are under pressure and become distorted, those in *G. totani* for example appearing oval in outline.

With the different geographical positions, the different hosts and the small differences in body dimensions the two species must be considered as distinct until their life-cycles are known.

Life-cycle studies.

McLeod and Little (1942) reported the presence of a schistosome species in the lesser yellow-legs and the pectoral sandpiper (*Pisobia malanotus*). They were of minute size, situated in the veins of the wall of the intestine and were considered to belong to the genus *Pseudobilharziella* (=*Trichobilharzia*). Only fragments of the worm were recovered and the authors were not able to come to any definite decision regarding the genus of

Figure XII. Areas of infestation with _G. totani_

1. Twin Beaches, Lake Manitoba
2. Shoal Lake
3. Meadows

4,5. Moose Lake

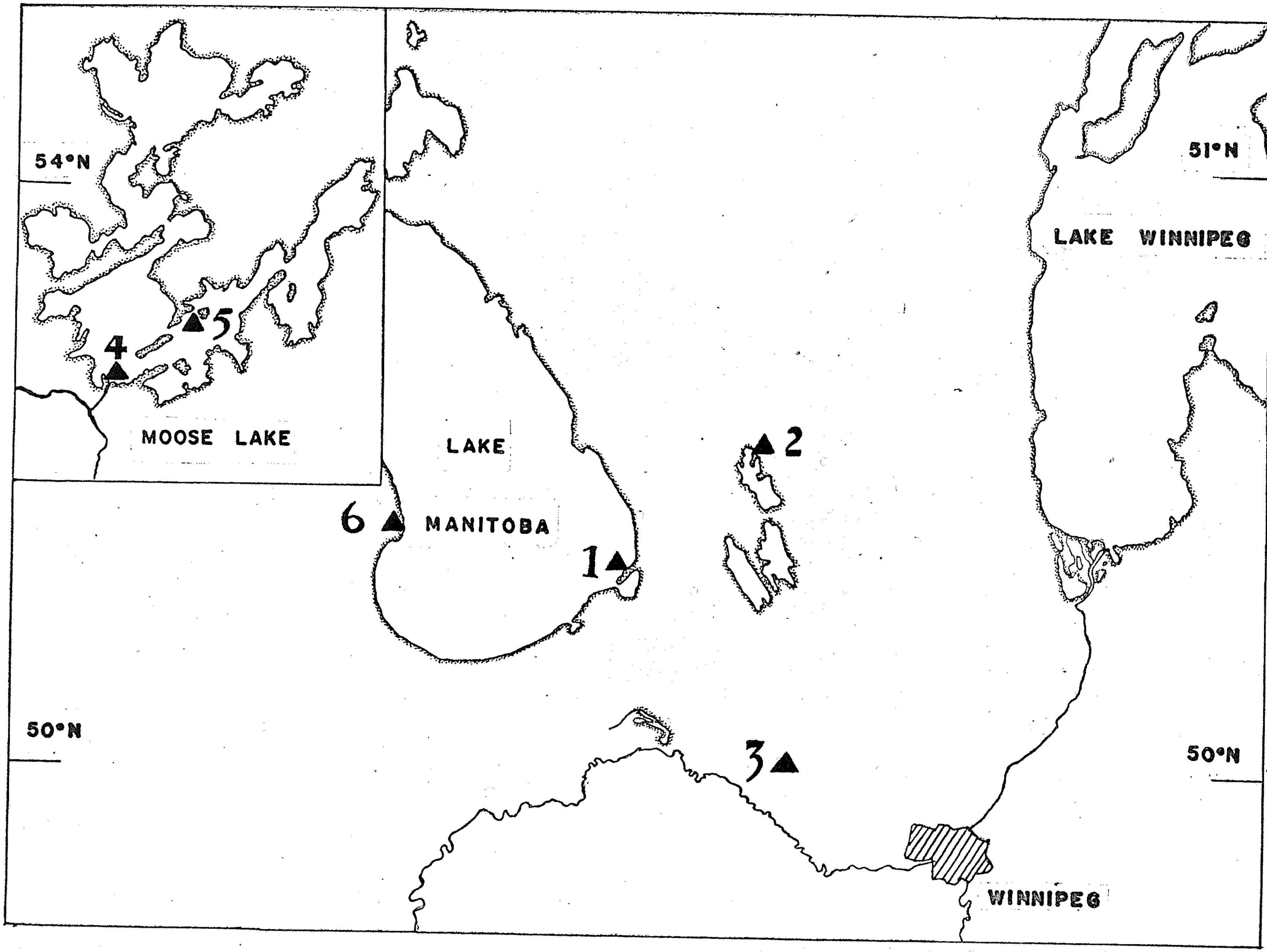

54°N
4
5
MOOSE LAKE
LAKE
MANITOBA
6
1
2
51°N
LAKE WINNIPEG
50°N
3
50°N
WINNIPEG

TABLE 6. COMPARATIVE MEASUREMENTS OF G. TOTANI; G. GYRAULI; G.HUTTONI AND G.PLECTROPTERI

MALE	G.TOTANI	G. GYRAULI	G. HUTTONI	G.PLECTROPTERI
BODY LENGTH	-	approx. 10 mm	4.72 mm	8-9 mm
BODY WIDTH	0.025-0.056	0.03 - 0.05	0.02-0.04	0.04-0.055
GYNAECOPHORIC CANAL LENGTH	0.375	0.937	0.235-0.33	0.2
DISTANCE ANT. END	-	1.875	0.96-1.12	1.8
SEMINAL VESICLE LENGTH	0.87	0.875 (Internal)	0.36 - 0.72	approx. 0.6
DISTANCE ANT. END	-	-	0.4-0.6	approx. 1.2
TESTES	-	-	60	130-170
FEMALE				
BODY LENGTH	-	As male	5.26-7.22	6.6
BODY WIDTH	As male	As male	0.03-0.04	0.045-0.07
OVARY LENGTH	0.575-0.687	0.4-0.58	0.23-0.38	0.35-0.4
DISTANCE ANT. END	1.625-2.012	1.4-1.86	0.49-0.65	1.325
SEMINAL RECEPTACLE LENGTH	0.11-0.21	0.1-0.125	-	0.085
OOTYPE DISTANCE FROM OVARY	0.212-0.225	0.13-0.25	0.09-0.17	0.20
EGG	Oval spineless 55.8x55.7	Oval, spineless 63.9x62.5	Oval, spineless 90-99x61-67	100 x 18 (in utero)
HOST	Yellow-legs	Blackbirds	Expt. infections only	Spur-Winged goose

the worm. Most likely the species to which they referred was _G. totani_, the genera _Trichobilharzia_ and _Gigantobilharzia_ being easily confused.

The above authors also suggested that schistosomes located in the intestinal walls of a pigeon, exposed to _Cercariae dermolestes_ McLeod, 1940 from _Lymnaea palustris_, were identical to those from the yellow-legs and the sandpiper. This was only a suggestion, however, since neither group of worms was recovered.

The present writer is convinced that _C. dermolestes_ is not the larval stage of _G. totani_. Repeated attempts to infect _Lymnaea palustris_ with the miracidia of _G. totani_ were unsuccessful, and also _C. dermolestes_, if the original description is correct, is an 'Ocellate' cercaria and thus from the genus _Trichobilharzia_. It is also quite unlikely that shore birds would be the definitive host of cercariae from a snail such as _Lymnaea palustris_, which is found in sloughs and marshy areas. Considering the fairly high incidence of infection with _G. totani_ (approximately 30%), it seems more likely that the intermediate host of the parasite would be associated with the nesting-sites of the shore birds. Such a high incidence of infection suggests that the birds were in contact with the infected snails over a long period, i.e. at their nesting sites and not over the short period of migration when yellow-legs are found in sloughs. _Lymnaea palustris_ is a northern species not found in the Carolinian, Lower

Mississippian and Central American regions, which again decreases the period of contact between it and the shore-birds.

With the great simularity between G. Totani and G. gyrauli, repeated attempts were also made to infect Physa gyrina and Gyraulus parvus, all without success.

Finally, the following specimens of snails found along the shore line of many lakes in the province were exposed to the parasite, again without success:

Lymnaea catascopium

Physa ancillaria

Gyraulus hirsutus

Helisoma campanulatum.

SUB-FAMILY: BILHARZIELLINAE Price, 1929

GENUS: TRICHOBILHARZIA Skrjabin et Zakharow,1920

(Key to genus: Part II, page 212)

TRICHOBILHARZIA QUERQUEDULAE (McLeod, 1937) McMullen et Beaver, 1945

Figure 64, page 289 .

Nine of 25 blue-winged teal and 1 of 2 shoveller ducks were found infected with T. querquedulae. A total of 20 males and 2 female worms were removed in a state of relaxation suitable for examination.

Descriptions of Species.

The description of this parasite is given in Part II, page 243 . Table 7 gives the dimensions of this parasite and also of T. physellae which are often considered synonymous.

Identity of the species.

As is shown in Part II, the author considers T. querquedulae and T. physellae to be distinct species. This view is based on the morphology of the adult and the size and behaviour of the cercariae, which in toto seem sufficient to warrant their retention as distinct species.

1. The body length of T. querquedulae never exceeded 4.5 mm whilst T. physellae reached 7.5 mm. Body size is of course very variable especially in soft bodied flukes, however the specimens obtained by the author were allowed to relax in chloral hydrate and even in specimens

obviously distorted and thus not utilized in the descriptions, the body length never approached the 7 mm mark.

2. The body width and sucker sizes were consistently larger in T. querquedulae.

3. The length of the gynaecophoric canal is absolutely and relatively much greater in T. querquedulae. The canal of T. physellae had a maximum length of 0.19 mm or 0.03 of the total body length, whilst that of T. querquedulae averaged 0.3 mm or 0.08 of the total body length, a relative increase of 2.66 times. As Part II shows, the gynaecophoric canal length seems to be important in differentiating species - at least with our present very limited knowledge, so that such a difference between the species has some importance.

4. The number of testes in T. querquedulae is approximately twice that in T. physellae. McMullen and Beaver (1945), who synonymized the two species, considered that McLeod (1937) was confusing interstitial cell masses with testes, however close examination of the local specimens clearly proves that the testes of T. querquedulae do indeed number well over 200.

5. The dimensions of the cercariae differ slightly (Part II, page 249 , table VII). This in itself is of very little consequence. Of more importance is the differences in behaviour. Cort and Talbot (1936) first described the behaviour of the cercariae of T. physellae as follows: 'C. physellae escapes from its snail host in the early morning about 4.30 a.m. when it first begins to light. By

TABLE 7. DIMENSIONS OF MALE *TRICHOBILHARZIA QUERQUEDULAE* AND *T. PHYSELLAE*

AUTHOR	PRESENT WORK		MCLEOD	MCMULLEN & BEAVER T. PHYSELLAE
HOST	SHOVELLER	BLUE WING TEAL	BLUE WING TEAL	EXPT IN PIGEONS, MALLARDS, CANARIES.
LENGTH BODY	3.0-4.25(3.74) mm	3.38-4.50(3.87)mm	3.7 mm	up to 7.5 mm
MAX. WIDTH	0.08-0.12	0.08-0.11	0.15	0.056-0.08
DIAM. ORAL SUCK.	38-50x38-50μ	38-63x38-50μ	50-62x40-45μ	28-40x24-28μ
DIAM. ACET'M.	0.06-0.11	0.05-0.075	0.04-0.07	0.06-0.832
ORAL SUCK TO ACET.	0.225-0.375(0.29)	0.29-0.43(0.38)	0.25-0.44	0.16-0.34
GYN CANAL LENGTH	0.2-0.44(0.30)	0.2-0.375(0.29)	0.23-0.42	0.1-0.19
DIST. FROM ANT. END	0.65-0.86(0.74)	0.6-1.03(0.80)	0.68	0.3-0.68
SEMINAL VESICLE LENGTH	0.31-0.45(0.37)	0.24-0.5(0.38)		
DIST. ANT. END	0.3-0.48(0.36)	0.34-0.55(0.42)		
TESTES	200-300	200-300(250)	210-240	96-160
NO SPECIMENS	5	15	Many	8

7:00 a.m. almost all of those to emerge for a complete 24 hour period have already escaped. The cercariae of this species are active swimmers and swim in all directions when the water is agitated. They have a tendency to sink to the bottom of the container where they become attached. Occasionally they attach to the side of the bottle but always near the bottom and with no relation to the source of light. In fact there is nothing in their activity that suggests any reaction to light, either positive or negative. (Authors own italics). When at rest they assume a characteristic position with the ventral sucker attached and the anterior part of the body in contact with the surface. The post acetabular region of the body and the tail are held rigid and extend in a straight line away from the surface of attachment and form almost a right angle with that surface, with the furcae of the tail usually spread apart. When the container is not disturbed for sometime most of the cercariae in it will come to rest on the bottom.'

Brackett (1940) also examined the behaviour of C. physellae from Physa sp in Wisconsin. The behaviour pattern he noted differed from that described by Cort and Talbot. Brackett found that the cercariae were quite definitely attracted to the light and attached to the side of the container, not to the bottom.

The behaviour of C. querquedulae in Manitoba was similar to that described by Brackett. The cercariae were attracted to the light although not as strongly as *C. elvae*, and after a period of activity when bursts of swimming were followed by sinking, the cercariae attached to the side of the container nearest the light. The method of attachment also differed from that described by Cort; they attached by their ventral suckers only and their tails and anterior end of the body were bent away from the surface of attachment.

It would seem feasible therefore to regard the species examined by Brackett as being *Cercariae querquedulae*.

The writer thus regards *T. physellae* and *T. querquedulae* as distinct species although it must be stated that this assumption cannot be adequately proven until such experimental animals as pigeons and canaries are exposed to *C. querquedulae* and the adult worms examined. Very little is known of the effect of abnormal hosts on the gross morphology of schistosome adults. Unfortunately attempts to infect birds with *C. querquedulae* proved unsuccessful.

Sub-family: SCHISTOSOMATINAE Stiles et Hassall, 1926

Genus: AUSTROBILHARZIA (Johnston, 1917): amended

(Key to genus; Part II, page 156)

AUSTROBILHARZIA LARI (McLeod, 1937) Penner, 1953b.

(Description of species Part II, page 173 . Fig.22)

Two complete males, one complete female and seven pairs *in copula* were recovered from 2 of 12 mature Bonaparte gulls and 1 of 8 juveniles examined. All were recovered during the summer of 1962, and none were located in herring, ring-billed or Franklin's gulls.

One mature Bonaparte gull was found to harbour both *A. lari* and *G. lawayi* the only case of a double infection found in this survey. A comparison of present measurements with those by McLeod is shown (Table 8).

LIFE-HISTORY STUDIES.

The finding of the adult parasite in immature gulls on their fall migration points to the intermediate host being present in the local waters.

At the time of collection however only one species of snail, *Lymnaea catascopium*, found on the shores of Lake Manitoba and thus being in contact with gulls was available for infection. This species and others: *L. stagnalis*, *L. palustris* and *Physa gyrina* proved negative to infection.

TABLE 8. DIMENSIONS OF AUSTROBILHARZIA LARI (McLeod, 1937) Penner, 1953b.

	Present findings	McLeod, 1937
Male.		
Length of Body	2.87-5.60(av.3.77) mm	3.72 mm
Maximum Width	0.38-0.58(av 0.47)	0.49
Oral sucker	0.125-0.15x0.15-0.175 (average 0.13x0.16)	0.135 x 0.18
Acetabulum	0.125-0.20x0.16-0.26 (average 0.17 x 0.20)	0.247
Acetabulum to anterior end.	0.29-0.56(av 0.37)	0.44
Testes	20 - 25 (av 23)	22 - 26
Acetabulum to seminal ves.	0.21-0.29 (av 0.24)	-
Seminal vesicle to testes	0.17-0.25 (av 0.18)	-
Number of specimens	9	10
Female		
Length of body	2.25-2.94 (av 2.6)	2.76
Width of body		0.18
Oral sucker	0.05 - 0.06	0.06 x 0.05
Acetabulum	0.05	0.056
Oral to acetabulum	0.25 - 0.26	0.247
Ovary: Length	0.286	0.326
Distance ant. end	0.89	0.715
Length of uterus	0.07 - 0.12	-
Eggs	-	Oval, spineless 67 by 60
Host	Bonaparte gull	Herring and ring-billed gulls.

GENUS: ORNITHOBILHARZIA (Odhner, 1912) amended.

(Key to genus Part II, page 175)

ORNITHOBILHARZIA CANALICULATA (Rudolphi, 1819) Odhner 1912.

(Description of species: Part II, page 176 , Fig. 23)

Only 2 males and one female of this species were recovered from a single mature Bonaparte gull during the fall migration of 1962. As outlined in Part II, this parasite described as Ornithobilharzia aviani by McLeod (1940) is considered identical to O. canaliculata. Table 9 shows the dimensions of the local parasite compared with the measurements given by McLeod and Rudolphi.

LIFE-HISTORY STUDIES.

No eggs of this parasite were seen and no miracidia recovered, thus no attempts to infect snails could be made.

TABLE 9. DIMENSIONS OF ORNITHOBILHARZIA AVIANI (McLeod, 1940); ORNITHOBILHARZIA CANALICULATA (Rudolphi, 1819) and PRESENT FINDINGS.

	McLeod	Rudolphi	Present
MALE:			
Length of body	12 - 15 mm	16 mm	7.8 - 8.1 mm
Width of body	0.83 mm	1.0 - 1.4	0.9
Diameter oral sucker	0.25	0.312 - 0.1	0.25 - 0.26
Diameter acetabulum	0.40	up to 0.45	0.345
Oral to acetabulum	0.82	1.0	0.7 - 0.8
Oesophagus	-	-	0.46 - 0.58
Testes	54 - 74	Many	-
FEMALE:			
Length of body	7.2 mm	Shorter than male	4.4
Width. Anterior end	-	0.06	0.09
Maximum	0.23	0.145	-
Diameter oral sucker	0.05	-	0.05
Diameter acetabulum	0.06	-	0.05
Oral to acetabulum	0.25	-	0.17
Oral to ovary	1.0	-	0.85
Length ovary	0.78	-	0.63
Ovary to ootype	0.20	-	0.07
HOST	Larus argentatus (herring gull)	Thalasseus maximus (royal tern)	Larus philadelphia (Bonaparte gull)

GENUS: SCHISTOSOMATIUM Tanabe, 1923.

(Account of genus: Part II, page 117)

SCHISTOSOMATIUM DOUTHITTI (Cort,1914) Price, 1931.

(Description of species: Part II, page 118 . Fig.1)

One female of this species was recovered from one of 34 small wild rodents examined (Table 10). This was the first record of the adult being located in Canada, although the cercariae had been found in Ontario (Bourns, 1961).

Since the majority of work on this species was concerned with the cercarial stage, an account of the adults will be postponed until Part 1B of this thesis.

TABLE 10. MAMMALS EXAMINED FOR SCHISTOSOME ADULTS, GULL LAKE, MANITOBA.

Species examined	No: exam.	No:Infected	Species
Microtus pennsylvanicus	13	1	*S.douthitti*
Citellus franklini	19	-	
Clethrionomys gapperi	2	-	

SECTION B.

THE LARVAL SCHISTOSOMES.

Many hundreds of snails were examined for schistosome cercariae over the three summers. Table 11 shows the species of snails examined and the larval schistosomes located.

TABLE 11. SNAILS EXAMINED AND SCHISTOSOME CERCARIAE LOCATED DURING THE SURVEY.

HABITAT	SPECIES OF SNAIL	SPECIES OF CERCARIAE.
Temporary Ponds	*Lymnaea palustris*	Nil
	Aplexa hypnorum	*Cercaria douthitti var.*
Small sloughs & marsh areas of lakes	*Lymnaea stagnalis jugularis*	*Cercaria ocellata var.*
		Cercaria douthitti
	Lymnaea palustris	*Cercaria dermolestes* *
	Physa gyrina	*Cercaria querquedulae* *
	Gyraulus parvus	*Cercaria gyrauli*
	Menetus exacuous	*Cercaria gyrauli*
	Helisoma trivolvis	Nil
Lake shores	*Helisoma campanulatum*	Nil
	Helisoma antrosum *	Nil
	Lymnaea stagnalis lillianae *	Nil
	Lymnaea catascopium	Nil
	Physa ancillaria	*Cercaria ancillariae* * n.sp
	Gyraulus hirsutus	Nil
	Gyraulus sp.	Nil
	Amnicola sp.	Nil

* Limited number

Thus seven species of schistosome cercariae were located during the survey. The life-cycles and definitive hosts of only three of these cercariae are known:

Larvae	Adults
Cercariae douthitti	Schistosomatium douthitti
Cercariae querquedulae	Trichobilharzia querquedulae
Cercariae gyrauli	Gigantobilharzia gyrauli

The adult stages of these three cercariae have been located in Manitoba, the details being found in Section A.

It is proposed to discuss each of the above snail hosts in turn, together with a discussion of the larval schistosomes found within them.

Snail Hosts of Schistosomes in Manitoba.

LYMNAEA STAGNALIS JUGULARIS Say.

This snail is by far the most common in the southern area of the province. It is found in all the prairie sloughs and marsh areas of the lakes. It was found to harbour two species of schistosome cercariae: Cercariae ocellata var., and Cercariae douthitti, the distribution of which is shown (Fig. XIII).

Cercariae ocellata var. was very wide spread throughout the area, whilst C. douthitti was only found in two isolated localities, both species however were recovered in sufficient numbers to determine their incidence of infection.

Growth of Lymnaea stagnalis jugularis.

In order to determine the seasonal incidence of infection of any trematode larva it is necessary to have some idea of the life history of the snail host. Unfortunately the areas in Manitoba in which a good supply of infected snails were present were never accessible in the early spring because of muddy roads, and thus were not suitable for studies on the snail host.

Growth studies on _L. stagnalis jugularis_ were conducted at St. Andrew's Lagoon, near Lockport. This area is accessible the year round by a good gravel road.

Fig. XIV shows the lengths of the snails over the summer months of 1963. It shows that in the 3rd week in May there were two quite distinct populations: those ranging between 0.4 and 1.1 inches in length, and those between 1.3 and 1.6 inches. The two populations averaged 0.7 (∓0.03) and 1.49 (∓0.01) inches respectively.

During June the smaller population rapidly increased in size so that by mid-July only one population was seemingly present. The mean lengths of the two populations are shown in Table 12.

TABLE 12 Mean Lengths of Lymnaea stagnalis jugularis populations over the summer of 1963.

DATE		POPULATION A		POPULATION B	
Week	Month	Mean	Standard Error	Mean	Standard Error
1	May	0.64	0.03	None located	
3	May	0.70	0.026	1.49	0.013
1	June	0.80	0.027	1.56	0.016
2.	June	0.84	0.016	1.56	0.019

TABLE 12, cont'd.

DATE		POPULATION A		POPULATION B	
Week	Month	Mean	Standard Error	Mean	Standard Error
2	July			1.53	0.017
2	August			1.79	0.012
2	September			1.83	0.016
2	October			1.80	0.010

Eggs were first seen in the early part of June, although the maximum period of egg laying occured in July. Young snails first appeared on the leaves of aquatic plants during the last week of June but throughout the summer these young snails were never found to exceed 0.4 inches in length and the majority of them were only half that size.

It may be inferred from these results that the snails hatch during the summer months and grow only slowly during their first summer. The following spring they rapidly increase in size and become almost fully grown by late July and August. These snails do not all die out at the end of their second summer, as previously thought, but some survive and reappear as mature snails the following spring. The larger of the two populations found in the early spring, were snails that had over-wintered twice, once as immature snails and once as mature individuals.

In future the three populations found during a

FIGURE XIII. Distribution of schistosome cercariae in the study area.

■ *Cercaria douthitti*

◪ *Cercaria douthitti* var.

▲ *Cercaria ocellata* var.

✚ *Cercaria gyrauli*

● *Cercaria ancillariae*

○ *Cercaria dermolestes*.

1. Twin Beaches, Lake Manitoba.
2. Norris Lake.
3. Netley Marsh.
4. Gull Lake.
5. Grand Beach, Lake Winnipeg.
6. St. Andrew's Lagoon, Lockport.
7. Creek, near Marquette.
8. Long Lake, Reaburn.

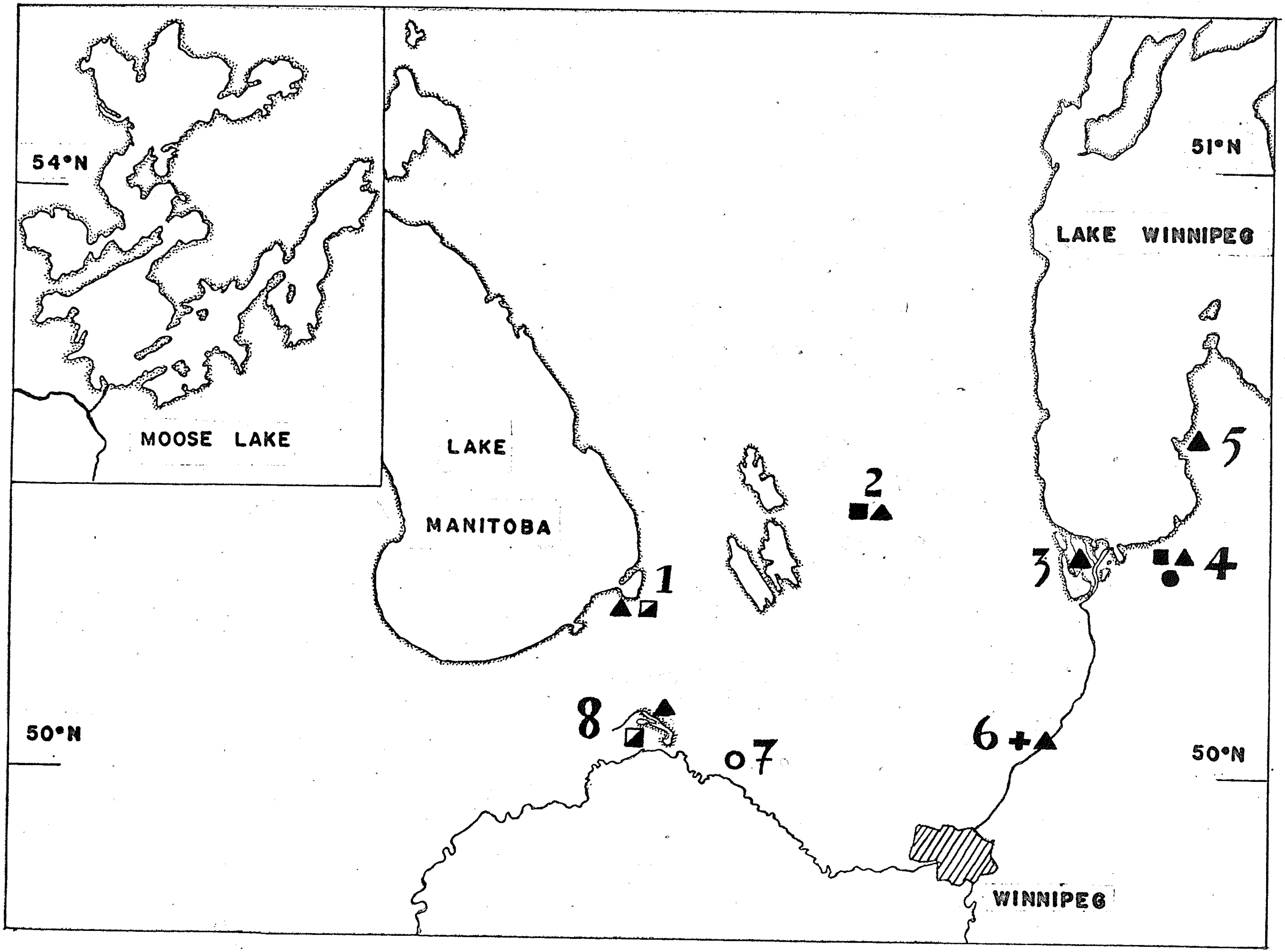
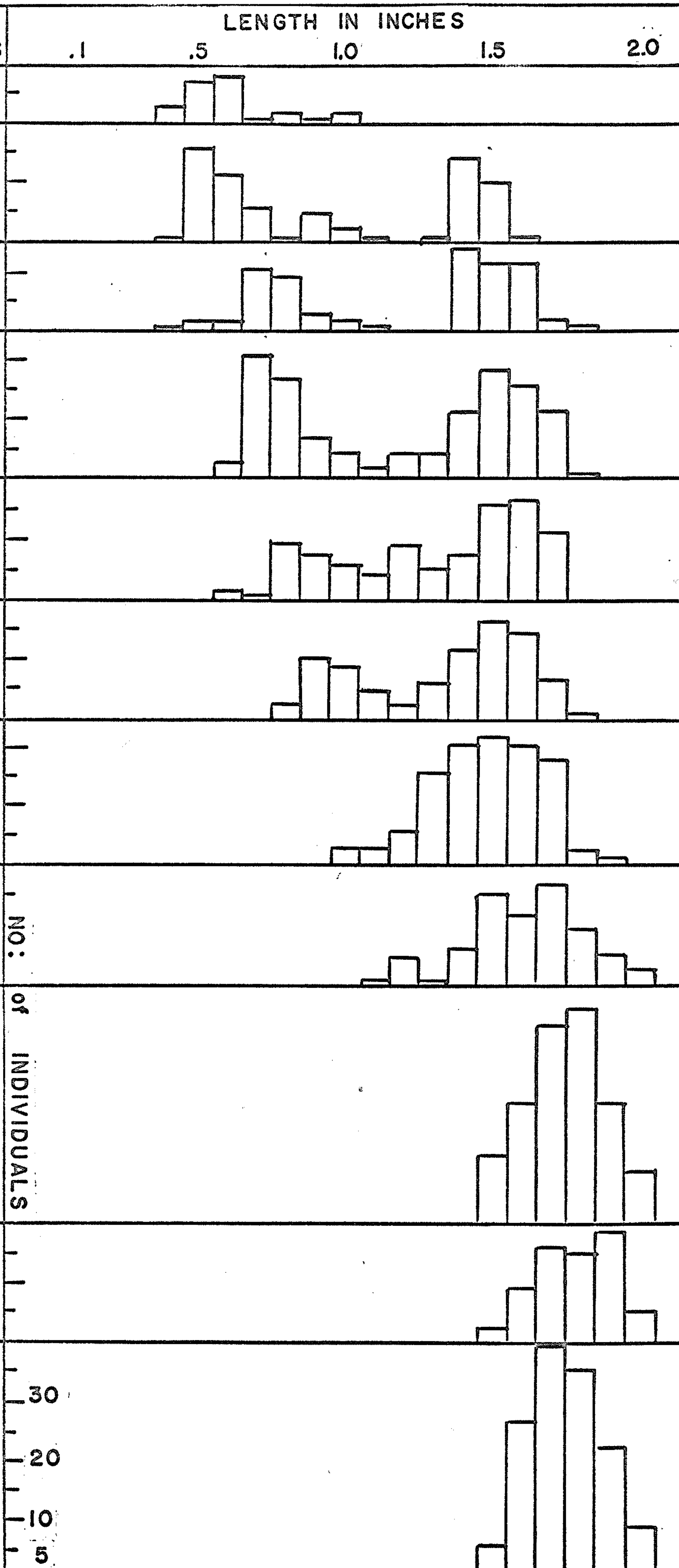

54°N
MOOSE LAKE
LAKE
MANITOBA
51°N
LAKE WINNIPEG
1
2
3
4
5
6
7
8
50°N
50°N
WINNIPEG

FIGURE XIV. Lengths of the snail *Lymnaea stagnalis jugularis* from St. Andrews Lagoon, Lockport during the 1963 summer months.

WEEK	MONTH	NO: SNAILS
1st	MAY	25
3rd	MAY	71
1st	JUNE	72
2nd	JUNE	120
3rd	JUNE	95
4th	JUNE	86
2nd	JULY	115
4th	JULY	74
2nd	AUGUST	129
2nd	SEPTEMBER	66
2nd	OCTOBER	140



summer: the newly hatched, those having overwintered once, and those having overwintered twice, will be referred to as juvenile, sub-adults and adults respectively.

Larval schistosomes, developing in L. stagnalis jugularis.

Cercariae ocellata var.

As outlined in the introductionto the thesis, much confusion exists as to the identity of the 'ocellata' group of schistosome cercariae. On this continent there are three common species of this group recognized: C. elvae Miller, 1923; C. stagnicolae and C. physellae Talbot, 1936.

To date the common ocellate schistosome cercaria of Manitoba has been considered as C. elvae (McLeod, 1940; Farley, 1962). The dimensions of C. elvae were first given by Miller (1923) and repeated by Talbot (1936), the latter using the same technique as the author. The dimensions of the local ocellate cercariae is compared with the dimensions as given by the other two authors (Table 13).

As seen from the table the dimensions by Talbot and the author are identical, the lengths of body, tail and furcae falling in the same range. Those of Miller are different but the same fixing and relaxing technique was not used so that strictly the measurements cannot be compared.

It was first shown by Cort and Talbot (1936) that species of cercariae may be distinguished by their behaviour patterns, In this respect the local cercariae do not show the same behaviour as Cort and Talbot described for C. elvae:-

> '...These cercariae usually swim horizontally and soon come to rest on the side of the container toward the greatest intensity of light... The resting position is quite characteristic. They attach themselves to the surface of the glass by the anterior tip and the protruded ventral sucker with the body between arched away from the furcae. The tail stem is turned back over the body and forms an acute angle. The tail however is not straight but is bent in the form of a hook with the tips of the furcae way from the dorsal surface of the body. When the tail is in this position the furcae are always crossed...'

The local species differs from the above in that, although always attaching to the side of the container nearest the light, the method of attachment is not the same. Local species attach only by the ventral sucker with both anterior end of body and tail held away from the surface of attachment. The furcae are usually crossed.

This is the same mechanism of attachment as reported for the 'ocellata' complex of Europe: C. pseudocellata, C. neocellata and C. parocellata. Mathias (1930) described the position of attachment of 'C. ocellata' as follows:

> 'Après quelques instants de nage libre, C. ocellata se fixe sur les parois du récipient à l'aide de sa ventouse ventrale qui est fortement pédiculée. La surface dorsale de la cercaire est alors concave et la queue est redressée sensiblement dans la prolongement de la partie inférieure du corps, les deux branches de la fourche étant rapprochées l'une de l'autre. La queue peut du reste être rabattue plus complètement sur les corps, somme Ssinitzin l'a indiqué.'

TABLE 13. DIMENSIONS OF <u>CERCARIAE</u> <u>ELVAE</u> AS GIVEN BY MILLER (1923) and TALBOT (1936), compared with the dimensions of the local ocellate cercaria.

	MILLER 1923		TALBOT 1936		PRESENT WORK	
	Living	Fixed	Fixed		Fixed	
			Size	S.E.*	Size	S.E.
Length of body	368	368	307	2.1	312.12	3.4
Width of body	80	41	67	1.38	50.84	0.7
Length of Head organ	-	96	97	0.76	-	-
Width of Head organ	-	-	42	0.74	-	-
Length of tail	501	382	400	2.4	396	2.5
Width of tail	-	-	45	0.87	35.15	0.5
Length of furca	328	290	254	2.4	261.1	1.8
Width of furca	-	-	23	0.82	22.1	0.3
Ventral sucker to posterior end body	-	-	108	1.48	106.31	1.0
Diameter ventral sucker	33	23	-	-	23-35	
No. of specimens.			50		50	

Dimensions in micra. *Standard Error.

In the original description of C. elvae, Miller says very little on the behaviour of the free-swimming cercariae. The little that is said however would lead one to question whether Cort and Talbot were examining C. elvae. Miller states that the emerged cercariae sink slowly through the water with body down and furcae 60 to 80 degrees apart, and tail stem usually straight. No mention is made of the attachment of the cercariae to the surface of the container nearest the greatest intensity of light, in fact Miller speaks of the direction of movement as being 'erratic'. It would seem impossible for anyone to miss the attachment so typical of the local species and those examined by Cort and Talbot.

It would seem very likely that there is a similar complex of 'ocellata' cercariae in North America as there is in Europe, and that C. elvae Miller and the local species are two members of this complex. Also the cercariae examined by Cort and Talbot may well be a third member.

It is obvious that without a knowledge of their life-cycles the identity of these cercariae cannot be determined. Unfortunately, over the years only two semi-successful attempts have resulted in locating adult worms: Brumpt (1931) in Europe and McMullen and Beaver (1945) in the U.S.A.

Seven budgies were exposed to C. ocellata var. These birds were very susceptible to the cercariae and only one of them survived long enough to be suitable for examination for adult schistosomes. The bird examined had many worms in the minute mesenteric veins but none were recovered. Many eggs were removed from the gut mucosa, they were spindle shaped with one spine more elongate and pointed than the other.

The mature eggs averaged 245 ($\mp$ 2.4) by 58 ($\pm$ 1.0) micra compared with an average of 220 by 60 micra for *Trichobilharzia elvae* (McMullen et Beaver, 1945). Attempts to infect domestic ducklings and pigeons with *C. ocellata* var. were unsuccessful.

The parthenitae of the species is shown in fig. XV. Since those of *C. elvae* have not been described such information is of no use in the identification of the parasite.

For the reasons outlined above the author regards the common ocellate schistosome larvae from *Lymnaea stagnalis jugularis* as being *C. ocellata* var., rather than *C. elvae* as previously considered.

Distribution of C. ocellata var.

The distribution of the parasite is shown in fig. XIII. The widespread occurrence of the parasite is indicated, although within a single lake the infected snails are often restricted to a fixed area. For example at St. Andrews lagoon infected snails were only found at the south-west corner of the lake whilst at Norris Lake they were found only in the marsh area at the south end. In lakes similar to Gull Lake where infected snails were only found in the marsh area, this was due to the distribution of the snail host, but at St. Andrew's and Norris Lake the snail was present in all areas of the lake.

Incidence of Infection.

Through the latter part of the summer of 1961 and throughout the spring and summer months of 1962 and 1963 the incidence of *C. ocellata* var. in *Lymnaea stagnalis jugularis* was determined. The data are shown in fig.XVI and table 14.

The data show a gradual fall in intensity of infection over the summer months with perhaps a more rapid decrease in August than in the other months.

In 1961 Gull Lake had a much higher incidence of infection (approximately 20%) but for two reasons the lake was unsuitable for incidence studies: firstly snails were only present in very small numbers despite the serious outbreaks of swimmers itch there, and secondly copper sulphate treatment during 1962 and 1963 made any work of this nature invalid.

Age of Infected snails.

The growth pattern of *L. stagnalis jugularis* in Norris Lake differed slightly from that at St. Andrew's. The sub-adult population was generally larger and grew at a more rapid rate so that by mid-June the sub-adult and adult populations had merged. In many cases it was impossible to estimate the age of an infected snail.

Table 15 shows the age of infected snails from Norris Lake over a two year period. It is seen that there

FIGURE XV. Daughter sporocysts of <u>Cercariae</u> <u>ocellata</u>
var.

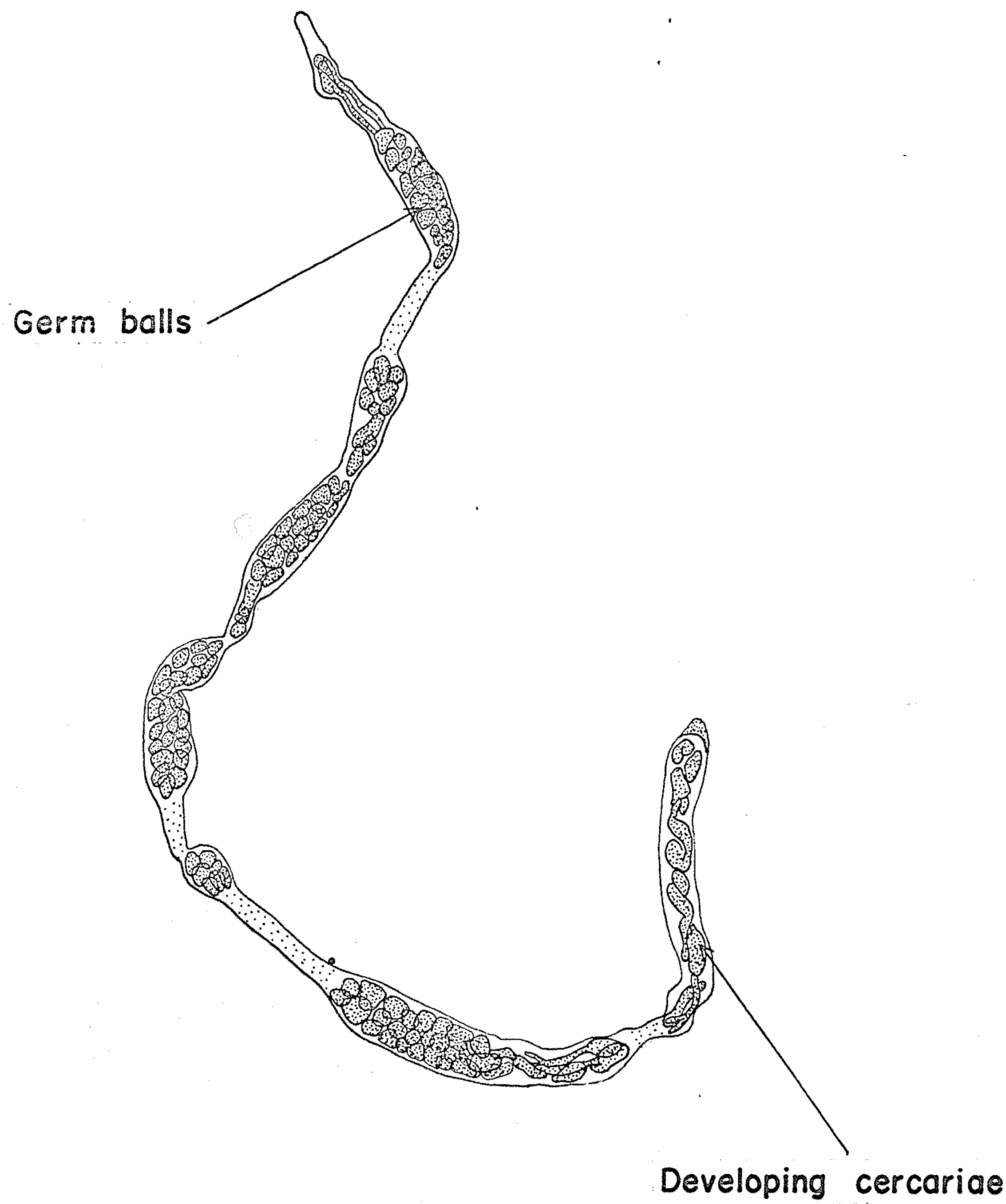
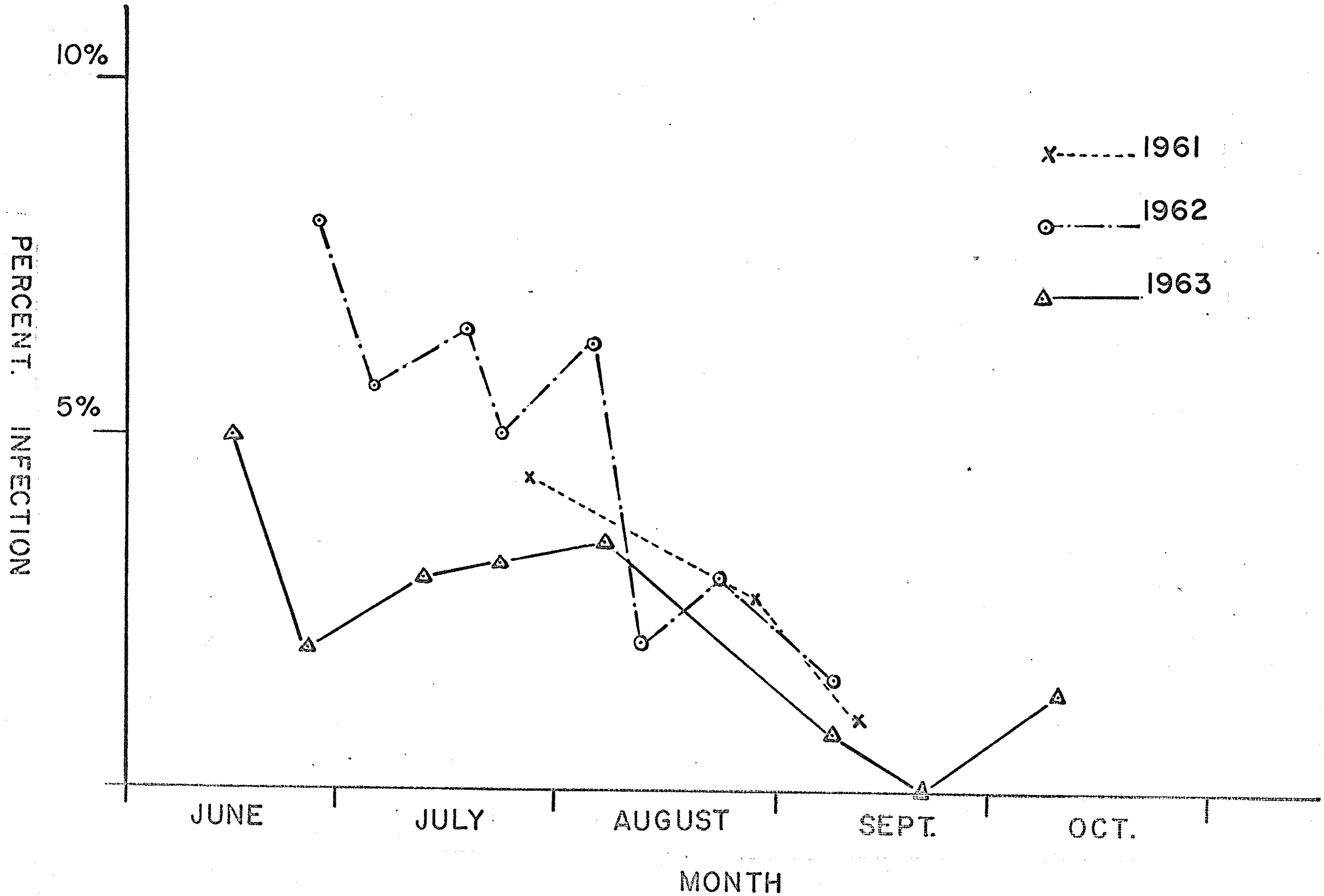

Germ balls
Developing cercariae

FIGURE XVI. Incidence of infection of *C. ocellata* var in *Lymnaea stagnalis jugularis* from Norris Lake.



10%
5%
PERCENT. INFECTION
1961
1962
1963
JUNE
JULY
AUGUST
SEPT.
OCT.
MONTH

TABLE 14. INCIDENCE OF INFECTION OF C. OCELLATA VAR. IN LYMNAEA STAGNALIS JUGULARIS FROM NORRIS LAKE.

DATE Week	Month	NO: SNAILS COLLECTED	NO: INFECTED	% INFECTED
1961				
4	July	158	7	4.4
4	August	75	2	2.7
2	September	102	1	1.0
1962				
4	June	38	3	8.0
1	July	88	5	5.7
3	July	92	6	6.5
4	July	100	5	5.0
1	August	79	5	6.3
2	August	140	3	2.1
3	August	67	2	3.0
1	September	128	2	1.6
1963				
2	June	80	4	5.0
4	June	97	2	2.0
2	July	67	2	3.0
3	July	92	3	3.2
1	August	114	4	3.5
2	September	123	1	0.8
3	September	69	0	0.0
2	October	73	1	1.4

were no infected juvenile snails found during either summers, all the infected snails being from the sub-adult and adult populations.

TABLE 15. Number of infected *Lymnaea stagnalis jugularis* of different age groups from Norris Lake.

DATE Week	Month	AGE OF SNAILS Juvenile	Sub-adult	Adult	Undetermined
1962					
4	June	Nil	Nil	3	Nil
1	July	Nil	Nil	4	1
3	July	Nil	3	2	1
4	July	Nil	2	3	Nil
August onwards		Nil			All
1963					
2	June		Nil	4	Nil
4	June	Nil	Nil	1	1
2	July	Nil	Nil	2	Nil
3	July	Nil	1	2	Nil
August onwards		Nil			All

In both years infected sub-adult snails did not appear until mid-July, all the infected snails from the early summer being adult forms.

<u>Cercaria douthitti. Cort, 1914</u>.

<u>Cercaria douthitti</u> was recovered from Gull and Norris Lakes (fig.XIII). The identity of the cercaria was definitely established by successful infection of laboratory mice and the recovery of many adult specimens of <u>Schistosomatium douthitti</u>.

This is the first record of this common rodent parasite in Manitoba and although its cercariae had been located in Canada previously (Bourns, 1961), the finding of a naturally infected meadow-vole <u>Microtos pennsylvanicus</u> represents the first report of the adult worm in this country.

The cercariae were recognized by their general body shape and size and by their behaviour which corresponded exactly with the description given by Cort and Talbot (1936):

> 'The cercariae swim upward to the surface and attach to the surface film. They rest with the ventral side up and the tail hanging down at approximately right angles to the body. They hold themselves in position with the help of the ventral sucker which is attached to the surface film.'

The dimensions of the adult parasite obtained by experimental infection of mice with the above cercariae, proves conclusively the identity of the cercariae.

<u>Incidence of Infection</u>.

The incidence of infection of <u>C. douthitti</u> in <u>Lymnaea stagnalis jugularis</u> from Norris Lake was determined over the latter part of 1961 and during the summer of 1962. Repeated attempts to locate infected snails in 1963 were unsuccessful. (Fig. XVII, Table 16).

The seasonal incidence of this parasite seems to differ from that of _C. ocellata_ var. In the latter case the level of parasitaemia decreased fairly regularly during the summer months, whilst in the case of _C. douthitti_ the level reached a peak in July and remained at this level throughout July and August. It was unfortunate that no infected snails were found in 1963 since the unusually frost-free autumn would have allowed collecting through until October.

FIGURE XVII. Incidence of infection of C. douthitti in Lymnaea stagnalis jugularis from Norris Lake.

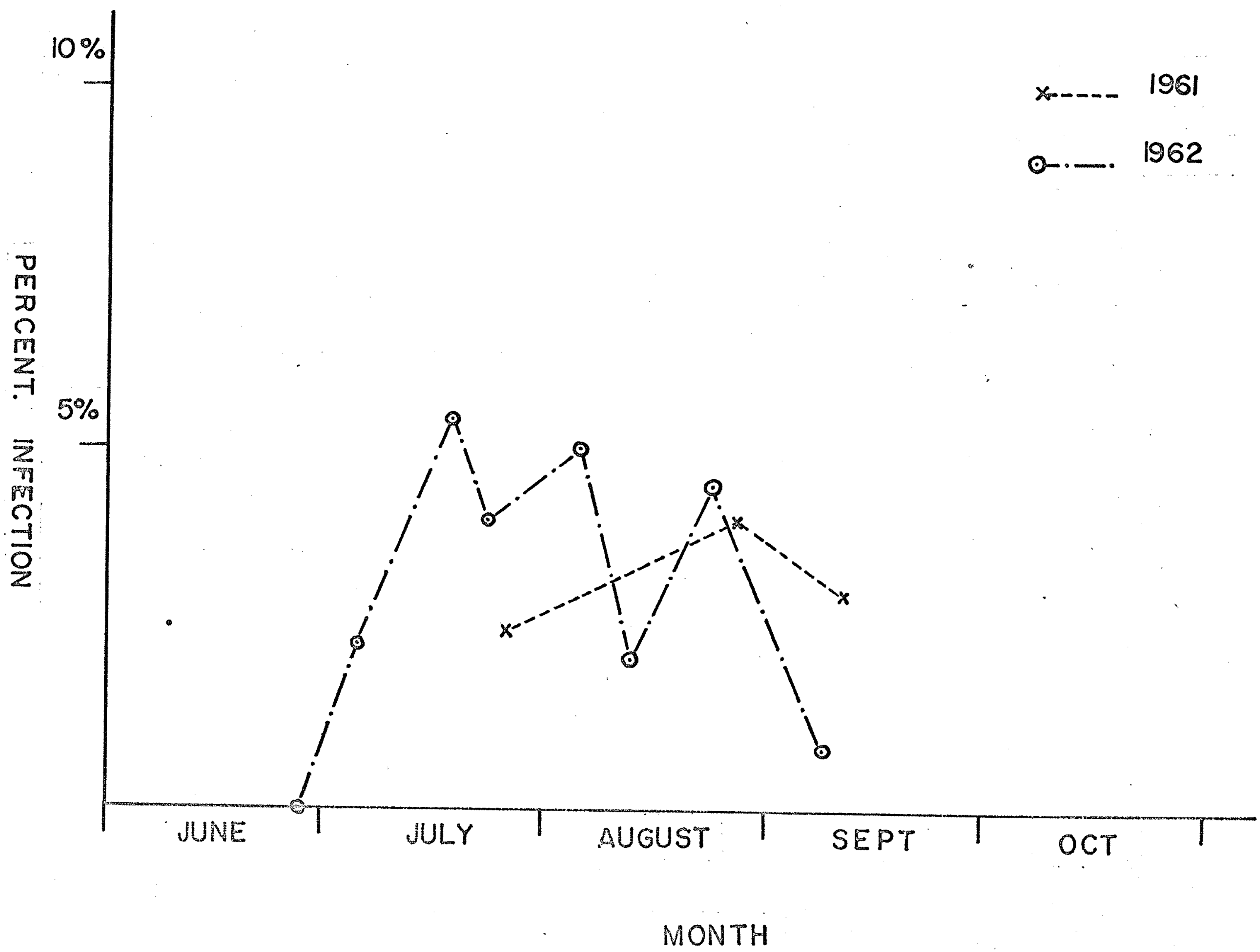

10%
5%
PERCENT. INFECTION
1961
1962
JUNE
JULY
AUGUST
SEPT
OCT
MONTH

TABLE 16. INCIDENCE OF INFECTION OF C. DOUTHITTI IN LYMNAEA STAGNALIS JUGULARIS FROM NORRIS LAKE

Week	Month	NO: SNAILS COLLECTED	No: INFECTED	% INFECTED
1961				
4	July	158	4	2.5
4	August	75	3	4.0
2	September	102	3	3.0
1962				
4	June	38	0	0
1	July	88	2	2.3
3	July	92	5	5.4
4	July	100	4	4.0
1	August	79	4	5.0
2	August	140	3	2.1
3	August	67	3	4.5
1	September	128	1	0.8
1963				
Whole summer		715	None infected	

APLEXA HYPNORUM.

This snail is very abundant in the region, being located in temporary ponds and road-side ditches which dry up in the summer.

The early summer of 1963, being especially wet, provided ample opportunity for collecting this snail. In two localities, a road-side ditch near Long Lake, Reaburn, and a ditch near Twin Beaches, infected snails were recovered.

The cercariae obtained resembled C. douthitti in size, structure and behaviour (Table 17). Repeated attempts to infect 25 mice with this parasite failed. Since the author has had ample experience with C. douthitti, infecting 216 mice during work towards the M.Sc. degree, it would seem unlikely that this failure to infect mice was due to a faulty technique.

On the other hand the author is very loathe to erect a new species since the cercariae resembles in every way that of C. douthitti. If this cercaria is C. douthitti it represents a new host record and adds to the following surprisingly long list of susceptible snails:

1. Lymnaea reflexa Say .... Cort 1915
2. Lymnaea stagnalis appressa Say.Cort 1918
3. Lymnaea stagnalis perampla Walker......Cort 1918
4. Lymnaea stagnalis jugularis Say.Brackett 1940
5. Lymnaea stagnalis lillianae Baker...Brackett 1940
6. Lymnae stagnalis sanctaemaniae Walker......Brackett 1940

7. Lymnaea palustris Mueller ....Price, 1931
8. Lymnaea palustris elodes Say......Cort, 1936
9. Physa ancillaria parkeri Cuvier...Cort, 1918
10. Physa gyrina elliptica Lea........Price, 1931
11. Stagnicola exiles.................Cort, 1936
12. Stagnicola emarginata angulata Sowerby.....Cort, 1936

It appears likely that there are varieties of this parasite as there are of Schistosoma japonicum. (Part II, page 154). This view is supported by the observations that although Lymnaea palustris is a susceptible host to the parasite only L. stagnalis has been found infected in this area even though they often shared the same habitat. In the same way the ditches containing infected Aplexa hypnorum were also full of L. palustris, none of which were found infected.

Until work is done on this probable species complex it would seem feasible to regard the cercariae from Aplexa hypnorum as a variety of C. douthitti.

TABLE 17. DIMENSIONS OF C. DOUTHITTI VAR COMPARED WITH DIMENSIONS OF C. DOUTHITTI.

	C. DOUTHITTI VAR		C. DOUTHITTI	
	Mean	S.E.*	Cort, 1915	Price, 1931
Length of body	205	3.02	190	204
Width of body	50	0.92	67	68
Length Head organ	-	-	57	76
Width Head organ	-	-	45	48
Length of tail	229	2.6	220	210
Width of tail	18.6-27.9		25	-
Length of furca	116	1.72	89	96
Width of furca	9.3-18.6		-	-
Ventral sucker to posterior end body	65	1.14	-	59
Diameter ventral sucker	15.5-21.7		25	25
No: specimens	30		-	25
Hosts	_Aplexa hypnorum_		_L. reflexa_	_L. stagnalis appressa_ _Lymnaea palustris_ _Physa gyrina_

*Standard Error.

PHYSA ANCILLARIA

This snail was extremely common along the shore of Moose Lake and was also present on the sandy bottom of Gull Lake, where, from a collection of many hundred snails, one was found infected with a new species of schistosome cercariae: *C. ancillariae* n.sp.

Cercaria ancillariae n.sp. Figure XVIII

Specific diagnosis: Apharyngeal, furcocercous, brevifurcate cercaria with pigmented eye-spots. Average measurements of thirty specimens: Body 254 ($\mp$ 1.28) micra in length by 43.3 ($\mp$ 0.64) wide. Diameter of ventral sucker 23 to 38 micra, situated 71.04 ($\mp$ 0,79) micra from posterior end of the body. Tail stem 285 ($\mp$1.88) micra long by 28 ($\mp$0.39) wide. Furcae 178 ($\mp$1.66) micra long by 20 ($\mp$0.32) micra wide.

With dorso-ventral furcal fin-folds; five pairs of penetration glands and a flame cell formula of $2(3+(3+1))$.

Behaviour: Cercariae shed in first morning light. Immediately after shedding they tend to remain just beneath the surface of the water, maintaining themselves in that position by sporadic swimming. In this position there is no obvious attraction to light, but after a few minutes in still water they become attached to the side of the container near the surface towards the greatest intensity of light. They assume the same position of attachment as *C. ocellata* var.

Type Host: *Physa ancillaria*

Type Locality: Gull Lake, Manitoba.

This cercaria is a typical member of the ocellate group of schistosome cercaria. It is distinguishable from the others of the group by its much smaller size (Table V, Part II, page 234).

FIGURE XVIII. *Cercaria ancillariae* n.sp.

Abbreviations used:

a. Head organ

b. Anterior flame cell

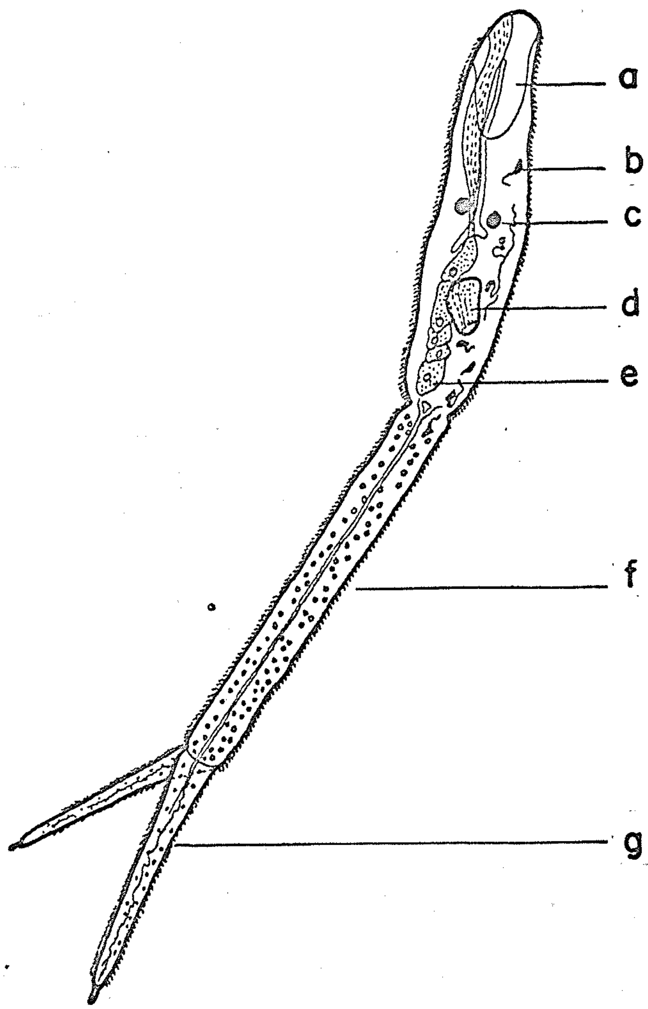
c. Eye-spot

d. Ventral sucker

e. Penetration gland.

f. Tail

g. Furca


a
b
c
d
e
f
g

GYRAULUS PARVUS and MENETUS EXACUOUS.

These snails are typical of small bodies of stagnant water, where they may be found clinging to the underside of floating algae etc. *Gyraulus parvus* is especially common in the area.

Two specimens of *G. parvus* and one of *Menetus exacuous* were found infected with *Cercaria gyrauli*, the larval stage of *Gigantobilharzia gyrauli*, commonly found in the red-winged and yellow-headed blackbirds of Manitoba (p.48...). The dimensions of this cercaria compared with the original description by Brackett is shown (Table 18).

TABLE 18. DIMENSIONS OF CERCARIAE GYRAULI

	Brackett, 1940	Present Work	
	Gyraulus parvus	Gyraulus parvus	M. exacuous.
Length of body	190-270 (215)	212 ∓ 1.3	217 ∓ 1.3
Width of body	56-100 (73)	56 ∓ 0.6	67 ∓ 0.7
Length of Head organ	60-92 (77)		
Width of Head organ	36-60 (46)		
Length of tail stem	270-342 (298)	303 ∓ 3.2	300 ∓ 2.9
Width of tail stem	24-36 (29)	28 ∓ 0.4	28 ∓ 0.4
Length of furcae	126-162 (135)	165 ∓ 1.7	161 ∓ 1.9
Width of furcae		12.5 to 37.5	12.5 to 30
Ventral sucker to posterior end body	54-90 (73)	76 ∓ 0.9	83 ∓ 0.7
Diameter ventral sucker	24-32 (28)	25-38	25-38
No. of specimens		30	30

The behaviour of C. gyrauli resembles that of C. douthitti in that the cercariae hang from the surface of the water by the ventral sucker.

LYMNAEA PALUSTRIS

Widespread collections of this snail only revealed a single snail infected with a schistosome parasite, tentatively identified as C. dermolestes, McLeod, 1940. However, since the snail died the day after collection only a few measurements were taken and no examination of the living cercariae was made.

Many collections of other species of snails were examined but no further parasites were found. A list of the species is included in Table 10.

DISCUSSION

Prior to the commencement of this work six articles had been published regarding the Manitoba schistosomes: (McLeod, 1934, 1936, 1937, 1940: McLeod and Little, 1942 and Swales, 1936). Table 19 gives a complete list of schistosome adults and cercariae which have now been recovered in this province.

TABLE 19. LIST OF SCHISTOSOME ADULTS and CERCARIA RECOVERED IN MANITOBA.

Species	Host	First Manitoban Record
Microbilharzia manitobensis	Canvas-back duck	McLeod, 1936
Microbilharzia canadensis	"	McLeod, 1936
Trichobilharzia querquedulae	Blue-winged teal	McLeod, 1937
	Pintail duck	McLeod and Little 1942
	Shoveller duck	"
Austrobilharzia lari	Herring gull	McLeod, 1937
	Bonaparte's gull	Present author
	Ring-billed gull	McLeod, 1940
Ornithobilharzia canaliculata	Herring gull	McLeod, 1940
	Bonaparte's gull	Present author
Ornithobilharzia filamenta	Herring gull	McLeod, 1940
	Ring-billed gull	McLeod, 1940
Gigantobilharzia lawayi	Herring gull	Farley, 1963
	Bonaparte's gull	Farley, 1963
	Ring-billed gull	Present author

TABLE 19. LIST of SCHISTOSOME ADULTS and CERCARIA RECOVERED IN MANITOBA (cont'd)

Species	Host	First Manitoban Record
Gigantobilharzia totani	Greater and Lesser Yellow Legs	Present Author
Gigantobilharzia gyrauli	Red-winged and yellow-headed blackbirds	Present Author
	Brown-headed cowbird	Present Author
	Common grackle	Present Author
Schistosomatium douthitti	Meadow-vole	Farley, 1962.

Species	Host	First Manitoban Record
Cercaria ocellata var (*C. elvae*)	*Lymnaea stagnalis*	McLeod, 1940
	Lymnaea obrussa	McLeod, 1936
Cercaria stagnicolae	*Stagnicola emarginata*	McLeod, 1940
Cercaria querquedulae	*Physa gyrina*	McLeod, 1940
Cercaria dermolestes	*Stagnicola palustris*	McLeod, 1940
Cercaria douthitti	*Lymnaea stagnalis*	Farley, 1962
Cercaria douthitti var.	*Aplexa hypnorum*	Present author
Cercaria gyrauli	*Gyraulus parvus*	Present author
	Menetus exacuous	Present author
Cercaria ancillariae	*Physa ancillaria*	Present author

Ten adult species and eight larval species of schistosomes have thus been recovered in Manitoba. Of these the life-cycles of only three are known to be completed in Manitoba: *Schistosomatium douthitti* with the adult stage in meadow-voles (*Microtus pennsylvanicus*) and the cercariae in *Lymnaea stagnalis jugularis* and perhaps *Aplexa hypnorum*; *Gigantobilharzia gyrauli* with the adults in red-winged and yellow-headed blackbirds, cow-birds and grackles and the cercariae in *Gyraulus parvus* and *Menetus exacuous*; and *Trichobilharzia querquedulae* with the adults in blue-winged teals, pintails and shoveller ducks and the cercariae in *Physa gyrina*.

The results show conclusively that the life-cycle of *Gigantobilharzia lawayi* is completed in this province although the larval stages have not been located. Immature gulls were found to harbour this parasite during the late summer and prior to their southward migration. It appears likely that the intermediate host of this parasite inhabits the larger lakes of the province where the gulls nest but repeated examination of some of the common snails from these areas proved negative.

Austrobilharzia lari was also recovered from an immature Bonaparte's gull during the fall migration which is evidence that the life-cycle of this parasite is completed in the more northern regions of the province.

Unfortunately in the case of most bird species it is not always possible to determine the ages of the birds so that although it appears likely that the life-cycle of G. totani is completed in this province there is no supporting evidence beyond the high incidence of infection.

Apart from Microbilharzia canadensis and M. manitobensis, which may be identical and be a variety of of Austrobilharzia terrigalensis, and also Ornithobilharzia filamenta, none of which were recovered in this survey, Trichobilharzia ocellata var. remains the most puzzling of all.

Despite the very widespread occurrence of Cercaria ocellata var, by far the most common larval schistosome in local waters, the adult stage has never been recovered. The speciation of the entire 'ocellata' complex is in complete confusion largely because very few adult stages have been recovered and those which have are usually from experimentally infected birds such as canaries which may well provide misleading results since they are unnatural hosts.

An attempt was made in this investigation to determine the seasonal incidence of snail infection with C. ocellata var and by comparing with C. douthitti to come to some conclusion regarding the habits of the bird host. If the host of C. ocellata were nesting in the area and not a passing migrant one would expect the same general pattern of infestation as C. douthitti.

In neither case were infected juvenile snails located, neither at Norris Lake or in any other region of the province. This finding supports a similar report by other workers in the United States. This absence seems difficult to explain especially as juvenile snails are much easier to infect in the laboratory than older snails (Farley, M.Sc. thesis).

The general pattern of infestation of C. ocellata var during the summer months appears identical to that of C. stagnicolae in Stagnicola emarginata (Cort et al, 1940). There is a general fall in intensity and no evidence of any fresh infections gained over the summer. Evidence points to the infection being acquired during the fall and spring and the highest incidence of infection thus occuring in the early summer.

All experimental evidence shows the susceptibility of snails to parasitic infection decreases with the age of the snail. This is not only due to age immunity but also to an acquired immunity through exposure to many species of cercariae. Thus the most susceptible period for snails subject to infection with C. ocellata would be the first fall and spring.

Present evidence supports this view. In no cases were infected sub-adults located until the early part of July. Since development of cercariae within the snail took about 6 weeks in the laboratory it appears likely that the sub-adults acquired the parasite in early May, the colder temperatures prolonging the period of development. Presumably the parasite acquired in the fall would remain dormant over the winter months and commence development in the spring.

There are conflicting reports regarding the duration of schistosome infections within the snail. Kagan et al (1954) stated that the duration of infection with C. douthitti depended upon the age at which the snails were infected, young snails carrying the infections as long as 18 months. Cort et al (1940) found that the infection was exhausted three months after the first appearance of C. elvae from Stagnicola palustris (a questionable result since to the writers knowledge Stagnicola palustris is not susceptible to C. elvae). Similarly they also suggested that C. stagnicolae was only liberated from Stagnicola emarginata for a maximum of three months.

Since there is a high level of parasitaemia in the adult snails taken in the late spring it appears that the parasite is carried over a second winter and that the duration of infection is longer than 3 months, assuming that the maximum infection takes place in juvenile snails. The drop in the intensity of infection over the summer is probably due to a mortality of adult snails and also termination of infection within them.

The pattern of parasitic infection with C. ocellata over the summer months does support the contention that the infection is aquired by juvenile and sub-adult snails during the fall and spring and that the definitive host is a temporary migrant bird.

The seasonal incidence of C. douthitti in Manitoba supports the findings of Bourns (1961) in Ontario. He found a 1.6% infection rate in June increasing to 5.6% in

August and remaining at that level until the freeze-up. Thus whilst the level of infection with C. ocellata falls fairly constantly over the spring and summer months, that of C. douthitti reaches a peak in August and remains at that level. The maximum period of snail infestation occurs in the early summer. Since there appears to be few infected snails which overwinter, it seems that either the parasite is much more pathogenic to the snail than C. ocellata (not supported by the experimental data of Kagan et al) or that very little snail infection takes place in summer and fall and that the infections are exhausted by the following spring. This is very hard to understand as the definitive host of C. douthitti is in contact with the snails throughout the year.

There is a vast amount of work that could be done in Manitoba on the local snails and their parasites. To the writers knowledge, despite the amount of work done on the trematodes of Manitoba, the larval schistosomes have been the only cercariae studied. Before any work of this nature can be undertaken however an exhaustive survey of the local aquatic snails must be done. There are no really adequate guides to Canadian snails and to the non-specialist the mere identification of the snails presents great difficulties. For this reason the snail classification in this thesis is rather shaky especially for the genus Physa. Fortunately in this work the identity of all the infected snails, with the possible exception of Physa ancillaria, is fairly conclusive.

PART TWO. THE SCHISTOSOMATIDAE. A MONOGRAPH.

CLASSIFICATION SCHEME.

Family	Sub-family	Genera
SCHISTOSOMATIDAE	SCHISTOSOMATINAE	Afrobilharzia
		Austrobilharzia
		Bivitellobilharzia
		Heterobilharzia
		Macrobilharzia
		Orientobilharzia
		Ornithobilharzia
		Schistosoma
		Schistosomatium
	GIGANTOBILHARZIINAE	Gigantobilharzia
		Dendritobilharzia
	BILHARZIELLINAE	Bilharziella
		Trichobilharzia

SCHISTOSOMATIDAE (Looss, 1899) amend. Poche, 1907

Synonyms: Schistosomidae Looss, 1899; Bilharziidae Odhner, 1912.

Family diagnosis: Trematoda: Dioecious. Pharynx absent, oesophagus short, paired caeca reuniting to form a common caecum extending to near posterior end of body. Suckers present or absent. Acetabulum when present situated anterior to genital pore in male. Body of male may be widened and infolded to form a gynaecophoric canal. Testes consist of four or more follicles lying posterior to acetabulum when present, situated anterior or posterior to caecal union. Seminal vesicle present, with or without a cirrus pouch. Female with elongate ovary, sometimes spiral, lying anterior to caecal union. Laurer's canal present or absent, with or without a seminal receptacle. Uterus opens either immediately posterior to acetablum or at anterior end of body. Vitellaria extensive, extending from ovary to posterior end of body. Eggs non-operculate, embryonated, with terminal or lateral spine, or spineless. Parasitic in blood vessels of birds and mammals.

Life-cycle: On reaching water the egg hatches releasing the miracidium enclosed within it. The miracidium penetrates the tissues of a snail intermediate host and developes into a mother sporocyst whose germ balls later form daughter sporocysts. The daughter sporocysts pass into the digestive gland of the snail where the cercariae develop. The cercariae, released from the snail into the water, actively penetrate the skin of the definitive host and pass to the lungs where they commence development to the adult condition. Ultimately the adults accumulate in the venules of the hepatic portal system, the bladder or cloacal regions, or the nasal sinuses.

Miracidium: With two pairs of flame cells.

Cercaria: Apharyngeal, brevifurcate, distome types with or without furcal fin-folds.

KEY TO THE SUB-FAMILIES OF SCHISTOSOMATIDAE.

1. Male with well developed gynaecophoric canal extending to posterior end of body. Testes situated anterior to caecal union.

..........SCHISTOSOMATINAE.

Male without gynaecophoric canal or with less well developed gynaecophoric canal, not extending to posterior end of body. Testes posterior to the caecal union. 2

2. Oral sucker and acetabulum present. Female genital pore situated immediately posterior to the acetabulum

..........BILHARZIELLINAE.

Acetabulum absent. Female genital pore at anterior end of body ..........GIGANTOBILHARZIINAE.

Sub-family SCHISTOSOMATINAE Stiles et Hassall, 1926.

Synonyms: Schistosominae Stiles et Hassall, 1898.

Sub-family diagnosis: Schistosomatidae: Both suckers usually present. Male with well developed gynaecophoric canal extending to posterior end of body. Testes situated anterior to caecal union. Genital pore immediately posterior to acetabulum in both sexes. Female slender with oval or spiral ovary, with or without a small oval seminal receptacle posterior to ovary.

Type genus: Schistosoma. Weinland, 1858.

KEY TO THE GENERA OF SCHISTOSOMATINAE

1. Gynaecophoric canal commences at a distance posterior to the acetabulum ...........SCHISTOSOMATIUM

   Gynaecophoric canal commences either anterior to or immediately posterior to the acetabulum......2.

2. Vitellaria consisting of two complete sets of paired follicles lying either side of the paired caeca. Testes 48 to 85, in anterior third of body ..........BIVITELLOBILHARZIA

   Vitellaria consisting of one set of follicles, paired or unpaired. ....3.

3. Testes few in number, grouped immediately posterior to acetabulum. ....4.

   Testes more than 13, extending to equatorial region of body or beyond ....5.

4. Testes 4 to 13. Ovary in anterior half of body with a short uterus containing at the most a single egg. ............AFROBILHARZIA.

   Testes 4 to 8. Ovary posterior to or at the equator with a long uterus usually containing many eggs. ....SCHISTOSOMA.

5. Testes in posterior third of body ..................HETEROBILHARZIA.

Testes commence immediately posterior to acetabulum or lie in equatorial region of the body 6

6. Uterus very short, ootype lying immediately posterior to acetabulum. ...............AUSTROBILHARZIA.

Uterus longer, ootype situated just anterior to ovary ....7.

7. Ovary elongate, spiral with seminal receptacle ....8.

Ovary oval or with only the anterior part spiral. No seminal receptacle or Laurer's canal ................ORIENTOBILHARZIA.

8. Male very large, female much smaller with ovary situated posterior to equator, uterus containg many eggs. ................MACROBILHARZIA.

Male and female similar, both of intermediate size. Ovary situated in anterior half of body with few if any eggs present in uterus. ................ORNITHOBILHARZIA.

Genus. SCHISTOSOMATIUM Tanabe, 1923.

Generic diagnosis: Schistosomatinae. Male: anterior two-fifths of body flattened, posterior three-fifths infolded to form a gynaecophoric canal, commencing at a distance posterior to acetabulum. Suckers well developed. Testes 15 to 36 irregularly placed at the anterior end of the gynaecophoric canal. Post-testicular portion of the paired caeca with lateral diverticula, uniting near posterior end of body. Genital pore immediately anterior to the testes. Female: flattened. Ovary oval in anterior half of body. Intestinal caeca as male. Uterus containing many eggs, opening immediately posterior to the acetabulum. Vitellaria of densely packed small follicles. Eggs oval and spineless. Parasitic in mammals.

Cercaria: Apharyngeal, brevifurcate with two eye spots, without furcal fin-folds. Five pairs of penetration glands and an excretory system with a flame cell formula of 2 (3 + 2) + 1 .

Type species: Schistosomatium pathlocopticum. Tanabe, 1923.

SCHISTOSOMATIUM DOUTHITTI (Cort, 1914) Price, 1931.

Fig. 1.

Synonym: Schistosomatium pathlocopticum (Tanabe, 1923) Penner, 1942.

Diagnosis: Schistosomatium.

Male: 1.9 to 6.3 mm. long. Forebody flattened, 0.8 to 1.7 mm long by 0.237 mm. wide, hindbody with edges infolded to form gynaecophoric canal 0.8 to 3.4mm. long. Oral sucker subterminal, 0.1 mm., acetabulum 0.135 mm. in diameter. Cuticle spined. Oesophagus 0.49 mm. long, bifurcates immediately anterior to acetabulum, paired caeca with lateral diverticula reunite near posterior end of body. Testes at anterior end of hindbody, 15 to 36 follicles. Seminal vesicle immediately anterior to testes, enclosed in cirrus pouch. Genital pore at anterior end of gynaecophoric canal to the left of mid-line.

Female: 1.6 to 5.35 mm. long. Oral sucker 0.07 by 0.65 mm. acetabulum 0.076 mm. in diameter. Cuticle spiny in anterior part of body and around the suckers. Gut as male. Ovary oval or slightly spiral, in anterior half of body. Oviduct from posterior end of ovary turns anterior and extends to ootype immediately in front of ovary. Small seminal receptacle present immediately posterior to ovary. Vitelline duct joins with oviduct immediately posterior to ootype. Ootype with Mehlis' gland. Uterus full of eggs, opens immediately posterior to acetabulum. Eggs oval, spineless. In utero: 42-80 by 30-58 micra.

Cercaria: C. douthitti Cort, 1914.

Hosts: Primary. Mammals; Microtus pennsylvanicus,
Ondatra zibethica,
Lepus americanus.

Secondary. Lymnaea reflexa, Lymnaea stagnalis, Stagnicola palustris, Physa ancillaria, Physa gyrina, Stagnicola exiles, Stagnicola emarginata. (For complete list see Part I, page 96).

Location: Portal and mesenteric veins.

Distribution: Northern United States and Canada.

Tanabe (1923) erected the genus Schistosomatium with the discovery of Schistosomatium pathlocopticum from Massachusetts, U.S.A. His description of this species differs from that of S. douthitti in three ways: size, number of testes and number of penetration glands in the cercariae. Penner (1942) re-examined Tanabe's material and postulated the two species to be synonymous. Two of the specimens from Tanabe's collection contained 20 and 22 testes which is typical of a 33 day old adult of S. douthitti; the number of penetration glands in the cercaria of S. pathlocopticum was five pairs, similar to C. douthitti, and not three pairs as reported by Tanabe; and finally the size difference was shown to be insignificant especially as Penner was able to extract a 10 mm. long adult of S. douthitti from a mouse dead before autopsy. The synonymy was further supported by the identical behaviour and time of emergence of the two types of cercariae.

Porter, (1938) located cercariae in S. Africa which she described as C. pathlocopticum on the basis of 3 pairs of penetration glands and five pairs of flame cells in the body and one in the tail. In her comparison with C. douthitti she misquotes Price by stating that C. douthitti had ten flame cells on each side of the body, a misunderstanding which would convince her of the identity of her cercariae and perhaps prevented her critically examing the cercariae to ascertain the number of penetration glands. For the present it would seem feasible to regard this cercaria as C. douthitti occuring in Lymnaea natalensis and Bulinus tropicus from S. Africa.

The species Schistosmatium pathlocopticum should therefore be suppressed in favour of Schistosomatium douthitti (Cort, 1914) Price, 1931.

BIVITELLOBILHARZIA Vogel and Minning, 1940.

Genus:

Generic diagnosis: Schistosomatinae: Male and female nearly equal in length. Suckers present. Paired caeca reunite near posterior end of body. Male with gynaecophoric canal beginning immediately posterior to acetabulum extending to posterior end of body. Testes 48 to 85, in anterior third of body. Genital pore at anterior end of gynaecophoric canal. Cirrus pouch absent. Female flattened, with spiral ovary in anterior thirdof body. Seminal receptacle and Laurer's canal present. Vitellaria consisting of two complete sets of paired follicles extending from behind ovary to posterior end of body alongside paired caeca. Uterus with one egg, opening immediately posterior to acetabulum. Eggs very large with polar process. Parasitic in elephants.

Type species: Bivitellobilharzia loxodontae Vogel et Minning, 1940.

BIVITELLOBILHARZIA LOXODONTAE Vogel et Minning, 1940

Fig...2.......

Diagnosis: Bivitellobilharzia

Male: 6.7 to 15.1 mm. long. Oral sucker 0.25 to 0.38 mm. in diameter, acetabulum 0.3 to 0.48 mm. Gynaecophoric canal extending from acetabulum to posterior end of body. Entire body surface covered in small spines, those on dorsal surface being situated on tubercles. Paired caeca unite in posterior region of body. Testes 48 to 85 (average 68) occupying a length of 1.1 to 2.5 mm. in anterior half of the body.

Female: 6.4 to 16.8 mm. long. Entire body flattened with a maximum width of 0.4 to 0.86 mm. in the posterior region of worm. Oral sucker 0.062 to 0.080 mm. in diameter, acetabulum 0.045 to 0.059 mm. Surface covered with minute spines. Two lateral zones of dense spines between oral and ventral suckers. Paired caeca reunite near posterior end of body with vitellaria paired around each caecum and single after they fuse to form the common caecum. Ovary situated in anterior part of body with the distance from the oral sucker to the posterior end of ovary being 1/3rd to 1/7th of distance between ovary and posterior end of body. Ovary 0.43 to 0.76 mm. long. Seminal receptacle behind the ovary with Laurer's canal present. Paired vitelline ducts fuse just posterior to seminal receptacle and proceed anteriorly to ootype just anterior to ovary. Uterus containg no eggs although one may be present in ootype.

Eggs: Mature: 145 to 203 by 53 to 86 micra. Average 168 by 71. Terminal or subterminal spine average 26 micra long, often bent to form hook.

Cercariae: No description available.

Host: Primary: African elephant (*Loxodonta africana*) from Hamburg Zoo, Germany.

Secondary: Vogel infected local snails, *Galba sp.* ~~with the cercariae~~. This snail not being native to Africa, is not therefore the natural intermediate host.

Location: Veins of alimentary canal.

Distribution: Unknown

BIVITELLOBILHARZIA NAIRI (Mudaliar et Ramanujachary, 1945) Dutt et Srivastava, 1955.

Synonyms: *Schistosoma nairi* Mudaliar et Ramanujachary 1945; *Ornithobilharzia nairi*, Bhalerao, 1947.

Diagnosis: *Bivitellobilharzia*

Male: 9.4 mm. long by 0.5 mm. wide. Dorsal part of body with tubercles. Oral sucker 0.3 mm. in diameter, acetabulum 0.4 mm. in diameter. Oesophagus 0.45 mm. long, paired caeca reunite at posterior end of body. Testes 52.

Female: Slender 10.5 mm. long by a maximum of 0.25 mm. wide. Suckers delicate. Ovary in anterior quarter of worm, 0.4 mm. in length. Oesophagus 0.15 mm. long, paired caeca reunite at posterior part of body.

Egg: Elongate with one side flattened, short terminal spine. 80 by 30 micra.

Host: Primary: Indian elephant (*Elephas indicus*)

Secondary: Unrecorded.

Distribution: India

With consideration of the different hosts and smaller egg size in the above species the two must remain as separate species.

Genus: AFROBILHARZIA Le Roux, 1958.

Generic diagnosis: Schistosomatinae. Dorsal surface of male tuberculate with or without spines. Paired caeca reunited in anterior half of body (usually). Gynaecophoric canal begins immediately posterior to acetabulum. Ovary well in anterior half of body with ootype immediately in front of ovary. Uterus short containing only one egg at a time. Seminal receptacle may be present. Eggs oval with lateral or sub-terminal spine. Parasitic in mammals.

Cercariae: Apharyngeal, brevifurcate, without eyespots, with five pairs of penetration glands and a flame cell formula of 2 (4 + 2). No furcal fin-folds.

Type species: *Afrobilharzia mansoni* (Sambon, 1907) Le Roux 1958.

KEY TO SPECIES OF AFROBILHARZIA

1. Egg oval or suboval with short stout asymmetrical or lateral spine..............................2.

   Egg with subterminal spine and an appendix at other end of egg turned in opposite direction to spine or with terminal straight spine and straight appendix........................*A. rodhaini*.....

2. Egg oval with stout lateral spine .....*A. mansoni*.

   Egg suboval with one side flattened, stout spine being continuous with straight edge...*A. incognitum*.*

* Considered synonymous to *Schistosoma hippopotami*, Thurston, 1963.

AFROBILHARZIA MANSONI (Sambon, 1907) Le Roux, 1958.

Fig....3...........

Synonyms: *Schistosoma mansoni* Sambon, 1907; *Distoma haematobium* Bilharz 1852, in part; *Schistosomum americanum* Piraja da Silva, 1909; *Bilharzia mansoni* Ascanio-Rodriquez, 1916.

Diagnosis: *Afrobilharzia*.

Male: 3 to 11 mm. long by 1 to 1.2 mm. wide. Cuticle tuberculate and spiny on dorsal surface. Oral sucker subterminal, 0.15 to 0.35 mm. in diameter. Acetabulum pedunculate 0.2 to 0.45 mm. in diameter, 0.53 mm. posterior to oral sucker. Oesophagus divides immediately anterior to acetabulum and reunites about one-third along length of body. Testes small, 7 to 9, at anterior end of gynaecophoric canal. Seminal vesicle anterior to testes, genital pore at anterior end of gynaecophoric canal.

Female: 4 to 16 mm. long by 0.15 to 0.35 mm. wide. Filiform. Suckers small acetabulum 0.22 to 0.25 mm. posterior to oral sucker. Digestive system as male. Ovary oval, well into the anterior half of body. Vitellaria of minute follicles extend from ovary to posterior end of body. Uterus short with only one egg at a time although occasionally there are more.

Egg: Oval 120 to 160µ by 60 to 70µ with a stout lateral spine.

Cercariae: Dimensions given by Porter (1938) and Faust (1929).

Hosts: Primary. Experimental infections:
Rodentia: *Arvicanthis niloticus*, *Mus musculus praetextus*, Albino mouse, *Acomys cahirinus*, *Gerbillus pyramidum*, *Jaculus*

jaculus, Meriones shawi shawi, Nesokia indica suilla, (Kuntz and Malakatis, 1955) Syrian Hamster and Guinea Pig. Rattus norvegicus a poor host (Stunkard 1946). Sigmodon hispidus hispidus (Stirewalt, Kuntz and Evans, 1951). Meriones lybicus, Apodemus sylvaticus, Citellus citellus, Eliomys quercinus, Evotomys glareolus, Glis glis (Buttner 1953). Cercomys cunicularius (Amorim, 1953). Cuniculus pacca pacca (Ruiz, 1953a). Dasyprocta aguti (Price, 1953). Oryzomys palustris (Moore & Meleney, 1952).
Primates: Cercopithecus aethiops sabaeus, C. aethiops cynosurus (Archibald & Marshall 1932). Papio ursinus griseipes (Le Roux 1939). Papio hamadryas (Newsome, 1956). Macaca mulatta, Macaca mordax (Stunkard, 1946). Cebus capucinus apella, Cebus capucinus albifrons.
Insectivora: Hemiechinus auritus aegyptius (Kuntz & Malakatis 1955).
Xenarthra: Euphractus sexcinctus (Pinto, 1944).
Artiodactyla: Low susceptibility displayed by pigs and sheep.
Carnivora: Dog, (Kuntz, Malakatis & Wells, 1953). Felis cattus shown to be a poor host by Stunkard, (1946). Procyon cancrivorus, Nasua narica, (Grison furax, (Ruiz, 1952,53).
Marsupialia: Didelphis aurita, Didelphis paraquavensis (Travassos 1953).

Natural Infections:
Primates: Cercopithecus sabaeus (Cameron 1928) in St. Kitts, West Indies. Cercopithecus aethiops cynosurus (Porter, 1938) in S. Africa. Papio doguera (Miller, 1960) in East Africa. Papio papio (McQuay, 1952) of unknown origin New Orleans, Man.
Insectivors: Crocidura luna (Stijns, 1952) in the Belgian Congo. (Kuntz, 1955) reported a number of infected Crocidura from Egypt.
Rodentia: Cerbillus pyramidum (Kuntz 1952) from Egypt. Rattus rattus (Schwetz, 1955) in the Belgian Congo, Mastomys natalensis, Otomys tugelensis (Pitchford, 1959a) from the transvaal. Lemniscomys griselda (Pitchford & Visser, 1962) from the transvaal. Nectomys squamipes (45.31%), Holochilus sciureus (25%), Oxymycterus angularis (11.11%), Zigodontomys pixuna (1.78%) and Oryzomys subflavus (1.03%) in North-East Brazil (Amorim, 1953 and Amorim et al, 1954). Rattus, rattus

frugivorus (59%) from N.E. Brazil (Barbosa et al, 1953). *Oryzomys mattogrossae* (100%), *Nectomys squampipes* (57.5%), *rattus norvegicus norvegicus* (46.8%), *Cavia aperea aperea* (33.3%) *Oryzomys subflavus* (12%) and *Zygodontomys lasiurus* (2.7%) from Eastern Brazil (Martins *et al*, 1955).
Marsupialia: *Didelphis aurita* (Travassos, 1953) and *Didelphis paraguayensis* (Martins *et al*, 1955) both from Brazil.

Secondary. *Biomphalaria boissyi* in Egypt; *Biomphalaria pfeifferi* in Central and S. Africa. *Biomphalaria ruppellii* in *Eritrea*; *Biomphalaria adowensis* in *Ethiopia*; *Biomphalaria alexandrina*, in *Uganda* and *Congo*; *Australorbis glabratus* and *Tropicorbis centimetralis* in S. America.

Location: Portal and mesenteric veins.

Distribution: Egypt, West Africa, Congo, Rhodesia, S. Africa, Tanganyika, Uganda, Kenya, Nyasaland, Sudan, Mozambique, Madagascar. Brazil, Venezuela, Dominican Republic, Puerto Rico, St. Kitts, Antigua.

AFROBILHARZIA RODHAINI (Brumpt 1931a) Le Roux, 1958.

Fig.....4.........

Synonym: *Schistosoma rodhaini*, Brumpt, 1931a.

Diagnosis: *Afrobilharzia*.

Male: 6.5 mm.long by 0.4 mm. wide. Gynaecophoric canal well developed extending from immediately posterior acetabulum to posterior end of body. Cuticle striated, preacetabular portion smooth, postacetabular portion tuberculated. Oral sucker spined, 0.05 mm. in diameter, acetabulum spined 0.5 mm. from anterior end, 0.25 mm. in diameter. Oesophagus divides at acetabulum reunites two-thirds along body length. Testes 6 to 8 at beginning of gynaecophoric canal. (Schwetz in redescription of species found from 8 to 9 testes).

Female: 9 to 10.5 mm. long by 0.2 mm. wide. Cuticle striated, without tubercles and only spined in suckers and over the posterior 0.3 mm. length of worm. Oral sucker 0.052 mm. in diameter, acetabulum 0.05 mm. in diameter, 0.25 mm. from anterior end. Oesophagus divides just anterior to acetabulum paired caeca reunite very early, being only seven-eighteenths of total length of body. Ovary lies immediately anterior to caecal union. Vitelline duct and oviduct open into shell gland immediately posterior to ootype from which uterus runs forward to open behind acetabulum. Uterus contains one egg.

Egg: Polymorphic, 65 to 70µ by 33 to 35µ in uterus; 145 by 58µ when mature. The most common form bears a subterminal spine at one end turning to one side with an appendix at the opposite end turning in the opposite direction to the spine. About thirty percent of the eggs had terminal straight spine and straight appendix, resembling eggs of *S. haematobium*.

Hosts: Primary: *Lophuromys aquilus*, *Praomys jacksoni*, *Pelomys frater*, *Mastomys coucha* (Stijns, 1952). *Dasymys benteyae*. *Pelomys fallax*, *Oenomys hypoxanthus* (Schwetz, 1954) Dogs (Deramee, 1953)

Secondary: *Biomphalaria pfeifferi*, *Biomphalaria tanganyikanus*

Location: Portal and mesenteric veins.

Distribution: Belgian Congo.

Remarks: *A. rodhaini* infection matures sooner than that of *A. mansoni* and the infection is much more acute resulting in a greater number of deaths in experimemtal animals.

Schwetz, (1953) discovered a further parasite of rodents which he termed Schistosoma mansoni var rodentorum. It was found in 4% of the rodents, Mastomys coucha, Pelomys fallax, Oenomys hypoxanthus, Dasymys bentleyae, Lophuromys aquilus from river areas containing Biomphalaria pfeifferi. The parasite may be distinquished by the shape of the egg which is elongate with one obtuse and rounded off extremity, the other extremity being narrow and sometimes bent and twisted. The spine is near the rounded end. The parasite causes a light chronic infection.

The position of this form is still in question. Le Roux (1954) successfully hybridized A. mansoni and A. rodhaini with the production of eggs bearing a close resemblance to those described for var rodentorum. On the other hand Teesdale and Nelson (1958) found similar eggs in the urine and faeces of children where neither A. rodhaini nor var rodentorum occurred, suggesting that var rodentorum are indeed infections of A. mansoni. In either case the variety should be discarded.

The relationship of A. mansoni and A. rodhaini in Africa to A. mansoni in America is of interest. In America the natural infection of rodents with A. mansoni is common, the non-human reservoir hosts being of extreme importance. In Africa however the infection of wild rodents is a rare occurence whether by A. mansoni or var rodentorum, the infection being limited to A. rodhaini which is of no importance in human bilharziasis. Miller (1960) discovered 23.9% of Papio doguera in East Africa to be infected with A. mansoni suggesting that these may act as reservoir hosts in such areas.

It can perhaps be said that _A. rodhaini_ is _A. mansoni_ fully adapted to rodents or vice versa that _A. mansoni_ is _A. rodhaini_ adapted to man. In America _A. rodhaini_ is not found and presumably _A. mansoni_ was introduced by the slaves where it has since become readily adapted to both man and rodents.

AFROBILHARZIA INCOGNITUM (Chandler, 1926) Sinha and Srivastava 1954.

Nom. amend. Fig.....5.......

Synonym: _Schistosoma suis_ Rao et Ayyar, 1933. _Schistosma incognitum_ (Chandler, 1926). _Schistosoma hippopotami_ Thurston, 1963.

Diagnosis: _Afrobilharzia_

Male: 2.43 to 8.86 mm. long by 0.1 to 0.457 mm. maximum width, size dependent on the host. Gynaecophoric canal extending from acetabulum to posterior end of body. Cuticle in posterior region of body spined ventrally and tuberculate dorsally. Anterior portion smooth. Oral sucker 0.1 to 0.2 mm. by 0.08 to 0.18 mm. in size, acetabulum pedunculate 0.085 to 0.26 mm. in diameter. Oesophagus 0.16 to 0.36 mm. long, divides anterior to acetabulum and reunites near to the posterior end of body. Common caecum may bifurcate at a few places. Testes spherical, 2 to 7 mostly 5 to 7 situated in two rows behind acetabulum. Seminal vesicle in front of testes with genital pore at the beginning of gynaecophoric canal.

Female: Shorter and more slender than male. 2.57 to 7.57 mm. long by 0.05 to 0.14 mm. maximum width. Cuticle armed with minute spines. Oral sucker 0.051 to 0.1 mm. by 0.028 to 0.07 mm. in size, acetabulum pedunculate 0.03 to 0.057 mm. in diameter. Oesophagus 0.07 to 0.21 mm. long, bifurcates anterior to acetabulum and reunites just posterior to ovary. Common caecum bifurcates anterior to acetabulum and reunites just posterior to ovary. Common caecum bifurcates a few times. Ovary oval with anterior end narrow and spirally elongated, of varying lengths, 0.3 to 0.47 mm. long. Oviduct from posterior end of ovary runs forward to ootype with expanded portion, the seminal receptacle, in loop of oviduct posterior to ovary. Vitelline duct opens into oviduct at ootype into which shell gland also opens. Uterus 0.257 to 0.757 mm. long opening immediately posterior to acetabulum. Never more than one egg at a time.

Egg: Uterine: 86-114 (av.98) by 36 - 43 (av.39) micra. with spine 5 to 7.5 (av.6.5) micra long. Mature egg suboval with one side flattened with short stout spine asymmetrical more or less continuous with the flattened side. 97-148 (av.118) by 45-81 (av. 61) micra, spine averages 7 micra long. The type of host determines the size of egg, from Guinea Pigs they average 106 by 48 micra whilst from pigs and dogs the average is 123 by 67 micra.

Cercariae: Sinha et Srivastava (1954)

Hosts: Primary: Experimental. Rabbit, Guinea Pig, Albino mouse, Albino rat, Goat and Calf.
Natural: Pig and Dog.

Secondary: *Lymnaea luteola* var *australis*. *Lymnaea luteola* var *succinea* (Khaw, 1947)

Location: Portal and mesenteric veins

Distribution: India

Chandler (1926) described the finding of schistosome eggs from a human being in India which he described as *Schistosoma incognitum*. These eggs measured 0.095 to 0.10 mm. long by 0.0415 to 0.050 mm. wide with a subterminal spine 7.3µ long. In 1933 Rao and Ayyar described a new species of schistosome, *Schistosoma suis* from naturally infected pigs and dogs in India and from the shape of the eggs suggested it may be synonymous with *S. incognitum*. Sinha and Srivastava (1954,56,&60) carried out morphological and life-history studies on the schistosome and postulated that the two species previously described be considered synonymous.

Thurston (1963) described a new species *Schistosoma hippopotami*, from the hippopotamus of Western Uganda. This species clearly resembles *A. incognitum* and only differs in the size of the egg spine (11 micra compared with 7 micra for *A. incognitum*). Since egg sizes in *A. incognitum* have been shown to be very variable, depending on the host species, and since the egg measurements given for *S. hippopotami* were only based upon one egg *in utero*, the author regards these two species as synonymous. The close relationship between the pig and hippopotamus also supports this contention.

Genus SCHISTOSOMA Weinland 1858

Synonyms: Gynaecophorus Diesing, 1858. Bilharzia Cobbold, 1859, Thecosoma Moquin - Tandon, 1860.

Generic Diagnosis: Schistosomatinae: Male with well developed gynaecophoric canal extending from acetabulum to posterior end of body. Surface smooth or tuberculate, armed with spines. Testes 4 to 8 at beginning of gynaecophoric canal. Caeca reunite near posterior end of body. Ovary posterior to or at equator and with uterus long containing many eggs. Vitellaria consisting of minute follicles alongside common caecum. Cercaria as Afrobilharzia.

Type species: Schistosoma haematobium (Bilharz 1852) Weinland, 1858.

KEY TO SPECIES OF SCHISTOSOMA

1. Cuticle of male smooth. Egg oval with rudimentary lateral spine ....Schistosoma japonicum.

Cuticle of male tuberculate and spiny. Egg with well developed terminal spine or subterminal knob or spine ....2.

2. Adult worm located in nasal sinuses .....Schistosoma nasalis.

Adult worm located in portal and mesenteric veins ....3.

3. Egg with subterminal knob or spine .....Schistosoma margrebowiei

Egg with well developed terminal spine...........4.

4. Egg asymmetrical spindle shaped ....5.

Egg symmetrical oval, fusiform or spindle shaped ....6.

5. Testes 4 to 6, caeca reunite in posterior quarter of worm, ovary equatorial....Schistosoma leiperi.

Testes 6 to 7, caeca reunite in anterior half of worm, ovary in posterior half of body .....Schistosoma spindale.

6. Egg oval with terminal spine ....7.
Egg fusiform or spindle shaped with terminal spine ....8.

7. Testes 5 to 9, caeca reunite in posterior quarter of body, ovary equatorial....*Schistosoma indicum*.
Testes 4 to 5, caeca reunite at level of equator, ovary in posterior half of body..
.....*Schistosoma haematobium*.

8. Egg symmetrical spindle shaped..*Schistosoma bovis*.
Egg fusiform, intermediate in size between those of *S. bovis* and *S. haematobium*...*Schistosoma mattheei*.

The distinction between the three egg types of *bovis*, *haematobium* and *mattheei* is difficult as there is overlap between the species and possible hybridization. However there is a fairly consistent difference between the three forms. The eggs of *S. haematobium* are the smallest, oval in shape with lateral walls regularly convex. Those of *S. bovis* are the largest, spindle shaped with lateral walls concave anteriorly and posteriorly and convex in the centre with attenuated ends. Those of *S. mattheei* are intermediate in size with lateral walls straight anteriorly and concave posteriorly with posterior end attenuated.

SCHISTOSOMA HAEMATOBIUM (Bilharz, 1852) Weinland 1858.

Fig......6...........

Synonyms: *Distoma haematobium* Bilharz, 1852; *Gynaecophorus haematobium* Diesing 1858; *Bilharzia haematobia* Cobbold, 1859; *Thecosoma haematobia* Moquin-Tandon, 1860; *Bilharzia haematobia hominis* Kowalewski, 1895; *Bilharzia aegyptiaca* Miyagawa, 1924.

Specific diagnosis: *Schistosoma*

Male: 4 to 18.5 mm. long by approximately 1mm. maximum width. Anterior part of body short, subcylindrical, posterior part long and flattened with lateral edges infolded to form gynaecophoric canal extending from acetabulum to posterior end of body. Cuticle tuberculate and spiny. Oral sucker subterminal, finely spined, 0.19 to 0.4 mm. in diameter; acetabulum pedunculate and muscular 0.225 to 0.53 mm. in diameter. Oesophagus short, divides immediately anterior to acetabulum with caeca reuniting at level of equator with occasional anastomoses. Testes 4 to 5, dorsally situated at beginning of gynaecophoric canal. Spherical seminal vesicle situated in front of testes with genital pore situated immediately posterior to acetabulum.

Female: 8.5 to 22.5 mm. long by 0.25 mm. maximum width. Filiform. Cuticle smooth except for spines in the suckers and at the posterior part of body. Digestive tract as male reuniting immediately posterior to the ovary. Ovary elongate in posterior half of body with ootype in front of ovary and shell gland, oviduct and vitelline duct uniting just behind the ootype. Uterus long containing up to 30 eggs at a time.

Eggs: Round or oval with terminal spine, 120 to 160µ long by 40 to 60µ wide. Ratio of breadth to length; with spine included 29 to 58, with an optimum between 40 and 45 and a near optimum between 45 and 50 (Amberson and Schwarz, 1953); without spine included 32 to 49 with an optimum between 35 and 45. (Le Roux 1958).

Hosts: Primary: Experimental infections:
Primates: Cercopithecus sabaeus (Archibald and Marshall, 1932).
Papio sp (Stunkard, 1946). Papio hamadryas (Kuntz and Malakatis 55),(Newsome, 1956).
Macaca mulatta (Meleney & Moore,1954).
Macaca irus (Brumpt, 1928).

Insectivora: Erinaceus europaeus (Brumpt, 1928), Hemiechirus auritus (Kuntz & Malakatis, 1955).
Rodentia: Albino mouse, Syrian Hamster (Standen 1949). Guinea pig and Rattus norvegicus of little susceptibility. Acomys cahirinus, Arvicanthus niloticus, Jaculus jaculus. Nesokia indica suilla, Gerbillus pyramidum, Meriones shawi shawi, Rattus rattus, Mus muscularis praetextus (Kuntz & Malakatis in Kuntz, 55).
Others: Rabbits, sheep and dogs appear resistant. Light infections were obtained in goats (Kuntz and Malakatis 1955) and cats.
Natural infections:
Man. Cobbold (1859) described the adult from Cercopithecus fuliginosus, the mangabey. Since at that time no other species similar to haematobium were known this find must remain questionable.
(Otomys sp (Pitchford, 1959). Nelson (1960) found terminal spined eggs of the haematobium complex in Papio doguera, Cercopithecus aethiops johnstoni and Cercopithecus mitis from areas of East Africa where S. haematobium was endemic.

It seems justifiable to assume that animals play little or no part in the epidemiology of Schistosoma haematobium, it being primarily a parasite of man.

Secondary: Bullinus truncatus in Egypt, N. Africa and Middle East; Bullinus globosus south of the Sahara; Bullinus africanus in S. Africa: Bullinus nasutus in Uganda and Tanganyika; Bullinus coulboisi in the Congo; Bullinus madagascariensis in Madagascar; Bullinus forskali in Mauritus but not infected in Uganda, Rhodesia nor Egypt. Bullinus dufourii in Portugal.

Location: Veins of urinary bladder in man, may be located in mesemteric veins of experimental animals.

Distribution: Egypt, Libya, Tunisia, Algeria, Morocco, Portugal, Cyprus, Sudan, West Africa and Equatorial Africa. Congo. East Africa, Abyssinia, Rhodesia and South Africa, Madagasgar. Palastine, Syria, Iraq, Mauritius.

The common species causing urinary schistosomiasis in South Africa differs from the type species in the size of egg and the natural hosts. Le Roux considered it to be a distinct species _Schistosoma capense_ Harley whilst Amberson and Schwartz (1953) referred to it as a sub-species _Schistosoma haematobium capense_ Harley.

The Egyptian form will readily infect _Bullinus truncatus_, _Bullinus coulboisi_, and _Bullinus forskalii_ whilst attempts to infect the above together with _Bullinus senegalensis_ from Gambia with the strain of _haematobium_ found in S. Africa and Nyasaland failed. This form readily infected _Bullinus africanus_ and _Bullinus globosus_.

Porter (1938) described the egg size of _S. haematobium_ as 99 to 149µ by 36 to 57µ, although the eggs ranged in size from 80 to 166 by 30 to 66µ. Le Roux (1958) compared the length to breadth ratios of the two forms and found that the Egyptian form varied from 32 to 49 with an optimum between 35 and 45; whilst the S. African form varied from 33 to 60 with an optimum between 39 and 50-measurement not including length of spine. Amberson and Schwarz (1953) compared two samples of eggs taken from human infection in Egypt and Mozambique. The Mozambique sample showed optima between 35 and 40 and 40 to 45 with a maximum of 44 whilst the Egyptian sample showed a range of 29 to 58 with an optimum of 40 to 45 and a near optimum between 45 and 50-measurement of spine included. The data gathered by Amerson and Schwarz shows the S. African form to be longer and narrower than the Egyptian form whilst

Porter and Le Roux show the opposite to be the case, thus the only clear difference between the two is in their intermediate hosts. Clearly the two forms overlap in the central area of Africa so that egg measurements become extremely precarious. The elevation of the South African form to a separate species does not seem justifiable but rather to regard it as a variety similar to the varieties of S. japonicum throughout Asia and the varieties of S. mansoni found in Africa and America.

A separate variety of S. haematobium also exists in Portugal where the eggs are slightly larger with a shorter spine and they have as their intermediate host Physopsis dufourii. Although this snail occurs in North Africa there is no evidence that it is infected with S. haematobium.

Schistosomiasis in India is primarily a disease of cattle, but human infections cannot be ruled out. Gadgil et Shah (1952) reported an endemic focus of urinary schistosomiasis in the Ratnagin district of Bombay State. Terminally-spined haematobium - like eggs were recovered from 250 patients who showed little discomfort. Obviously the host-parasite compatibility differed markedly from that in Africa.

Cercariae undistinguishable from those of S. haematobium were recovered from Paludomus obesa.

SCHISTOSOMA BOVIS (Sonsino, 1876) Blanchard, 1895

Fig.....7..........

Synonyms: Bilharzia bovis Sonsino 1876; Bilharzia crassa Sonsino 1878; Bilharzia ovis Cobbold 1885;

Gynaecophorus crassus Stossich 1892; *Gynaecophorus bovis* Raillet 1893; *Bilharzia haematobia crassa* Kowalewski 1895; *Schistosomum crassum* Looss 1899; *Schistosoma haematobium bovis* Amberson et Schwarz 1953.

Specific diagnosis: Schistosoma.

Male: 8.5 to 21.5 mm. long by 0.9 - 1.3 mm. in maximum width. Cuticle covered with tubercles and spines. Oral sucker subterminal 0.23 by 0.15 mm., acetabulum 0.4 to 0.55 mm. diameter situated 0.6 - 0.8 mm. posterior to the oral sucker. Oesophagus 0.28-0.47 mm. long divides just anterior to acetabulum reuniting at the beginning of posterior quarter of body with several anastomoses. Testes 3 to 6 (mostly 4) in a single row just posterior to acetabulum. Seminal vesicle, 80μ diameter, immediately anterior to testes with genital pore immediately posterior to acetabulum.

Female: 12 to 20 mm. long by 0.15 - 0.25 mm. in width, cylindrical attenuated at the extremities. Cuticle smooth. Oral sucker small, 0.04 mm. diameter, acetabulum 0.05 mm. diameter situated 0.09 - 0.17 mm. behind oral sucker. Digestive tract as male. Ovary elongate 0.3 by 0.15 mm. in size immediately anterior to caecal union usually in posterior quarter of worm but may be as far forward as equator. Lengy (1962b) reported a variability of ovary shape and size depending on the age of the worm. In the early stages of development, the ovary is narrow, coiled or twisted which later broadens and straightens out, tending to become S-shaped. Eventually it assumes a straight, elongated oval shape having a size of 0.56 by 0.125 mm.

Small seminal receptacle present. Ootype small, immediately in front of ovary surrounded by weakly staining Mehlis gland. Uterus long with many eggs, usually 20-30, but as few as 3 and as many as 65 at any one time.

Egg: Spindle shaped fairly regular in outline, with blunt spine at one pole. (V. table).

Cercariae: Lengy (1962a)

Hosts: Primary: Cattle and sheep.
Experimental: Guinea pigs (Cawston, 1921), Mice (Dowdeswell, 1938), Rabbits and rats (Porter, 1938). *Erinaceus europeus europaeus*. *Cricetus cricetus*, *Felis catus* (Brumpt, 1949), Sheep, goats, cattle and water buffalo (Nagaty, 1942).
Secondary: *Bullinus africanus*. ***Bullinus truncatus***.

Location: Intestinal and portal veins.

Distribution: Egypt, Sardinia, Sicily, Italy, South Africa.

There is a great deal of confusion surrounding this species regarding its relationship to *Schistosoma matteei* and its ability to infect man. An account of this is given after the description of *S. mattheei* page .143......

SCHISTOSOMA MATTHEEI (Veglia et Le Roux, 1929)

Synonym: *Schistosoma curassoni* Brumpt, 1931a *Schistosoma bovis* MacHattie et Chadwick 1932; *Schistosoma haematobium mattei* Amberson et Schwarz, 1953; *Schistosoma bovis* var *matthei* Van den Berge, 1937

Specific diagnosis: *Schistosoma*

Male: 17 to 22mm. long (Average 18 to 19.5 mm.). Oral sucker 0.4 mm. diameter with spines, acetabulum 1 mm. posterior to oral sucker, 0.5 to 0.6 mm. in diameter. Testes 4 to 6. Gynaecophoric canal begins 0.5 mm. posterior to acetabulum, spined ventrally, tuberculate and spined dorsally. Oesophagus bifurcates at level of

TABLE I Dimensions of *S. bovis* eggs according to various authors.

Author	In Utero		In Faeces		No Location Given		Host
	Size	Index	Size	Index	Size	Index	
Sonsino (1876)	160-180 x 40-50	-	-	-	-	-	Cattle & sheep
Khalil (1924)					160-180 x 40-60		Cattle & sheep
Brumpt (1930)	63-175 x 20-50		190-230 x 55-80				Mice
Porter (1938)			160-230 x 50-80				Rabbits, rats, Guinea pigs.
Alves (1949)			179-232 x 40-73				
Amberson et Schwarz(1953)						estimation from graph 18-38	
Lengy (1962)	106-154 x 29-44	24-29	168-242 x 54-67	26-30			White mouse
	132-182 x 33-48	22-26	189-258 x 59-70	22-31			Sheep

All Dimensions in Microns; Index = $\frac{\text{breadth}}{\text{length}} \times 100$

acetabulum, caeca reunite at posterior end of body, with several anastamoses.

Female: Cylindrical, 17 to 25 mm. long. Suckers reduced and spined. Oesophagus divides at acetabulum and reunites posterior to equatorially placed ovary. Ootype in front of ovary with uterus 8 to 9 mm. long containing many, eggs, as many as 95.

Eggs: Oval or fusiform with terminal spine. In utero: 92 to 170 by 40 to 44µ. In faeces 180 to 240 by 60 to 80µ.

Hosts: Primary: Experimental. All laboratory animals (Alves, 1948); Gerbillus sp. (Azim et Cowper, 1950).
Natural: Sheep; man, Papio ursinus griseipes, cattle (Blackie, 1932) Redunca arundinum, Adenota vardoni, Adenota leche (LeRoux); Cercopithecus aethiops cynosarus, (Blackie, 1932; Le Roux, 1939) Papio babouin kindae (Van den Berge, 1937)

Secondary: Bullinus africanus.

Location: Portal and Intestinal veins.

Distribution: Central, West and South Africa.

Schistosoma intercalatum. (Fisher, 1934)

In the Belgian Congo there are different regions of schistosomasis amongst which there is a curious zone of an intestinal type in the Stanleyville district along the Congo river. In this area Bullinus snails abound whilst Biomphalaria have not been located. Chesterman (1923) was the first to record this abnormal type; he also noted that the eggs were longer than those present in normal urinary infections of S. haematobium. Fisher (1934) using the cercariae shed from naturally infected Bullinus africanus infected mice and described an adult fluke identical to S. bovis but with different type of egg:

In utero: 130 by 40µ
Faeces: 140 to 240 by 50 to 85µ.
(av. 175 by 60)

The shape of the egg varied from a short, squat form resembling S. haematobium although the latter usually has a more rounded extremity, to long spindle shaped eggs resembling S. bovis. The majority of eggs however occupied an intermediate place in shape and size between S. bovis and S. haematobium. Fisher referred to it as a distinct species. Schwetz (1951, 56) regarded intercalatum as a variety of S. mattheei adapted to man, being unable to distinguish between the two types of egg. As will be explained the author favours the suppression of the species as being identical to S. mattheei.

The relationship between S. haematobium, S. bovis and S. mattheei.

As can be seen the morphological differentiation of the above flukes based on the structure of the adult worms is extremely precarious especially since such characters as the position of the ovary are very variable. Lengy (1962b) showed that in the case of S. bovis the ovary tends to assume a more equatorial position with increasing length of the body. For this reason the relationship between them is open to a great deal of question, relying as it does on egg shape and size and host specificity.

Schistosoma haematobium and Schistosoma bovis can clearly be distinguished by egg size and shape, the former being much smaller and oval in outline. Schistosoma haematobium is primarily a parasite of man with possible primate infections whilst S. bovis infects cattle and sheep. The infection of man by S. bovis is very questionable, all such reports being based on the findings of S. bovis like eggs in the urine or faeces of patients. (Cawston, 1921; Raper 1951 etc.) Such reports are however quite rare so that it is perfectly justifiable to assume that S. bovis in primarily a cattle schistosome which rarely if ever infects man.

The position of S. mattheei is much more involved. The parasite was first described from cattle and sheep in South Africa and was given specific rank mainly through the different position of the ovary and and egg intermediate in size between S. haematobium and S. bovis. However MacHattie and Chadwick, (1932) held that S. bovis from Iraq was synonymous with S. mattheei, the characteristic shape of mattheei eggs being due to a faulty sphincter action of the ootype. They also noted that eggs characteristic of S. haematobium were also passed. Schwetz, (1951) showed that if sufficient eggs be examined, the three types S. haematobium, S. mattheei and S. bovis may be distinguished and that the eggs of S. mattheei and S. intercalatum are identical. Amberson and Schwarz (1953) were also able to distinguish the three types on the basis of the breadth to length ratio and came to the following conclusions:

1. The egg of S. bovis is large, spindle-shaped, and narrow with a long terminal spine.
2. The egg of S. haematobium is small, short and broad with a short spine.
3. There is little to no overlap between the frequency graphs of S. bovis and S. haematobium.
4. The egg of S. mattheei and S. intercalatum are intermediate in shape and size between those of S. bovis and S. haematobium.
5. The frequency graphs of S. mattheei and S. intercalatum are identical.
6. The variations of S. mattheei and S. intercalatum are very large, there being a considerable overlap with the graphs of S. bovis and S. haematobium.

The host specificity of S. mattheei differs quite radically from that of S. bovis. There seems to be a much greater affinity for man in the former species. Blackie (1932), Jones (1942) and Alves (1949) reported S. mattheei infections of man whilst Pitchford, (1959b) found up to 23% human infection with cattle schistosomes, in all cases the infection being accompanied by eggs of the haematobium or mansoni types. Like Van den Berge (1937) and Amberson and Schwarz (1953) they noted the polymorphic nature of the cattle-type eggs. This polymorphism of S. mattheei eggs may explain the reports of S. bovis in man, the bovis-like eggs being produced from females of S. mattheei.

Speciation of this group of parasites must be veryartificial. All are obviously very closely related, differing chiefly in host specificity; the human form, S. haematobium on one hand, the cattle form S. bovis on the other. Relationships between them are further complicated by possible hybridization (Pitchford, 1959b, 1961). In the later paper, eggs indistinguishable from S. *mattheei* and recovered from man with a concurrent S. *haematobium* infection were passed through snails and white mice. This resulted in eggs intermediate between S. *mattheei* and S. *haematobium* in the first and third generations and in a series of eggs from typical *mattheei* to typical *haematobium* in the fourth, the most plausable explanation of this phenomenon being that of hybridization between S. *mattheei* and S. *haematobium*.

There seems to be one of two explanations possible for this complex of schistosomes. Either, as Amberson and Schwarz proposed they are all subspecies of S. *haematobium* (or of *bovis* or even of *mattheei*) or they are all closely related but distinct species. The status given by Van den Berge whereby *intercalatum* is a variety of S. *haematobium* and S. *mattheei* a variety of *bovis* cannot be accepted as *intercalatum* and *mattheei* are more closely related to each other than either is to S. *haematobim* or S. *bovis*. The differences between S. *mattheei* and the other two species are such that if one retains both S. *bovis* and S. *haematobium* as distinct species one must also regard S. *mattheei* as a species.

Most workers will agree that the differences between S. *bovis* and S. *haematobium* are such that they must be considered as separate species. Both are so host specific to cattle and man respectively that no hybridization can occur. On the other hand the host specificity of S. mattheei is such that hybridization with both S. bovis and S. haematobium may well occur and much of the polymorphic characteristics of its eggs may well be due to that very fact.

Since the author agrees with Lengy (1962b) that both S. haematobium and S. bovis may well have evolved from a S. mattheei-like ancestor and since S. mattheei occupies such an intermediate position that it is impossible to justify any attempt to regard it as a subspecies of either S. haematobium or S. bovis, it seems logical to regard it as a separate species.

On the grounds of identical egg size and because of the range of hosts available to S. mattheei there seems to be no justification in regarding S. intercalatum as a separate species or a sub-species of mattheei and for this reason the name should be suppressed.

SCHISTOSOMA MARGREBOWIEI Le Roux 1933

Fig....8..........

Synonyms: Bilharzia margrebowiei Le Roux, 1933; Rhodobilharzia margrebowiei Le Roux, 1958.

Specific diagnosis: Schistosoma

Male: 12 to 18 mm. long by 0.857 to 1.254 mm. wide. Cuticle covered with bosses dorsally and spines ventrally. Suckers spined. Oral sucker 0.2 to 0.24 mm. in diameter. Testes 4 or 5 with seminal vesicle in front of testes. Caeca reunite at posterior end of body.

Female: 14 to 20 mm. long by 0.27 to 0.32 mm. wide. Inner surface of suckers and posterior part of body covered with spines. Ovary pear shaped, 0.688 by 0.225 mm. in size, situated at the equator. Uterus long with numerous eggs in clumps.

Eggs: Oval, 60 by 45µ to 70 by 42µ. Small subterminal knob or rudimentary spine present.

Cercariae: Unknown

Hosts: Cattle, zebra, ruminants - *Cobus leche*, *Redunca arundinum*, *Cobus vardoni* *Hippotragus equinus*.

Location: Portal veins.

Distribution: Northern Rhodesia

SCHISTOSOMA LEIPERI Le Roux 1955

Specific diagnosis: *Schistosoma*

Male: 5.5 to 7.5 mm. long. Testes 4 to 6. Cuticle with bosses armed with spines dorsally and ventrally. Caeca reunite in posterior quarter of worm.

Female: 6.5 to 8.5 mm. long. Ovary equatorial.

Eggs: Spindle shaped. Intrauterine: 195 by 35µ to 245 by 40µ.
Faeces: 240 by 45µ to 300 by 60µ.

The eggs resemble those of *S. spindale*, but the latter are bigger with one lateral edge straight.

Cercariae: from *Bulinus africanus*

Hosts: A range of 21 herbivore species. *Tragelaphus spekei selousi*, host of type species.

Teesdale and Nelson, (1958) view this species to be a form of *S. bovis* found south of the Sahara, with relationships similar to those between *S. capense* and *S. haematobium*.

Location: Portal and Intestinal veins.

Distribution: Northern Rhodesia.

SCHISTOSOMA INDICUM Montgomery, 1906

Fig.....9..........

Specific diagnosis: Schistosoma

Male: 8.35 to 16.2 mm. long. Anterior portion 1 to 1.5 mm. long gradually widening to a maximum width of 0.4 mm. Oral sucker 0.27 to 0.32 mm. in diameter, acetabulum 0.35 mm. in diameter, situated 0.9 to 1.3 mm. posterior to oral sucker. Dorsal surface of worm tuberculate and spined, with spines also lining the gynaecophoric canal and the acetabulum. Oesophagus divides anterior to acetabulum and reunites at posterior end of the worm. Testes 5 to 9 with seminal vesicle lying in front of testes, opening just posterior to acetabulum.

Female: 9 to 22 mm. long by 0.09 mm. at the acetabulum, widening to 0.190mm. at posterior part of body. Cuticle smooth except for suckers. Oral sucker small, acetabulum 0.05 to 0.06 mm. in diameter. Oesophagus 0.158 mm. long reunites posterior to ovary. Ovary oval at equator 0.5 to 0.75 mm.long. Oviduct from posterior end of ovary turns forward and unites with vitelline duct at the shell gland. Uterus 5 to 7 mm. long, opening immediately posterior to acetabulum, containing many eggs. Vitellaria consist of dense lobular bodies entending posterior to ovary.

Eggs: Oval with terminal spine. In utero: 92 to 100µ by 42 to 44µ. Fully mature eggs: 120 to 140µ by 68 to 72µ. Spine about 14µ long. Mature eggs: mean dimensions 84 to 94 by 31 to 41µ (Datta 1933).

Cercariae: Srivastava and Dutt, 1951.

Hosts: Primary: *Ovis aries*, Sheep and dogs. *Equus caballus*, *Equus asinus*, *Camelus dromedarius*. Expt: Rabbits (Khaw, 1947).
Secondary: *Indoplanorbis exustus* (Khaw, 1947)

Location: Mesenteric and Portal veins.

Distribution: India.

SCHISTOSOMA SPINDALE Montgomery, 1906.

Specific diagnosis: *Schistosoma*

Male: 8.24 to 9.58 mm. long by 0.527 mm. wide. Cuticle covered with spines and tubercles, spines also lining the gynaecophoric canal and suckers. Oral sucker 0.306 mm. in diameter. Acetabulum 0.9 mm. posterior to oral sucker, 0.357 mm. in diameter. Testes 6 to 7, 0.85 mm. in diameter. Terminal end of body ends in conical projection with the excretory pore at the end.

Female: 14.1 mm. long by 0.2 mm. wide. Cuticle spineless except at the posterior end and in cavity of oral sucker. Oral sucker 0.66 mm. diameter, acetabulum small situated 0.268 mm. posterior to oral sucker. Oesophagus divides anterior to acetabulum, reunites posterior to ovary in posterior half of body. Ovary small. Uterus long containing many eggs.

Eggs: Asymmetrical spindle-shaped with spine 14 to 15µ long at one pole. Uterine egg 248 by 44µ. Immature egg: 364 to 400μ by 68 to 72μ.

Rao (1934) compared eggs to those of _S. nasale_. The spine of _S. spindale_ is often turned towards convex border. One side of the egg is flat or slightly convex the other side convex. The horns of the egg are straight or turned slightly to the flat side.

Cercariae: Life-cycle by Liston and Soparker, 1918. A cause of 'paddy itch' in Malaya (Buckley, 1938). _Cercaria_ described by Soparker, 1921.

Hosts: Primary: _Bos indicus_, calf buffalo, sheep, goat, horse, antelope.

Secondary: _Planorbis exustus_ and rarely _Lymnaea accuminata_.

Location: Intestinal and Portal veins.

Distribution: India. Malaya.

Eggs regarded as those of _S. spindale_ were found in the urine of man from Zululand by Cawston, (1925). Porter, (1926) reported the occurence of similar eggs in the urine and faeces of man from South Africa. She considered it to be a variety and termed it _S. spindale_ var _africanus_. The characters upon which this new variety is based are the egg size, smaller than that reported by Montgomery, and the cercarial dimensions, again smaller than that described by Soparker, 1921.

Egg: 163 to 258μ by 46 to 70μ.

Cercariae: from _Bullinus pfeifferi_ and _Bullinus tropicus_

Porter, (1938) suggested it may be synonymous with the Sumatra strain of _S. spindale_ (Vryburg, 1907) whose egg size is also smaller than the type species.

Egg: 258 to 333 by 50 to 67µ.

SCHISTOSOMA NASALE Rao, 1933.

Fig.....10...........

Specific diagnosis: Schistosoma

Male: 7.2 mm. long. Dorsal surface tuberculate and covered with spines. Oral sucker 0.1 mm. diameter, acetabulum 0.12 mm. in diameter. Oesophagus bifurcates anterior to acetabulum and reunites a little posterior to the equator. Testes 2 to 4 with a small seminal vesicle anterior to testes.

Female: 7 mm. long. Cuticle smooth. Oral sucker small with acetabulum 0.24 mm. behind oral sucker. Oesophagus bifurcates anterior to acetabulum and reunites posterior to ovary. Ovary, 0.12 mm. long, situated at the beginning of the posterior third of the worm. Uterus long containing 4 to 5 eggs at a time. Vitellaria consisting of small linear follicles.

Eggs: Boomerang shaped. One side of the egg convex the other concave with terminal spine often bent towards concave border. The horn at the opposite end of the egg is straight or bent toward the convex side (Rao, 1934). Size 380 to 420µ by 50 to 55µ (Rao, 1933). 336 to 581µ by 60 to 80µ (Rao, 1934).

Cercariae: Cercariae indicae XXX (Sewell, 1922). (Rao, 1933, 1938, 1939)

Hosts: Primary: Cattle and buffalo.

Secondary: Lymnaea accuminata and rarely in Indoplanorbis exustus.

Location: Nasal turbinate veins.

Distribution: India.

SCHISTOSOMA JAPONICUM Katsurada, 1904

Fig......11.........

Synonyms: Schistosoma cattoi Blanchard in Catto, 1905; Bilharzia japonica Hutyra et Marek, 1913: Sinobilharzia japonicum Le Roux, 1958.

Specific diagnosis: Schistosoma

Male: 9.5 to 17.8 mm. long by 0.557 to 0.967 mm. wide. Cuticle smooth except for small spines along gynaecophoric canal and in suckers. Oral sucker 0.2 to 0.35 mm. diameter, acetabulum 0.156 to 0.42 mm. in diameter situated 0.55 to 0.78 mm. posterior to oral sucker. Caeca reunite in posterior quarter of body. Testes 7, 6 to 8 in some authors. Seminal vesicle in front of anterior testis.

Female: 15 to 20 mm. long by 0.312 to 0.358 mm. wide. Cuticle smooth. Oral sucker 0.06 to 0.07 mm. in diameter. Acetabulum 0.045 to 0.06 mm. in diameter situated 0.266 to 0.298 mm. posterior to oral sucker. Ovary elongate, 0.58 to 0.7 mm. long, situated either at or posterior to equator. Uterus long opening immediately posterior to acetabulum. Faust and Bonne (1948) described the presence of a seminal receptacle.

Eggs: Oval with very small lateral hook or rudimentary spine. 74 to 106µ by 60 to 80µ.

Cercariae: Described by Cort (1919); Faust and Meleney (1923,24).

Hosts: Primary: Experimental. Guinea-pig, monkey, rabbit, rat and mouse. Natural: Man, cattle, dog, cat, swine, sheep, water buffalo,goats, Rattus rattus, Rattus norvegicus, Rattus losea, Mus formosana, Crocidura murina.

Secondary: Oncomelania nosophora, in Japan; Oncomelania formosana in Formosa; Oncomelania hupensis in China; Oncomelania quadrasi in the Philippines.

Location: Intestinal and Portal veins.

Distribution: China, Japan, Formosa, Philippines and Celebes.

Hsu et Hsu, (1958a) demonstrated that there are at least four geographical strains of Schistosoma japonicum, the Chinese, Japanese, Formosan and Philippines. Each has its own biological characteristics but Hsu, Hsu et Chu (1962) showed that the fertility between the strains is not reduced by interstrain crossings and that the infectivity of the filial generation was not impaired. They should thus be regarded as strains.

Hsu, Hsu, et Richie, (1955) showed that the Formosan strain is a parasite of small mammals and domestic animals and is not endemic to man. Examination of 4,197 people revealed only three with a doubtful S. japonicum egg whilst in the same area 62% of the dogs and a lower percentage of other small mammals were infected. The other strains appear to be primarily parasites of man but still capable of infecting a wide range of mammals (Magath and Mathieson, 1945; Wright, 1950).

Many workers have shown that the strains are fairly narrow in their choice of snail host. Hunter et al, (1952) showed O. formosana to be only slightly susceptible to the Japanese strain. Dewitt, (1954) showed that _O. formosana_, _O. nosophora_, _O. quadrasi_ were susceptible to the Chinese strain and that the Formosan strain was infective to _O. formosana_ and _O. nosophora_ but only slightly infective to _O. quadrasi_ and not infective to _O. hupensis_. He also showed _O. nosophora_ and _O. hupensis_ to be susceptible to the Japanese strain whilst the other two snail species were not. Hsu et Hsu, (1960) showed the Philippine strain to be infective to _O. quadrasi_ and to a lesser degree _O. hupensis_ and _O. nosophora_ but not to _O. formosana_.

Observations on the structure of the adult worm and eggs of the three strains (Hsu et Hsu, 1957, 58b) revealed few consistent differences, the host species having a great influence on the dimensions. Nevertheless in all hosts examined the breadth to length index of the egg showed a variation between the strains, their order of magnitude being Japanese (75-79), Formosan (69 to 80), Philippine (69-73) and Chinese (65-70).

Genus. AUSTROBILHARZIA (Johnston, 1917) Amended.

Synonym: Microbilharzia (Price, 1929) Penner, 1953b.

Generic diagnosis: Schistosomatinae. Male with well developed gynaecophoric canal extending from acetabulum or oral sucker to the posterior end of the body. Suckers present. Testes 11 to 60 either occupying a middle region of the body and commencing at some distance posterior to the acetabulum or commencing immediately posterior to the acetabulum and not extending beyond the equatorial region. Cirrus pouch present or absent. Paired caeca reunite in posterior region of body, with or without anastomoses. Female slender, both suckers present with one possible exception. Ovary spiral, situated in anterior half of body, rarely postequatorially. Seminal receptacle and Laurer's canal present or absent. Uterus very short with ootype lying just posterior to the acetabulum. Genital pore opens immediately posterior to the acetabulum. Egg oval with or without spine. Parasitic in birds.

Cercariae: Apharyngeal, brevifurcate, with eye-spots and without furcal fin-folds. 6 pairs of penetration glands and a flame cell formula of 2 (3 + (2 + 1)). All known cercariae marine.

Type species: Austrobilharzia terrigalensis Johnston, 1917.

KEY TO THE SPECIES OF AUSTROBILHARZIA

1. Testes over 60, occupying the middle three-sevenths of body. Vitellaria of single large follicles arranged tandemly ....A. odhneri.

   Testes less than 30 occupying the middle third of body or situated in the anterior half of body ....2.

2. Ovary very elongate, occupying the second-fifth of body length ....*A. pricei*.

Ovary loosely spiral occupying much less than a fifth of the body length 3

3. Testes 11 to 16; ovary situated in anterior third of body with seminal receptacle and Laurer's canal ....*A. penneri*.

Testes 12 to 26 in anterior half of body. Ovary equatorial with or without seminal receptacle and Laurer's canal ....4.

4. Testes 12 to 23 (usually 18 to 20). Female without seminal receptacle and Laurer's canal ....*A. terrigalensis* (1)

Testes more than 22, female with seminal receptacle 5 (2)

5. Egg with very large terminal spine ...*A. hoepplii*.

Egg oval without spine ....*A. lari*.

Footnotes:

1. *A. terrigalensis* is here considered to include *A. variglandis*, *M. chapini* and *M. manitobensis*. *M. canadensis* differs from the above in lacking an acetabulum in the female.
For a comparison of these forms see p. 159....

2. *A. bayensis*, with only the male described is impossible to key satisfactorily.

The above genus no doubt constitutes a heterogeneous group. The writer however was unable to set up a satisfactory scheme to split the group without erecting genera with only one species. For example, a good case can be made for removing *A. odhneri* and *A. pricei* from the genus and erecting new ones for each.

Since, however, many of the characteristics occur so randomly throughout the group the writer favours the more conservative approach of maintaining the genus intact.

<u>AUSTROBILHARZIA</u> <u>TERRIGALENSIS</u> Johnston, 1917

<u>Diagnosis</u>: <u>Austrobilharzia</u>

<u>Male</u>: A length of 3.5 - 4.0 mm. by 0.4 mm. wide. Cuticle smooth, both suckers 0.175 mm. in diameter. Acetabulum pedunculate with spines and situated approximately 0.6 mm. posterior to oral sucker. Gynaecophoric canal may begin just posterior to the oral sucker. Oesophagus divides anterior to acetabulum and caeca reunite by a few commissures in posterior quarter of body. Testes 12 to 20, beginning 0.325 mm. posterior to acetabulum and extending to the equator. Seminal vesicle enclosed within cirrus pouch with prostate cells and genital pore 0.125 mm. posterior to acetabulum.

<u>Female</u>: 4.5 to 5 mm. long, anterior portion slender, 0.058 mm. wide, posterior part flattened, 0.136 mm. wide. Oral sucker 0.05 mm. in diameter, acetabulum 0.065 mm. in diameter, situated approximately 0.3 mm. posterior to oral sucker. Ovary spiral, 0.8 mm. long, at equator of body, intestinal caeca reunite immediately posterior to the ovary. Oviduct runs anteriorly and joins vitelline duct 0.15 mm. posterior to acetabulum. Uterus short with genital pore immediately posterior to acetabulum.

Eggs: Oval with or without terminal spine with bent end. Ova in gut, 88 by 83 with spine 7 to 10µ long. Egg in uterus 55µ in diameter. (Bearup, 1956)

Cercaria: Cercaria variglandis var pyrazi (Bearup, 1955); C. terrigalensis (Bearup, 1956)

Host: Primary: Larus novae-hollandiae. Experimentally in pigeons and canaries.
Secondary: Pyrazus australis.

Location: Hepatic portal veins

Distribution: Australia, N.S. Wales.

The above description is taken from Johnston (1917) and Bearup (1956). In 1955 Bearup described a species of cercaria which he considered to be a variety of C. variglandis, described from America by Miller and Northup (1926). Later (1956) he found this cercaria to be the larval stage of the parasite A. terrigalensis and thus he renamed it C. terrigalensis.

Stunkard and Hinchcliffe (1952) described the adult of C. variglandis as Microbilharzia variglandis, and came to the conclusion that it was synonymous with M. chapini described earlier by Price (1929) from the Lesser Scaup duck in Maryland. Chu and Cutress (1954) identified as Austrobilharzia (=Microbilharzia) variglandis a schistosome species from Hawaii found in Ruddy turnstones, and with the larvae from Littorina pintado. They did not however regard A. variglandis as being identical to M. chapini, since the common caecum in the former anastomoses and in the latter remains straight.

Short and Holliman (1961) went even further by suggesting that the species from Hawaii is not identical to A. variglandis.

McLeod (1936) described two species from the canvas-back duck: M. canadensis and M. manitobensis. Both closely resemble the other species mentioned above. M. canadensis, however, was recovered from preserved viscera, which may account for the peculiar absence of the acetabulum in the female. M. manitobensis was considered as distinct from M. chapini on the grounds of the anastomosing common caecum, the exact condition reported for A. variglandis.

Table ..II.. shows a comparison of all the forms mentioned above. The writer does not regard them as separate species but rather as three geographical varieties of A. terrigalensis: var australasia, var americana and var pacifica.

All the forms show identical adult morphology and the differences between their cercariae are very slight, the Hawaian form having the shortest and the Australian form the longest tail. Further the cercariae show identical behaviour: rising to the surface of the water and bending the tail back alongside the body.

The writer thus feels that this species complex should be broken up as follows:

1. *AUSTROBILHARZIA TERRIGALENSIS* var *australasia*.

Synonym: *A. terrigalensis* Johnston, 1917

Hosts: Primary: *Larus novae-hollandiae*.

Secondary: *Pyrazus australis*.

Distribution: N.S.W. Australia.

2. *AUSTROBILHARZIA TERRIGALENSIS* var *americana*

Synonym: *A. variglandis* (Miller and Northup, 1926) Penner, 1953

M. variglandis Stunkard and Hinchcliffe, 1952.

M. chapini Price, 1929.

M. manitobensis McLeod, 1936; possibly
M. canadensis McLeod, 1936.

Hosts: Primary: *Nyroca valisineria* (McLeod); *Mergus serrator* (Penner) *Aythya affinis* (Price).

Secondary: *Nassa obsoleta*

3. *AUSTROBILHARZIA TERRIGALENSIS* var *pacifica*.

Synonym: *A. variglandis* (Chu et Cutress, 1954)

Hosts: Primary: *Arenaria interpres* (ruddy turnstone)

Secondary: *Littorina pintado*.

See figures 12 to 16 inclusive

TABLE II. COMPARISON OF *AUSTROBILHARZIA TERRIGALENSIS*, *A. VARIGLANDIS*, *M. CHAPINI*, *M. CANADENSIS* AND *M. MANITOBENSIS*

[1] Measurement in mm. [2] Measurement in micra.

MALE[1]	*A. terrigalensis* (Baerup)	*A. variglandis* (Stunkard)	*M. chapini* (Price)
Length Body	3.4-3.5 (mean)	2.94-4.22	3.27-4.25
Max. Wid. Body	0.4	0.46	0.63
Diam. Oral Suck	0.2	0.13-0.16	0.152
Diam. Ventral S.	0.2	0.18-0.22	0.175
Oral to Ventral	app. 0.6	app. 0.4-0.6	0.437
Testes	12-20	18-20	18-20
Test. Diam.	0.02 - 0.03	0.05-0.1	
Posn. Testes	Second quarter of body	Anterior half of body	Extent to slightly posterior to equator
	Paired caeca anastomase with diverticula	Paired caeca anastomase with diverticula	Paired caeca straight without diverticula
No. specimens	17 males and 17 females examined	41 males, 6 females and 72 juveniles examined	
FEMALE			
Length Body	4.6-5.0	2-3.5	3.7
Width Body	0.25	0.05-0.175	0.1
Oral Sucker Diam.	0.05	0.045-0.054	0.03
Ven. Sucker Diam.	0.065	0.04-0.05	-
Oral to Ventral	app. 0.3	app. 0.2	-
Oral to Ovary	ovary equatorial		-
Length Ovary	0.8	0.3-0.38	0.39
Acet to Ootype	0.15	0.1-0.15	-
EGG (Faeces)	Oval with or without bent terminal spine 88 x 83u	Oval	
DEFINITIVE HOSTS	*Larus novae - hollandae* Expt. in pigeons, canaries	Expt: canaries, pigeons, gulls and ducklings	*Marina affinis*
LOCATION	Australia	New England Coast, U.S.A.	Maryland, U.S.A.

TABLE II (cont'd)	*A. terrigalensis* (Baerup)	*A. variglandis* (Stunkard)
CERCARIAE[2]	25 measured	10 specimens
Length Body	235 ∓ 3.0	237
Width Body	69 ∓ 1.0	72.5
Length Tail	265 ∓ 4.9	228
Width Tail	-	22 - 36
Length Furca	148 ∓ 3.4	126
Width Furca	-	12 -16
Vent. Suck——Post End.	Approx. 105	107
Length Head Organ	-	72
Width Head Organ	-	43
HOST	*Pyrazus australis*	*Nassa obsoleta*

A. variglandis (Chu et Cutress)	*M. canadensis* (McLeod)	*M. manitobensis* (McLeod)
4.0 - 7.0	4.02 - 4.5	4.5 - 4.9
0.20 - 0.70	0.48	0.47 - 0.48
-	0.214	0.169
-	0.09	0.215
-	0.320	0.56
up to 23	18 - 20	18 - 20
	anterior half of body	extend a little posterior to equator
Paired caeca anastomose, with diverticula	Paired caeca straight, without diverticula	Paired caeca anastomose
Over 100 specimens	1 specimen of each sex	1 specimen
3.0 - 7.0	3.20	
0.2 - 0.3	0.27	
-	0.024	
-	not seen	
-	-	
-	ovary pre-equatorial	
-	0.45 - 0.47	
-	-	
Oval with bent terminal spine 75-140 x 67-126u	-	
Arenaria interpres. Expt. Noddy and sooty terns, chicks and ducks	*Nyroca valisineria*	*Nyroca valisineria*
Hawaii	Manitoba, Canada	Manitoba, Canada
50 specimens		
248		
91		
202		
-		
108		
-		
-		
-		
-		
-		
Littorina pintado		

AUSTROBILHARZIA CANADENSIS (McLeod, 1936) Penner, 1953b.

Diagnosis: Austrobilharzia.

Male: 4.02 to 4.5 mm. long by 0.48 mm. wide. Well developed gynaecophoric canal beginning just posterior to oral sucker. Cuticle finely tuberculate. Oral sucker 0.214 mm. in diameter, acetabulum sessile 0.08 to 0.09 mm. in diameter, situated 0.32 mm. posterior to oral sucker. Oesophagus opens into large bulb-like structure with heavy walls containing muscle fibres, 0.15 to 0.17 mm. in diameter 0.18 mm. posterior to oral sucker. Caecal branches originate from this bulb and join about the level of the junction between the middle and posterior third of body. Testes 18 to 20 in irregular row beginning 0.29 mm. posterior to acetabulum and confined to anterior half of body. Genital pore not seen.

Female: 3.2 mm. long by 0.27 mm. wide. Anterior part cylindrical and slender, posterior part broad and flattened. Oral sucker weak, 0.024 mm. in diameter, acetabulum not seen. Gut as in male with caeca reuniting immediately posterior to ovary. Ovary slender and spiral, pre-equatorial in position, 0.45 to 0.47 mm. long. Uterus long genital pore not seen.

Eggs: Not seen.

Cercariae: Not known.

Host: Nyroca valisineria (canvas-back duck).

Location: Intestinal and Portal veins.

Distribution: Manitoba, Canada.

Analysis of the above must be tempered by the knowledge that the two worms were recovered from preserved viscera. There are however certain unique characteristics which demand for the time being retention of this species: the bulb-like structure at the end of the oesophagus, and the absence of a ventral sucker in the female in particular. Further McLeod states that the uterus is long but the genital pore was not seen and neither is there any mention of the ootype. It can be assumed therefore that the uterus was in fact very short as in all other members of the genus, but that the ootype was not visible.

AUSTROBILHARZIA HOEPPLII (Tang, 1951) Amend.

Fig.....17..........

Synonyms: Ornithobilharzia hoepplii Tang, 1951; Microbilharzia hoepplii Dutt et Srivastava, 1961.

Specific diagnosis: Austrobilharzia

Male: 4.5 to 7.4 mm. long by 0.27 mm. wide. Oral sucker 0.171 to 0.181 mm. in diameter, acetabulum 0.234 to 0.252 mm. in diameter. Oesophagus divides just anterior of acetabulum and reunites at the beginning of the posterior quarter of body. Gynaecophoric canal extends from oral sucker to posterior end of body. Testes 25 to 26 in single row just posterior to acetabulum. Cirrus and prostate absent.

Female: 3.65 to 7.4 mm. long by 0.126 to 0.153 mm. wide. Oral sucker 0.06 to 0.067 mm. in diameter. Oesophagus divides anterior to acetabulum and reunites posterior to ovary. Ovary equatorial, loosely spiral, 0.39 to 0.7 mm. long. Oviduct from posterior end of ovary joined by duct from seminal receptacle and turns forward to join vitelline duct at ootype. Laurer's canal from lateral aspect of seminal receptacle. Uterus very short, with genital pore immediately posterior to acetabulum.

Eggs: Oval with very large terminal spine. 132 to 172 by 89 micra. Spine 57 micra.long.

Location: Portal vein and liver.

Hosts: Primary: Capella megala (Swinhoe's snipe)

Distribution: Foochow, China.

AUSTROBILHARZIA BAYENSIS Tubangui, 1933

Fig..18....

Specific diagnosis: Austrobilharzia

Male: 5.2 mm. long by 0.32 mm. maximum width. Cuticle smooth. Oral sucker 0.18 by 0.14 mm. in size. Acetabulum 0.22 mm. in diameter situated one-seventh the distance of body from anterior end. Oesophagus bifurcates immediately posterior to acetabulum, paired caeca reunite 1.5 mm. from the posterior end of body. Gynaecophoric canal extends from acetabulum to posterior end of body. Testes 26, extending from posterior of acetabulum to middle of body. Cirrus pouch present, enclosing seminal vesicle and prostate cells, immediately in front of testes. Genital pore ventral between acetabulum and first testis.

Female: Unknown

Host: *Gallinago gallinago* (snipe)

Location: Mesenteric and hepatic portal veins

Distribution: Philippine islands.

AUSTROBILHARZIA ODHNERI (Faust, 1924) Comb. nov.

Fig....20.........

Synonyms: *Ornithobilharzia odhneri* Faust, 1924;

Sinobilharzia odhneri Dutt et Srivastava, 1961.

Specific diagnosis: *Austrobilharzia*

Male: 6 to 7 mm. long by 0.22 to 0.26 mm. wide. Cuticle spiny. Oral sucker 0.12 to 0.15 mm. in diameter, acetabulum 0.16 to 0.165 mm. in diameter. Gynaecophoric canal extending from acetabulum to posterior extremity of body, deep and broad. Oesophagus divides immediately anterior to acetabulum, paired caeca reunite near posterior end of body. Testes oval, 65, lying in the equatorial three-sevenths of the body. Seminal vesicle mid-way between testes and acetabulum communicating directly with rudimentary cirrus pouch and ejaculatory duct.

Female: 3 mm. long by 0.1 to 0.12 mm. wide. Cuticle spiny. Oral sucker and acetabulum both 0.07 mm. in diameter. Oesophagus divides anterior to acetabulum, paired caeca reunite four-fifths the length of body from the anterior end. Ovary elongate, loosely coiled in anterior third of body. Oviduct from posterior end of ovary bends and passes forward to ootype. Seminal receptacle well developed, posterior to ovary connected by short duct to the oviduct. Laurer's canal opens dorsally from the seminal receptacle. Vitellaria of tandemly arranged large follicles extend from seminal receptacle posteriorly to end of body. Ootype just posterior to acetabulum, uterus very short, opening immediately posterior to acetabulum.

Eggs and Cercariae: Unknown.

Hosts: Primary: Numenius arquatus (Asiatic curlew)

Location: Portal vein.

Distribution: China.

Dutt and Srivastava (1961) erected a new genus, Sinobilharzia (nec. Le Roux, 1958) to include this single species. The genus was erected mainly on the basis of the vitellaria structure found in the species and the position of the caecal reunion in the female. In those species with the caecal union immediately posterior to the ovary the follicles are usually paired, whilst in those with the caecal union at the posterior end the follicles consist of two complete pairs, each pair arranged round one of the lateral caeca. In A. odhneri the follicles are very large, arranged in a single row and bear no relation to the caeca which unite half-way along their length. In all other members of the genus the caeca reunite immediately posterior to the ovary and the vitellaria are paired around the caecum. The writer feels that such a single follicular structure may be accounted for by the fusion of the paired follicles, typical of the genus, to form a single large follicle. In this case the erection of a new genus is not indicated. Similarly the position of the caecal union - always a variable character, at a distance posterior to the ovary does not warrant a generic rank. The writer agrees with Dutt et Srivastava in removing the species from the genus Ornithobilharzia, but on the grounds of the position of the testes, the short uterus and the shape of the ovary considers it to be a member of the genus Austrobilharzia.

AUSTROBILHARZIA PRICEI (Wetzel, 1930) Comb. Nov.

Fig....19.........

Synonyms: Ornithobilharzia pricei Wetzel, 1930

Specific diagnosis: Austrobilharzia.

Male: 5.3 to 6.2 mm. long by 0.6 to 0.625 mm. wide. Gynaecophoric canal extending from acetabulum to posterior end of body. Cuticle covered with small blunt spines. Oral sucker, 0.125 to 0.15 mm. in diameter, acetabulum 0.23 to 0.3 mm. posterior to oral sucker, 0.185 mm. in diameter. Oesophagus divides anterior to acetabulum, paired caeca reunite four-fifths the body length from anterior end. Testes 28, in two rows in second fifth of body, 0.45 mm. posterior to acetabulum with seminal vesicle mid-way between testes and acetabulum. Genital pore immediately posterior to acetabulum.

Female: Longer than male. 9 mm. long by 0.05 mm. wide, widening to 0.1 mm. at the ovary. Cuticle spined. Oral sucker poorly developed, acetabulum 0.5 mm. posterior to oral sucker 0.06 to 0.07 mm. in diameter. Oesophagus divides anterior to acetabulum and reunites immediately posterior to ovary. Ovary very elongate and coiled, 1.3 mm. in length occupying the second-fifth of body length. Oviduct from posterior end of ovary runs forward to ootype just posterior to acetabulum. Uterus very short, genital pore immediately posterior to acetabulum.

Eggs: Oval, with small terminal spine. 63 to 69μ by 48 to 51 micra.

Host: Primary: *Branta canadensis canadensis* (Canada goose).

Location: Portal veins.

Distribution: Virginia, U.S.A.

The species differs from other members of the genus in possessing a very long coiled ovary, a characteristic of the genus *Ornithobilharzia*. Nevertheless the writer feels that such characters as the short uterus, and the position and number of testes warrant inclusion in the genus *Austrobilharzia*.

AUSTROBILHARZIA PENNERI Short and Holliman, 1961

Fig.....21.........

Specific diagnosis: *Austrobilharzia*

Male: 1.34 to 2.9 mm. long. Oral sucker 0.12 to 0.177 mm. in diameter, acetabulum 0.12 to 0.224 mm. in diameter situated usually one-fifth to one-sixth the length of body from anterior end. Gynaecophoric canal begins posterior to acetabulum but some infolding of lateral walls in front of acetabulum. Oesophagus divides anterior to acetabulum, paired caeca reunite posterior to testes usually at the beginning of the posterior third of body. Common caecum with many diverticula and anastomoses. Testes 11 to 16, in irregular double row in middle third of body. Seminal vesicle enclosed within cirrus pouch which also contains prostate cells and ejaculatory duct.

Female: 1.876 to 3.062 mm. long by 0.2 mm. wide. Oral sucker 0.06 mm. in diameter, acetabulum 0.066 mm. in diameter, situated one-seventh to one-twentieth the distance of body from oral sucker. Cuticle smooth, spines present only on suckers. Oesophagus divides immediately anterior to acetabulum, paired caeca reunite posterior to ovary, common caecum without anastomoses. Ovary elongate, loosely spiral, 0.228 to 0.369 mm. long in anterior third of body. Oviduct from posterior end of ovary extends forward to ootype just posterior to acetabulum. Seminal receptacle near posterior end of ovary with Laurer's canal opening into oviduct a short distance anterior to seminal receptacle. Uterus very short, opening immediately posterior to acetabulum.

Eggs: Oval with terminal spine or knob approximately 10µ long. Immature eggs: average 69.8 by 60.9µ. Mature: 88.5 to 113.8 by 79 to 101.1µ (av.102.4 by 90.1µ).

Cercariae: Described by Holliman, (1961).

Hosts: Primary: Unknown, experimentally in Parakeets, chicks and pigeons.

Secondary: *Cerithidea scalariformis*

Location: Mesenteric veins

Distribution: Gulf coast, Florida, U.S.A.

AUSTROBILHARZIA LARI (McLeod, 1937) Penner, 1953b.

Fig.....22...........

Synonyms: *Ornithobilharzia lari* McLeod, 1937; *Microbilharzia lari* McLeod, 1940.

Specific diagnosis: *Austrobilharzia*

Male: 3.72 mm. long by 0.49 mm. maximum width, both measurements being the average of ten specimens. Gynaecophoric canal deep and very well formed extending from anterior to the acetabulum to the posterior extremity of body. Cuticle spiny. Oral sucker 0.18 by 0.135 mm. acetabulum 0.247 mm. in diameter, 0.44 mm. from the anterior end. Oesophagus opens into muscular bulb just anterior to acetabulum from which the lateral caeca arise, reuniting near posterior end of body. Testes 22 to 26, in two irregular rows in anterior half of body. Seminal vesicle in front of anterior testis, no cirrus pouch present. Genital pore immediately posterior to acetabulum.

Female: 2.76 mm. long by 0.18 mm. wide, average measurements. Worm filamentous and flattened. Oral sucker 0.06 by 0.05 mm. in size, acetabulum 0.247 mm.

from anterior end, 0.056 mm. in diameter. Caeca as male, reuniting just posterior to ovary. Ovary coiled in anterior part of body. Oviduct from posterior end of ovary to ootype just posterior to acetabulum. Seminal receptacle small just posterior to ovary, Laurer's canal not seen. Uterus very short containing single egg. Vitellaria of numerous indistinct transverse follicles.

Egg: Oval to spherical in shape without spine. 67 by 60µ.

Cercariae: Unknown.

Hosts: *Larus argentatus*, *Larus delawarensis* (McLeod, 1940); *Larus philadelphia*.

Location: Portal and Mesenteric veins.

Distribution: Nova Scotia and Manitoba, Canada.

Genus. ORNITHOBILHARZIA Odhner, 1912

Generic diagnosis: Schistosomatinae. Male with well developed gynaecophoric canal extending from posterior of acetabulum to posterior end of body. Suckers present. Oesophagus divides anterior to acetabulum and reunites at posterior part of body. Testes numerous (54 to 112) extending from immediately posterior of acetabulum to posterior part of body. Seminal vesicle present and in species adequately described a well developed or rudimentary cirrus. Female filamentous. Ventral sucker may be absent. Ovary elongate and spiral in anterior half of body. Ootype lying immediately in front of ovary with a long uterus. Genital pore immediately posterior to acetabulum. Seminal receptacle and Laurer's canal present in those species adequately described. Egg oval with or without rudimentary spine in those species described. Parasitic in birds.

Type species: Ornithobilharzia intermedia Odhner 1912.

Unfortunately this group contains many species which bear inadequate descriptions. Further only one of the life-cycles is known and this remains unpublished. For this reason the diagnosis of the group must remain in question.

KEY TO THE SPECIES OF ORNITHOBILHARZIA

1. Testes extending into posterior quarter of body..2

Testes extending only to region of equator ....O. canaliculata *

2. Female very long, 15 to 20 mm. and thin, 0.1 mm. Without acetabulum ....*O. filamenta*

Female shorter, with both suckers...*O. kowalewski* +

Footnotes: (*) Considered as identical to *O. aviani*

(+) Considered as identical to *O. intermedia*

ORNITHOBILHARZIA CANALICULATA (Rudolphi, 1819) Odhner, 1912

Fig.....23.........

Synonyms: *Distoma canaliculata* Rudolphi, 1819; *Bilharziella canaliculata*

Braun, 1902; *Ornithobilharzia aviani* McLeod, 1940

Diagnosis: *Ornithobilharzia*.

The parasite was originally described from *Sterna galericulata* of South America by Rudolphi, but since this description ~~of O. aviani by McLeod~~ is inadequate, and no other is available, the account below is taken from the description of *O. aviani* McLeod, 1940. The author considers these two parasites to be identical.

Male: 12 to 15 mm. in length by 0.83 mm. wide. Well developed gynaecophoric canal present, extending from acetabulum to posterior end of body. Cuticle smooth. Oral sucker 0.25 mm. in diameter, acetabulum 0.4 mm. in diameter situated 0.82 mm. from anterior end of body. Paired caeca reunited in posterior part of body. Testes 54 to 74 extending from just posterior of acetabulum to the equator or just beyond, but not into the posterior quarter of body. Genital pore immediately posterior to acetabulum.

Female: Shorter than male and filamentous, 7.2 mm. by 0.23 mm. Oral sucker 0.05 mm. in diameter, acetabulum 0.063 mm. in diameter, situated about 0.25 mm. from anterior end of the body. Body narrow anteriorly, gradually increasing in width to reach a maximum at the level of the ovary. Ovary spiral, commencing 1.0 mm. from the anterior end of the body, 0.78 mm. in length. Small seminal receptacle present posterior to the ovary with a Laurer's canal. Oviduct passes forward to ootype, 0.2 mm. anterior to ovary. Genital pore opens immediately posterior to acetabulum.

Egg: Unknown

Cercaria: Unknown.

Hosts: *Larus argentatus*.

Distribution: Manitoba, Canada.

Ornithobilharzia canaliculata is obviously very closely related to *O. aviani*. According to Penner (Person, comm.), the latter species is slightly smaller in size. Examination of material from Dr. Penner and comparison with the type material of *O. aviani* showed that the size range of both types overlapped, although it must be stated that the material of *O. canaliculata* examined was from experimentally infected pigeons. In all other respects the two types were identical; position and length of ovary, number of testes, etc. In addition both species occur in Gulls in the same vicinity and thus, although not proven conclusively, the writer prefers to regard the two as synonymous. The name

Ornithobilharzia aviani must therefore be suppressed in favour of O. canaliculata.

Penner, (1953a) discovered the cercaria of O. canaliculata from the marine snail Batillaria minima but has not as yet published an account of the cercaria or a redescription of the adult.

ORNITHOBILHARZIA FILAMENTA McLeod, 1940

Fig....24............

Diagnosis: Ornithobilharzia.

Male: 12 to 15 mm. long by 0.63 mm. wide. Gynaecophoric canal occupying region between acetabulum and posterior end of body. Cuticle smooth. Oral sucker 0.21 mm. in diameter, acetabulum 0.33 mm. in diameter situated 0.81 mm. from the anterior end of body. Oesophagus divides pre-acetabulums, may or may not reunite in posterior part of body. Testes 88 to 112 extending into posterior quarter of body.

Female: Long and filamentous, 15 to 20 mm. long by 0.1 mm. wide. Short anterior portion cylindrical, remainder of body broad. Oral sucker feeble, 0.016 mm. wide, no acetabulum. Cuticle spined. Ovary elongate lying in middle of anterior eighth of body, 0.61 mm. from anterior end. Genital pore short distance from anterior region of body.

Egg: Unknown.

Cercaria: Unknown.

Host: Primary: Larus argentatus and Larus delawarensis

Secondary: Unknown.

Location: Mesenteric veins.

Distribution: Manitoba, Canada.

ORNITHOBILHARZIA KOWALEWSKI (Parona et Ariola, 1896) Odhner, 1912

Synonyms: *Bilharzia kowalewski* Parona et Ariola, 1896; *Schistosoma kowalewski* Raillet, 1899; *Bilharziella kowalewski* Looss, 1899.

Diagnosis: *Ornithobilharzia*

Male: Up to 14 mm. long by 1.0 mm. wide. Oral sucker 0.364 mm. in diameter, acetabulum up to 0.56 mm. in diameter. Cuticle smooth. Oesophagus 0.75 mm. long reunites at posterior end of body. Testes numerous extending into posterior quarter of body.

Host: *Larus argentatus*

Distribution: Italy.

There appears to be no difference between the above description and that of *O. intermedia* Odhner, 1912.

ORNITHOBILHARZIA INTERMEDIA Odhner, 1912

Fig.....25.........

Male: 8 to 10.6 mm. long by 0.42 mm. wide. Oral sucker 0.2 to 0.25 mm. in diameter, acetabulum 0.3 to 0.35 mm. Testes 90 to 110 extending into posterior quarter of body. Seminal vesicle lying outside a rudimentary cirrus pouch.

Female: 4.5 to 5.75 mm. long by 0.17 to 0.22 mm. wide. Cuticle spiny. Oral sucker 0.04 to 0.05 mm. in diameter, acetabulum 0.025 to 0.035 mm. in diameter. Ovary spiral in anterior quarter of body.

Egg: 70 by 50 micra.

Hosts: Primary: *Larus fuscus* and *Larus argentatus*

Distribution: Sweden

With the data now available it is quite impossible to come to any final conclusion regarding the relationships between these two species and their relationship to *O. canaliculata* and *O. aviani* of the Americas. However since the number of testes in the former pair seem greater and occupy a larger part of the body they must be separated for the time being.

INCERTAE GENERIS

ORNITHOBILHARZIA sp. Gogate, 1934

Male: Two immature specimens. 9.5 mm. long by 0.488 mm. wide. Oral sucker 0.196 mm. in diameter, acetabulum 0.472 mm. in diameter. Paired caeca reunite 0.52 mm. from posterior end of body. Testes approximately 70. Rudimentary cirrus pouch. Gynaecophoric canal well developed.

Host: *Dendrocygna javanica*.

Distribution: Rangoon.

Although this species most likely belongs to the *Ornithobilharzia* the description is too inadequate to fully determine this.

ORNITHOBILHARZIA sp. Young 1937

Male: 3.9 mm. long by 0.34 mm. Oral sucker 0.139 mm. in diameter, acetabulum 0.178 mm. in diameter. Gynaecophoric canal extends from acetabulum to posterior end of body. Testes about 40 in irregular double row in middle third of body.

Female: Filiform. 0.80 to 1.0 mm. in diameter. Appeared to be slightly longer than male. Oral sucker 0.065 mm. in diameter, acetabulum 0.88 to 0.148 mm. in diameter. Genital pore a short distance posterior to acetabulum. Ovary in anterior third or two-fifths of body.

Host: *Limosa fedoa* (Marbled godwit)

Distribution: California, U.S.A.

From the description it is impossible to determine whether the species should be included among the *Ornithobilharzia* or *Austrobilharzia*, although from the position and number of testes it appears more likely to belong to the latter genus.

Genus MACROBILHARZIA Travassos 1923

Generic diagnosis: Schistosmatinae. Male with well developed gynaecophoric canal extending from posterior of acetabulum to posterior end of body. Suckers present. Male very long, up to 57 mm., female much smaller up to 7 mm. Testes very numerous over 200 in mature specimens, extending into posterior region of body. Ovary spiral, at or posterior to equator with very long uterus containing many eggs. Eggs oval. Cercariae unknown. Parasitic in birds.

Type species: *Macrobilharzia macrobilharzia* Travassos 1923

KEY TO SPECIES OF MACROBILHARZIA

1. Ovary in posterior third of body, uterus packed with eggs ....*M. macrobilharzia*

   Ovary in region of equator, uterus containing fewer eggs (i.e. 14) ....*M. baeri*

MACROBILHARZIA MACROBILHARZIA Travassos 1923

Figure......26.........

Synonyms: *Ornithobilharzia macrobilharzia* (male) Price, 1929. *Paraschistosomatium anhinga* Price 1929 (female)

Travassos (1923) described the male as *M. macrobilharzia*. Price (1929) placed this species in the genus *Ornithobilharzia* and at the same time erected the genus *Paraschistosomatium* for a female found in *Anhinga anhinga*. Later, (1931) he recognised this female as being that of *M. macrobilharzia* and suppressed the genus *Paraschistosomatium*, at the same time reerecting the genus *Macrobilharzia*.

Diagnosis: *Macrobilharzia*

Male: 40 to 57 mm. long by 3.5 mm. wide. Oral sucker 0.74 mm. in diameter, acetabulum 1.3 mm. in diameter. Oesophagus 1 mm. long paired caeca reuniting near posterior end of body. Testes 230 to 250 in two rows in anterior part of body.

Female: 6.9 mm. long by 0.325 mm. wide. Cuticle smooth except in the suckers. Suckers both 0.143 mm. in diameter, acetabulum situated 0.48 mm. posterior to oral sucker. Ovary spiral in posterior third of body, uterus long packed with eggs.

Eggs: In utero: 70 by 43 micra

Cercaria: Unknown

Hosts: *Anhinga anhinga*

Location: Portal veins

Distribution: South America and southern U.S.A.

MACROBILHARZIA BAERI (Fain, 1955a) Comb. nov.

Figure.....27.........

Synonyms: *Ornithobilharzia baeri* Fain 1955a.

Diagnosis: *Macrobilharzia*

Male: Length of body 7.3 mm. to 41 mm. with number of testes varying with the length of body; from a minimum of 138 in a specimen 8.3 mm. long, to 274 in the specimen 41 mm. in length. In the long specimens width of body in acetabular region varied from 1.4 to 2.0 mm. Cuticle smooth. Oral sucker 0.26 to 0.35mm. in diameter in small specimens, 0.43 to 0.56 mm. in those over 20 mm. in length. Acetabulum 0.55 to 0.9 in smaller specimens and 1.0 to 1.2 mm. wide in the larger, situated 1.1 to 2.25 mm. from the anterior end of the body. Well marked gynaecophoric canal with small muscles and some with scales and spines. Oesophagus 1.0 to 1.8 mm. long, paired caeca reuniting at posterior end of body. Testes extend into posterior quarter of body. Seminal vesicle behind acetabulum curved ventro-dorsally, opening into cirrus pouch which terminates in the ventrally situated genital pore. Prostate posterior to genital pore in the form of a tube 0.13 to 0.16 mm. long lying outside the cirrus.

Female: 2.582 to 3.55 mm. long with its diameter increasing regularly anterior to posterior reaching a maximum at the level of the ovary. Oral sucker 0.065 to 0.09 mm. by 0.055 to 0.073 mm., acetabulum 0.45 to 0.54 mm. from oral sucker, 0.07 to 0.09 mm. in diameter. Paired caeca reunite at posterior end of body. Ovary 0.3 to 0.56 mm. long situated in the region of the equator. Seminal receptacle posterior to the ovary, ootype a little anterior to the ovary. Uterus opens behind acetabulum containing up to 14 eggs.

Eggs: In utero: Oval with small subterminal spine. 75 to 85 by 40 to 45 micra.

Cercaria: Unknown

Host: Primary: *Phalacrocorax africanus* (Cormorant)

Location: Portal and mesenteric veins.

Distribution: Ruanda-Urundi. C. Africa.

Genus ORIENTOBILHARZIA Dutt et Srivastava, 1955

Generic diagnosis: Schistosomatinae. Male and female almost of equal length. Gynaecophoric canal extending from acetabulum to posterior extremity of body. Testes 37 to 80 beginning a short distance posterior to acetabulum with seminal vesicle. Cirrus pouch absent. Female filiform. Ovary oval or with posterior portion oval and anterior portion more slender and sometimes spirally twisted. Situated in anterior or middle third of body. Ootype in front of ovary, uterus long. Seminal receptacle and Laurer's canal absent. Parasitic in mammals.

Cercariae: Apharyngeal, brevifurcate, without eyespots, with 5 pairs of penetration glands and a flame cell formula of $2(2 + (1 + 1))$.

Type species: Orientobilharzia dattai Dutt et Srivastava, 1952

KEY TO SPECIES OF ORIENTOBILHARZIA

1. Ovum with terminal spine at one end and leaf-like appendage at the other.....Orientobilharzia turkestanicum.
   Ovum oval with terminal spine..................2.

2. Ovary in anterior third of body. Body of male tuberculate ....Orientobilharzia bomfordi
   Ovary in posterior half of body. Body of male non-tuberculate ....Orientobilharzia dattai

ORIENTOBILHARZIA DATTAI (Dutt et Srivastava, 1952) Dutt et Srivastava, 1955

Figure.....28..........

Synonyms: Ornithobilharzia dattai Dutt et Srivastava, 1952

Specific diagnosis: Orientobilharzia.

Male: 3.042 to 7.6 mm. long by 0.114 to 0.243 mm. maximum width. Oral sucker 0.114 to 0.234 mm. in diameter, acetabulum 0.3 to 0.66 mm. posterior to oral sucker, 0.135 to 0.243 mm. in diameter. Cuticle spiny but without tubercles. Oesophagus divides anterior to acetabulum, caeca reunite in posterior quarter of worm. Testes 37 to 66 in single row. Seminal vesicle a little in front of testes.

Female: 3.9 to 7.5 mm. long by 0.067 to 0.1 mm. wide. Cuticle spiny especially at the suckers. Oral sucker 0.043 to 0.073 mm. in diameter, acetabulum 0.027 to 0.037 mm. in diameter. Ovary in posterior half of body just anterior to caecal union, oval in shape with slightly coiled anterior portion, 0.2 to 0.266 mm. in length. Oviduct from posterior end of ovary, turns forward to unite with vitelline duct immediately in front of ovary, with ootype just anterior to the union. Genital pore immediately posterior to acetabulum.

Egg: Asymmetrical oval with bent terminal spine. Uterine eggs: 73 to 110μ by 23 to 40μ. Spine 7 to 17μ long. Voided eggs: 120 to 137μ by 43μ.

Cercariae: Described by Dutt and Srivastava, (1952).

Hosts: Primary. Experimental. Guinea pigs. Natural: Buffalo (*Bos bubalus*) Cattle (*Bos indicus*)
Secondary: *Lymnaea luteola*.

Location: Portal and mesenteric veins.

Locality: India.

ORIENTOBILHARZIA BOMFORDI (Montgomery, 1906)
Dutt et Srivastava 1955

Synonyms: *Schistosoma bomfordi* Montgomery, 1906; *Ornithobilharzia bomfordi* Price, 1929. *Eurobilharzia bomfordi* Le Roux, 1958

Specific diagnosis: *Orientobilharzia*

Male: 7.089 mm. long by 0.357 mm. wide at anterior end, 0.4 mm. wide at position of testes and 0.17 mm. wide at the posterior end. Gynaecophoric canal extending from acetabulum to posterior end of body. Cuticle tuberculate and spiny. Oral sucker 0.306 mm. in diameter, acetabulum 0.85 mm. posterior to oral sucker, 0.34 mm. in diameter. Testes 61, total chain of testes 3.06 mm. long, extending into posterior half of body. Seminal vesicle in front of testes, cirrus pouch absent.

Female: 7.31 mm. long by 0.172 mm. wide at ovary. Cuticle smooth except for spines in suckers and at the posterior end of body. Oral sucker 0.046 mm. in diameter, acetabulum 0.042 mm. in diameter. Oesophagus divides anterior to acetabulum and reunites immediately posterior to ovary. Ovary oval, 0.3 mm. long, in anterior third of body. Uterus 1.4 mm. long opening immediately posterior to acetabulum.

Egg: Oval with terminal spine. Immature: 100 to 115µ by 44 to 48µ with spine 8 to 10µ long. Mature: 125 to 136µ by 53 to 60µ with spine 6 to 8µ long.

Cercariae: Unknown

Hosts: Primary. *Bos indicus*.

Location: Mesenteric veins.

Distribution: India.

ORIENTOBILHARZIA TURKESTANICUM (Skrjabin, 1913)

Dutt et Srivastava 1955

Synonyms: *Schistosoma turkestanicum* Skrjabin, 1913;

Ornithobilharzia turkestanicum Price, 1929.

Specific diagnosis: *Orientobilharzia*.

Male: 4.2 to 8 mm. long by 0.34 to 0.47 mm. wide. Cuticle without tubercles. Oral sucker 0.25 by 0.15 mm. in size, acetabulum 0.425 mm. posterior to oral sucker, 0.28 by 0.27 mm. in size. Oesophagus with two dilations divides anterior to acetabulum and reunites in posterior quarter of body. Transverse commissures sometimes present. Testes 70 to 80, extending into posterior part of body. Genital pore immediately posterior to acetabulum.

Female: 3.4 to 5.5 mm. long by 0.1 mm. wide. Suckers 0.072 mm. in diameter, acetabulum 0.17 mm. posterior to oral sucker. Oesophagus divides anterior to acetabulum reunites immediately posterior to ovary. Ovary a broad spiral 0.255 mm. long in region of equator. Uterus long containing one egg.

Egg: Oval with terminal spine at one end and leaf-like appendage at the other. 72 to 74μ by 22 to 26μ. Spine 8μ long.

Cercaria: Life-cycle and incomplete description of cercaria by MacHattie (1936). Cercaria stated to have only 4 pairs of penetration glands.

Hosts: Primary: *Bos taurus* (Skrjabin) *Felis domestica* (Popov, 1926) Sheep, goats, water buffalo, horse, donkey, camels, (MacHattie, 1936)
Secondary: *Lymnaea tenera euphratica* (MacHattie, 1936)

Location: Portal veins

Distribution: Turkestan, U.S.S.R. (Skrjabin); Aral sea, U.S.S.R. (Papov); Iraq (MacHattie); China (Kuo,1946); Mongolia and Manchuria.

Marotel (1908) reported the occurence of a parasite which he termed *Schistosoma bomfordi* in France. The species described has an egg measuring 80 to 100μ long by 30 to 35μ wide with a spine at each pole. For this reason Price, 1929, held it to be synonymous with *O. turkestanicum*. Bhalerao (1932) referred to the species from France as *Orientobilharzia turkestanicum* var *tuberculata*.

Genus HETEROBILHARZIA Price, 1929

Generic diagnosis: Schistosomatinae. Preacetabular portion of male short, subcylindrical; posterior part with edges inrolled to form a deep gynaecophoric canal. Suckers present. Intestinal caeca reunite near posterior end or do not reunite. Testes numerous, up to 83 in number in posterior third of body. Cirrus pouch present, containing the seminal vesicle just posterior to the acetabulum. Genital pore immediately posterior to acetabulum. Female slender, both suckers present. Ovary with four loops in anterior half of body with seminal receptacle and Laurer's canal. Ootype immediately anterior to ovary, uterus long with many eggs opening immediately posterior to acetabulum. Intestinal caeca as male with post-ovarial portion of caeca bearing many lateral diverticula. Egg oval without spine. Parasitic in mammals. Cercaria furcocercous, apharyngeal, with eye spots and furcal fin-folds. Five pairs of penetration glands and a flame cell formula of 2((3) +(2 + 1)).

Type species: H. americana Price, 1929

HETEROBILHARZIA AMERICANA Price, 1929

Figure.....29.........

Diagnosis: Heterobilharzia.

Male: 10 to 14 mm. long by 3 mm. wide. Cuticle covered with small tubercles. Oral sucker subterminal 0.35 mm. in diameter, acetabulum pedunculate 0.426 to 0.453 mm. in diameter situated about 0.57 mm. posterior to oral sucker. Oesophagus surrounded by glands with paired caeca usually reuniting at posterior end of body.

Seminal vesicle enclosed within cirrus pouch about 0.57 mm. posterior to acetabulum Genital pore immediately anterior to seminal vesicle.

Female: Slender, 9 mm. long by 0.58 mm. wide. Cuticle spined. Oral sucker subterminal 0.05 mm. in diameter, acetabulum 0.5 mm. from anterior end 0.09 mm. in diameter. Oesophagus divides at level of acetabulum and reunites near posterior end of body, caeca posterior to ovary bearing many lateral diverticula. Ovary with four loops anterior to the equator, oviduct from posterior end of ovary opens into seminal receptacle and turns forward giving off Laurer's canal. Opens into ootype in front of ovary receiving vitelline duct posterior to ootype. Mehlis gland present. Uterus opens immediately posterior to acetabulum, and contains many eggs. Vitellaria consisting of many small follicles.

Eggs: Oval without spine. 78 by 50μ (Price); 87 (74-113) by 70 (60-80)μ (Lee, 1962). In utero 65(58 to 76) by 46(39 to 53) Lee.

Cercariae: Described by Lee (1962)

Hosts: Primary: *Procyon lotor*, *Lynx rufus floridanus*, *Myocastor coypus*, Dog, rabbit (*Sylvilagus aquaticus*)

Secondary: *Lymnaea cubensis* and experimentally in *Pseudosuccinea columella*. (Lee, 1962)

Location: Hepatic portal veins.

<u>Distribution</u>: Florida (Price), Texas (Price), North Carolina (Miller et Harkema 1960), Louisiana (Malek et al, 1961), U.S.A.

Sub-family: GIGANTOBILHARZIINAE.. (Mehra, 1940)
Amended

Sub-family diagnosis: Schistosomatidae. Male and female similar, threadlike or flattened. Oral sucker absent or present, ventral sucker always absent. Gynaecophoric canal absent or small, not extending to posterior end of body. Testes numerous extending along either side of the common caecum posterior to genital pore. Seminal vesicle elongate, anterior to genital pore with posterior part enclosed within cirrus pouch leading to genital pore. Ovary elongate in threadlike forms, spiral in flattened forms, in anterior half of body. Seminal receptacle present, elongate, posterior to ovary; ootype anterior to ovary with long uterus which may be filled with a large number of eggs. Uterus opens at the anterior end of body. Parasitic in birds.
Type genus: Gigantobilharzia

KEY TO GENERA OF GIGANTOBILHARZIINAE

1. Body threadlike. Gynaecophoric canal present. Oral sucker present or absent. Uterus elongate with few if any eggs present.......Gigantobilharzia.

   Body flattened without suckers or gynaecophoric canal. Uterus packed with eggs...Dendritobilharzia

Genus GIGANTOBILHARZIA Odhner, 1910

Generic diagnosis: Gigantobilharziinae. Both sexes threadlike without ventral sucker, with or without oral sucker. Gynaecophoric canal present and short. Testes numerous, situated on either side of the common caecum posterior to gynaecophoric canal. Seminal vesicle elongate, anterior to gynaecophoric canal, cirrus pouch enclosing posterior part of seminal vesicle together with prostate and ejaculatory duct. Genital pore at anterior end of gynaecophoric canal. Ovary elongate and coiled in anterior part of body. Seminal receptacle long, posterior to ovary, with Laurer's canal. Eggs oval with or without terminal spine.

Cercariae: Apharyngeal, brevifurcate with eye spots and furcal fin-folds.

Type species: *Gigantobilharzia acotylea* Odhner, 1910

KEY TO SPECIES OF GIGANTOBILHARZIA

1. Oral sucker present in both sexes.................2
   Oral sucker absent...............................3

2. Distance of gynaecophoric canal to anterior end almost twice the length of canal. Eggs oval without spine..............................*G. gyrauli*
   Distance of gynaecophoric canal to anterior end almost the same as the length of canal. Eggs with small terminal spine..............*G. tantali*

3. Testes less than 100.............................4
   Testes over 100..................................5

4. Cuticle striated. Length of worm approximately 5 mm. with gynaecophoric canal approximately 1 mm. from anterior end.....................*G. huttoni*
   Cuticle smooth. Length of worm approximately 15 mm. with gynaecophoric canal approximately 3.5 mm. from anterior end of worm.........*G. nettapi*

5. Testes well over 300 in number...................6
   Testes approximately 300 or under................8

6. Worm of very large size up to 165 mm. long. Gynaecophoric canal a groove like depression less than 1 mm. in length very near anterior end of worm ....*G. acotylea*
   Worm much shorter up to 35 mm. in length. Gynaecophoric canal well marked with transverse supporting bands...7

7. Gynaecophoric canal less than 1 mm. in length with five transverse bands. Seminal vesicle approximately 1.5 mm. from anterior end of worm, internal seminal vesicle much longer than external ....*G. ardeola*

Gynaecophoric canal as long as 2.5 mm. (in length) with up to 50 transverse bands. Seminal vesicle 0.5 mm. from anterior end with internal and external parts of approximately the same length ....*G. lawayi*

8. Testes less than 200. Gynaecophoric canal short, approximately 0.2 mm. long with no transverse bands..........................*G. plectropteri*
Testes number approximately 300. Well formed gynaecophoric canal over 1 mm. in length.......9

9. Body approximately 20 mm. in length with gynaecophoric canal bearing 14-15 transverse bands ....*G. adami*
Body approximately 10 mm. in length with well developed gynaecophoric canal without transverse bands.............................*G. huronensis*

The above key is based on the male worms only since only a very few female worms are known. The descriptions of *G. sturniae* and *G. monocotylea* are too inadequate to be included in any key.

GIGANTOBILHARZIA ACOTYLEA Odhner, 1910

Figure......30...........

Diagnosis: *Gigantobilharzia*

Male: 140 to 165 mm. in length by 0.25 to 0.35 mm. wide in expanded specimens. When preserved the length is approximately half of the above. Gynaecophoric canal a groove like depression situated 0.5 mm. from the anterior end of body 0.55 to 0.7 mm. in length. Suckers absent. Oesophagus 0.18 mm. long with paired caeca short, reuniting at anterior end of gynaecophoric canal. Testes numerous along common caecum. Seminal vesicle spiral, lying between the paired caeca, cirrus pouch containing the ejaculatory duct, prostate and part of the seminal vesicle. Genital pore opening at anterior end of canal.

Female: 30 to 35 mm. long by 0.1 to 0.12 mm. wide.

Oesophagus 0.7 to 0.9 mm. in length, paired caeca reuniting about 2 to 3 mm. posterior to the anterior end of worm. Ovary spiral anterior to caecal reunion, with large seminal receptacle posterior to ovary. Oviduct united with vitelline duct a short distance in front of ovary. Uterus with one egg opening at anterior end of body. Vitellaria of unpaired rounded follicles.

Egg: Oval, 100μ long.

Cercariae: Unknown.

Hosts: Larus fuscus (Lesser Black-backed gull), Larus ridibundis (Black-headed gull), ~~Larus melanocephalus~~, Larus minutus (Little gull)

Location: Intestinal veins.

Distribution: Sweden and England.

GIGANTOBILHARZIA ADAMI Fain, 1960

Figure.....31.........

Diagnosis: Gigantobilharzia

Male: 21 mm. in length by 0.1 mm. wide at the anterior end of body, 0.125 to 0.15 mm. at the level of gynaecophoric canal and 0.09 to 0.14 mm. posterior to canal. Suckers absent. Cuticle smooth. Gynaecophoric canal 1.4 to 1.5 mm. in length, anterior part reinforced by 14 to 15 transverse bands. Oesophagus 0.7 mm. in length with paired caeca usually reuniting immediately anterior to the seminal vesicle. Testes 280. External seminal vesicle 0.42 mm. long, internal seminal vesicle 0.5 mm. long. Genital pore at anterior end of the gynaecophoric canal.

Female: Unknown.

Cercariae: Unknown

Host: *Nettapus auritus* (Pygmy goose)

Location: Mesenteric veins.

Distribution: Ruanda-Urundi, Africa.

GIGANTOBILHARZIA ARDEOLAE Fain, 1955b

Figure....32...........

Diagnosis: *Gigantobilharzia*

Male: 35 mm. long by 0.15 to 0.16 mm. wide before staining. Cuticle without spines. Suckers absent. Gynaecophoric canal 0.8 to 0.9 mm. long with five transverse reinforcing bands. Oesophagus 1.2 mm. long with paired caeca reuniting in region of internal seminal vesicle. External seminal vesicle 0.35 mm. long commencing approximately 1.7 mm. from the anterior end. Internal seminal vesicle much larger 1.66 mm. in length. Genital pore on spined papilla opening at anterior end of gynaecophoric canal. Testes more than 700 commencing immediately posterior to gynaecophoric canal.

Female and Cercariae: Unknown

Host: *Ardeola idae* (Ruff backed heron)

Location: Superior vena cava.

Distribution: Madagascar.

GIGANTOBILHARZIA GYRAULI (Brackett, 1940)
Brackett, 1942

Figure 37 and Fig. VII & VIII

Diagnosis: *Gigantobilharzia*.

Extremely filamentous worms found embedded in the small veins encircling the intestine. As they are virtually impossible to remove the description of the worm is based upon the study of fragments. Both sexes are of equal length, Brackett states them to be about 10 mm, although the observations of the writer points to this being a rather conservative figure. Body width uniform about 0.045 to 0.05 mm. with a well developed oral sucker about 0.03 mm. in length.

Male: Gynaecophoric canal 0.8 mm long situated 1.38 mm from the anterior end. Seminal vesicle in front of gynaecophoric canal, commences 0.28 mm. from anterior end of the body, 0.26 mm. in length. Testes very numerous extending from posterior of gynaecophoric canal to posterior end of the body.

Female: Ovary coiled, situated 1.4 mm. fron anterior end of the body, 0.45 mm. in length. Seminal receptacle at posterior end of ovary 0.15 mm. in length. Oviduct from posterior end of ovary receives branch from seminal receptacle, and proceeds forward to ootype about 0.3 mm. in front of ovary. Oesophagus 0.54 mm. long, reunites immediately posterior to the seminal receptacle. Genital pore opens immediately posterior to the oral sucker.

The above description differs from that of Brackett in the position of the oviduct which was stated to leave the posterior end of the seminal receptacle. The writer was able to examine various fragments found in local blackbirds to correct the original description.

Eggs: Round without spines. 60 micra in diameter

(Brackett) 63.9 by 62.5 (Farley).

Cercariae: *C. gyrauli* Brackett, 1940

Hosts: Primary: *Agelaius phoeniceus* (Red-winged blackbird) *Xanthrocephalus xanthrocephalus* (Yellow-headed blackbird) also *Molothrus ater* (Cowbird) and Purple grackle (*Quiscalus quiscula*)

Secondary: Naturally in *Gyraulus parvus*, experimentally in *Physa sp*.

Location: Small veins of intestine.

Distribution: Wisconsin, U.S.A. and Manitoba, Canada.

This is an extremely common parasite, very widely spread throughout Wisconsin and Manitoba, and no doubt in all parts of North America where the red-winged and yellow-headed blackbirds occur. Although the description could be greatly improved, its position within the host, its size and dark appearance render it unmistakable.

GIGANTOBILHARZIA HURONENSIS Najim, 1950

Figure....35.......

Diagnosis: *Gigantobilharzia*

Male: 9.6 mm. long by 0.05 mm. wide at anterior end, and 0.04 mm. posterior to canal. Gynaecophoric canal 1.084 mm. in length, muscular and well formed. Cuticle smooth, suckers absent. Oesophagus 0.48 mm. long with paired caeca of variable length. Seminal vesicle commences 0.6 mm. from anterior end of worm, 0.75 mm. long with thin walled anterior part and thick walled posterior part. Prostate cells well developed 0.17 mm. in length surrounded by cirrus pouch. Ejaculatory duct well developed, genital pore at anterior end of gynaecophoric canal. Testes about 300 in number extending posteriorly from the gynaecophoric canal.

Female: Length varies from 16 to 29 mm. by 0.05 mm. wide at anterior end, 0.07 mm. at level of ovary and 0.05 mm. at the posterior region of body. Oesophagus 0.55 mm. long, with paired caeca reuniting at posterior end of seminal receptacle. Ovary spiral, 1.23 mm. from the anterior end, 0.43 mm. long. Oviduct from posterior end of ovary into seminal receptacle 0.13 mm. long. Oviduct turns forward to give off Laurer's canal, which opens on dorsal surface, and then travels anterior to ootype, 0.1 mm. anterior to ovary with Mehlis gland posterior to ootype. Uterus containing up to seven eggs opens at anterior end.

Egg: Oval 93 (83 to 105) by 88 (82.5 to 90) micra.

Cercariae: *Cercaria huronesis* Najim, 1956.

Hosts: Primary: *Spinus tristis* (Goldfinch) and *Richmondena cardinalis* (Cardinal) experimentally in chicks and canaries.
Secondary: *Physa gyrina*

Location: Intestinal veins

Distribution: Michigan, U.S.A.

GIGANTOBILHARZIA HUTTONI (Leigh, 1953) Leigh, 1955

Figure.....34.........

Diagnosis: *Gigantobilharzia*

Male: 4.72 mm. in length by 0.02 mm. wide anterior to gynaecophoric canal and 0.04 mm. wide post to canal. Gynaecophoric canal 0.96 to 1.12 mm. from anterior end of body, 0.235 to 0.33 mm. long. Oesophagus bifurcates a little anterior to seminal vesicle, paired caeca reunite in posterior third of gynaecophoric canal. Testes 60, beginning 0.2 mm. posterior to gynaecophoric canal. Seminal vesicle spiral, commencing 0.4 to 0.6 mm. from anterior end of body. Cirrus sac not seen. Genital pore at anterior end of canal. Suckers absent.

Female: 5.26 to 7.22 mm. in length by 0.03 to 0.04 mm. wide at level of ovary. Oesophagus bifurcates anterior to ootype, 0.27 to 0.38 mm. long, paired caeca reuniting immediately posterior to seminal receptacle. Ovary 0.23 to 0.38 mm. long, commencing 0.49 to 0.65 mm. from anterior end of body. Oviduct opens into spiral seminal receptacle posterior to ovary. Oviduct turns forward and opens into ootype 0.09 to 0.17 mm. anterior to ovary. Uterus opens at anterior end of body.

Egg: In faeces: oval, 90 to 99 by 61 to 67µ. Without fully developed spine but occasionally with rudimentary terminal spine.

Cercariae: *Cercaria J.* (Hutton, 1952) Leigh, 1953 reported as only having 3 pairs of penetration glands and 5 pairs of flame cells.

Host: Primary: Experimentally in parakeet
Secondary: *Haminoea antillarum*

Location: Intestinal veins.

Distribution: Florida, U.S.A.

GIGANTOBILHARZIA LAWAYI Brackett, 1942

See Part I pages 37-47.

GIGANTOBILHARZIA NETTAPI Fain, 1960

Figure.....35.........

Diagnosis: Gigantobilharzia

Male: 15 mm. in length by 0.138 mm. wide in the anterior part, 0.21 mm. wide at the level of the gynaecophoric canal and 0.15 to 0.2 mm. wide posterior to the canal. Cuticle smooth. Suckers absent. Gynaecophoric canal 3.7 mm. from the anterior end of body, 1.25 mm. in length with five transverse bands commencing 0.6 mm. posterior to the genital papilla. Anterior 0.1 mm. of canal covered in small spines. Oesophagus 0.725 mm. long with paired caeca 1.9 mm. in length. Testes 57. Seminal vesicle anterior to gynaecophoric canal, the external portion 0.36 mm. long and the internal seminal vesicle 0.735 mm. in length with the posterior 0.285 mm. surrounded by prostate cells. Genital pore on papilla at the beginning of the gynaecophoric canal.

Female and Cercaria: Unknown

Host: Nettapus auritus (Pygmy goose)

Location: Intestinal veins.

Distribution: Ruandi-Urundi

Description based on the examination of ~~two females and~~ three males. All specimens a little macerated.

GIGANTOBILHARZIA TANTALI Fain, 1955c.

Figure.....39.........

Diagnosis: Gigantobilharzia

Male: Length based on numerous fragments up to 18.5 mm.

unstained. Width of anterior part 0.07 to 0.09 mm., at the gynaecophoric canal 0.1 to 0.13 mm. gradually decreasing to 0.08 mm. at the posterior end of canal and 0.05 to 0.075 mm. posterior to canal. Oral sucker present, 0.04 mm. in diameter. Cuticle spineless but with fine striations. Gynaecophoric canal 2.1 to 2.5 mm. long, anterior end distinct but posterior end tapers away gradually. It commences 1.9 to 2.3 mm. posterior to anterior end of body. Internal face of canal covered in rows of spines and 28 transverse supporting bands are present. Oesophagus 0.575 to 0.675 mm. long, paired caeca reunite in region of external seminal vesicle. Testes 196, gradually increasing in size posteriorly. External seminal vesicle commences approximately 1 mm. from anterior end of worm, 0.3 to 0.5 mm. in length, internal seminal vesicle 0.6 to 0.75 mm. long. Genital pore opening on heavily spined papilla at anterior end of gynaecophoric canal.

<u>Female</u>: No complete worm obtained. Oral sucker 0.04 to 0.047 mm. by 0.028 to 0.035 mm. Oesophagus 0.75 mm. in length, paired caeca reuniting in region of seminal receptacle. Ovary spiral, 0.475 to 0.65 mm. long, situated 1.4 to 1.6 mm. from anterior end of body. Oviduct from posterior end of ovary opens into seminal receptacle and gives off a Laurer's canal in this region. Seminal receptacle 0.23 to 0.28 mm. long. Ootype 0.1 to 0.375 mm. anterior to ovary, Mehlis gland poorly developed. Uterus opens immediately posterior to oral sucker.

Eggs: In utero: oval 70 by 40 to 45µ with small terminal spine. In host tissues: 75 by 48µ.

Cercariae: Unknown

Location: Intestinal veins

Host: *Tantale ibis*

Distribution: Ruanda-Urundi

Species of incomplete description:

GIGANTOBILHARZIA STURNIAE Tanabe, 1948

Tanabe, 1948 briefly described a new species of furcocercous cercariae in *Segmentina nitidella* which he named *Cercariae segmentinae*. This name was subsequently discovered to be identical to the name proposed by Faust 1926, for a separate species and thus it became necessary to rename it *Cercariae sturniae*. Subsequent work showed it to be the larval stage of a *Gigantobilharzia* sp. which was long and threadlike, with an anteriorly placed genital pore and without an acetabulum.

C. sturniae is the causative agent of Kogan Bye (Lake-side disease) in Lake Shinji, Japan. The adult worms were located in the veins of *Corvus corone* and *Sturnia philippensis*.

GIGANTOBILHARZIA MONOCOTYLEA Szidat, 1930

Figure.....38..........

Male: Length of longest fragment found 7 mm. Oral sucker 0.02 mm. in diameter. Oesophagus 0.3 mm. long. Gynaecophoric canal not seen.

Female: At least 20 mm. in length. Elongate uterus and seminal receptacle. Uterus containing many eggs.
Eggs: Similar to *S. japonicum*, elliptical with a small spine at the posterior end. 130 by 100 micra.
Host: *Larus ridibundis*, (Black-headed gull) *Anas boschas*.

INCERTAE GENORIS

Gigantobilharzia egreta. Lal, 1937.
Male: 38.85 mm. long by 0.275 mm. wide at a maximum. Suckers absent. No gynaecophoric canal. Paired caeca short. Testes 600, lie either side of common caecum. Seminal vesicle lying between caecal branches, genital pore situated 0.175 mm. anterior to caecal reunion.

In all respects except the lack of a gynaecophoric canal this species resembles the *Gigantobilharzia*. Despite the lack of the canal however the body plan and shape are not such to place within the *Dendritobilharzia*.

If Lal was correct in his interpretation of this species then a new genus must be erected to house it. However it seems more likely that he was mistaken and that a small canal does exist, thus retaining the parasite amongst the *Gigantobilharzia*.

Genus DENDRITOBILHARZIA Skrjabin et Zakharrow, 1920.

Considered as separate sub-family Dendritobilharziinae by Mehra (1940)

Generic diagnosis: Gigantobilharziinae. Body of both sexes elongate, flattened and similar. Suckers absent, gynaecophoric canal absent. Paired caeca short common caecum long, zig-zag with lateral diverticula. Genital opening of male just anterior to the caecal union. Testes numerous alongside common caecum. Ovary spiral intercaecal in position. Seminal receptacle present, no Laurer's canal. Uterus long, opening at anterior end of body, coiled with many eggs. Parasitic in birds. Cercariae unknown.

Type species: Dendritobilharzia pulverulenta (Braun, 1901) Skjabin, 1924.

KEY TO SPECIES OF DENDRITOBILHARZIA

A satisfactory key to this group at the moment is impossible, since only one of the four species has been adequately described.

The descriptions as they stand are given below.

DENDRITOBILHARZIA ANATINARUM Cheatum, 1941

Figure....41............

Diagnosis: Dendritobilharzia

Male: 6.2 mm. long by 0.6 to 0.75 mm. wide. Oesophagus 0.427 mm. long, caeca reunite 1.08 mm. from the bifurcation. Testes 120 to 130, extending from caecal union to posterior end of body. Seminal vesicle elongate, between intestinal caeca. Genital pore dextral, 1.2 mm. from anterior end of body. Cirrus well developed.

Female: Body flat and elongate. 8.0 mm. in length by 0.89 to 1.01 mm. wide. Oesophagus 0.621 mm. long, paired caeca reunite 1.55 mm. posterior to bifurcation. Common caecum zig-zag with lateral diverticula. Ovary 0.525 mm. long, spiral with seminal receptacle immediately posterior to ovary 0.078 mm. long. Uterus looped opening near anterior end. Ootype at level of anterior part of ovary.

Eggs: Numerous in uterus, when deposited spherical spindle shaped 0.06 to 0.065 mm. in diameter. Spineless.

Cercaria: Unknown

Host: *Anas platyrhynchos*, (Mallard) *Anas ruripes*, (Black duck), *Aythya valisineria* (Canvasback).

Distribution: New York, U.S.A.

Description based on the examination of five males and two females.

DENDRITOBILHARZIA ASIATICUS. Mehra 1940

Figure.......42..........

Diagnosis: Dendritobilharzia

Male: Unknown

Female: Body elongate and flattened. 6 mm. long by 1.3 mm. wide. Cuticle spineless without tubercles. Suckers absent. Oesophagus 0.5 mm. long with paired caeca uniting 1.2 mm. posterior to bifurcation. Common caecum zig-zag with short diverticula. Ovary intercaecal, 1.05 mm. from anterior end, 2.8 mm. in length. Seminal receptacle oval, immediately posterior to ovary. Shell gland 0.52 mm. posterior to bifurcation, uterus with four large convolutions filling entire intercaecal space and passing forward to genital pore at anterior end of body.

Egg: Thick shelled, nearly oval with spine. 27 to 33µ long with spine 15 to 18µ long.

Cercariae: Unknown

Host: *Nettion crecca crecca* (Common teal)

Location: Anterior mesenteric vein

Distribution: India.

Description based on the examination of one specimen only.

DENDRITOBILHARZIA LOOSSI Skrjabin, 1924

Diagnosis: *Dendritobilharzia*.

Male: Unknown

Female: 14.2 mm. long by 1.41 mm. wide. No suckers. Oesophagus 0.45 mm. long, caeca reuniting 3.47 mm. posterior to bifurcation. Common caecum zig-zag with lateral diverticula. Spiral tubular ovary.

Host: *Plecanus onocrotalus* (Rosy pelican)

Distribution: U.S.S.R.

DENDRITOBILHARZIA PULVERULENTA (Braun, 1901) Skrjabin 1924

Synonyms: *Bilharziella pulverulenta* Braun, 1901;

Dendritobilharzia _ochneri_ Skrjabin et Zakharrow, 1920.

Diagnosis: _Dendritobilharzia_

Male: 8 to 8,3 mm. long by 1 to 1.5 mm. wide. Cuticle spineless without tubercles. Suckers absent. Paired caeca reunite about 1 mm. posterior to bifurcation. Testes 110 along each side of the common caecum which is long and zig-zag and provided with lateral caeca. Seminal vesicle long and spiral in anterior sixth of body between paired caeca. Genital pore situated 1.35 mm. posterior to anterior end of worm.

Female: 6.31 mm. long by 0.62 mm. wide. Body flattened without suckers. Cuticle covered with a layer of very fine spines. Gut as male, paired caeca reuniting 1.80 mm. posterior to anterior end of worm. Ovary lies between paired caeca closely resembling the position of the seminal vesicle of the male. Genital pore 0.24 mm. from the anterior end of the body.

Hosts: _Anas_ _quequedulae_ (Garganey), _Anas_ _platyrhynchus_ (Mallard)

Location: Mesenteric blood vessels.

Distribution: Africa, Europe and U.S.S.R.

Sub-family: BILHARZIELLINAE Price 1929

Diagnosis: Schistosomatidae: Male and female similar, threadlike or flattened. Oral and ventral suckers present. Gynaecophoric canal absent or small, not extending to posterior end of body. Testes numerous, extending along either side of the common caecum posterior to the genital pore or gynaecophoric canal. Seminal vesicle elongate in anterior part of the body with posterior end enclosed in cirrus pouch leading to the genital pore. Ovary very elongate in threadlike forms, compact in flattened species, in anterior half of body. Seminal receptacle present and elongate posterior to the ovary. Ootype anterior to ovary with uterus opening immediately posterior to the acetabulum. Parasitic in birds.

Type genus: Bilharziella. Looss, 1899.

KEY TO THE GENERA OF BILHARZIELLINAE

1. Body of both sexes flattened. Gynaecophoric canal absent.....Bilharziella.
   Body of both sexes threadlike. Gynaecophoric canal present. ....Trichobilharzia.

Genus TRICHOBILHARZIA Skrjabin et Zakharrow, 1920

Synonyms: Pseudobilharziella, Ejsmont, 1929.

Diagnosis: Bilharziellinae. Both sexes threadlike. Posterior end of body spatulate. Gynaecophoric canal short, testes occupying space posterior to canal on either side of the common caecum. Both suckers present in both sexes. Seminal vesicle elongate between gynaecophoric canal and acetabulum. Cirrus and prostate small. Genital pore at anterior end of gynaecophoric canal. Ovary elongate and coiled in anterior part of body. Seminal receptacle well formed immediately posterior to ovary. Laurer's canal present in those species adequately described. Genital pore immediately posterior to acetabulum. Eggs produced singly. Cercariae with 5 pairs penetration glands, eye spots and flame cell formula of 2 ((3) + (3 + 1)).

<u>Type species</u>: <u>T</u>. <u>ocellata</u> (LaValette, 1855) Brumpt 1931b. Syn <u>T</u>. <u>kossarewi</u> Skrjabin et Zakharrow, 1920.

<u>KEY TO THE SPECIES OF TRICHOBILHARZIA</u>

1. Parasitic in the nasal fossa....................2

   Parasitic in the veins of the alimentary canal...4

2. Body armed with heavy spines.........<u>T</u>. <u>spinulata</u>

   Body smooth or with small spines................3

3. Gynaecophoric canal over 0.30 mm. in length, external and internal seminal vesicles of approximately equal length. Ovary 0.60 mm. long. Eggs fusiform. ....<u>T</u>. <u>nasciola</u>

   Gynaecophoric canal less than 0.30 mm. in length. External seminal vesicle approximately twice the length of internal. Ovary less than 0.5 mm. long. Eggs 'nacelle-like'..................<u>T</u>. <u>sureliani</u> (1)*

4. Body extremely long and filamentous, up to 50 mm. Gynaecophoric canal very short in relation, less than 0.1 mm., testes over 500...........<u>T</u>. <u>brantae</u>.

   Body less than 15 mm. long with less than 250 testes...5

5. Gynaecophoric canal over 1.0 mm. in length........6

   Gynaecophoric canal less than 1.0 mm. in length...7

6. Worm of medium length (8.0 mm.) and narrow. Acetabulum 0.3 to 0.4 mm. posterior to oral sucker. Gynaecophoric canal 1.3 to 1.5 mm. long. Testes up to 150..........................<u>T</u>. <u>anatina</u>.

   Worm longer and wider (up to 12 mm. by 0.38 mm.). Acetabulum over 1.0 mm. posterior to oral sucker. Gynaecophoric canal smaller. Testes up to 180 ....<u>T</u>. <u>corvi</u>

*See footnote.

7. Adult worms long and wide, approximately 12 mm. by 0.2 mm. in testicular region..................8

Adult worms shorter and narrower, approximately 8 mm. by less than 0.1 mm. in region of testes....9

8. Gynaecophoric canal 2 mm. from anterior end of body, seminal vesicle occupying half the zone between acetabulum and canal..........*T. cerylei*

Gynaecophoric canal less than 2 mm. from anterior part of body, seminal vesicle occupying all available space between acetabulum and canal ....*T. filiformis*.

9. Gynaecophoric canal between 0.5 and 1.0 mm. in length..............................*T. schoutedeni* (2)

Gynaecophoric canal less than 0.5 mm. in length...10

10. Gynaecophoric canal at least 0.75 mm. posterior to acetabulum......................*T. stagnicola* (3)

Gynaecophoric canal at a maximum of 0.40 mm. posterior to acetabulum..............................11

11. Gynaecophoric canal more than 0.2 mm. in length...12

Gynaecophoric canal less than 0.2 mm. in length...15

12. Testes in the region of 200..........*T. querquedulae*

Testes number approximately 100 or less...........13

13. Ovary not more than 2 times the length of the seminal receptacle..................................14

Ovary approximately 4 times the length of seminal receptacle..........................*T. cameroni* (4)

14. Suckers small, approximately 28 and 20 micra in diameter for the oral and ventral suckers respectively. Gynaecophoric canal less than 0.3 mm. in length. Ovary situated almost 1 mm. from the anterior end of body, over 0.3 mm. long....*T. szidati*

Suckers much larger, approximately 40 to 50 micra in diameter. Gynaecophoric canal over 0.3 mm. long. Ovary situated approximately 0.5 mm. from anterior end of body, less than 0.3 mm. long...*T. oregonensis* (5)

15. Gynaecophoric canal very short, less than 0.1 mm. long.......................................*T. elvae*

Gynaecophoric canal between 0.1 and 0.19 mm. in length..............................*T. physellae* (6)

Footnotes:

1. *T. rodhaini* cannot be keyed, no appreciable difference between it and *T. aureliani*. See note on page. .251. . .

2. No appreciable difference between it and *T. kowalewski*

3. Gynaecophoric canal not actually seen, its position deduced from fragments.

4. Considered as synonymous to *T. waubesensis* (Brackett). Most likely also synonymous with *T. oregonensis*.

5. No distinguishing characters between it and *T. berghei*

6. Considered as synonymous to *T. burnetti*, *T. horiconensis* and *T. kegonsensis*.

TRICHOBILHARZIA ADAMSI Edwards and Jansch, 1955

Figure.....43.........

Diagnosis: *Trichobilharzia*.

Male: Unknown

Female: (Immature) 3.61 mm. long by 0.105 mm. wide at anterior end, 0.093 mm. wide posteriorly. Acetabulum 0.064 by 0.026 mm. in size, oral sucker 0.036 by 0.039 mm. Acetabulum 0.111 mm. posterior to oral sucker. Coarse spines over anterior part of body, posterior end spatulate. Oesophagus divides 0.026 mm. anterior to acetabulum, reunites posterior to ovary. Ovary convoluted 0.286 mm. posterior to oral sucker.

Egg: Unknown.

Cercaria: *C. adamsi* Edwards et Jansch 1955

Host: Secondary: *Physa* c.f. *coniformes*.

Primary: Experimentally in domestic ducklings.

Location: Liver

Distribution: B.C. Canada.

The dimensions and morphology of *C. adamsi* agree in **all** respects to that of *C. dermolestes* McLeod, 1940.

TABLE II. Comparison of *C. adamsi* and *C. dermolestes*.

	C. adamsi	C. dermolestes
Length of body	230.1 ± 6.9*	226
Width of body	80.2 ± 1.4	70
Length of head organ		68
Length of tail	341.3 ± 2.3	340
Width of tail prox	43.8 ± 0.8	42
dist	37.1 ± 2.0	
Length of furca	200.7 ± 5.4	210
Acetabulum to posterior end	96.6 ± 5.9	94
Acetabulum diameter	37.2 ± 0.6	24
Oral sucker diameter	51.5 ± 0.7	

*Standard Error.

Although the host of these two cercariae differ (*Stagnicola palustris* for *C. dermolestes*) they must be tentatively regarded as synonymous. If such is the case the specific name must be suppressed in favour of *T. dermolestes*).

TRICHOBILHARZIA ANATINA Fain, 1955d.

Figure....45.......

Diagnosis: *Trichobilharzia*.

Male: 7.05 and 8.0 mm. long, by 0.9 to 0.1 mm. wide at acetabulum, 0.122 to 0.13 mm. at anterior end of gynaecophoric canal, and 0.08 to 0.09 mm. at posterior end of canal. Posterior to canal a uniform diameter of 0.065 to 0.075 mm. Posterior end of body spatulate. Cuticle finely spined. Oral sucker 0.035 to 0.042 mm.

by 0.035 mm. wide. Acetabulum 0.31 to 0.39 mm. posterior to oral sucker, larger than oral sucker. Gynaecophoric canal 1.3 to 1.5 mm. long, 0.75 to 0.9 mm. from anterior end of body. Internal face spined heavily. Oesophagus divides anterior to acetabulum and paired caeca reunite 0.075 to 0.11 mm. posterior to acetabulum anterior to seminal vesicle. Testes 110 to 149 extending from just posterior of gynaecophoric canal to near posterior end of body. External seminal vesicle very short, 0.09 to 0.11 mm. in length, internal seminal vesicle 0.185 to 0.25 mm. long with cirrus pouch containing prostate cells extending over the posterior 0.035 mm. to seminal vesicle with ejaculatory duct opening on small papilla at anterior end of canal.

Female: Unknown

Eggs and Cercaria: Unknown.

Host: Primary: *Anas undulata undulata* (South African Yellow-billed duck)

Location: Portal veins.

Distribution: Ruanda-Urundi

Description based on the examination of only two complete specimens. The specimens were found together with *T. berghei*, however the differences between the two seem sufficient to regard them as distinct species. In particular the gynaecophoric canal of the above is much larger and the number of testes greater than in *T. berghei*. On the other hand *T. berghei* may well be the immature form of the above species.

TRICHOBILHARZIA AURELIANI Fain, 1956

Figure....55........

Diagnosis: Trichobilharzia.

Male: 17 mm. in length by 0.05 to 0.075 mm. wide at acetabulum, 0.06 to 0.065 mm. wide at the seminal vesicle, 0.07 to 0.075 mm. wide at the gynaecophoric canal and 0.03 to 0.06 mm. wide posterior to canal. Posterior end of body spatulate. Cuticle with very minute spines. Oral sucker 0.04 to 0.036 mm. wide. acetabulum 0.366 to 0.5 mm. posterior to oral sucker, 0.039 to 0.041 mm. in diameter. Gynaecophoric canal 0.75 to 1.0 mm. posterior to oral sucker, 0.23 to 0.275 mm. in length. Inner face covered with dense small spines. Oesophagus divides just anterior to acetabulum, point of reunion not observed. External seminal vesicle 0.13 to 0.15 mm. long, commencing 0.04 to 0.055 mm. posterior to acetabulum. Internal seminal vesicle nearly twice as long, 0.25 to 0.3 mm. in length. Genital pore on small papilla at anterior end of gynaecophoric canal. Testes 125 commencing just posterior to canal.

Female: Only fragments seen. Body width 0.06 to 0.075 mm. at acetabulum, 0.055 to 0.075 at the ovary and 0.05 to 0.06 mm. behind the seminal receptacle. Cuticle as male. Acetabulum 0.035 to 0.04 mm. in diameter, situated 0.3 to 0.41 mm. from oral sucker. Ovary spiral, 0.368 to 0.46 mm. in length, 0.7 to 1.0 mm. from anterior end. Oviduct from posterior end of ovary receives branch from seminal receptacle 0.1 to 0.15 mm. in length. Oviduct then turns forward giving off Laurer's canal and enters vitelline duct and ootype 0.15 to 0.3 mm. in front of ovary.

Eggs: Spindle-shaped and 'nacelle' like, with small terminal spine.

Intrauterine:	150 to 180 by 30 to 35 micra.
Immature in mucus:	175 to 220 by 32 to 40
Mature eggs:	250 to 280 by 50 to 65

Cercariae: Unknown

Host: Primary. Podiceps cristatus (African great crested grebe), Policcephalus ruficolles capensis (African little grebe).

Location: Veins of the nasal fossa.

Distribution: Ruanda-Urundi. C. Africa.

For comparison with other nasal forms, refer to page..251....

TRICHOBILHARZIA BERGHEI Fain, 1955d.

Figure....47.........

Diagnosis: Trichobilharzia.

Male: 4.4 to 5.8 mm. in length by 0.1 to 0.125 mm. wide at the gynaecophoric canal, 0.08 to 0.1 at the acetabulum and 0.06 mm. posterior to acetabulum. Posterior end dilated. Cuticle with fine spines. Oral sucker 0.04 by 0.05 mm., in size, acetabulum 0.04 mm. diameter situated 0.35 to 0.45 mm. posterior to oral sucker. Gynaecophoric canal 0.75 to 0.9 mm. from anterior end of body, 0.28 to 0.375 mm. in length. Inside surface heavily spined. Oesophagus divides anterior to acetabulum, reunites a little anterior to genital pore. Testes 40 to 65. External seminal vesicle 0.12 to 0.18 mm. long, internal 0.15 to 0.2 mm. in length. Genital pore at anterior end of gynaecophoric canal.

Female, eggs and cercaria: Unknown.

Host: *Anas undulata undulata*

Location: Hepatic portal veins.

Distribution: Ruanda-Urundi C. Africa.

This species closely resembles *T. oregonensis*. For comparison refer to page 238...It was also found together with *T. anatina* (Page 215.) and may well be an immature form of the latter species.

TRICHOBILHARZIA BRANTAE Farr et Blankemeyer, 1956

Figure......44..........

Diagnosis: *Trichobilharzia*.

Male: Two complete specimens measured 33.5 and 42.28 mm. in length, and up to 0.18 mm. wide at the level of the gynaecophoric canal. Cuticle spiny, posterior end of body spatulate. Oral sucker up to 0.075 mm. in diameter, acetabulum 0.38 to 0.6 mm. posterior to oral sucker, 0.074 to 0.098 mm. in diameter. Oesophagus surrounded by glands, divides anterior to acetabulum and paired caeca reunite at various levels from the anterior fifth of body to the posterior end of seminal vesicle. Gynaecophoric canal, 0.9 to 1 mm. posterior to oral sucker, only 0.92 mm. in length. Anterior portion of canal non-muscular, whilst posterior portion bears muscles and spines. Genital pore lies near anterior border of muscular section. Seminal vesicle commences 0.194 mm. posterior to the acetabulum, 0.425

mm. in length, opens into posterior region 0.22 mm. long surrounded by prostate cells and enclosed in a cirrus pouch. Testes very numerous, from 585 up to 1,490. Vas deferens passing forward opens into third loop of seminal vesicle.

Female: 41 to 50 mm. in length by 0.12 to 0.22 mm. wide. Oral sucker 0.062 by 0.055 mm. in size, acetabulum 0.08 mm. in diameter. Ovary convoluted 1.47 mm. long by 0.022 to 0.044 mm. wide, beginning 1.31 mm. posterior to acetabulum. Seminal receptacle a little posterior to ovary, 0.223 mm. in length. Oviduct gives off Laurer's canal anterior to seminal receptacle and then proceeds forward to the ootype. Uterus very short, ootype lying very close to the acetabulum.

Egg: Elongate ovoid in shape with small recurved spine at the broad end.
In ootype: 25 to 35 by 52 to 61
In veins: 72 to 145 by 44-89 micra.

Cercariae: Unknown

Host: Primary: *Branta canadensis* (Canada goose).

Location: Renal, iliac veins and mesenteric veins.

Distribution: Eastern coastal States of U.S.A.

TRICHOBILHARZIA BURNETTI (Brackett, 1942) McMullen et Beaver, 1945

Synonym: *Pseudobilharzia burnetti* Brackett, 1942

Male: Body length unknown. Uniform diameter of 0.048 mm. Cuticle striated, non spined. Oral sucker 0.032 by 0.036 mm. in size. Acetabulum, 0.216 mm. from anterior end, 0.040 mm. in diameter, Gynaecophoric canal 0.144 mm. in length, 0.45 mm. from anterior end of body. Number of testes not known. Seminal vesicle short, only occupying half the distance between acetabulum and gynaecophoric canal.

Female, eggs and cercaria: Unknown.

Host: Aythya collaris (Ring-necked duck)

Location: Cloacal veins.

Distribution: Wisconsin.

The writer considers this species to be identical to T. physellae (Talbot, 1936) McMullen et Beaver, 1945. The only difference in the descriptions lies in the position of the seminal vesicle, in T. physellae occupying the whole distance between acetabulum and gynaecophoric canal. Such a characteristic however is very variable, being dependent to a great deal on the method of fixing, state of animal when fixed and maturity of the animal. For comparison see page. 248..

TRICHOBILHARZIA CAMERONI Liang-Yu Wu, 1953

Figure.....48.........

Diagnosis: Trichobilharzia.

Male: 3.18 to 5.71 mm. long. Body slender with smooth cuticle and posterior end spatulate. Oral sucker 0.031 to 0.040 mm. by 0.038 to 0.047 mm. in size. Acetabulum larger, 0.226 to 0.370 mm. posterior to oral sucker. Gynaecophoric canal 0.212 to 0.345 mm. in length, situated 0.456 to 0.906 mm. posterior to oral sucker. Inner surface thickly set with spines. Testes oval, 80 to 110. Vas deferens opens into anterior part of seminal vesicle which extends from immediately posterior of acetabulum to the gynaecophoric canal. It opens into a well developed prostate gland which opens in turn by way of the ejaculatory duct into a cirrus. The cirrus opening lies on the genital papilla on the anterior end of the gynaecophoric canal.

Female: 3.82 to .494 mm. long by 0.052 to 0.059 mm. wide. Oral sucker 0.025 to 0.034 by 0.032 to 0.040 mm. in size. Acetabulum 0.213 to 0.342 mm. posterior to oral sucker, approximately equal in size. Ovary stout and spiral, 0.287 to 0.358 mm. long, situated 0.39 to 0.59 mm. posterior to oral sucker. Oviduct from posterior end of ovary opens into seminal receptacle, 0.072 to 0.125 mm. long with Laurer's canal present. Oviduct turns anteriorly and receives vitelline duct just anterior to the ovary. Vitellaria follicles usually in groups of two or three on either side of common caecum.

Egg: Spindle-shaped. Mature: 147 to 212 by 57 to 63 micra.

Cercariae: *C. cameroni* Wu, 1953.

Host: Primary: Experimentally in ducks and canaries.

Secondary: *Physa gyrina*.

Location: Lungs, kidneys, livers and mesenteric blood vessels.

Distribution: Ontario, Canada.

In the description of the species by Wu a comparison is made with *T. physellae* and *T. querquedulae* from which it clearly differs both in body and cercarial dimensions. Wu, however, fails to mention T. waubesensis Brackett, 1942 which it closely resembles. The only difference between the two is found in the female, the ovary being rather more posteriorly situated and the seminal receptacle rather smaller in T. waubesensis. These differences are so slight however, that the author considers, at least tentatively, that the two are synonymous and that T. cameroni should therefore be suppressed in favour of T. waubesensis. For comparison see Table III. p. 225

T. cameroni also closely resembles T. oregonensis. For comparison see table VI. p. 241

The description of T. waubesensis is given below.

TRICHOBILHARZIA WAUBESENSIS (Brackett, 1942) McMullen et Beaver, 1945

Figure...49.........

Synonym: Pseudobilharzia waubesensis Brackett, 1942

Male: Up to 5.62 mm. long by 0.047 to 0.062 mm. wide at acetabulum. Acetabulum situated 0.275 mm. from anterior end, 0.040 mm. in diameter. Cuticle striated. Gynaecophoric canal 0.252 to 0.306 mm. long, 0.54 mm. from anterior end. Testes approximately 100. Seminal vesicle extending from just posterior to acetabulum to the gynaecophoric canal. Genital pore at anterior end of gynaecophoric canal.

Female: Similar in size to male. Acetabulum 0.306 mm. from anterior end. Ovary not coiled, 0.325 mm. in length and 0.684 mm. from the anterior end. Seminal receptacle 0.05 mm. long. Oviduct leads into ootype midway between ovary and acetabulum.

Egg, Cercaria: Unknown.

Host: *Aythya collaris* (Ring-necked duck), *Mareca americana* (Baldplate)

Location: Intestinal and cloacal veins.

Distribution: Wisconsin, U.S.A.

One point in the description of this species needs clarification: Brackett describes the uterus as proceeding past the acetabulum although the position of the genital pore was not observed. It seems almost certain that he was mistaken, as such a structure would necessitate the removal of this species from the sub-family *Bilharziellinae*.

TRICHOBILHARZIA CERYLEI Fain, 1956

Figure....46.......

Diagnosis: *Trichobilharzia*.

Male: Only incomplete specimens observed. Largest piece 6 mm. long. 0.25 to 0.275 mm. wide between acetabulum and canal, 0.2 to 0.25 mm. wide posterior to canal. Cuticle covered in small spines. Oral sucker 0.11 mm. in diameter, acetabulum 0.815 mm. posterior to oral sucker, 0.15 mm. in diameter. Gynaceophoric canal 0.55 mm. long, situated 2 mm. from anterior end of body. Inner face covered in small spines. Oesophagus divides anterior to acetabulum, paired caeca reunite 1/4 distance between acetabulum and gynaecophoric canal. Testes over 70, very large, 0.06 to 0.15 mm. in diameter. Seminal vesicle only occupying posterior half of zone between acetabulum and canal. External

TABLE III.

Comparison of *T. cameroni* and *T. waubesensis*

(All measurements in mm.)

	T. cameroni	*T. waubesensis*
Male:		
Length of body	3.18 - 5.71	5.62
Oral to Acetabulum	0.226 - 0.37	0.275
Oral to G. Canal	0.456 - 0.906	0.54
Length G. Canal	0.212 - 0.345	0.252 - 0.306
Testes	80 - 110	100
Female:		
Length of body	3.82 - 4.94	As male
Oral to Acetabulum	1.213 - 0.342	0.306
Oral to Ovary	0.39 - 0.59	0.684
Length ovary	0.287 - 0.358	0.325
Length Sem. Rec.	0.072 - 0.125	0.05

seminal vesicle 0.25 mm. long, internal 0.175 mm. long. Genital pore on small papilla at anterior end of canal.

Female: 10 mm. long in the only complete specimen. 0.19 mm. wide at ootype, 0.2 to 0.23 mm. wide at ovary and 0.175 to 0.2 mm. posterior to ovary. Oral sucker 0.1 mm. in diameter, acetabulum 0.105 mm. in diameter situated 0.5 mm. posterior to oral sucker. Ovary 1.525 mm. posterior to oral sucker, 0.65 mm. long. Oviduct from posterior end of ovary gives off Laurer's canal and receives branch from seminal receptacle, 0.2 mm. long, before turning forward to ootype 0.45 mm. posterior to acetabulum.

Eggs: In gut: Irregularly oval, one side more convex than the other. 95 to 110 by 46 to 51 micra with short subterminal spine.

Cercariae: Unknown.

Host: Primary: *Ceryle rudis* (Pied kingfisher)

Location: Hepatic portal veins.

Distribution: Ruanda-Urundi C. Africa.

TRICHOBILHARZIA CORVI (Yamaguti 1941)
McMullen et Beaver 1945

Figure.....50.........

Synonyms: *Pseudobilharzia corvi* Yamaguti, 1941.
Ornithobilharzia emberizae (female)
(Yamaguti, 1941) Ito, 1960

Diagnosis: *Trichobilharzia*.

Male: Two complete specimens, 12 and 9.4 mm. in length by 0.32 to 0.38 mm. at the gynaecophoric canal. Cuticle unarmed except at the gynaecophoric canal. Oral sucker

0.15 mm. in diameter, acetabulum 0.18 mm. in diameter, 1.1 to 1.2 mm. posterior to the oral sucker. Oesophagus divides anterior to acetabulum, paired caeca reunite 0.32 to 0.38 mm. posterior to acetabulum. Testes 110 to 180 in two or three rows. Seminal vesicle commences immediately posterior to caecal reunion, posterior part enclosed in cirrus pouch with a short prostate and ejaculatory duct. Gynaecophoric canal 1.23 to 1.33 mm. long.

Host: *Corvus corone corone*. (Carrion crow)

The above is taken from the original description of the species. At the same time Yamaguti described a female from *Emberiza sulphurata* which he named *Ornithobilharzia emberizae*. The description being as follows:

ORNITHOBILHARZIA EMBERIZAE

Filiform 4.5 to 6.5 mm. long by 0.11 to 0.125 mm. at the ovary. Cuticle spined. Oral sucker 0.042 mm. in diameter, acetabulum 0.27 to 0.37 mm. posterior to the anterior end of body, 0.063 mm. in diameter. Oesophagus divides anterior to acetabulum, reunites posterior to seminal receptacle at the junction of anterior and middle third of body. Ovary long, tubular and spiral, 0.38 to 0.45 mm. in length in posterior part of anterior third of body. Oviduct from posterior end of ovary receives branch from seminal receptacle where a Laurer's canal is given off, turns forward to join with vitelline duct 0.36 to 0.7 mm. posterior to acetabulum.

Seminal receptacle 0.09 to 0.105 mm. long. Uterus opens immediately posterior to the acetabulum.

Host: *Emberiza sulphurata*.

Ito, (1960) discovered male and female worms from *Corvus crone corone* and *Corvus coronoides hondoensis*. The males were found to be identical to *T. corvi* and the females to *O. emberizae*. Thus the name *O. emberizae* must be suppressed being synonymous to the female of *T. corvi*.

TRICHOBILHARZIA FILIFORMIS. (Szidat, 1938) McMullen et Beaver 1945

Figure.....51.........

Synonym: *Pseudobilharzia filiformis* Szidat, 1938

Diagnosis: *Trichobilharzia*.

Male: Description from fragments, from which it appeared that the body length was at least 11 to 12 mm. Width in region of testes 0.12 to 0.15 mm. Cuticle smooth except for suckers and gynaecophoric canal. Oral sucker 0.075 by 0.05 mm. in size. Oesophagus 0.03 mm. long, paired caeca reunite behind seminal vesicle. Acetabulum 0.075 mm. in diameter, situated 0.65 mm. from anterior end of worm. Seminal vesicle between paired caeca, enters cirrus and terminates in ejaculatory duct which is shown in the illustration as about 1/3rd the length of the seminal vesicle. Gynaecophoric canal deep with muscle bands and spines.

Female: Delicate and fragile. No description given.

Egg: Mature. 75 to 80 by 43 to 55 micra. Typical

TABLE IV.

Comparison of *O. emberizae* and of *T. corvi* females.

	O. emberizae Yamaguti	*T. corvi* Ito
Length of body	4.5 to 6.5 mm.	4.8 to 10.1 mm.
Width of body	0.11 to 0.125	0.12 to 0.21
Oral sucker diameter	0.042 to 0.054 by 0.042 to 0.048	0.08 to 0.116 by 0.064 to 0.109
Acetabulum diameter	0.063	0.088 to 0.129
A. distance from oral sucker	0.27 to 0.37	0.408 to 0.496
A. distance from caecal reunion	1.15 to 1.18	1.523 to 1.999
Ovary length	0.38 to 0.45	0.408 to 0.598
Seminal receptacle length	0.09 to 0.105	0.15 to 0.286
Uterus length	0.36 to 0.7	0.481 to 0.707
Egg in utero		81 to 96 by 26 to 44 micra.
Mature egg		115 by 63 micra.

'egg' shape with slightly bent spine at broad end.

Host: Cygnus olor (Mute swan)

Location: Blood vessels of gut.

Distribution: Germany.

The position of this species must remain in question since the description was based on specimens in a bad state of decay.

TRICHOBILHARZIA KOWALEWSKI (Ejsmont, 1929) McMullen et Beaver 1945

Synonyms: Immature Bilharziella polonica Kowalowski, 1896; Immature Dendritobilharzia. pulverulenta Odhner, 1912; Pseudobilharzia Kowalewski Ejsmont, 1929.

Diagnosis: Trichobilharzia.

Male: Up to 5.5 mm. in length, by 0.16 mm. wide at seminal vesicle, 0.18 mm. at the gynaecophoric canal and diminishing to a constant width of 0.1 mm. throughout the length of the testes. Oral sucker 0.045 mm. in diameter, acetabulum up to 0.5 mm. posterior to oral sucker, 0.064 mm. in diameter. Genital pore situated 0.54 mm. from the ventral sucker and thus presumably the gynaecophoric canal begins about 1 mm. posterior to oral sucker. Testes numerous, over 100 in the illustration, commencing 0.78 mm. posterior to sex opening. Seminal vesicle commences just posterior to acetabulum.

Female: Unknown.

Host: Anas crecca (Common teal)

Location: Blood vessels of gut.

Distribution: Poland.

On the above data comparison with other forms is impossible. Nevertheless it appears to closely resemble *T. shoutedeni*, Fain and *T. anatina* Fain.

TRICHOBILHARZIA NASCIOLA Fain, 1955d.

Figure.....56.........

Diagnosis: *Trichobilharzia*.

Male: Longest specimen seen, incomplete at posterior end, 19 mm. long. Two complete males measured 17 and 18.5 mm. respectively. Body 0.05 to 0.07 mm. wide at acetabulum, 0.1 to 0.12 mm. wide at gynaecophoric canal and 0.04 to 0.06 mm. wide posterior to canal. Posterior end of body spatulate. Cuticle smooth or with very minute spines. Oral sucker 0.038 to 0.046 mm. by 0.03 to 0.038 mm. in size, acetabulum 0.38 to 0.475 mm. posterior to anterior end of body, 0.04 to 0.047 by 0.035 to 0.041 mm. in size. Oesophagus bifurcates anterior to acetabulum, paired caeca reunite in region of seminal vesicle, actual position variable. Testes 170 to 200. External seminal vesicle 0.2 to 0.25 mm. long, internal seminal vesicle 0.25 to 0.34 mm. in length. Gynaecophoric canal 0.3 to 0.35 mm. long.

Female: Filiform and narrower than male, one complete specimen 15 mm. long by 0.04 to 0.053 mm. wide at acetabulum, 0.04 to 0.07 mm. at ovary and 0.035 to 0.05 mm. posterior to ovary. Cuticle as male. Oral sucker 0.04 by 0.036 mm. in diameter, acetabulum 0.42 to 0.52 mm. posterior to anterior end of body, 0.03

to 0.038 mm. in diameter. Oesophagus bifurcates anterior to acetabulum, paired caeca reunite immediately posterior to seminal receptacle. Ovary 0.625 to 0.65 mm. long, situated 1.2 mm. from anterior end of body, spiral. Oviduct from posterior end of ovary receives branch from seminal receptacle, 0.14 to 0.15 mm. long, gives off Laurer's canal and proceeds forward to ootype 0.15 to 0.2 mm. posterior to acetabulum. Uterus opens immediately posterior to acetabulum.

Eggs: Fusiform with small terminal spine. 280 to 330 by 50 to 70 micra. Two immature eggs measured 200 and 230µ long respectively.

Cercaria: Unknown.

Host: *Anas undulata undulata* (South African yellow-billed duck)

Location: Veins of nasal fossa.

Distribution: Ruandi-Urundi C. Africa

This species seems to differ sufficiently from *T. aureliani* to warrant its maintenance as a distinct species. However for a more detailed comparison with this and *T. rodhaini* refer to page 251..

TRICHOBILHARZIA OCELLATA

Brumpt (1931b) obtained adults of *T. kossarewi* Skrjabin et Zakharrow, 1920 by infecting the domestic duck with *C. ocellata* described by La Valette St. George in 1855. On grounds of priority the name became *T. ocellata*.

Szidat (1942) showed that the cercariae in

Europe which authors had referred to as *C. ocellata* were in fact members of different species. For this reason the term 'ocellata' should only be used as a general term to denote the cercariae of the sub-family *Bilharziellinae*. Table V shows the dimensions of the ocellata group. Szidat considered the cercaria used by Brumpt to be *C. neocellata*, since ducks infected with this cercariae produced eggs similar to those described by Brumpt.

Without a knowledge of the life-cycles of this group the problems cannot be resolved, the only conclusion being that the name *T. ocellata* should be suppressed in favour of *T. elvae* for the North American species described by McMullen and *T. kossarewi* for the European species described by Brumpt.

TABLE V.

DIMENSIONS OF THE OCELLATA GROUP OF CERCARIAE.

* Standard Error

	C.ADAMSI	C.CAMERONI	C.DERMOLESTES	C.ANCILLARIAE	C.ELVAE
Length body.	230 ± 6.9*	319 ± 4.7	226	254 ± 1.3	307 + 2.1
Width body	80 ± 1.4	57 ± 0.7	70	43 ± 0.6	67 + 1.4
Length Hd.Og.	-	108 ± 2.0	68	-	97 + 0.8
Width Hd. org.	-	38 ± 6.9	-	-	42 + 0.7
Length tail	341 ± 2.3	369 ± 4.4	340	285 ± 1.9	400 + 2.4
Width tail	44 ± 0.8	38 ± 0.3	42	28 ± 0.4	45 + 0.9
Length furca	201 ± 5.4	225 ± 2.1	210	178 ± 1.7	254 + 2.4
Width furca	-	23 ± 0.3	-	20 ± 0.3	23 + 0.8
Vent.suck. to post. end.	97 ± 5.9	90 ± 2.2	94	71 ± 0.8	108 + 1.5
Author	Edwards et al (1955	Wu (1953)	McLeod (1940)	Farley	Talbot (1936)
Location.	B. C. Canada	Ontario, Canada	Manitoba, Canada	Manitoba, Canada	North America
Host.	Physa coniformis	Physa gyrina	Stagnicola palustris.	Physa ancillaria	Lymnaea stagnalis

	C.LONGICAUDA	C.NEOCELLIATA	C.OREGONENSIS	C.PAROCELLATA	C.PAROCELLATA
Length body	322 ± 22	270	315	340	282
Width body	50 ± 9	55	69	70	54
Length Hd org.	-	85	97	90	89
Width Hd.org.	-	40	48	50	-
Length tail	484 ± 38	360 - 390	426	400 - 440	362
Width tail	-	36	47	40	-
Length furca	253 ± 9	230	222	240	250
Width furca	-	20	-	25	-
V.S. to Post.	-	100	83	125	-
Author	MacFarlane(1944)	Szidat (1942)	MacFarlane et al (1946)	Szidat, (1942)	Johnston et al (1939)
Location.	New Zealand	Europe	U.S.A.	Europe	Australia
Host	Myxas ampulla etc	Stagnicola palustris.	P. ampullacea	Lymnaea ovata	Lymnaea lessoni

TABLE V (cont'd)

	C. PHYSELLAE	C.PSEUDOCELLATA	C.QUERQUEDULAE	C.STAGNICOLA	C.SZIDAT
Length body.	265 ± 1.8	370	262 ± 6.6	260 ± 2.7	306
Width body	60 ± 1.0	80	40 ± 1.8	60 ± 1.2	72
Length Hd org.	95 ± 1.1	110	-	82 ± 1.0	92
Width Hd org.	39 ± 0.4	60	-	39 ± 0.5	55
Length tail	374 ± 2.2	580	334 ± 5.1	395 ± 1.5	431
Width tail	40 ± 0.8	50	33 ± 0.7	40 ± 0.8	44
Length furca.	196 ± 1.7	310	204 ± 3.5	219 ± 4.1	247
Width furca.	32 ± 0.2	28	22 ± 0.3	25 ± 0.5	24
V.S. to post.	80 ± 1.1	170	77 ± 1.6	59 ± 1.1	116
Author	Talbot(1936)	Szidat et al(1934)	Farley	Talbot (1936)	Neuhaus (1952)
Location.	N. America	Europe	N. America	N. America	Europe
Host.	*P.parkeri*. etc.	*Stagnicola palustris*	*Physa gyrina*	*Stagnicola emarginata*	*Lymnaea stagnalis* etc.

<u>TRICHOBILHARZIA</u> <u>ELVAE</u> (Miller, 1923)
McMullen et Beaver, 1945.

<u>Synonyms:</u> <u>Trichobilharzia</u> <u>ocellata</u> McMullen et Beaver

<u>Diagnosis:</u> <u>Trichobilharzia</u>.

<u>Male</u>: Over 5 mm. in length. Oral sucker 0.02 to 0.03 by 0.02 mm. in size. Acetabulum situated 0.32 to 0.4 mm. from anterior end of body. Oesophagus divides anterior to acetabulum and reunites just anterior to the seminal vesicle. Gynaecophoric canal 0.06 to 0.1 mm. in length, situated 0.3 to 0.36 mm. posterior to the acetabulum. Seminal vesicle anterior to the canal, 0.2 mm. in length. Testes numerous.

<u>Female:</u> 2.7 mm. long. Oral sucker 0.2 by 0.2 mm. in size with acetabulum situated 0.32 to 0.37 mm. posterior to the oral sucker. Oesophagus divides anterior to the acetabulum and reunites immediately posterior to the seminal receptacle. Ovary 0.24 to 0.36 mm. posterior to the acetabulum with seminal receptacle behind the ovary. Ootype immediately in front of ovary.

<u>Eggs</u>: Crescent-shaped and spindle in form with a long spine at each end, one more pointed than the other. Mature eggs 220 by 60 micra.

<u>Cercariae</u>: <u>C</u>. <u>elvae</u> Miller, 1923. More detailed description of structure by Talbot (1936) and of behaviour by Cort and Talbot (1936).

<u>Hosts</u>: Experimentally in domestic ducks, canaries and mallards.

Secondary: <u>Lymnaea</u> <u>stagnalis</u>.

Location: Intestinal veins.

Distribution: North America.

McMullen and Beaver postulated that this species is synonymous to *T. kossarewi* (Skrjabin et Zakharrow, 1920) and to *T. ocellata* which Brumpt (1931) obtained from infections with *Cercariae ocellata* (La Valette, 1855)

Since the size and behaviour of *C. elvae* differs quite markedly from that of *C. ocellata* as described by La Valette and other workers, and since only fragments of *T. ocellata* and *T. kossarewi* were obtained, it seems more feasible to regard the North American species as distinct.

TRICHOBILHARZIA OREGONENSIS (MacFarlane et Macy, 1946) Macy, 1952.

Figure....53........

Diagnosis: *Trichobilharzia*.

Male: 5.4 to 6.6 mm. in length by 0.05 to 0.09 mm. wide. Cuticle spiny. Oral sucker averages 0.056 to 0.043 mm. in size, acetabulum 0.4 to 0.56 mm. posterior to anterior end of body, 0.046 mm. in diameter. Oesophagus divides anterior to acetabulum, paired caeca reunite just anterior to gynaecophoric canal. Gynaecophoric canal 0.3 to 0.45 mm. in length with genital pore at the anterior end. Seminal vesicle 0.14 to 0.21 mm. in length.

Female: 3.4 to 5.1 mm. in length by 0.04 to 0.07 mm. wide. Oral sucker averages 0.046 to 0.035 mm. in size, acetabulum 0.04 mm. in diameter situated 0.23 to

0.32 mm. from anterior end of body. Ovary 0.168 to 0.24 mm. in length, situated 0.45 to 0.59 mm. from anterior end of body. Seminal receptacle well developed 0.084 to 0.164 mm. in length.

Eggs: Spindle shaped, straight or only slightly curved. 145 to 170 by 40 micra.

Cercariae: *C. oregonensis* MacFarlane et Macy, 1946.

Host: Primary: Experimentally in Peking ducklings.

Secondary: *Physa ampullacea*

Location: Mesenteric veins.

Distribution: Oregon, U.S.A.

Macy et al (1955) compared this species with *T. elvae* and *T. szidati* and on the basis of adult and egg characters showed it to be a distinct species.

T. oregonensis also closely resembles three other species: *T. szidati* Neuhaus, 1952; *T. berghei* Fain, 1955 and *T. cameroni* Wu, 1953. Comparisons of the adults and cercariae can be made with *T. szidati* and *T. cameroni*, but unfortunately only the male of *T. berghei* is known. (Table VI)

From the available data there is no appreciable difference between *T. oregonensis* and *T. berghei*. Two points however preserve their identity for the time being; lack of sufficient data and different geographical location.

Although the cercariae of *T. oregonenis* and *T. szidati* are very similar, the only difference being the more posterior position of the ventral sucker in the former species, the adults seem to differ significantly to warrant retaining them as distinct species. The male of T. szidati has a more narrow body, smaller suckers and a smaller gynaecophoric canal; whilst the female is also narrower, has smaller suckers and a larger ovary situated in a more posterior position. All such differences in toto seem sufficient to maintain their separate identities.

Comparison with T. cameroni is far more difficult, they clearly resemble each other in many ways as well as parasitizing the same snail genus, and both being present in North America. Only two differences exist between the cercariae, the tail of C. cameroni is shorter, and the diagrams of them show that whilst in C.cameroni four of the five penetration glands lie posterior to the acetabulum, in C. oregonensis only three of them do so. In the adult male, the only differences are very slight. The length of the gynaecophoric canal and the distance between the oral and ventral suckers are slightly greater in T. oregonensis, although this may simply be due to the slightly larger body size. In the female the only difference appears to be in the relative sizes of the ovary and seminal receptacle, in T. oregonensis the ovary being no more than twice the length of the seminal receptacle whilst in T. cameroni it can be as much as four times the length.

Unfortunately the natural hosts of these two forms remains unknown so that it is impossible to come to a final conclusion regarding them. The writer feels they are the same species in which case the specific name of this species would be *T. waubesensis* (Brackett), being synonymous to *T. cameroni* and *T. oregonensis*. For the present however they must remain separate.

TRICHOBILHARZIA PHYSELLAE (Talbot, 1936) McMullen and Beaver, 1945

Diagnosis: *Trichobilharzia*.

Male: Up to 7.5 mm. in length. Oral sucker 0.028 to 0.04 by 0.024 to 0.028 mm. in size, acetabulum situated 0.16 to 0.34 mm. posterior to oral sucker, 0.016 to 0.032 mm. in diameter. Oesophagus divides anterior to acetabulum, reunites an equal distance posterior to it near the anterior end of the seminal vesicle. Gynaecophoric canal, 0.1 to 0.19 mm. long, situated 0.3 to 0.68 mm. posterior to the oral sucker. Seminal vesicle extends from just posterior of the acetabulum to near the gynaecophoric canal, its posterior part enclosed in prostate cells. Testes 96 to 160 arranged on either side of the common caecum.

Female: Up to 4.4 mm. in length by 0.04 to 0.08 mm. wide. Oral sucker 0.024 to 0.044 by 0.024 to 0.028 mm. in size, acetabulum 0.024 to 0.032 mm. in diameter, situated 0.2 to 0.3 mm. posterior to the oral sucker. Oesophagus divides anterior to the acetabulum and reunites immediately posterior to the seminal receptacle. Ovary stout and looped, 0.1 to 0.3 mm. posterior to the acetabulum, 0.09 to 0.2 mm. in length. Oviduct from posterior

TABLE VI. COMPARISON OF T. OREGONENSIS, T. SZIDATI, T. BERGHEI and T. CAMERONI

[1]measurements in mm. [2]measurements in micra * Standard error

MALE[1]	T. OREGONENSIS	T. SZIDATI	T. BERGHEI	T.CAMERONI
Length body.	5.4 - 6.6	3.05	4.4 - 5.8	3.18 - 5.71
Width body.	0.05 - 0.09	0.02 - 0.034	0.06 - 0.125	-
Diam. oral sucker.	0.056 - 0.043	0.028 - 0.018	0.04 - 0.05	31-40 x 38 - 47[2]
Diam. acetabulum.	0.046	0.019	0.04	-
Oral to acetabulum.	0.4 - 0.56	0.43	0.35 - 0.45	0.226 - 0.37
Length gyn. canal.	0.3 - 0.45	0.22	0.28 - 0.375	0.212 - 0.345
Oral to gyn. canal	-	0.66	0.75 - 0.9	0.456 - 0.906
Length sem. ves.	0.14 - 0.21	0.20	0.27 - 0.38	-
No: testes.	-	70	40 - 65	80 - 110
FEMALE				
Length body.	3.4 - 5.1	3.0		3.82 - 4.94
Width body	0.04 - 0.07	0.036		0.052 - 0.059
Diam. oral sucker.	0.046 * 0.035	0.025 * 0.018		25 - 34 x 32 - 40[2]
Diam. acetabulum.	0.04	0.016		as oral
Oral to acetabulum.	0.23 - 0.32	0.27 - 0.31		0.213 - 0. 342
Oral to ovary	0.45 - 0.59	0.97		0.39 - 0.59
Length ovary.	0.168 - 0.24	0.34		0.287 - 0.358
Length sem. recept.	0.084 - 0.164	0.17		0.072 - 0.125
Egg.	145 - 170 x 40[2] Spindle-shaped	197 - 210 x 37 - 65 Spindle-shaped		147 - 212 x 57 - 63 Spindle-shaped

TABLE VI. (cont'd)

CERCARIAE[2]	T. OREGONENSIS	T. SZIDATI	C. PAROCELLATA	T. CAMERONI
Length body.	315	305.7	340	319 ± 4.6*
Width body	69	72.3	70	57 ± 0.7
Length Hd. org.	97	91.6	90	108 ± 2.0
Width hd. org.	48	54.7	50	38 ± 0.7
Length tail	426	431	400 - 440	369 ± 4.4
Width tail	47	44	40	38 ± 0.3
Length furca	222	247	240	225 ± 2.1
Width furca	-	24.3	25	23 ± 0.3
V.S. to post.	83	115.7	125	90 ± 2.2

end of ovary receives branch from seminal receptacle, gives off a Laurer's canal and runs forward to the ootype, mid-way between the acetabulum and the ovary.

Egg: Spindle-shaped, one end conical ending in a sharp point, the other tapering to form long blunt spine. 170 to 250 by 65 to 80 micra.

Cercariae: C. physellae Talbot, 1936.

Hosts: Experimentally in pigeons, mallards and canaries.

Secondary: Physa parkeri and P. magnalacustris.

Location: Intestinal veins.

Distribution: North America.

The status of this species is open to a great deal of question. It is obviously very closely related to T. burnetti, T. horiconensis, T. kegonsensis (Brackett) and T. querquedulae (McLeod). Most of the literature regards the latter species to be identical to T. physellae. For a detailed account of this problem see Table VII and discussion on page. 245..

TRICHOBILHARZIA QUERQUEDULAE (McLeod, 1937, McLeod and Little, 1942)

Synonyms: Pseudobilharziella querquedulae McLeod.

Diagnosis: Trichobilharzia.

Male: An average of 3.7 mm. in length by 0.15 mm. maximum width. Body compressed dorso-ventrally, cuticle covered with small spines. Oral sucker 0.05 to 0.062 mm. by 0.4 to 0.45 mm. in size, acetabulum 0.04 to 0.07 mm. in diameter, situated 0.25 to 0.44 mm. from the oral sucker. Gynaecophoric canal 0.23 to 0.42 mm. in length situated at an average distance of 0.68 mm. from the anterior end. Oesophagus forms bulb just anterior to acetabulum from which paired caeca arise. The caeca reunite just posterior to the genital pore. Common caecum zig-zag enclosed with the testes. Testes 210 to 240. Seminal vesicle occupies whole space between acetabulum and gynaecophoric canal with posterior part enclosed in cirrus pouch with numerous prostate cells present. Genital pore at the anterior end of the gynaecophoric canal.

Female: An average of 1.86 mm. in length by 0.06 mm. maximum width. Filamentous with posterior end spatulate and cuticle smooth or finely tuberculate. Oral sucker 0.034 mm. in diameter, acetabulum 0.036 mm. in diameter, situated 0.25 mm. from the anterior end. Ovary coiled, 0.17 mm. posterior to acetabulum, with seminal receptacle posterior to ovary. Genital pore immediately posterior to acetabulum. Oesophagus opens into bulb just anterior to acetabulum, paired caeca reunite immediately posterior to seminal receptacle.

Eggs: Spindle shaped. In utero 140 by 30 micra. Mature 217 by 76 micra. (McLeod) 201.25 by 54.5 micra (Farley)

Cercariae: See table VIII for dimensions.

Host: Primary: Blue-winged teal (*Anas discors*),
Shoveller duck (*Spatula clypeata*)

Secondary: *Physa gyrina*.

Location: Intestinal veins.

Distribution: North America

Relationship of T. physellae and T. querquedulae.

Although these two species are often regarded as being synonymous, there are differences between them which seem sufficient to the writer to maintain them as separate species. Notably they are:

1. The body length of *T. physellae* is stated to be as much as 7.5 mm., whilst the body length of all the specimens of *T. querquedulae* examined by the writer usually fell between 3 to 4 mm. and never exceeded 4.5 mm.

2. The length of the gynaecophoric canal in *T. querquedulae* always exceeded 0.2 mm., whilst the maximum range in *T. physellae* was stated to be 0.19 mm. If the views of McMullen were correct, that the specimens of *T. querquedulae* were in a state of contraction, the gynaecophoric canal would be expected to be of smaller size.

3. The number of testes in *T. querquedulae* far exceeded that in *T. physellae*. The testes were not arranged tandemly as illustrated by McMullen, but were arranged in tight clusters around the common caecum.

4. The suckers of *T. querquedulae* are far larger.

5. The eggs, although of the same shape are slightly smaller in *T. querquedulae*.

6. The cercariae of *T. querquedulae* differ in two respects from that of *T. physellae*: the tail is quite considerably smaller and their behaviour differs.

Cort and Talbot (1936) stated that the cercariae of *T. physellae* escaped in the early morning, did not respond to light and had a tendancy to sink to the bottom of the container and attach. The cercariae of *T. querquedulae* on the other hand did respond to light, although such response was not great. After a period of activity, when they underwent bursts of swimming followed by sinking, they eventually attached by the ventral sucker to the side of the container nearest the light. It is of interest to note that Brackett (1940) noted that the cercariae from Wisconsin, which he termed *C. physellae* behaved in the same way.

Such minor differences taken in toto seem sufficient to maintain these species separate identity.

The three species described by Brackett from ring-necked, canvas-backs and red-headed ducks of Wisconsin are quite obviously all of the same species, the very minor differences between them being due to the state of contraction of the worms. From the size of the gynaecophoric canal, the number of testes and the sucker sizes they appear to be identical to *T. physellae*, although their body size more closely resembles *T. querquedulae*.

Although with such little information it is impossible to come to any definite conclusion regarding these species, it would seem feasible to the writer to suppress the names _T. burnetti_, _T. kegonsensis_ and _T. horiconensis_ as being synonymous to _T. physellae_.

TRICHOBILHARZIA RODHAINI Fain, 1955d.

Figure...57........

Diagnosis: _Trichobilharzia_.

Male: Only fragments found. Length at least 6 mm. by 0.071 mm. wide at the acetabulum, 0.09 mm. wide at the gynaecophoric canal, and 0.05 mm. wide posterior to the canal. Oral sucker 0.046 by 0.033 mm. in size, acetabulum 0.285 mm. posterior to anterior end of body, about 0.04 mm. in diameter. Cuticle spineless but with small tubercles at anterior and posterior parts of body. Gynaecophoric canal deep, 0.219 mm. in length, 0.7 mm. posterior to anterior part of body. Oesophagus bifurcates anterior to acetabulum and paired caeca reunite mid-way between acetabulum and gynaecophoric canal. Greatest number of testes seen on a fragment: 137. External seminal vesicle 0.13 mm. in length, internal seminal vesicle 0.23 mm. long.

Female: Only one fragment seen, 0.56 mm. in length containing the ovary and seminal receptacle. Seminal receptacle 0.11 mm. in length, ovary at least 0.495 mm. long.

Eggs: Fusiform with often slight assymmetry, terminal spine present. Eggs in mucus 280 to 325 by 55 to 70 micra.

Location: Nasal fossa veins.

Host: _Hagedashia hegedasha_ (West African hadada)

See Table VIII page.252., for a comparison with

TABLE VII. COMPARISON OF T. PHYSELLAE, T. QUERQUEDULAE, T. BURNETTI, T. HORICONENSIS and T. KEGONSENSIS.

1. measurements in mm. 2. measurements in micra. * Standard error

MALE[1]	T. PHYSELLAE	T. QUERQUEDULAE	T. BURNETTI	T. HORICONENSIS	T. KEGONSENSIS
Length body	up to 7.5	3.7	-	3.56	4.03
Max. width	0.056 - 0.080	0.14	0.065	0.057	0.054
Diam. oral suck.	28 to 40 x 24 to 28[2]	50-62 x 40-45[2]	32 x 36[2]	36 x 32[2]	36 x 25[2]
Diam. acetabulum	0.016 - 0.032	0.04 - 0.07	0.04	-	0.036
Oral to acetab.	0.16 - 0.34	0.25 - 0.44	0.216	-	0.288
Oral to gyn.can.	0.3 - 0.68	0.678	0.45	0.482	0.54
Length gyn.can.	0.1 - 0.19	0.23 - 0.42	0.144	0.125	0.144
No: testes	96 - 160	210 - 240	-	115	150
No: specimens	8 complete	Many	One	One	One
FEMALE					
Length body	up to 4.4	1.86			
Max. width	0.04 - 0.08	0.06			
Diam. oral suck.	24 - 44 x 24-28[2]	0.034			
Diam. acetabulum	0.024 - 0.032	0.036			
Oral to acetab.	0.2 - 0.3	0.25			
Oral to ovary	0.3 - 0.6	0.42			
Length ovary	0.09 - 0.20	-			
Egg	170-250 x 65-80[2] Spindle-shaped	217 x 76 Spindle-shaped			
Hosts.	Expt. in cannaries etc				

TABLE VII. (cont'd)

CERCARIAE[2]	T. PHYSELLAE	T.QUERQUEDULAE	T.BURNETTI	T.HORICONENSIS	T.KEGONSENSIS
Length body	265 ± 1.8 *	262 ± 6.6 *			
Width body	60 ± 1.0	40 ± 1.8			
Length tail	374 ± 2.2	334 ± 5.1			
Width tail	40 ± 0.8	33 ± 0.7			
Length furca.	196 ± 1.7	204 ± 3.5			
Width furca	32 ± 0.2	22 ± 0.3			
V.S. to Post.	80 ± 1.1	77 ± 1.6			
Length Hd org.	95 ± 1.1	-			
Width Hd org.	39 ± 0.4	-			
Host	*Physa parkeri* *Physa magnalacustris*.	*Physa gyrina*			

other nasal forms.

TRICHOBILHARZIA SPINULATA Fain, 1955d.

Figure....58.........

Diagnosis: Trichobilharzia.

Male: Living worm 21 mm. in length, 15 mm. when fixed. 0.075 to 0.085 mm. wide at the acetabulum, 0.1 to 0.115 mm. wide at the canal and 0.075 to 0.085 mm. wide posterior to canal. Body covered with large spines. Oral sucker 0.038 by 0.034 mm. in size. Gynaecophoric canal 0.25 to 0.325 mm. in length, situated 0.7 to 0.875 mm. from the anterior end. Oesophagus divides anterior to acetabulum and reunites usually at the posterior part of the seminal vesicle. Testes 233. External seminal vesicle 0.12 to 0.22 mm. long, internal seminal vesicle 0.146 to 0.219 mm. long. Cirrus sac extends 0.03 to 0.06 mm. posterior to seminal vesicle. Prostate cells well developed, genital pore at the anterior end of gynaecophoric canal.

Female: Longest specimen incomplete, 17 mm. in length. 0.05 to 0.06 mm. wide at acetabulum, 0.04 to 0.06 mm. at ovary and 0.05 to 0.07 mm. posterior to ovary. Cuticle as male. Oral sucker 0.036 by 0.031 mm. in size, acetabulum 0.038 by 0.03 mm. in size, situated 0.32 to 0.375 mm. posterior to anterior end. Ovary 0.4 to 0.5 mm. long, situated 0.72 to 0.93 mm. posterior to anterior end of body. Seminal receptacle 0.085 to 0.12 mm. long with Laurer's canal given off posterior to ovary. Ootype 0.125 to 0.2 mm. anterior to ovary.

Egg: In ootype: 170 to 200 micra long. Spindle shaped, nacelle-like.

Immature eggs: 210 to 240 by 25 to 40 micra

Mature eggs: 250 - 300 by 50 to 70 micra

Host: *Alopochen aegyptiacus* (Egyptian goose),
Plectropterus gambensis (Spur-winged goose)

Location: Veins of nassal fossa.

Distribution: Ruandi-Urundi. C. Africa.

The four nasal inhabiting avian schistosomes from Africa are very closely related and could perhaps even be considered as variants of a single species.

T. spinulata differs from the others in bearing very heavy spines, a unique character which justifies its retention as a separate species.

The separation of the other three is much more difficult. The eggs of *T. rodhaini* and *T. nasciola* are identical whilst those of *T. aureliani* are slightly smaller and 'nacelle-like'. On the grounds of adult morphology however there is no reason to consider *rodhaini* and *nasciola* as synonymous and *aureliani* as a distinct species, indeed *rodhaini* resembles *aureliani* far more than it does *nasciola*. - for example, the length of gynaecophoric canal, the length of seminal vesicle, the number of testes.

There appears to be sufficient differences between *T. nasciola* and *T. aureliani* to regard them as distinct species whilst *rodhaini* occupies such a confused position that it might represent a hybrid form between the two. Such of course, is complete speculation but

TABLE VIII. COMPARISON OF THE NASAL INHABITING AVIAN SCHISTOSOMES FROM AFRICA

MALE	T. RODHAINI	T. NASCIOLA	T. AURELIANI	T. SPINULATA
Length body.	at least 6 mm.	approx. 20	17	15
Width body.	0.05 - 0.09	0.04 - 0.12	0.03 - 0.075	0.075 - 0.115
Oral to acetabulum	0.285	0.38 - 0.475	0.366 - 0.5	-
Oral to gyn. canal	0.7	-	0.75 - 1.0	0.7 - 0.875
Length gyn. canal.	0.219	0.3 - 0.35	0.23 - 0.275	0.25 - 0.325
Length sem. vesicle	0.36	0.45 - 0.59	0.38 - 0.45	0.27 - 0.44
No: testes	at least 137	170 - 200	125	233
Cuticle	Spineless tubercles anterior & posterior	Smooth or minute spines	Minute spines	Very heavy spines

FEMALE				
Length body	-	15		at least 17
Width body	-	0.04 - 0.07	0.06 - 0.075	0.04 - 0.06
Oral to acetabulum	-	0.42 - 0.52	0.3 - 0.41	0.32 - 0.375
Oral to ovary	-	1.2	0.7 - 1.0	0.72 - 0.93
Length ovary.	at least 0.495	0.625- 0.65	0.368- 0.46	0.4 - 0.5
Length sem.recept.	0.11	0.14 - 0.15	0.1 - 0.15	-
OOtype to acetabulum	-	0.15 - 0.2	0.25 - 0.28	0.125- 0.2
Egg.	280 - 325 x 55 - 70 Fusiform, slight asymmetry	280 - 330 x 50 - 70 Fusiform	250 - 280 x 50 - 65 'nacelle' shaped	250 - 300 x 50 - 70 'nacelle' shaped

nevertheless the writer feels loath to erect rodhaini as a distinct species.

TRICHOBILHARZIA SCHOUTEDENI Fain, 1955d

Figure.....52.........

Diagnosis: Trichobilharzia.

Male: 5.1 to 6.79 mm. long, by 0.09 to 0.13 mm. wide at acetabulum 0.14 to 0.19 mm. at the gynaecophoric canal and 0.1 to 0.07 mm. posterior to canal. Posterior end of body spatulate, cuticle finely spined. Oral sucker 0.06 by 0.05 mm. in size, acetabulum 0.075 mm. in diameter, both suckers spined. Acetabulum 0.42 to 0.56 mm. from the anterior end of body. Gynaecophoric canal 0.5 to 0.62 mm. long, situated 1.2 to 1.3 mm. from the anterior end of the body. Testes 92 to 125. External seminal vesicle 0.26 to 0.31 mm. long, internal seminal vesicle 0.225 to 0.3 mm. in length occupying whole space between acetabulum and gynaecophoric canal. Prostate cells present.

Female: Unknown

Host: Thalassornes leuconotus (White-backed duck)

Location: Mesenteric veins.

Distribution: Ruanda-Urundi. C. Africa.

TRICHOBILHARZIA STAGNICOLAE (Talbot, 1936) McMullen et Beaver, 1945

Figure.....60.........

Diagnosis: Trichobilharzia.

Male: 5.5 mm. in length. Oesophagus divides anterior to acetabulum and paired caeca reunite 0.06 mm. posterior to it. Seminal vesicle commences 0.17 mm. posterior to acetabulum, 0.59 mm. long. Testes 161. Acetabulum 0.015 mm. in diameter. Gynaecophoric canal and oral sucker not seen.

Female: 5.4 mm. long by 0.032 mm. wide. Paired caeca reunite posterior to seminal receptacle. Ovary 0.46 mm. long, seminal receptacle 0.08 mm. long and ootype situated slightly nearer the acetabulum then ovary. Acetabulum situated 0.28 to 0.48 mm. posterior to the oral sucker.

Egg: Cresent shape, round at one pole, sharply pointed at the other.

Mature: 130 to 160 by 50 to 60 micra.

Cercariae: *C. stagnicolae* Talbot, 1936.

Host: Experimentally in canaries, domestic ducks and herring gulls.

Location: Intestinal veins.

Distribution: North America ~~and Canada~~

TRICHOBILHARZIA SZIDATI Neuhaus, 1952

Figure.....54........

Diagnosis: *Trichobilharzia*.

Male: 3.05 mm. in length with a maximum width of 0.034 mm. Gynaecophoric canal 0.66 mm. from the anterior end of the body, 0.22 mm. long. Cuticle covered with minute spines. Acetabulum 0.43 mm. posterior to oral sucker. Oesophagus 0.30 mm. long, paired caeca reuniting immediately posterior to acetabulum. Testes 70. Seminal vesicle commences immediately posterior to the acetabulum, 0.20 mm. in length. Genital pore at anterior end of gynaecophoric canal.

Female: 3 mm. long by 0.036 mm. wide. Cuticle covered with very minute spines. Acetabulum 0.27 to 0.31 mm. posterior to oral sucker, 0.016 mm. in diameter. Ovary elongate, 0.97 mm. posterior to anterior end of body, 0.34 mm. long. Oviduct from posterior end of ovary receives branch from seminal receptacle, 0.17 mm. long, and turns forward to open into ootype just anterior to ovary. Uterus opens posterior to acetabulum, containing one egg.

Egg: In utero: 170 micra long.
Mature: 197 to 210 by 37 to 65 micra.
Spindle shaped but very plastic in shape.

Cercaria: *C. parocellata* Szidat, 1942

Host: Primary: Experimentally in domestic ducklings.
Secondary: *Lymnaea stagnalis*. *Lymnaea ovata*.

Neuhaus regarded the cercariae of this species to be identical to *C. parocellata* (Comparative measurements are given below). This being the case the name *T. szidati* must be suppressed in favour of *T. parocellata*. (Szidat) Neuhaus 1952.

TABLE IX.

Comparison of CERCARIA SZIDATI (Neuhaus) and C. PAROCELLATA (Szidat)

	C. szidati	C. parocellata
Length of body	305.7	340
Width of body	72.3	70
Length of Head-organ	91.6	90
Width of Head-organ	54.7	50
Length of Tail	431	400 to 440
Width of Tail	44	40
Length of furca	247	240
Width of furca	24.3	25
Ventral suck. to pos. end of body	115.7	125
Host	Lymnaea stagnalis L. ovata	L. ovata

Genus BILHARZIELLA Looss, 1899

Generic diagnosis: Bilharziellinae: Both sexes with posterior part of body distinctly flattened. Female shorter than male. Gynaecophoric canal absent. Intestinal caeca reunite near equator of body with testes lying alonside the common caecum about 110 in number. Genital pore in male at some distance posterior to acetabulum. Cirrus pouch present containing prostate and ejaculatory duct. Seminal vesicle long between the paired caeca. Female with caeca as male, with ovary lying between the paired caeca and genital pore immediately posterior to the acetabulum. Cercariae as Trichobilharzia. Parasitic in birds.

Type species: Bilharziella polonica.

BILHARZIELLA POLONICA (Kowalewski, 1895) Looss, 1899.

Synonyms: Bilharzia polonica Kowalewski 1895;
Schistosomum polonicum Raillet, 1898;
Ornithobilharzia polonica Tanabe, 1925.

Diagnosis: Bilharziella.

Male: 4.0 mm. long by 0.53 mm. wide. Body flattened and lanceolate. Oral sucker 0.1 mm. in diameter, acetabulum 0.76 mm. posterior to oral sucker, 0.136 mm. in size. Paired caeca reunite a short distance anterior to the equator of the body. Testes about 110 situated either side of the common caecum. Seminal vesicle lying between paired caeca, leading into ejaculatory duct enclosed by the cirrus pouch with prostate cells.

Genital pore situated 0.8 mm. posterior to the acetabulum.

Female: 2 mm. long by 0.25 mm. wide. Form of body as male. Oral sucker 0.05 mm. in diameter, acetabulum situated 0.37 mm. posterior to the oral sucker, 0.068 mm. in diameter. Digestive tract as male. Ovary weakly spiral lying between paired caeca in the region of equator. Genital pore just posterior to the acetabulum.

Egg: Elongate anteriorly, widened posteriorly with a small hooked spine at the broad end. 385 to 400 by 100 micra at the widest point.

Cercariae: Described by Szidat, 1929.

Host: Primary: *Anas platyrhynchus*, (Mallard); *Anas crecca* (European teal) *Anas acuta* (Pintail); *Fulica cristata* (red-knobbed coot); *Cygnus oler*.
Secondary: *Planorbis corneus* (Szidat); *Bullinus africanus* (Porter, 1938)

Location: Intestinal blood vessels.

Distribution: Europe, North America, and South Africa.

This parasite is probably identical to *Chinhuta indica* described by Lal (1937). Lal described the possession of a gynaecophoric canal extending the total length of the body and for this reason erected a new genus *Chinhuta*. Mehra (1940) questioned this find, maintaining that Lal mistook inturning of the body wall as a gynaecophoric canal. For this reason Mehra renamed it *Bilharziella indica*. From the description of the two species however it appears very likely that *B. indica* is synonymous with *B. polonica*.

It is of interest to note that Szidat (1929) noted that the hind end of the male could be inrolled to receive the female, thus functioning as a gynaecophoric canal. This would help to explain the description given by Lal for *B. indica*.

INCERTAE GENORIS

BILHARZIELLA YOKOGAWAI Oiso, 1927

Synonym: *Pseudobilharziella yokogawai* McLeod, 1940; *Trichobilharzia yokogawai* McMullen and Beaver, 1945.

Male: Flat, 2.3 mm. long by 0.096 mm. wide. Gynaecophoric canal short, extending from immediately posterior of acetabulum to level of the caecal union. Acetabulum 0.3 mm. posterior to the oral sucker. Paired caeca reunite 0.5 mm. from the anterior end of the body. Testes oval, 50 to 70 on either side of the common caecum. Seminal vesicle large, between paired caeca and thus in the region of the gynaecophoric canal.

Female: Very slender, 3.4 to 4.0 mm. long by 0.065 mm. wide.

Egg: Spindle shaped, 226 by 62 micra.

Cercariae: Described by Oiso.

Hosts: Primary: *Anas platyrhynchos*.

Secondary: *Lymnaea radix*.

Distribution: Formosa

The presence of a gynaecophoric canal immediately posterior to the acetabulum, and enclosing within its boundary the seminal vesicle removes this species from either the Bilharziella or the Trichobilharzia. If this interpretation is correct the species would require placing in a new genus. However the description is most suspect, both in the location of the canal and in the cercariae being described as pharyngeal.

The writer feels that for the time being this species should be removed from the schistosome classification until the structure of the worm can be clarified.

TRICHOBILHARZIA TATIANA. Spasskaia, 1954.

Male: 18 to 20 mm. long by 0.25 mm. wide at the seminal vesicle, 0.28 mm. at the testes. Cuticle with minute spines. Oral sucker 0.03 mm. in diameter, acetabulum situated 0.79 mm. from the anterior end of body, 0.03 mm. in diameter. Testes 220 to 230 grouped round the common caecum. Seminal vesicle large and in two sections, the anterior 0.52 mm. long, the posterior 0.7 mm. long. Gynaecophoric canal extends from level of seminal vesicle to near posterior end of body.

Female: 18 to 20 mm. long by 0.28 mm. wide at level of vitellaria. Details of ovary not seen, posterior end of it lobed (seminal receptacle?). Uterus proceeds from ootype, situated behind the ovary, to the genital pore posterior to the acetabulum. Paired caeca unite behind the ovary, common caecum surrounded by vitellaria.

Egg: Cercariae: Unknown

Host: *Rallus aquaticus*.

Location: Renal veins

Distribution: Northern Siberia.

Despite the range of measurements given, the description was based on the examination of only one specimen of each sex. From the description two points demand the erection of a new genus: the length of the gynaecophoric canal and the position of the ootype. However with such little evidence the writer does not feel justified in erecting a new genus, although it must be removed from the *Trichobilharzia*.

FIGURE 1. *Schistosomatium douthitti*.
(After Price, 1931)

FIGURE 2. *Bivitellobilharzia loxodontae*.
(After Vogel et Minning, 1940)

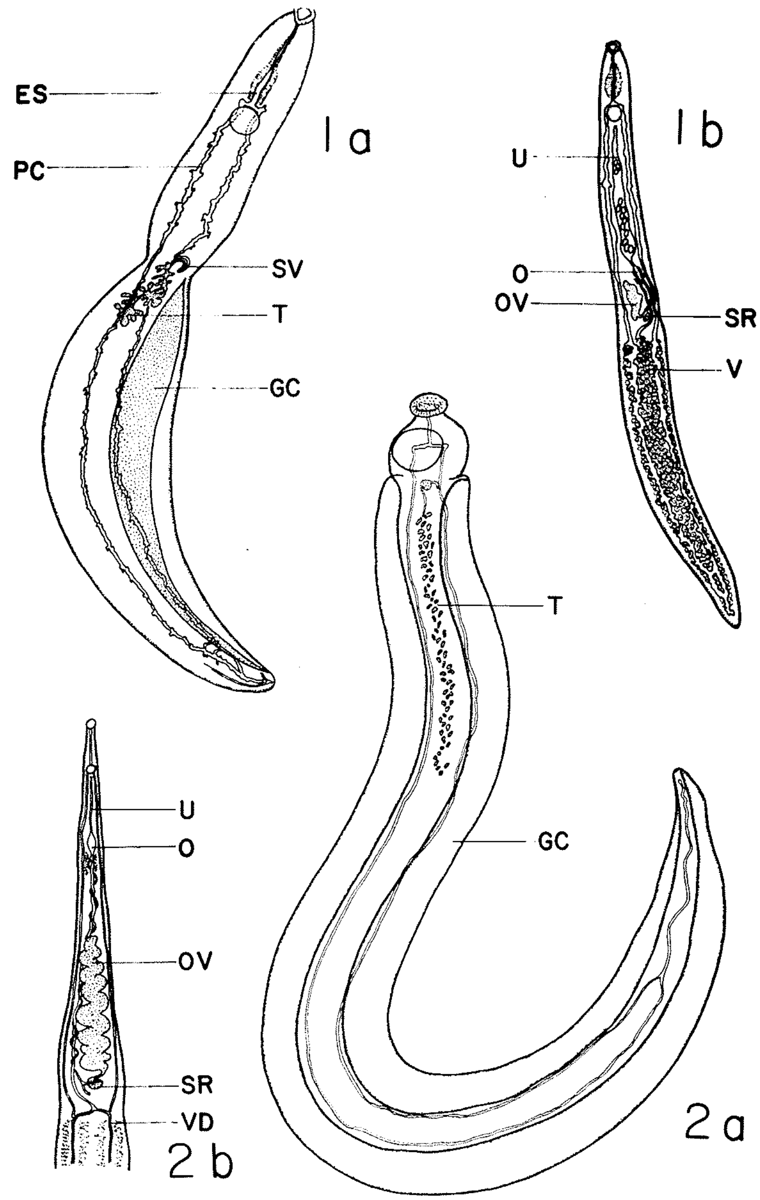


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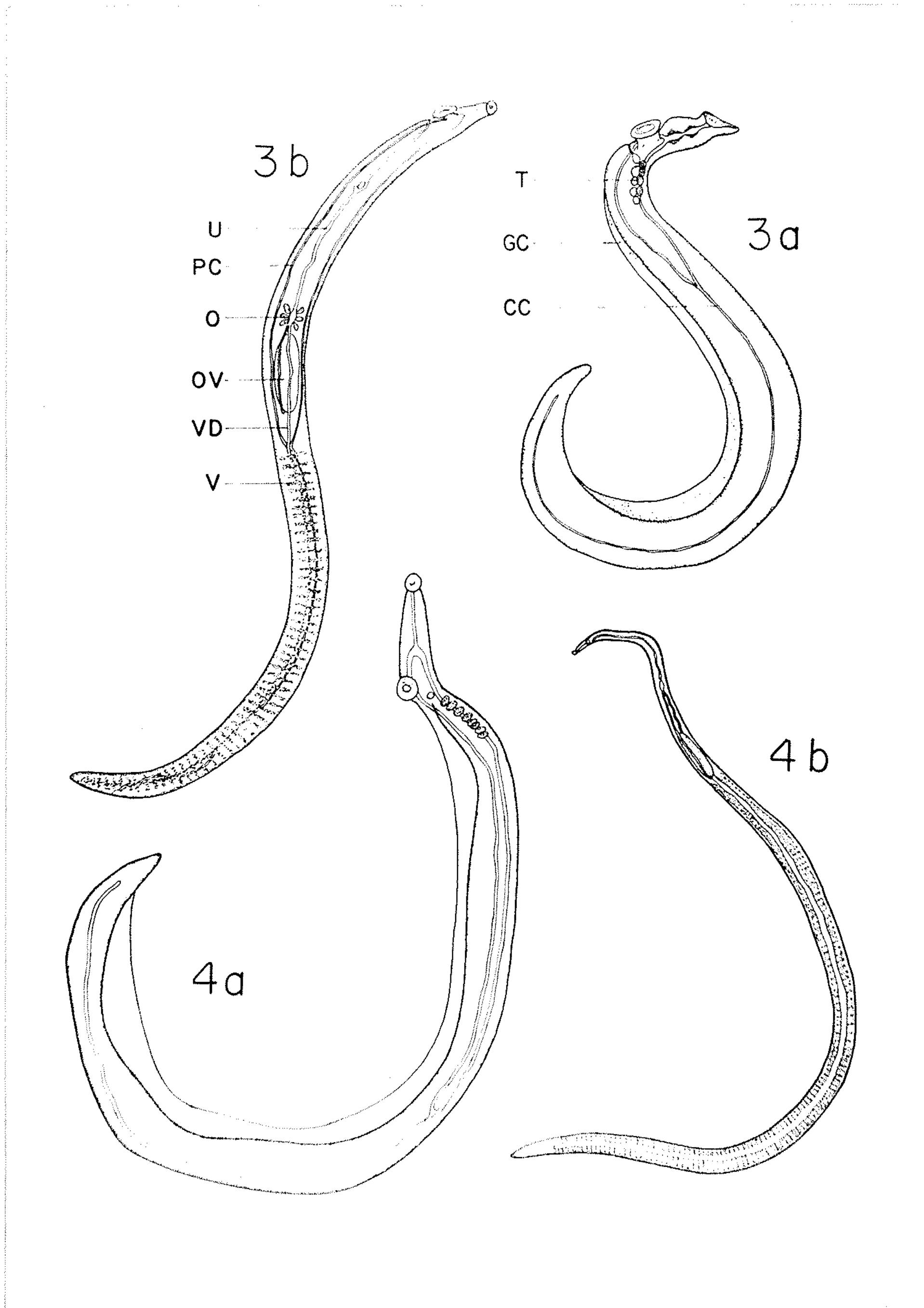
FIGURE 3. *Afrobilharzia mansoni*.
(After Porter, 1938)

FIGURE 4. *Afrobilharzia rodhaini*.
(After Schwetz, 1951)


3b
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3a
4a
4b

FIGURE 5. *Afrobilharzia incognitum.*

(After Sinha et Srivastava, 1956)

FIGURE 6. *Schistosoma haematobium.*

(After Porter, 1938)

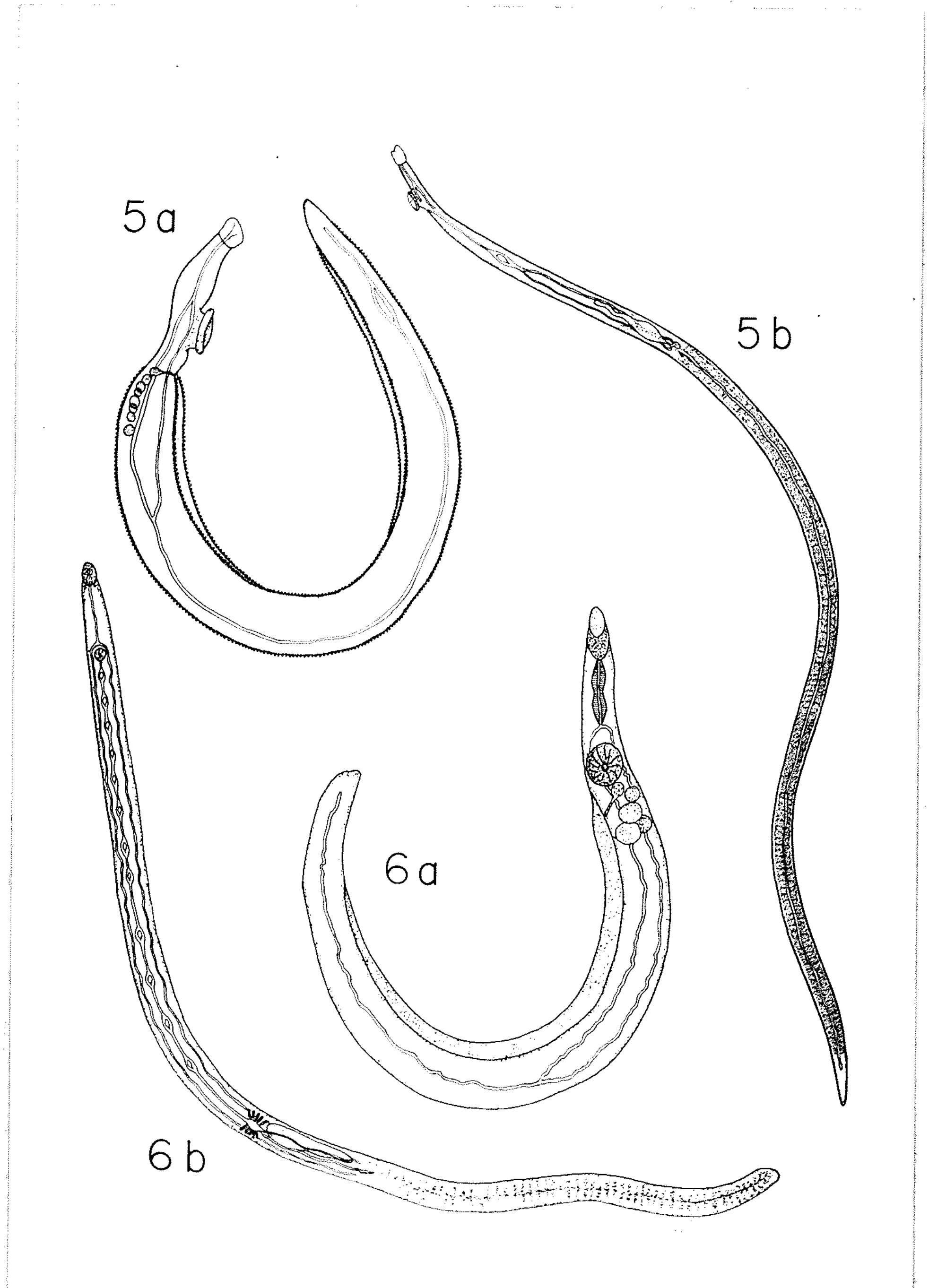

5a
5b
6a
6b

FIGURE 7. *Schistosoma bovis.*

(After Khalik, 1924)

FIGURE 8. *Schistosoma margrebowiei*

(After Le Roux, 1933)

FIGURE 11. *Schistosoma japonicum.*

(After Price, 1929)

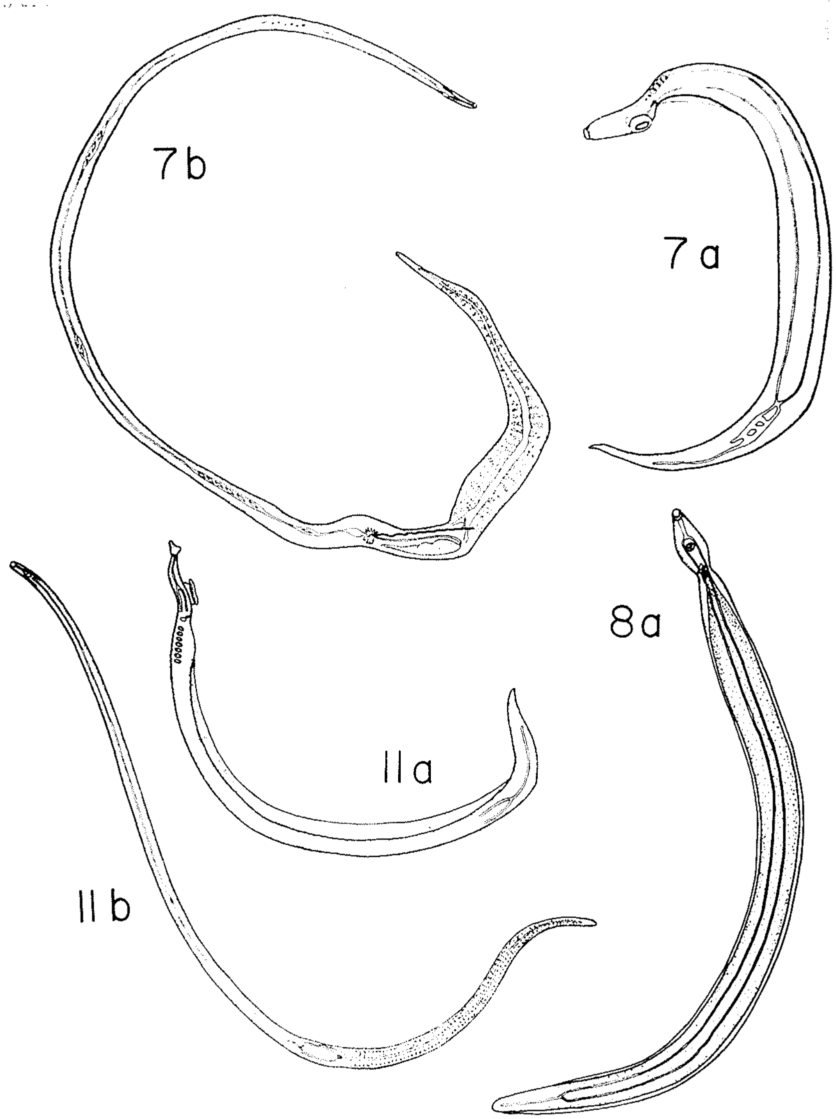

7b
7a
8a
11a
11b

FIGURE 9. *Schistosoma indicum.*

(After Montgomery, 1906)

FIGURE 10. *Schistosoma nasale.*

(After Rao, 1933)

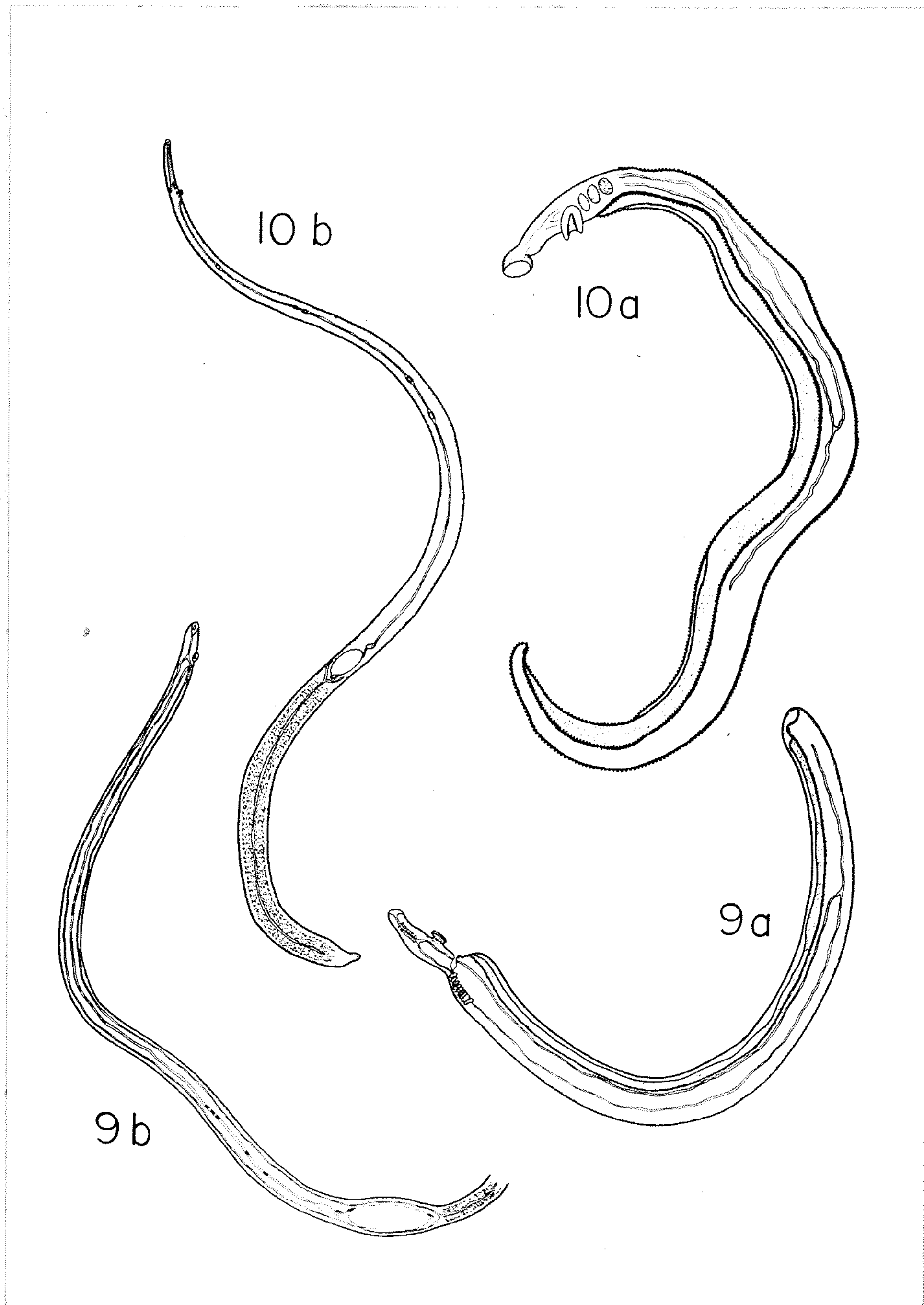
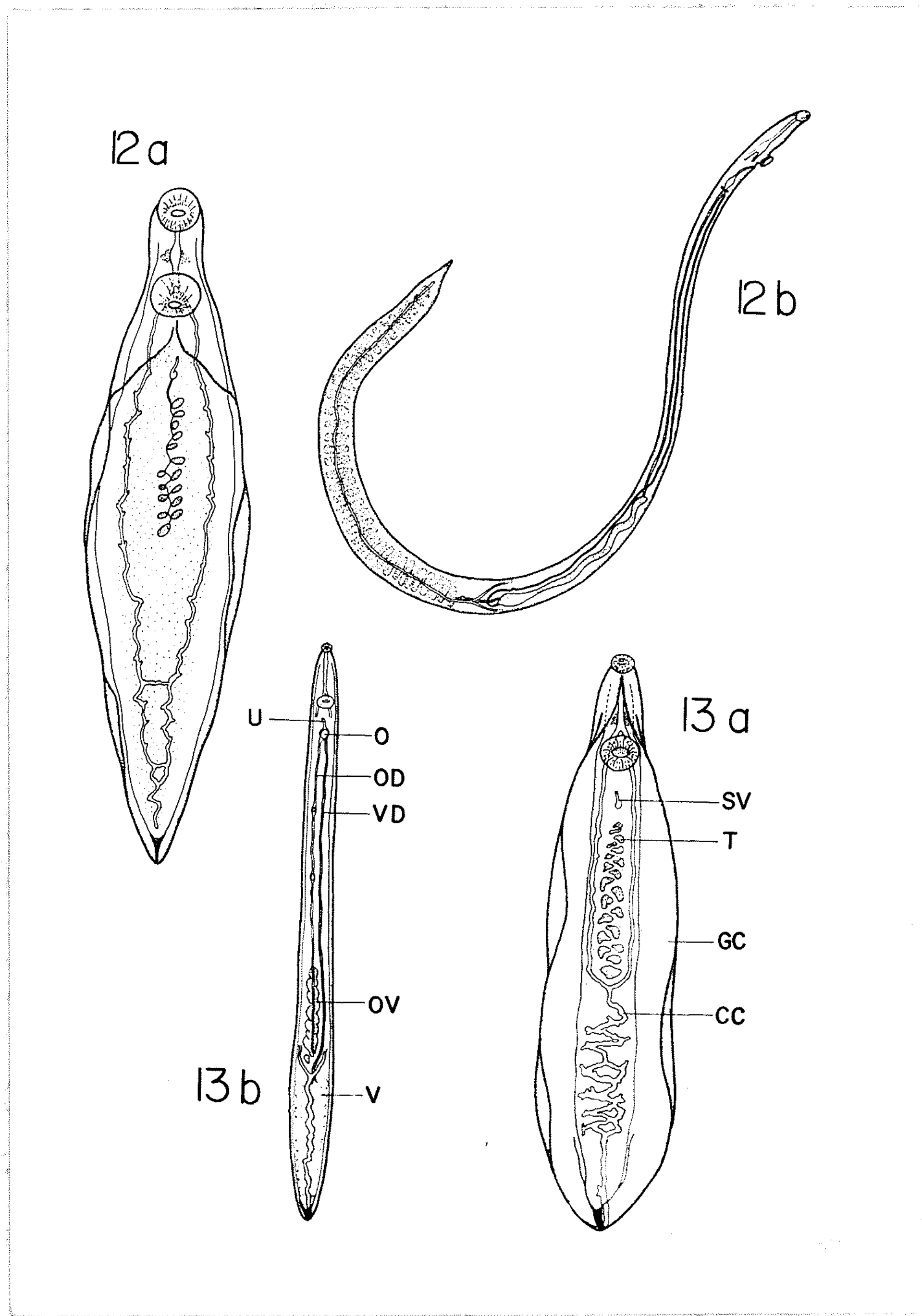

10 b
10a
9a
9b

FIGURE 12. *Austrobilharzia terrigalensis* var australasia.

(After Bearup, 1956)

FIGURE 13. *Austrobilharzia terrigalensis* var americana

(After Stunkard et Hinchcliffe, 1952)


12a
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13b
13a
SV
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CC

FIGURE 14. *Austrobilharzia canadensis*.

(After McLeod, 1936)

FIGURE 15. *Austrobilharzia terrigalensis*

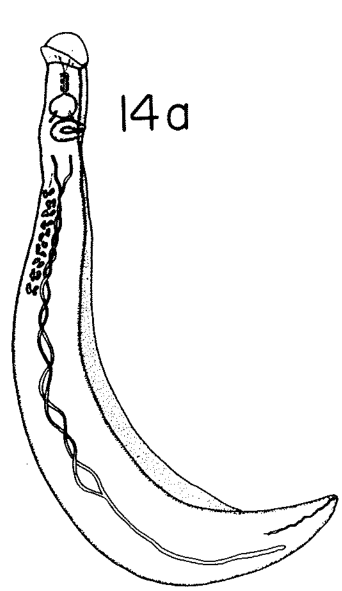
var americana.

(After Price, 1929)

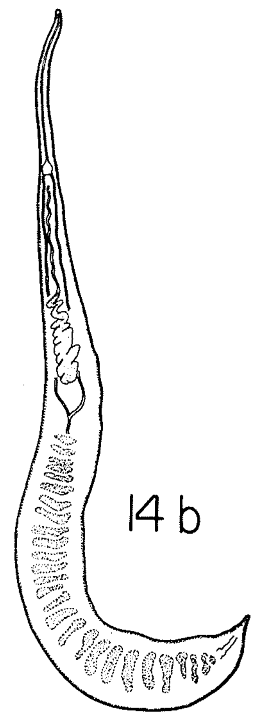
FIGURE 16. *Austrobilharzia terrigalensis*

var americana

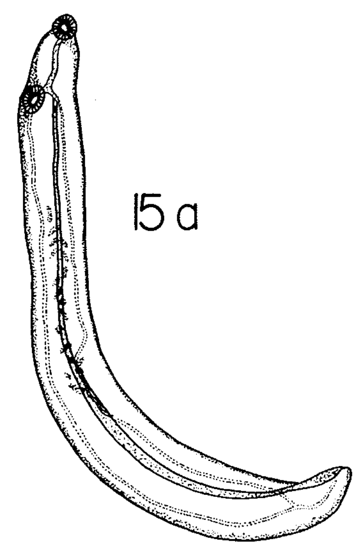
(After McLeod, 1936)



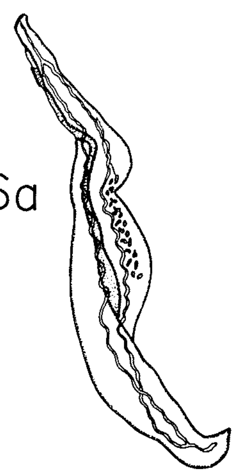
14a



14 b



15 a



16a

FIGURE. 17. <u>Austrobilharzia</u> <u>hoeppli</u>

(After Tang, 1951)

FIGURE. 18. <u>Austrobilharzia</u> <u>bayensis</u>

(After Tubangui, 1933)

FIGURE. 19. <u>Austrobilharzia</u> <u>pricei</u>

(After Wetzel, 1930)

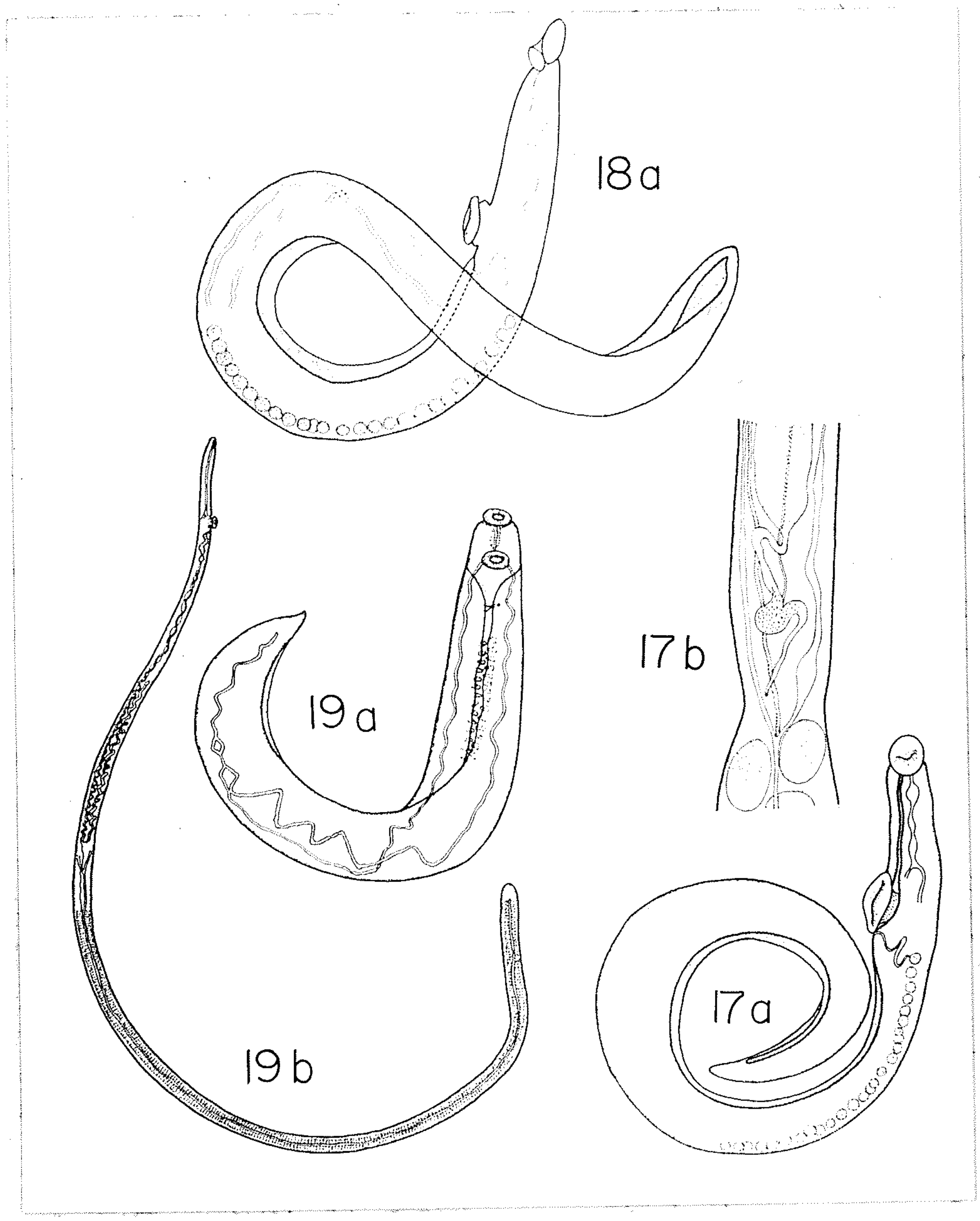

18a
17b
19a
17a
19b

FIGURE. 20. Austrobilharzia odhneri.

(After Faust, 1924)

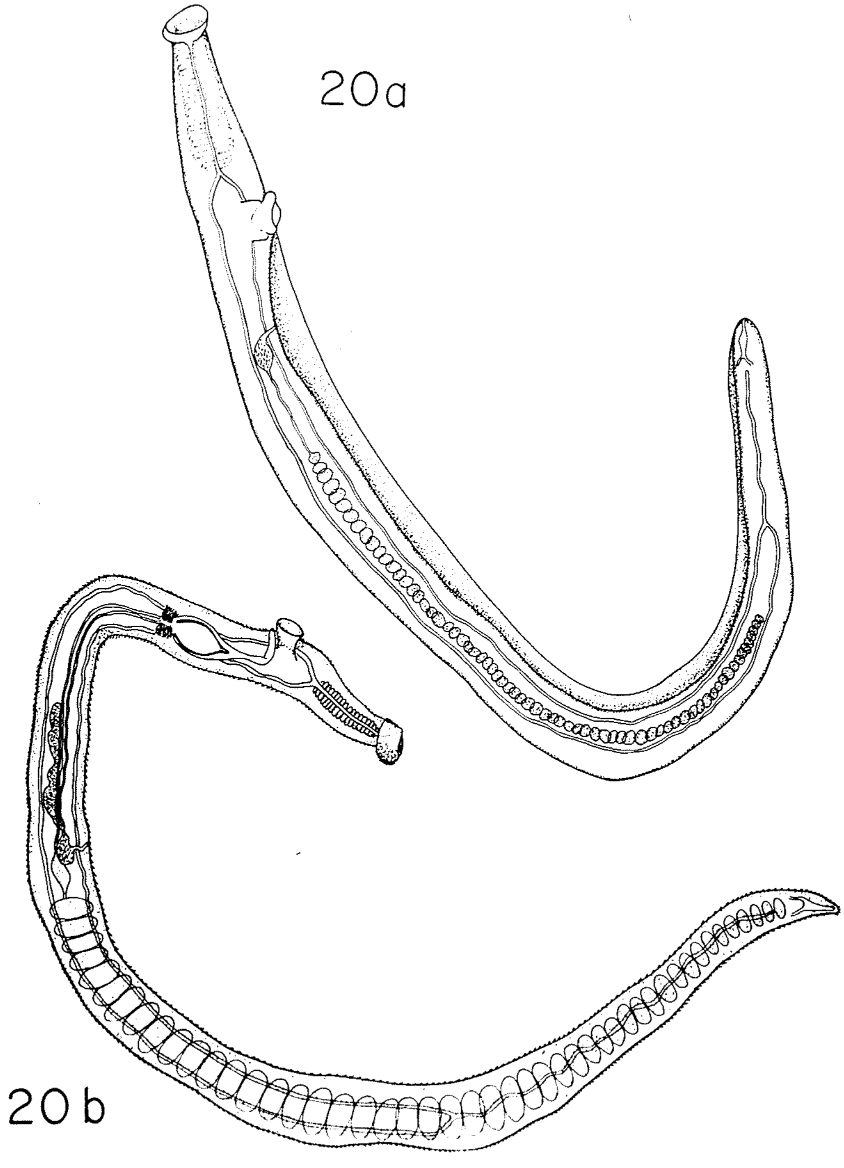

20a
20b

FIGURE. 21. *Austrobilharzia penneri*.

(After Short et Holliman, 1961)

FIGURE. 22. *Austrobilharzia lari*.

(After McLeod, 1937)

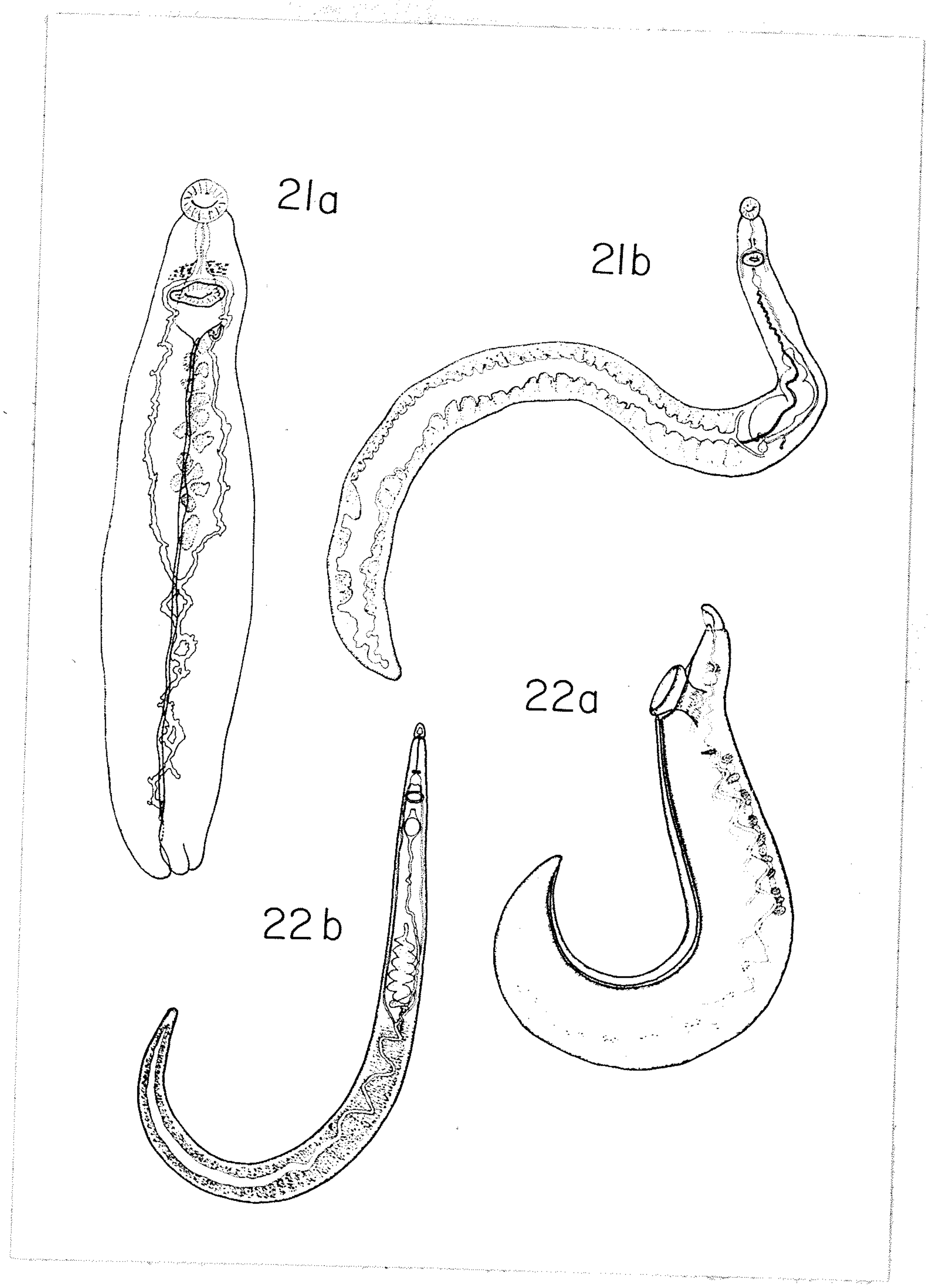

21a
21b
22a
22b

FIGURE. 23. *Ornithobilharzia canaliculata.*

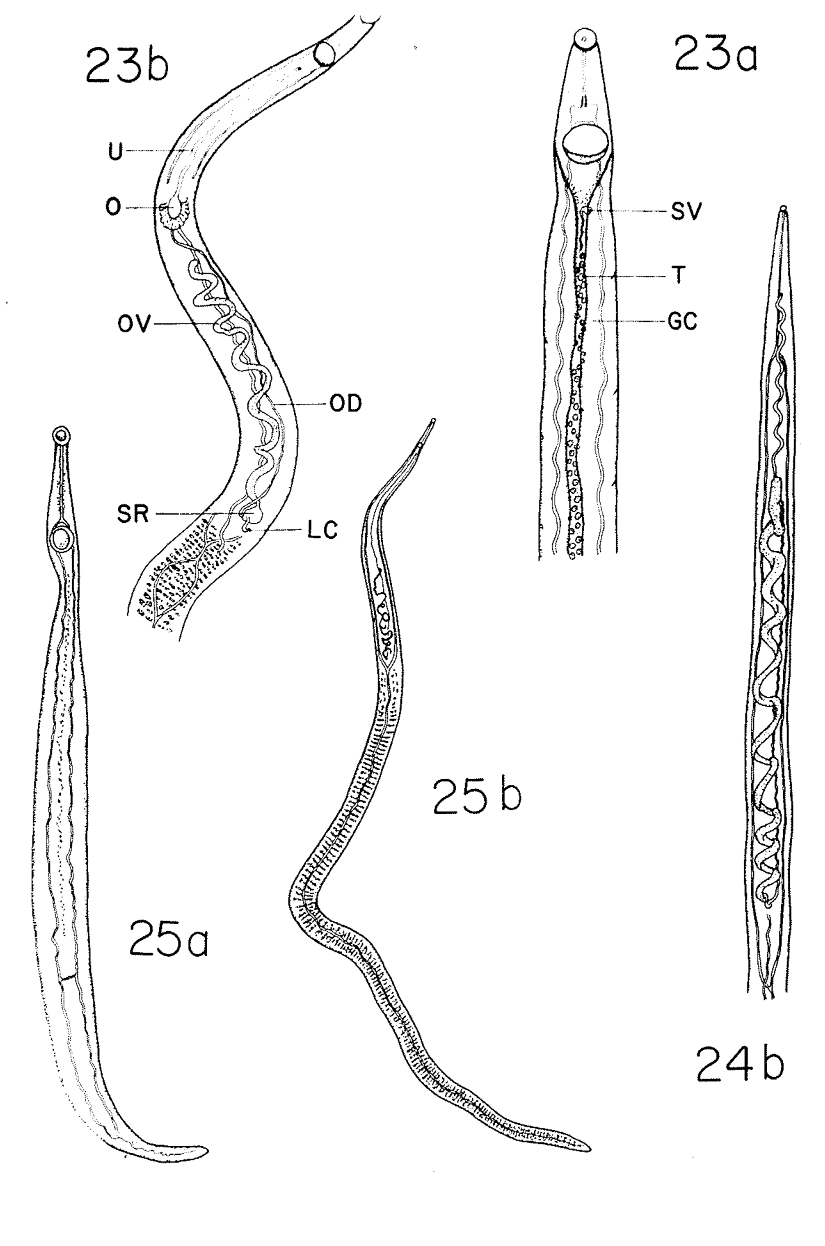
(After McLeod, 1940)

FIGURE. 24. *Ornithobilharzia filamenta.*

(After McLeod, 1940)

FIGURE. 25. *Ornithobilharzia intermedia*

(After Odhner, 1912)


23b
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25b

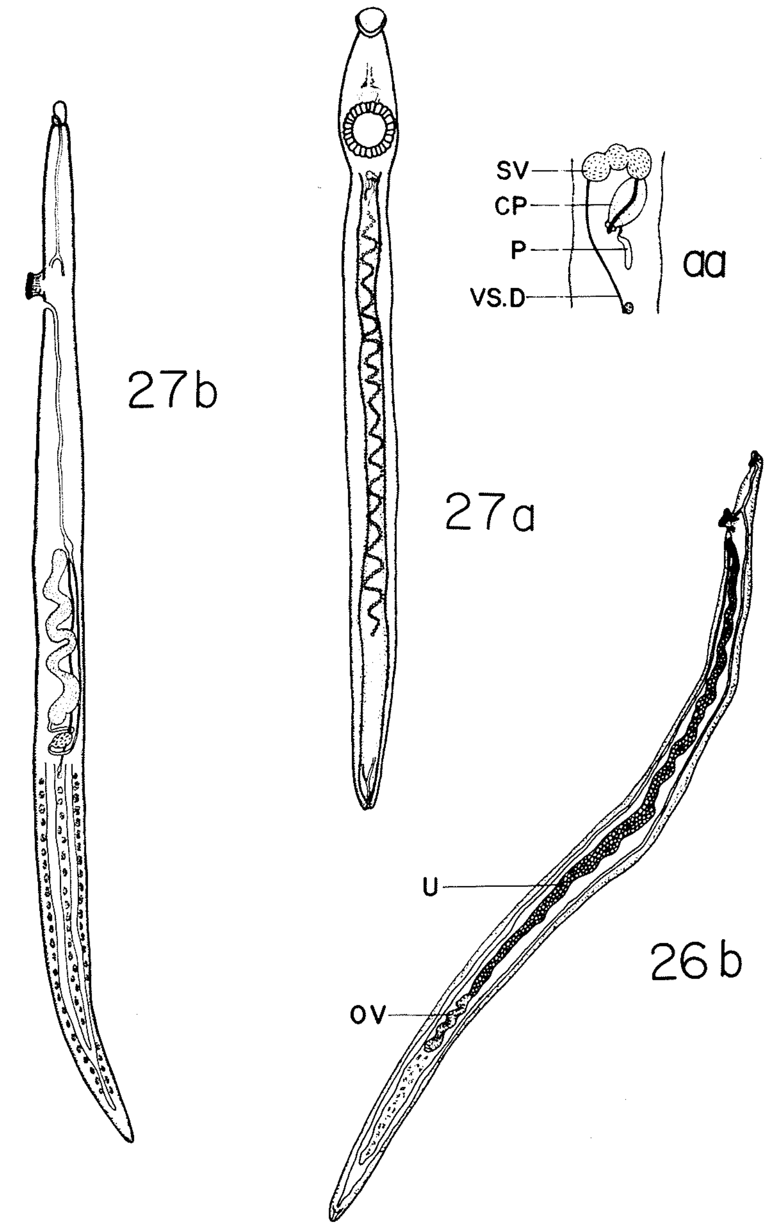
FIGURE. 26. *Macrobilharzia macrobilharzia*

(After Price, 1929)

FIGURE. 27. *Macrobilharzia baeri*

(After Fain, 1955)

aa. Area of seminal vesicle.


27b
27a
SV
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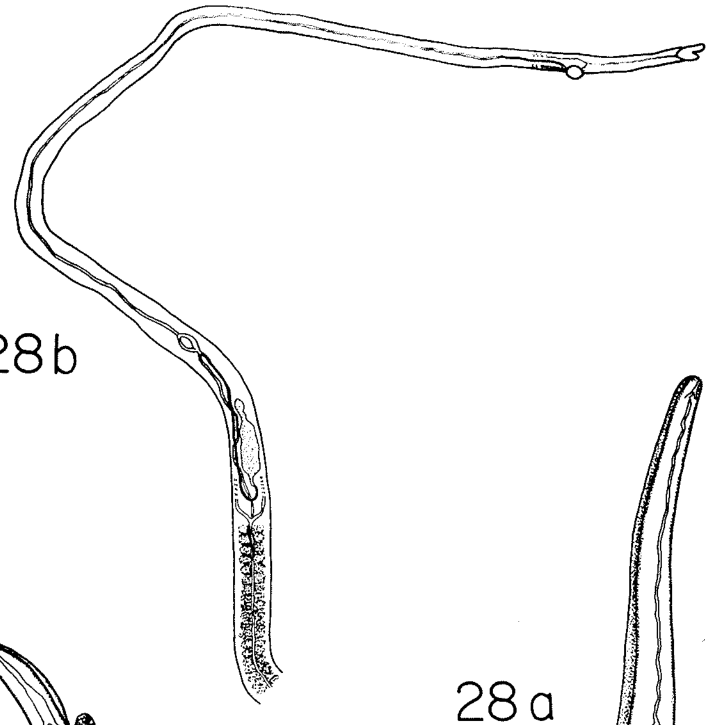
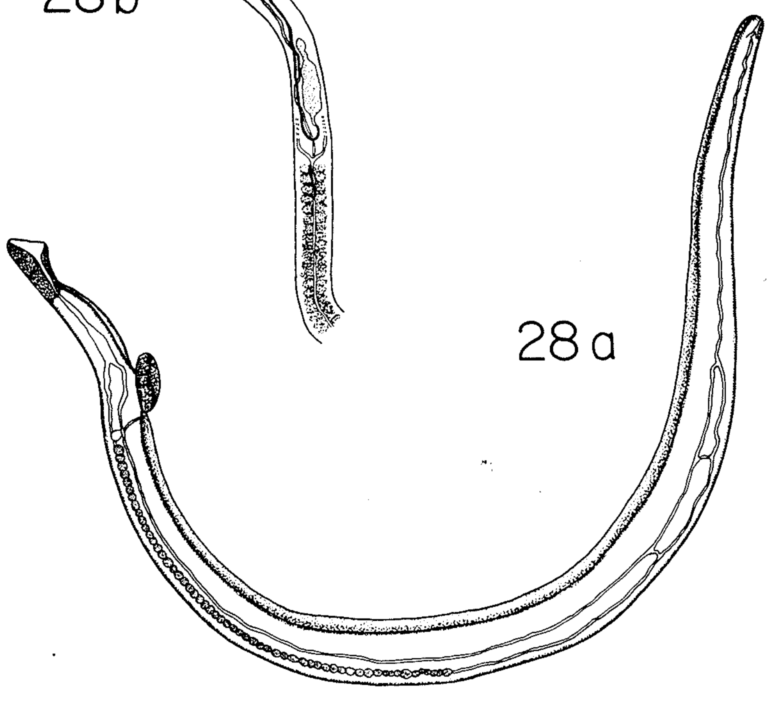
P
VS.D
aa
U
26b
OV

FIGURE. 28. Orientobilharzia dattai.

(After Dutt et Srivastava,1952)



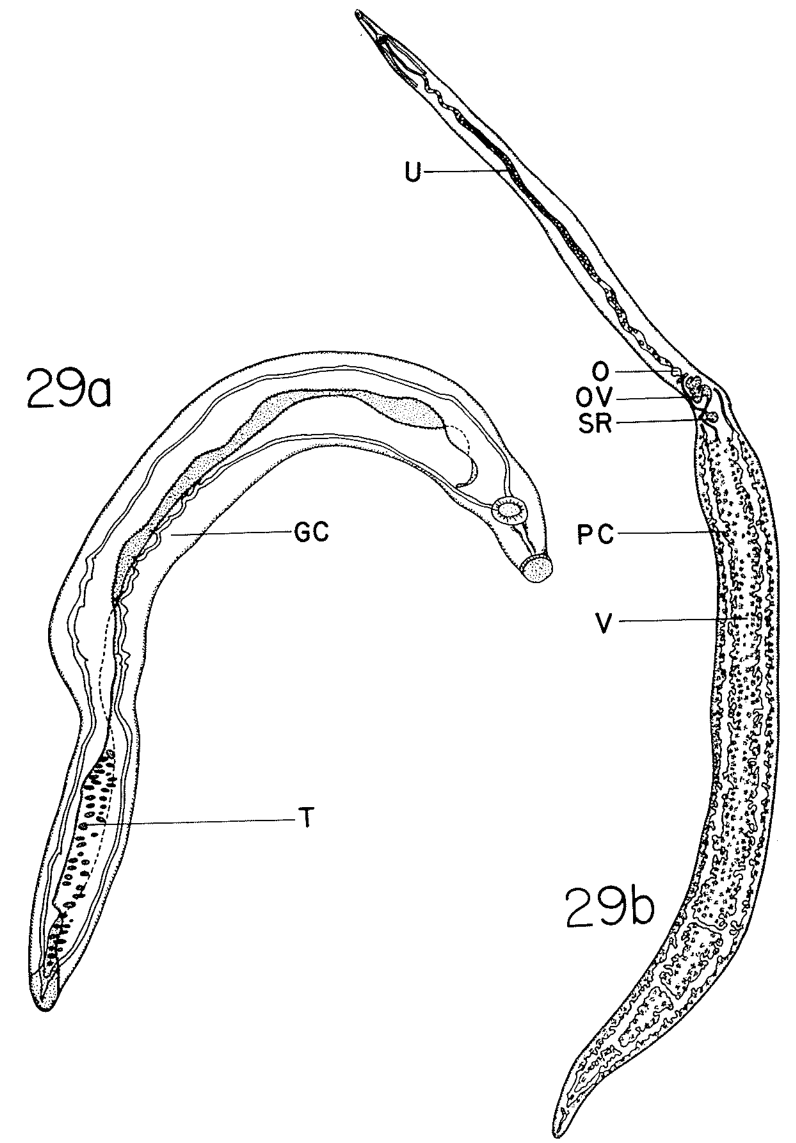
28b



28a

FIGURE. 29. *Heterobilharzia americana*.

(After Lee, 1962)


29a
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29b

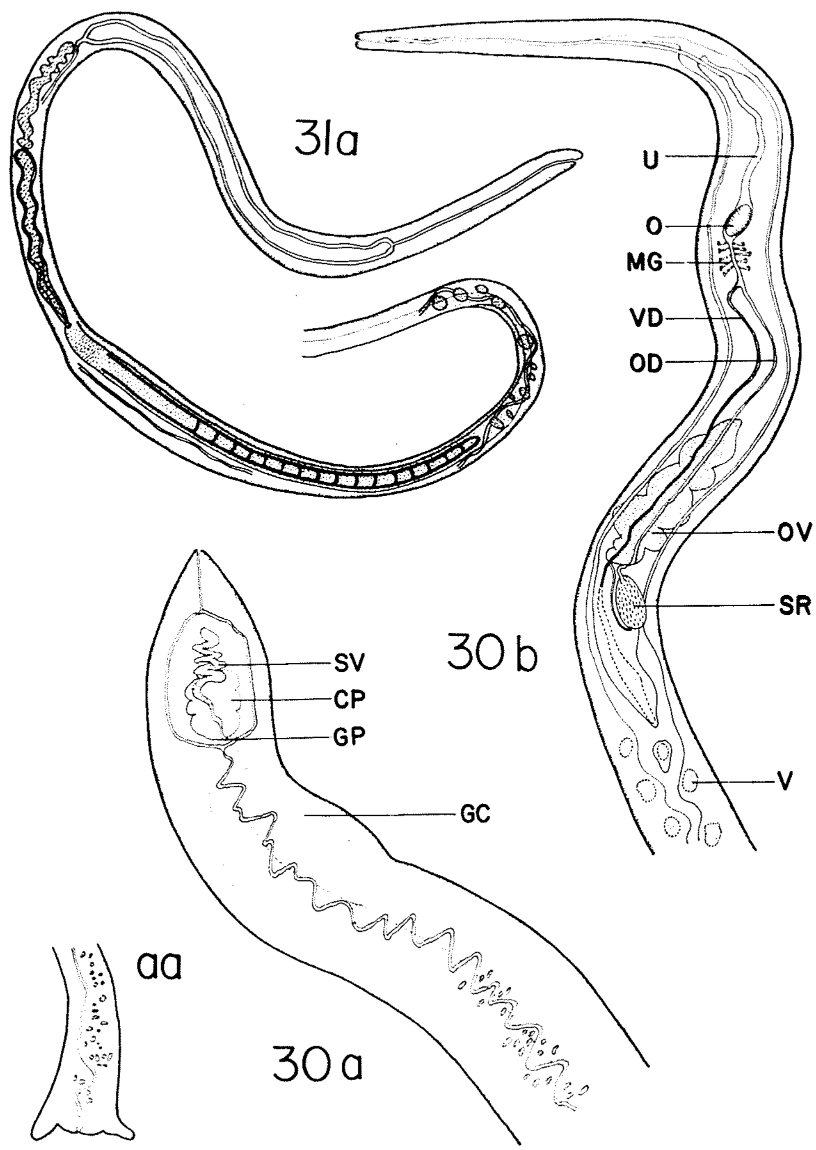
FIGURE. 30. Gigantobilharzia acotylea

(After Odhner, 1910)

aa. Posterior end of male.

FIGURE. 31. Gigantobilharzia adami.

(After Fain, 1960



31a
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30 b
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30 a

FIGURE. 32. *Gigantobilharzia ardeolae*.
(After Fain, 1955)

FIGURE. 33. *Gigantobilharzia huronensis*.
(After Najim, 1950)
bb. Area of Laurer's canal.

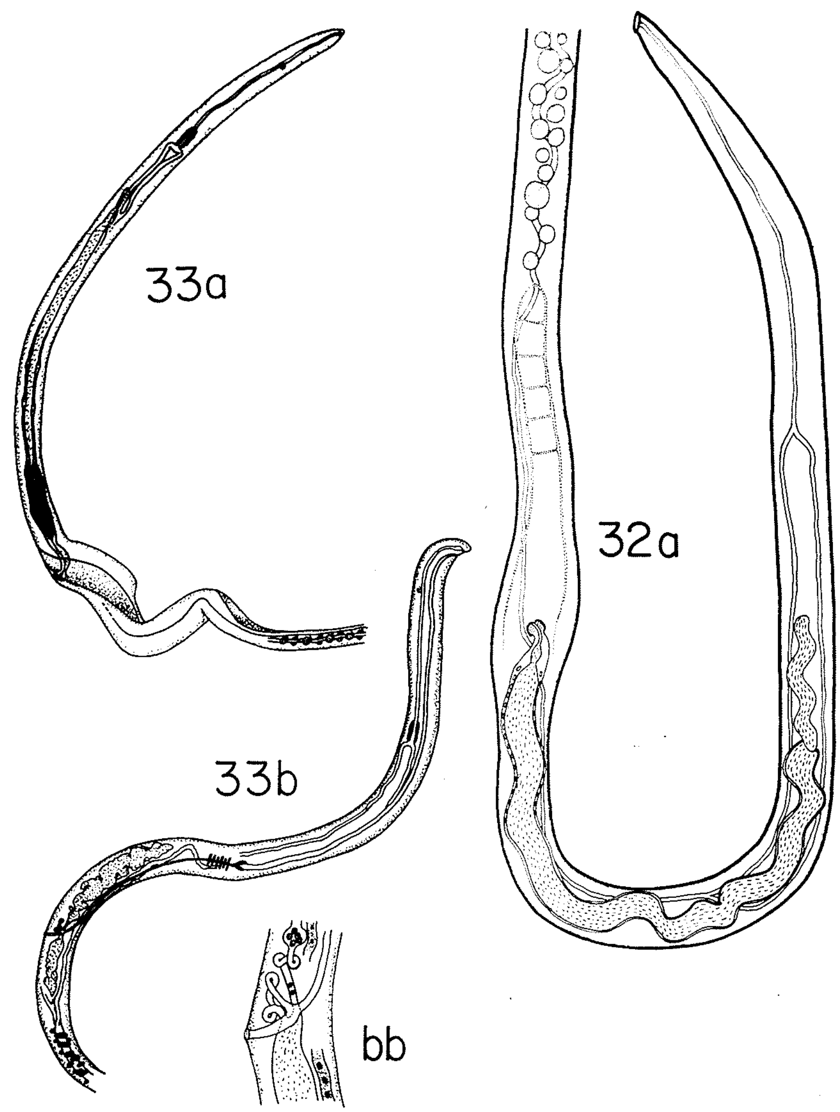

33a
32a
33b
bb

FIGURE. 34. Gigantobilharzia huttoni.
(After Leigh, 1955)

FIGURE. 35. Gigantobilharzia nettapi.
(After Fain, 1960)

FIGURE. 36. Gigantobilharzia plectropteri
(After Fain. 1960)

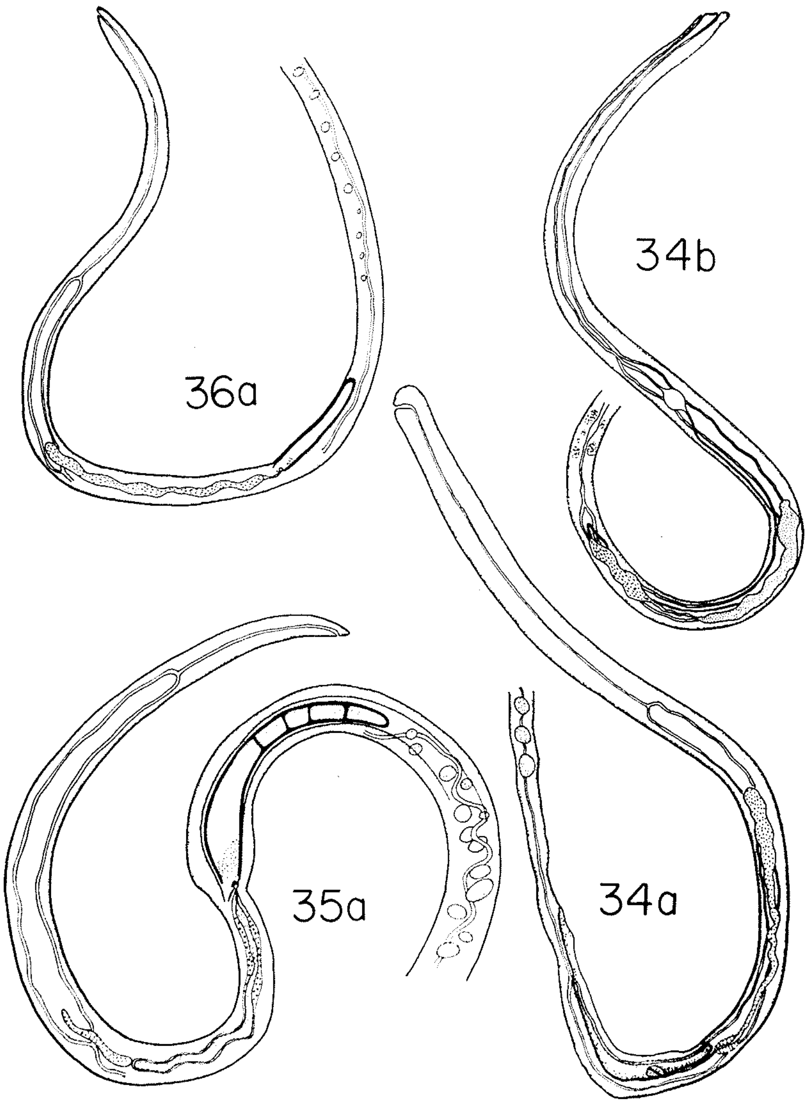

36a
34b
35a
34a

FIGURE. 37. *Gigantobilharzia gyrauli*.
(Male after Brackett, 1942)

FIGURE. 38. *Gigantobilharzia monocotylea*.
(After Szidat, 1930)

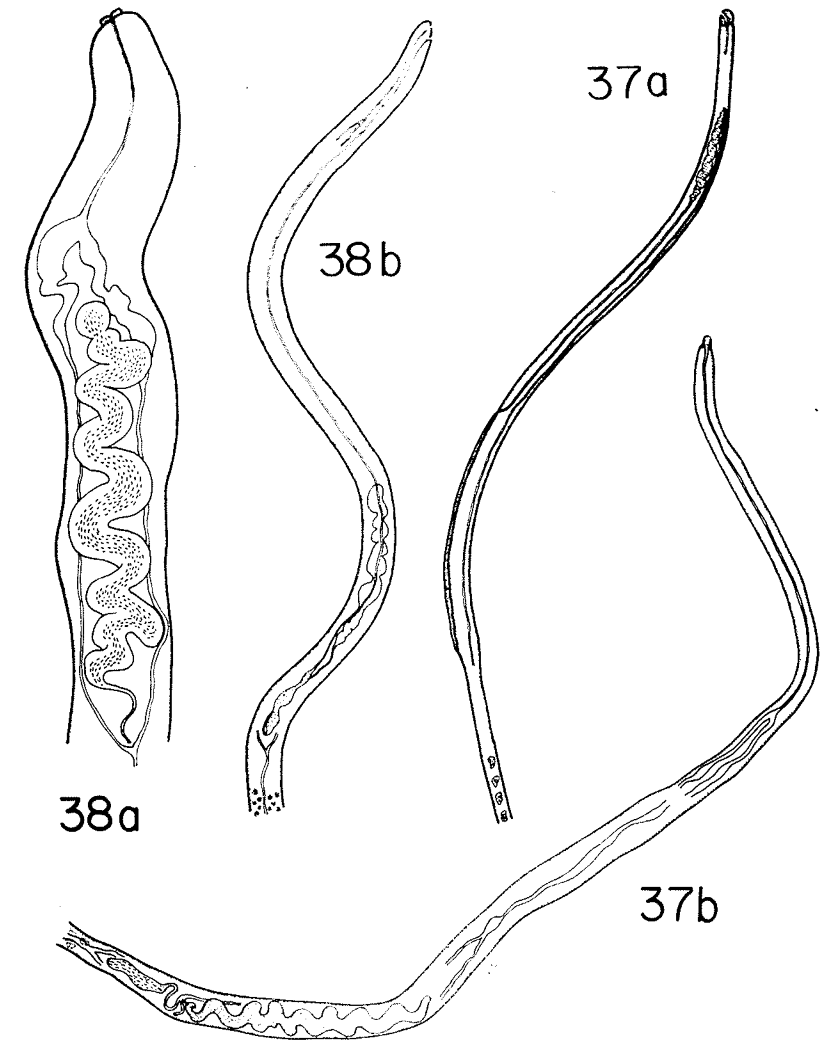

38a
38b
37a
37b

FIGURE. 39. <u>Gigantobilharzia</u> <u>tantale</u>.
(After Fain, 1955)

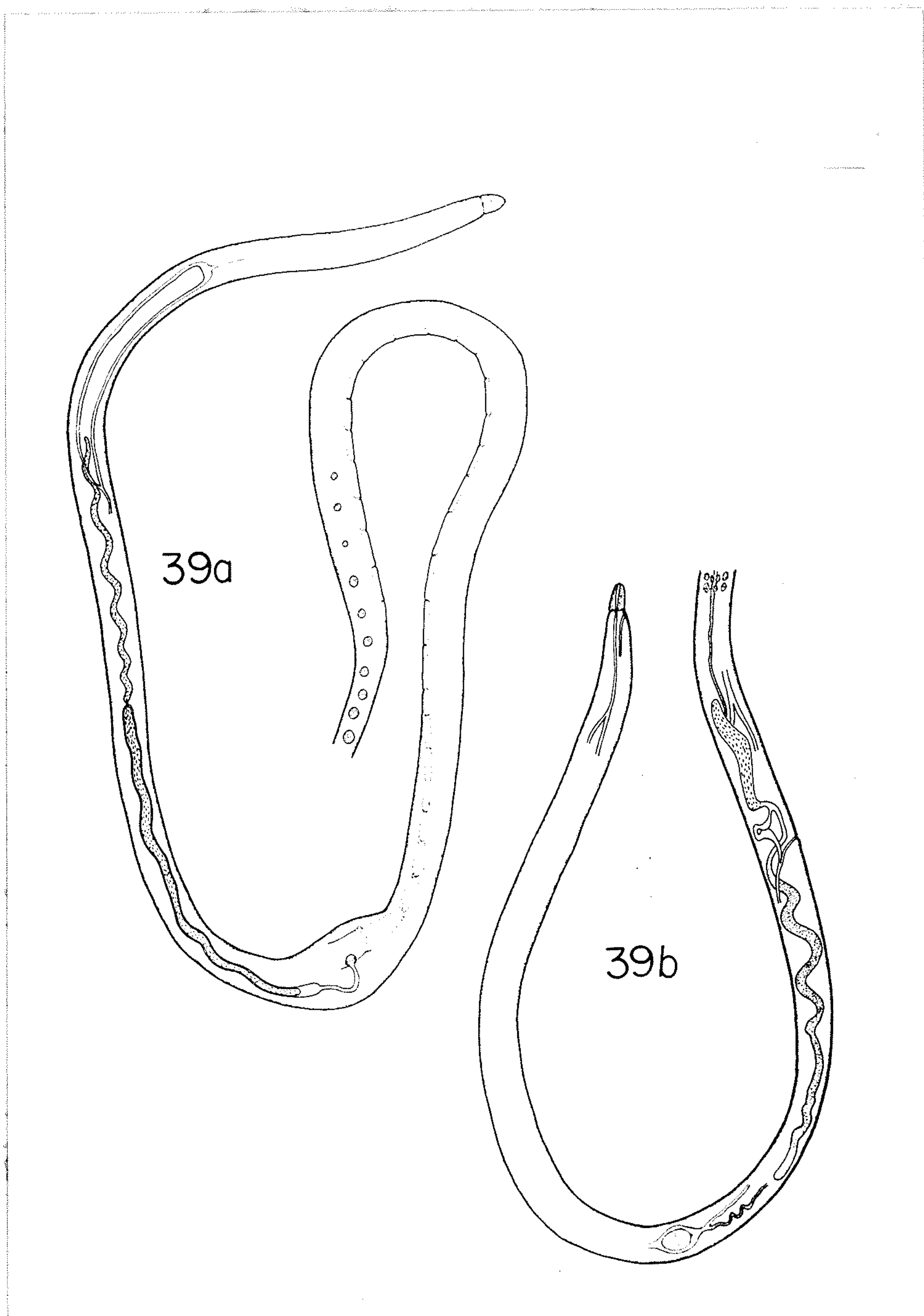
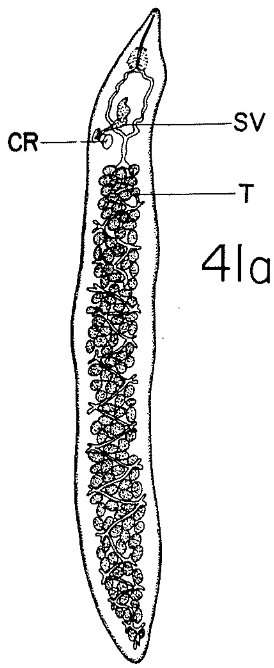

39a
39b

FIGURE. 41. *Dendritobilharzia anatinarum.*

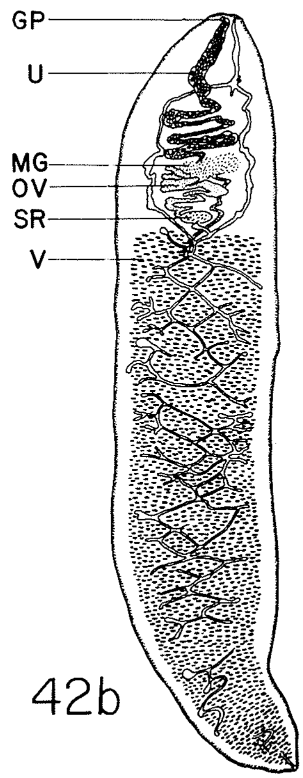
(After Cheatum, 1941)

FIGURE. 42. *Dendritobilharzia asiatica.*

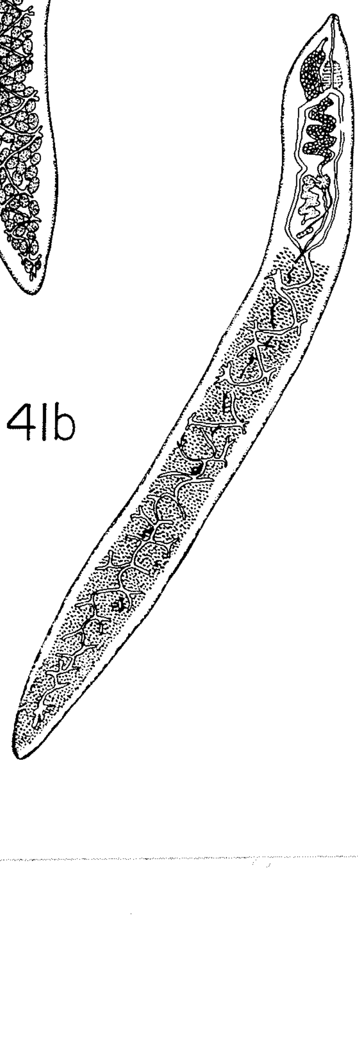
(After Mehra, 1940)



41a



42b



41b

FIGURE. 43. <u>Trichobilharzia adamsi</u>.

(After Edwards et Jansch, 1955)

FIGURE. 44. <u>Trichobilharzia brantae</u>.

(After Farr et Blankemeyer, 1956)

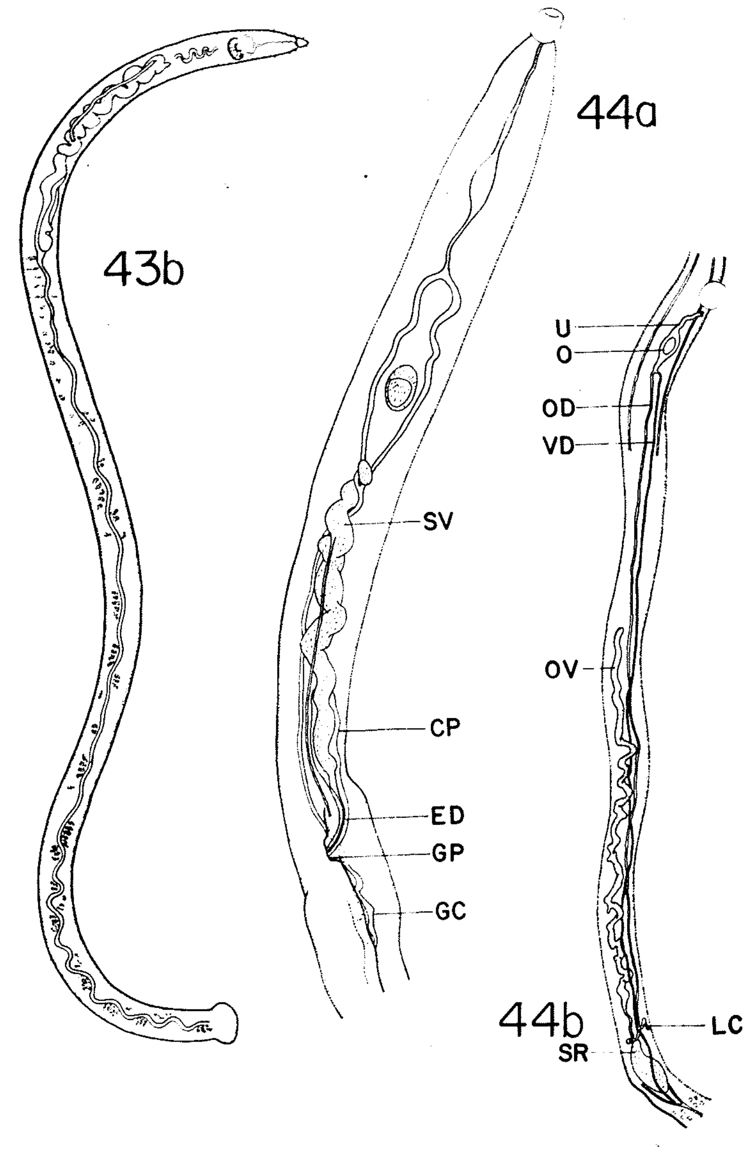

43b
44a
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FIGURE. 45. *Trichobilharzia anatina*.
(After Fain, 1956)

FIGURE. 46. *Trichobilharzia cerylei*.
(After Fain, 1956)

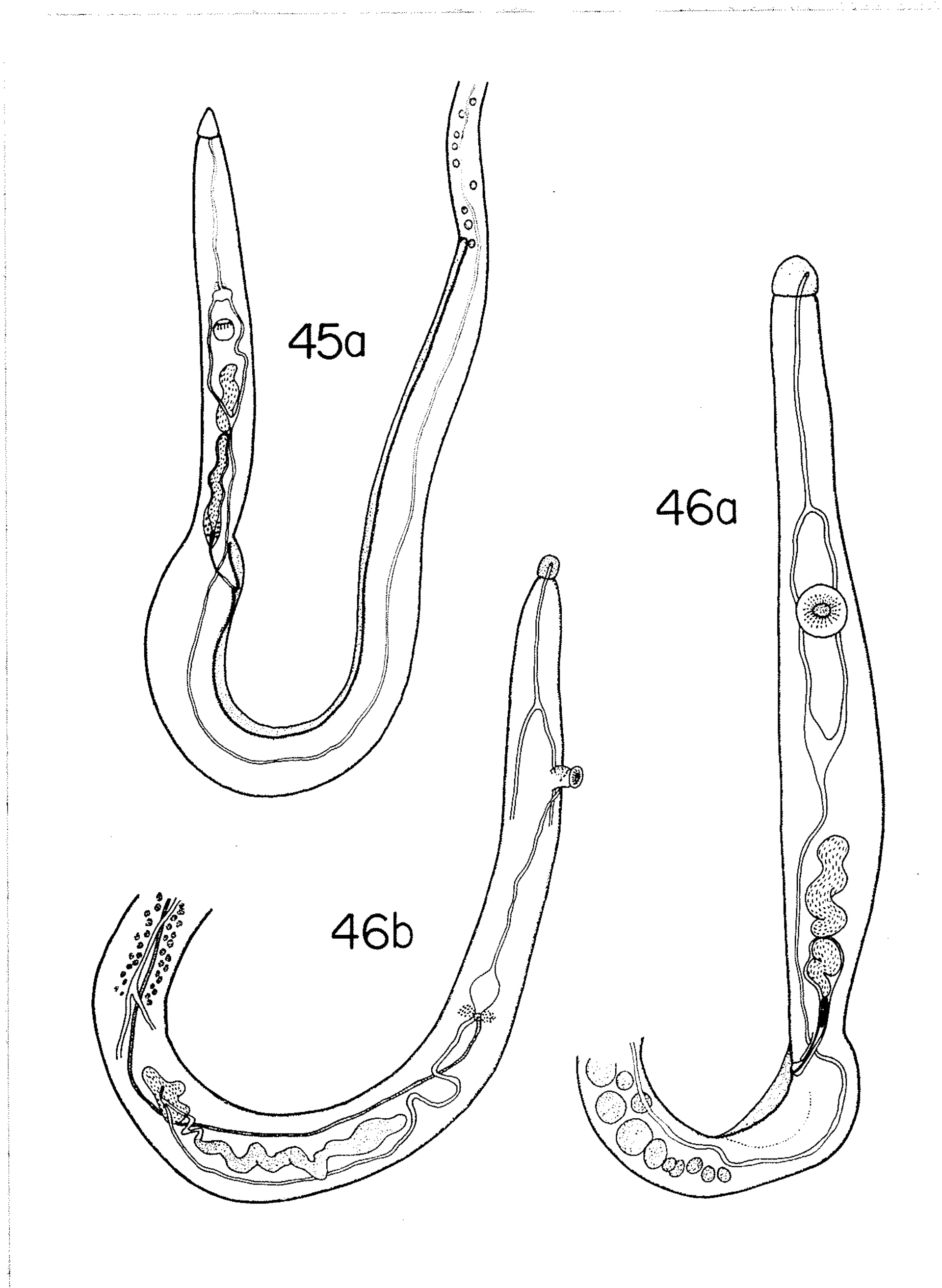

45a
46a
46b

FIGURE. 47. Trichobilharzia berghei

(After Fain, 1956)

FIGURE. 48. Trichobilharzia cameroni.

(After Wu, 1953)

FIGURE. 49. Trichobilharzia waubesensis.

(After Brackett, 1942)

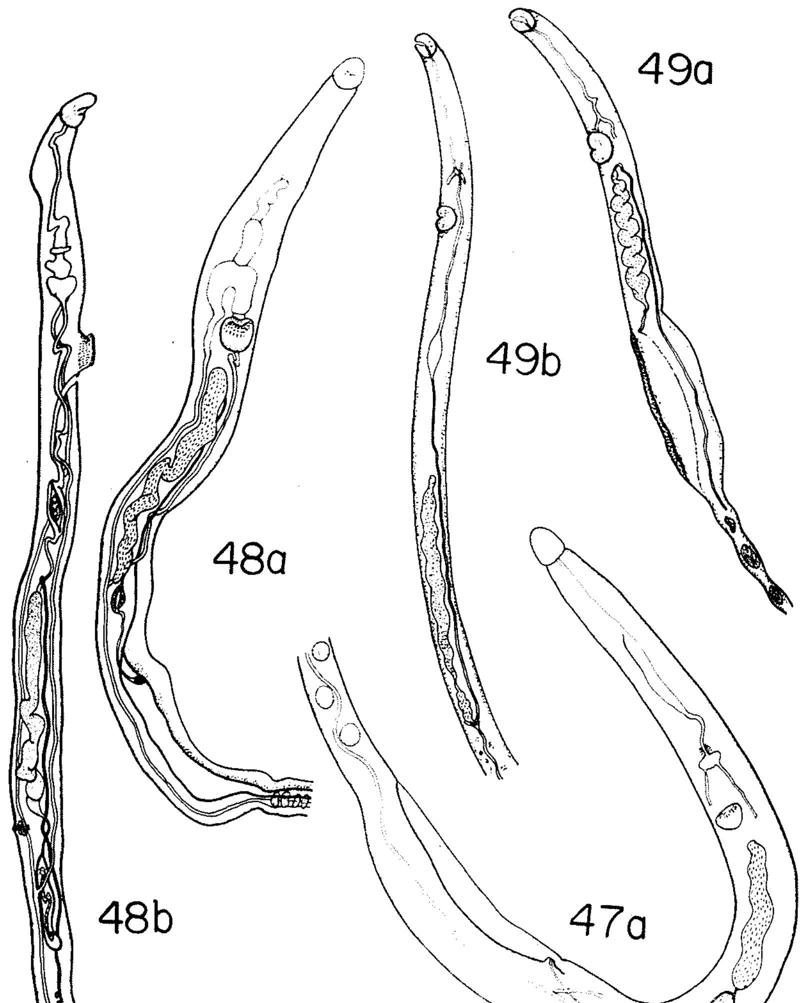

49a
49b
48a
48b
47a

FIGURE. 50. *Trichobilharzia corvi*.

(Male after Yamaguti, 1941; female after description of *Ornithobilharzia emberizae*, Yamaguti, 1941.)

FIGURE. 51. *Trichobilharzia filiformis*.

(After Szidat, 1938)

FIGURE. 52. *Trichobilharzia schoutedeni*.

(After Fain, 1956)

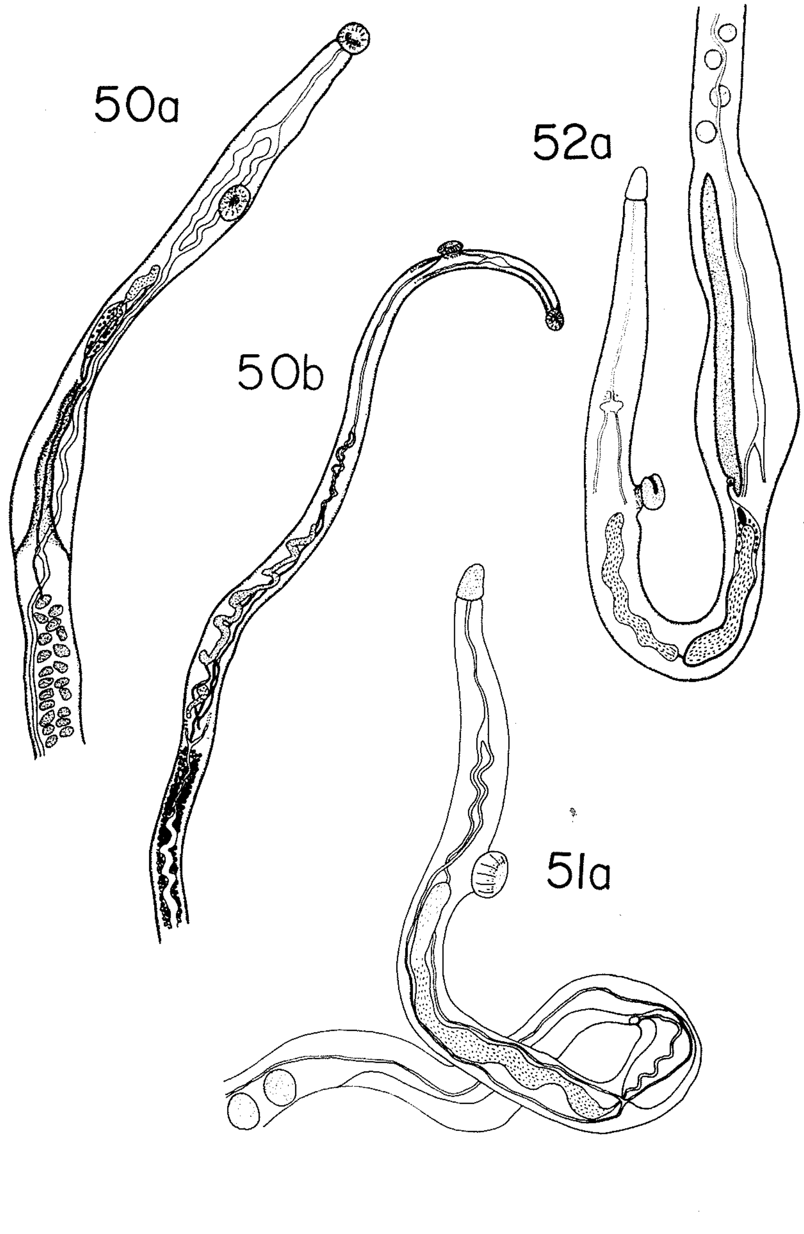

50a
50b
51a
52a

FIGURE. 53. *Trichobilharzia oregonensis*.

(After Macy, 1952)

FIGURE. 54. *Trichobilharzia szidati*.

(After Neuhaus, 1952)

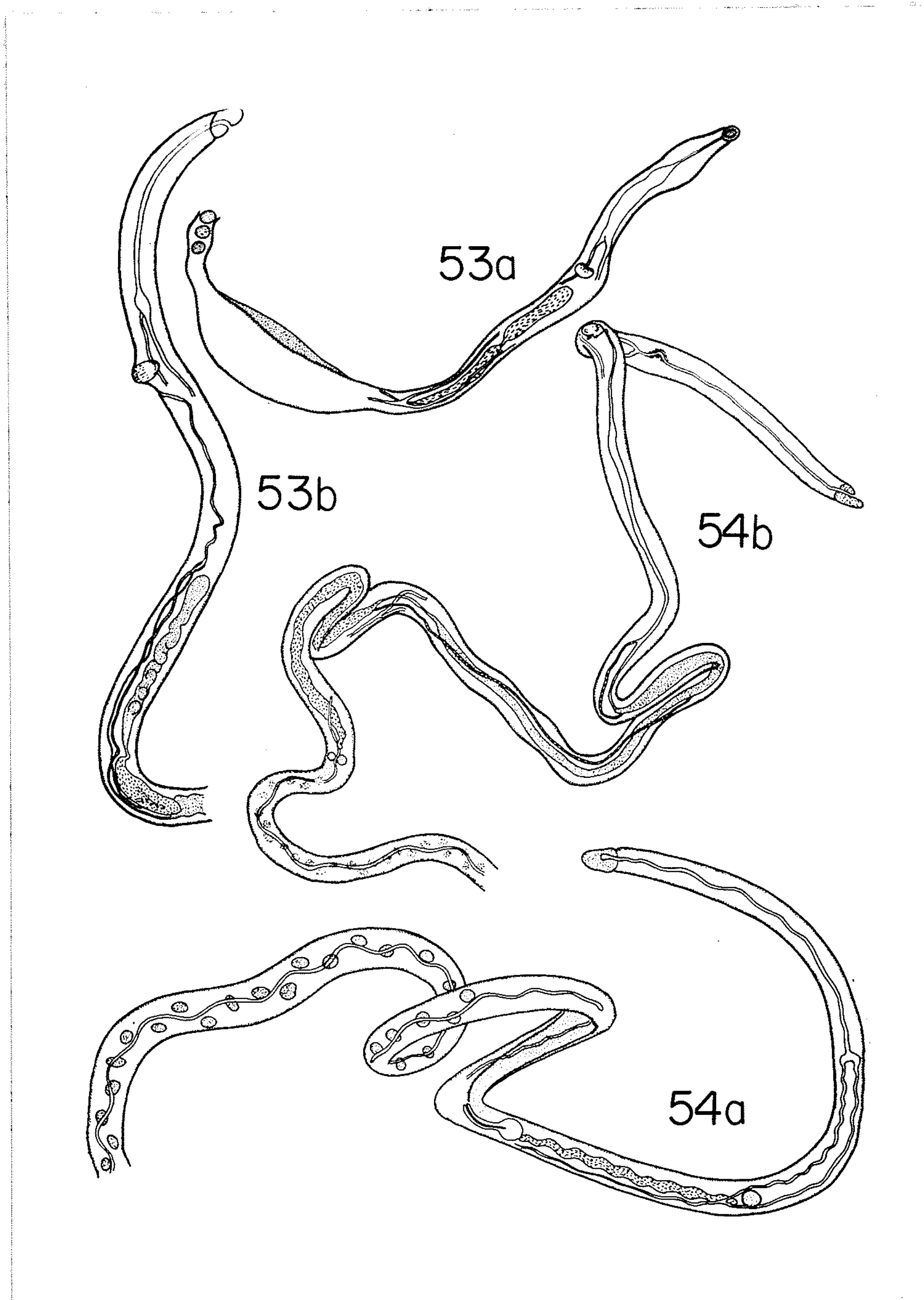

53a
53b
54b
54a

FIGURE. 55. Trichobilharzia aureliani.

(After Fain, 1956)

FIGURE. 56. Trichobilharzia nasciola

(After Fain, 1956)

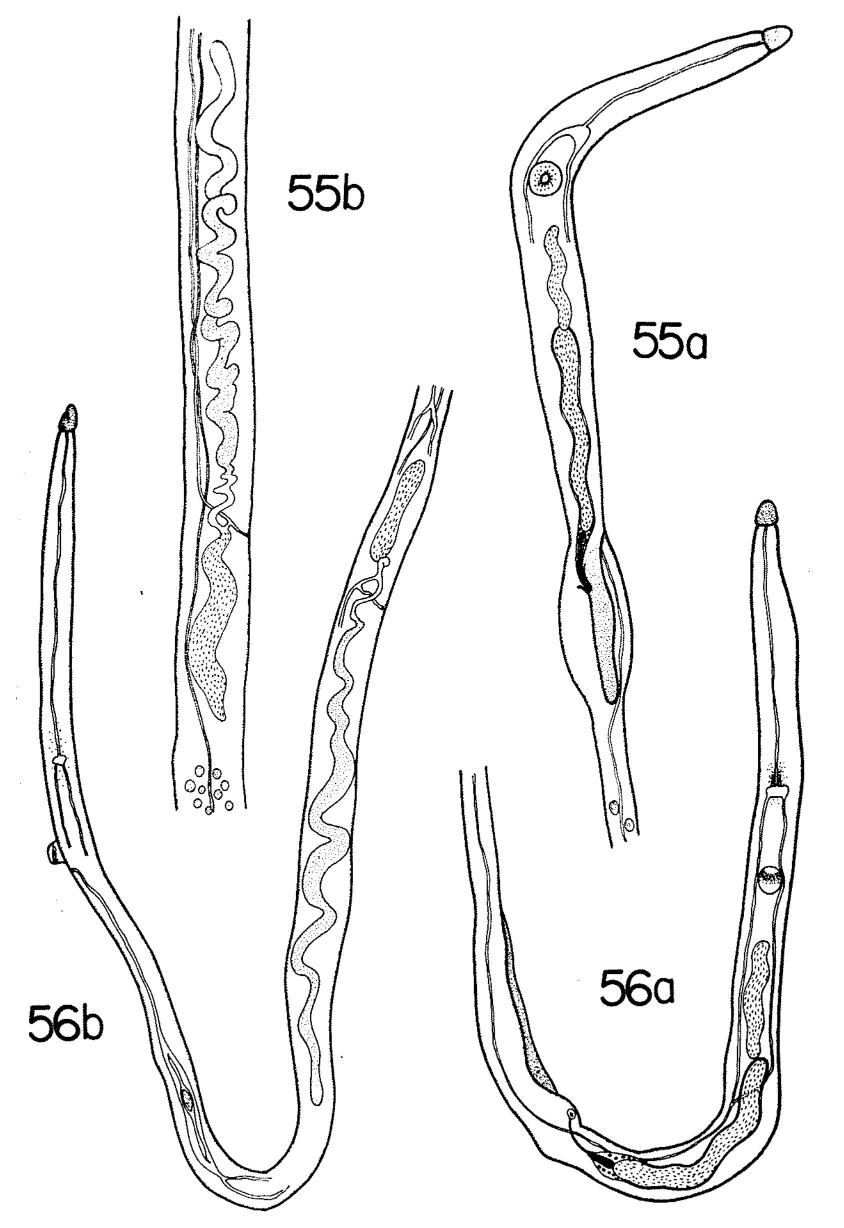

55b
55a
56b
56a

FIGURE. 57. <u>Trichobilharzia rodhaini</u>
(After Fain, 1956)

FIGURE. 58. <u>Trichobilharzia spinulata</u>.
(After Fain, 1956)

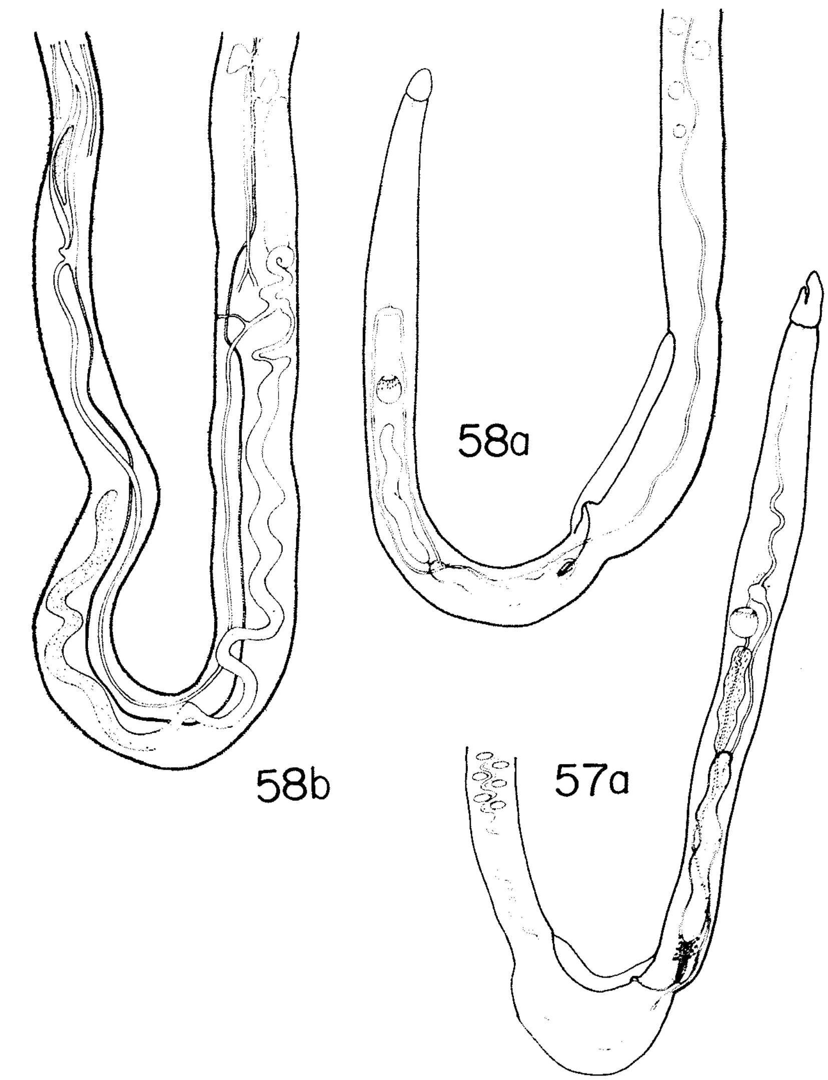

58a
58b
57a

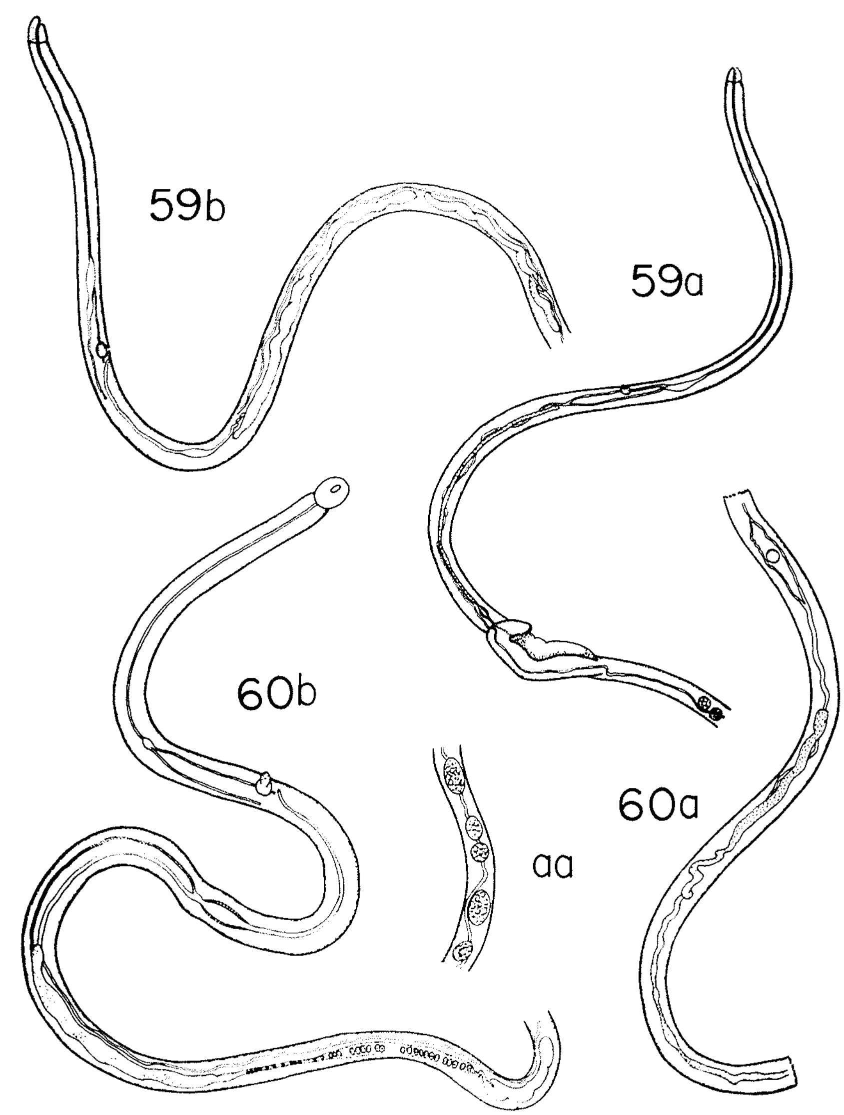
FIGURE. 59. _Trichobilharzia_ _elvae_.

(After McMullen et Beaver, 1945)

FIGURE. 60. _Trichobilharzia_ _stagnicola_

(After McMullen et Beaver, 1945)

aa. Area of testes.



59b
59a
60b
aa
60a

FIGURE. 61. <u>Trichobilharzia</u> <u>kegonsensis</u>.

FIGURE. 62. <u>Trichobilharzia</u> <u>horiconensis</u>.

FIGURE. 63. <u>Trichobilharzia</u> <u>burnetti</u>.

(All after Brackett, 1942)

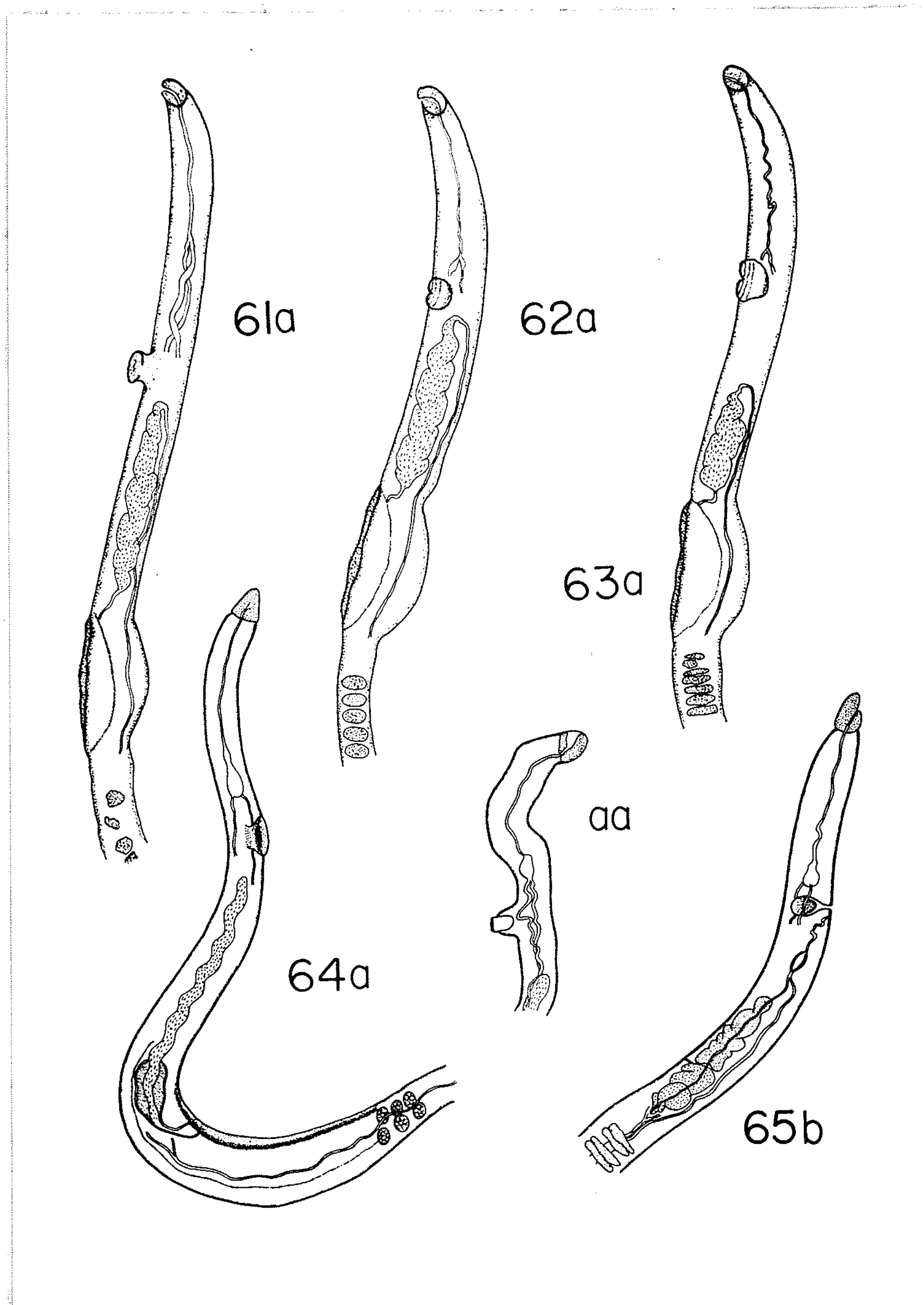
FIGURE. 64. <u>Trichobilharzia</u> <u>querquedulae</u>.

(After McLeod, 1937)

FIGURE. 65. <u>Trichobilharzia</u> <u>physellae</u>

(After McMullen et Beaver, 1945)

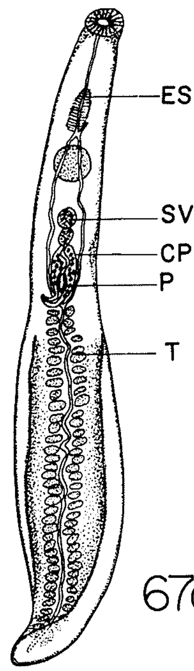
aa. Anterior end of male.



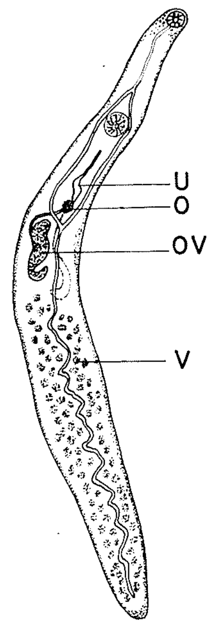
61a
62a
63a
64a
aa
65b

FIGURE. 66. _Bilharziella polonica._
(After Price, 1929)

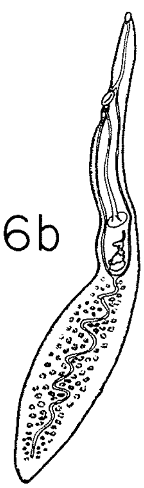
FIGURE. 67. _Bilharziella indica._
(After Lal, 1937)



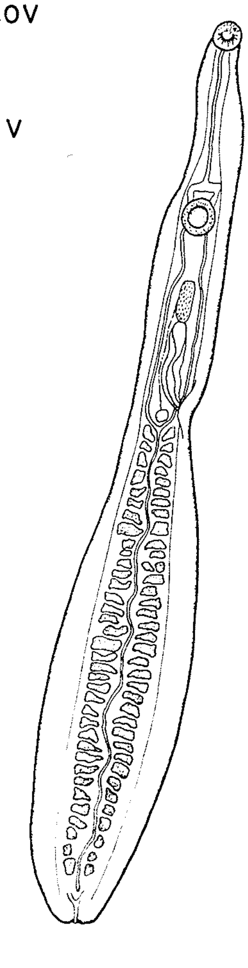
67a



67b



66b



66a

SUMMARY

1. A systematic survey of schistosome adults collected from bird and mammal hosts in Manitoba was made. There were two general areas of collection: in the vicinity of Winnipeg and in Moose Lake, approximately 500 miles north. In all, 431 birds representing 47 species and 34 mammals representing 3 species were examined.

2. Seven adult schistosome species were recovered. These included one new species, *Gigantobilharzia totani*; two species new to Canada, *Gigantobilharzia gyrauli* and *Gigantobilharzia lawayi* the latter of which has been redescribed; and one species new to Manitoba, *Schistosomatium douthitti*.

3. Included in these findings were five new definitive host records.

4. A survey of the larval schistosomes was also made. Seven species of schistosome cercariae were located. These include one new species, *Cercaria ancillariae*; two new varieties, *C. ocellata* var and *C. douthitti* var; one species new to Canada, *C. gyrauli* and one new to Manitoba, *C. douthitti*.

5. One new intermediate host record was included.

6. The life-cycles of *Trichobilharzia querquedulae*, *Schistosomatium douthitti* and *Gigantobilharzia gyrauli* were completed in the laboratory. It was postulated that *T. querquedulae* is not synonymous with *T. physellae*.

7. The growth pattern of *Lymnaea stagnalis* jugularis was determined. It was shown that the snails

overwintered at least twice, contrary to previously held views.

8. The seasonal incidence of *C. ocellata* var and *C. douthitti* in *Lymnaea stagnalis jugularis* was found. In the former the level of parasitaemia fell gradually through the summer, whilst in the latter it reached a peak in August and tended to maintain itself at that level.

9. A monograph on the schistosomes of the world was prepared. Briefly the number of sub-families was reduced to three and their characteristics emended. Although no new genera were erected many species were moved from one genus to another, thus the generic definitions have been amended in many cases. A complete key to each genus is given. A few species with suspect descriptions were removed from the scheme and placed in the *Incertae genoris*. The writer did not feel justified in erecting new genera and even a new sub-family to hold these species. Suggestions of species synonymy have been made. Figures of all known schistosome species have been included.

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