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TITLE LIFE HISTORY OF GIGANTOBILHARZIA HURONENSIS NAJIM, 1950 A DERMATITIS-PRODUCING BIRD BLOOD-FLUKE (TREMATODA-SCHISTOSOMATIDAE)

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LIFE HISTORY OF *GIGANTOBILHARZIA HURONENSIS* NAJIM, 1950

A DERMATITIS-PRODUCING BIRD BLOOD-FLUKE

(TREMATODA-SCHISTOSOMATIDAE)

by

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INTRODUCTION

The study of schistosome worms has interested students of parasitology and workers in the field of medicine for almost a hundred years. Although extensive work has been done on human schistosomes, only little attention has been given to non-human blood flukes, including those in birds. Most of the investigations on non-human schistosomes, including those of birds, were done when it was found that in certain regions some of the non-human schistosome cercariae were responsible for outbreaks of dermatitis commonly known in the United States as "swimmer's itch" or "water itch." For a number of years such a skin eruption among swimmers in certain areas was reported (Naegeli, 1923), but the etiology was not known. Some believed that the organisms responsible for the disease were to be found in green algae, others thought it was due to scabies. Cort (1928), at the Biological Station of the University of Michigan, found that this dermatitis was caused by cercaria elvae Miller, 1923, a non-human schistosome cercaria. Therefore, he called the disease "schistosome dermatitis." Workers in the United States, Canada and abroad soon reported similar findings and more investigations disclosed that a number of non-human schistosome cercariae were responsible for similar skin eruptions. However, Barlow (1936) was strongly of the opinion that the two human schistosomes in

Egypt also produce dermatitis. More work on dermatitis continued to elucidate problems of pathology, control, immunology, and treatment of the disease. As a part of a thorough natural control, studies on the biology and ecology of the intermediate host were carried out, and several life cycles were completed to find out the final natural hosts. Although the "schistosome dermatitis" annoys swimmers only in certain regions, it is in other regions, a serious problem of economic importance. Watson (1950) in his studies on Bilharziasis in Iraq stated, "dermatitis caused by cercariae of non-human species of bilharzia is a problem of grave economic importance, seriously interfering with agricultural activities owing to reluctance of the Felaheen[1] to descend into infected water."

Since the bird blood flukes are members of the same family as human schistosomes, interesting biological aspects as well as anatomical homologies may be disclosed during work on bird schistosomes. In the meantime, because of the similarity in the life-cycle some measures and methods of control might be applicable in both groups.

The problems selected for this thesis were: (1) a study of a schistosome cercaria found in Physa gyrina which appeared very similar to the cercariae of S. douthitti but experimentally failed to infect white mice (Mus musculus L.); (2) to work out the life cycle of this schistosome in the laboratory; (3) to study the morphology and some biological aspects of each stage; and (4) to find the final host in nature.

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[1]Felaheen = Farmers.

HISTORY

Rudolphi in 1819 described the first bird schistosome from Brazil, naming it Distomum canaliculatum, which later became Ornithobilharzia canaliculata (Rud., 1819) Odhner, 1912. Thirty three years later the first human schistosome was reported by Bilharz in Egypt. He named it Distoma haematobium, which later became Schistosoma haematobium (Bilharz, 1852) Weinland, 1858. Kowalewski (1896 a&b) republished and emended his descriptions of Bilharzia polonica. This species became Bilharziella polonica (Kow., 1895) Looss, 1899. Kowalewski, for the first time, made a detailed study of an adult bird schistosome. Parona and Ariola (1896) described another species of bird schistosome from Italy, Bilharzia kowalewskii, which later became Ornithobilharzia kowalewskii (Par. and Ariola, 1896) Odhner, 1912. Looss (1899) established the genus Bilharziella with B. polonica (Kow, 1895) as the type species. At the same time Looss applied the family name Schistosomidae. Braun (1901) added another species of bird schistosome, Bilharziella pulverulenta, which later became Dendritobilharzia pulverulenta (Braun, 1901) Skrjabin, 1924. Poche (1907) changed the name of the family to Schistosomatidae (Looss, 1899).

Odhner (1910) reported the species Gigantobilharzia acotylea, erecting the genus Gigantobilharzia for the newly described species. The same author in 1912 established a new

genus, Ornithobilharzia, describing a new species O. intermedia as the type species and including the species O. canaliculata (Rud.) and O. Kowalewskii (Par. and Ariola) in this newly erected genus. Odhner in the same article gave the family diagnosis as well as the diagnosis of the four genera known up to that time, namely: Bilharziella, Lss., 1899, Gigantobilharzia Odhn., 1910, Ornithobilharzia n. g. and Bilharzia Cobb., 1859. Johnson (1917) erected the genus Austrobilharzia, Describing a new species of bird blood fluke, Austrobilharzia terrigalensis, from New South Wales. Skrjabin and Zakharow (1920) erected the genus Dendritobilharzia, describing a new species, Dendritobilharzia odhneri as the type species. Four years later Skrjabin (1924) recognized that the new species was identical with Bilharziella pulverulenta (Braun, 1901) Skrjabin, 1924. Skrjabin and Zakharow (1920) erected another genus, Trichobilharzia with Trichobilharzia kossarewi as the type species. Travassos (1922) added another record of bird schistosomes by establishing a new genus, Macrobilharzia, with Macrobilharzia macrobilharzia as the type species. Only the male was described. Faust (1924 a) reported Ornithobilharzia odhneri from the asiatic curlew at Peking. In the same year Skrjabin added another species of Dendritobilharzia, D. loossi, from the blood vessels of a pelican.

Chapin (1924) reported the first bird blood fluke from the United States. The newly reported blood fluke was referred to the genus Ornithobilharzia. It was transferred by Price (1929) to his newly erected genus Microbilharzia and was given the

name Microbilharzia chapini. Oiso (1927) described a new species of bird blood fluke, Bilharziella yokogawai and worked out the first life cycle of a bird schistosome. The name of this species was changed by McLeod (1937) to Pseudobilharziella yokogawai (Oiso, 1927). Semenov (1927) claims to have found the female of Brauns B. pulverulenta. Linton (1928) reported another record of bird schistosomes from Woods Hole Ornithobilharzia species. Linton did not allocate the worms beyond the genus because of the unsatisfactory condition of his material.

Price (1929) published his "Synopsis of the Trematode Family Schistosomidae with Description of New Genera and Species," in which he accepted all the above forms excepting Travasso's Macrobilharzia which he regarded as a synonym of Orinthobilharzia Odhner, 1912. That author, in the same paper, erected three new genera and species; Microbilharzia, with M. chapini; Heterobilharzia, with H. americana; and Paraschistosomatium, with P. anhingae. Except for Heterobilharzia, which was a mammal blood fluke, the other two were bird schistosomes. Price also reported Bilharziella polonica from the new world and proposed the new subfamily Bilharziellinae for the species resembling Bilharziella polonica. Subsequently, the same author (1931) after examining a number of specimens, both males and females, of Macrobilharzia was convinced that the genus Macrobilharzia Travassos, 1922 should be revised as a valid genus and Paraschistosomatium was suppressed as a synonym.

Ejsmont (1929) erected the genus Pseudobilharziella from a young male described by Kowalewski (1895, 1896) with Bilharzia polonica. Because of its elongated filiform body and its difference from the typical forms, Ejsmont reorganized it in the newly established genus. In the same year Szidat (1929b) completed the life cycle of B. polonica. Wetzel (1930) described (Ornithobilharzia pricei from the canadian goose. Szidat (1930) added a second species to the genus Gigantobilharzia, describing G. monocotylea. Brumpt (1931) worked out a third life cycle of bird blood flukes, i. e. the life cycle of Trichobilharzia ocellata, and repeated experimentally the life cycle of B. polonica. In India Gogate (1934) obtained two immature male blood flukes from wild ducks which he referred to as Ornithobilharzia sp. McLeod (1936) described two species of the genus Microbilharzia from the canvas-back duck from Canada, M. canadensis and M. manitobensis. The same author (1937) added two new species of bird schistosomes, Pseudobilharziella querquedulae and Ornithobilharzia lari. McLeod (1940) changed the name of the last species to Microbilharzia lari.

Lal (1937) in India came across two blood flukes in birds and these forms were described under the subfamily Bilharziellinae. He created the genus Chinhuta to include one of these forms, describing Chinhuta indica as the type species. The second form, he placed in the genus Gigantobilharzia applying the name G. egreta to the single male specimen which was obtained from the cattle egret (Bulbulcus ibis coromandus).

Young (1937) described an avian schistosome from the marbled godwit (Limosa fedoa), but he did not determine its systematic position. Szidat (1939) reported a new species, Pseudobilharziella filiformis, from the mute swan (Cygnus olor). Mehra (1940) dropped Lal's new genus, Chinhuta and assigned its species to the genus Bilharziella. Thus the species became B. indica (Lal, 1937), Mehra, 1940. Mehra also described a new species of bird blood fluke, Dendritobilharzia asiaticus and raised both genera, Dendritobilharzia and Gigantobilharzia, to subfamily rank.

McLeod (1940) described two new avian schistosomes, Ornithobilharzia aviani and Ornithobilharzia filamenta. He also revised Price's classification (1929) of the family Schistosomatidae because of the discovery of several more species up to that time. At the same time McLeod reviewed the history of the family. In the historical review errors occurred as follows: "Ornithobilharzia intermedia odhner, 1910," which should read Odhner, 1912. Also, "Ornithobilharzia turkestanicum. . . from birds," which should read mammals and "Bilharziella polonica, life history by Brumpt (1931)" which should read Szidat (1929).

Brackett (1940c) referred to an incomplete life cycle of a bird schistosome studied by Beaver and by the author himself. During the attempt to carry through the life cycle only eggs were recovered from the mucosa of the intestine of an experimentally exposed pigeon. The pigeon was subjected to cercariae which were identified later as C. elvae. Brackett mentioned

that he exposed laboratory raised Stagnicola palustris elodes and was able to recover cercariae in forty days. After exposing a number of pigeons to those cercariae he recovered only one adult worm which was not described. He was the first to succeed in partially elucidating an avian schistosome life cycle in the United States. However, Talbot (1936) attempted to work out similar life cycles without positive results. Cheatum (1941) described a new species from the mallard, Dendritobilharzia anatinarum. He also emended Price's subfamily Bilharziellinae and the genus Dendritobilharzia, because of the long coiled uterus which contains many eggs in the new species.

Yamaguti (1941), during his studies of the Trematodes of birds in Japan, came across two new species of blood flukes, Pseudobilharziella corvi and Ornithobilharzia emberizae. It should be mentioned that the first species was not from a true aquatic bird but from the carrion crow (Corvus corone corone L.). Brackett (1942) described five new species of avian schistosomes from the United States: four were pseudobilharziellas; P. Waubesensis, P. Kegonsensis, P. horeconensis, P. burnetti; and one Gigantobilharzia, G. lawayi. He also completed the life cycle of Cercaria gyrauli Brackett, 1940, which turned out to be the cercariae of another species of Gigantobilharzia and so the name became G. gyrauli. This life cycle represents in fact, the first life cycle of a species within the genus Gigantobilharzia and the fourth among bird schistosomes.

McLeod and Little (1942) reported for the first time the female of Pseudobilharziella querquedulae McLeod, 1937. The authors also were able to infect three individual Physella gyrina[1] snails, which they had exposed to the miracidium of P. querquedulae. McMullen and Beaver (1945) succeeded in completing experimentally three life-cycles of three known cercariae, C. physellae Talbot, 1936, C. ocellata (elavae) Lavalette, 1855, and C. stagnicolae Talbot, 1936. The adults were identified as Trichobilharzia and so they became T. physellae, T. ocellata (Lavalette, 1855) Brumpt, 1931 and T. stagnicollae. The authors brought P. querquedulae McLeod, 1937 into synonymy with T. physellae (Talbot, 1936) McMullen and Beaver, 1945. They also considered Trichobilharzia kossarewi Skrjabin and Zakharow, 1920 as a synonym of T. ocellata (Lavalette, 1855) Brumpt, 1931. In the same paper McMullen and Beaver reduced to synonymy the genus Pseudobilharziella Ejsmont, 1929 with Trichobilharzia Skrjabin and Zakharow, 1920, and, without being aware of Mehra's modification (1940) of Lal's genus Chinhuta, they again dropped the genus which had been eliminated by Mehra (1940). Najim (1950, abstract) reported a new species of avian schistosome, Gigantobilharzia huronensis from the goldfinch and the completion of its life cycle. Tanabe (1951) designated Cercaria sturniae as Gigantobilharzia Sturniae Tanabe, 1948, n. comb.

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[1]Physella gyrina is the same as Physa gyrina.

MATERIALS AND METHODS

MATERIALS: Most of the snails used as intermediate hosts during this study were laboratory raised. About 1,000 snails were collected in the field. The snail used was identified as Physa gyrina (Say). Most of the collecting of the snails was from a back-water pool of the Huron River at Delhi, near Ann Arbor, Michigan. The pool is at the edge of a park east of the Delhi Bridge (Sc1 T2S. R5E. S2).

The experimental hosts that were found to be susceptible were chicks and canaries; both were obtained from local dealers in Ann Arbor. Fourteen canaries and thirty-three chicks were used during this work. The canaries were females 3-4 years old; all proved to be susceptible. The chicks were from 2-20 days old and all were susceptible with the exception of the first two chicks which were negative. It is believed that this failure was due to poor technique. White mice (Mus musculus L.), domestic ducklings and a mourning dove (Zenaidura macoura) failed to become infected. Natural final hosts were found by shooting birds, mostly from the same location where the intermediate host was found, (Table 1).

The eggs of the parasite were obtained, usually, from the feces of infected canaries which proved to be a rich source for these ova. Because chicken feces were so much larger than canary droppings the former was rarely used for collecting parasite eggs. Mother sporocysts and daughter sporocysts were

studied almost exclusively from laboratory infected snails. The cercariae were studied from laboratory infected snails as well as from natural infections. The adult worms were obtained mostly from the mesenteric veins around the intestines of the infected birds. A few worms, mostly immature, were recovered from the lungs and the livers of some birds in the early stages of infection. Usually it is difficult to obtain whole specimens but in the course of this work, one young male and four females were recovered entire. One more female was obtained almost complete. Nearly a hundred slides of whole mounts of both sexes were prepared. The anterior part of ter males and twelve females were sectioned, some transversely and others longitudinally. Living specimens were studied also. Hundreds of small fragments were fixed and preserved in 70% alcohol.

EXPERIMENTAL INFECTIONS: Young laboratory raised snails from about 2-4 weeks old were exposed to miracidia recently hatched from the eggs. One of the following two methods was used: (1) The feces of infected canaries usually were collected on wet filter paper on the bottom of the cage. These feces were ground with sand in a mortar and pestle, then placed in a one-liter distilling flask with a vertical side arm as devised by McMullen and Beaver (1945). The mass as diluted with river or spring water until the water filled the neck and the arm of the flask. An envelope of black photographic paper covered the whole flask excluding the side arm which remained uncovered. This arm was exposed to light by placing the flask

with its contents close to an electric light. Within several minutes the hatched miracidia were usually observed in the side arm, showing their phototropic nature. These miracidia were pipetted out with a fine pipette and they were separated, usually, into groups of from 4-6 miracidia in each 10 ml. stender dish. A young snail was then introduced to each dish and the container was filled with spring or river water after a short time and covered. These stender dishes were left from four hours to over-night under an electric light. This same technique was also followed using intestines and livers of infected birds instead of the feces.

(2) The eggs in the feces of the final host hatched without mechanical help by placing the feces in a 75 ml. stender dish containing spring or river water. The eggs hatched but required more time than was the case in the first method. The miracidia were either pipetted out and separated into smaller containers, as in the above mentioned method or a number of young snails were placed in the dish containing feces and left covered for a few hours. This rough method of exposure was followed when the purpose of exposing was to keep a stock of infected snails in the laboratory. The percentage of infection in the laboratory was 68.5% (taken from 274 surviving snails) and the percentage in nature during the summer was 5% (taken from 256 surviving snails).

The exposed snails were kept in culture dishes in an aquarium room. These containers were of 2500 ml. capacity or

larger and they were half filled with dechlorinated tap water. In each dish 7-14 snails were usually placed. The snails were fed soaked dried maple leaves. A small amount of calcium carbonate on the tip of a small spatula was added to each dish every 5-7 days. Later this food was replaced by preserved strained spinach. A small amount of spinach, on the tip of a small spatula, was added to each culture dish with half this amount of calcium carbonate. S. Hunt (personal communication) first used this food along with other preserved foods for his sphaeriid clams. At the end of every two days the water was changed and new amounts of spinach and calcium carbonate were added. This food was found to be convenient, since it is always available, does not require much space for storing, and needs no preparation whereas dry maple leaves take about one month of soaking and several water changes before they were ready to use. It is also true that in using the spinach food one can avoid losing small snails which are usually hidden between the maple leaves and may be thrown away when the leaves are changed. The spinach-food was found to be useful for raising Helisoma trivolvis and Lymnaea palustris in the laboratory and one generation of these species was raised from egg to egg. However, in the case of Lymnaea palustris lettuce leaves were used occasionally.

Chicks and canaries were infected by exposing them repeatedly to a heavy suspension of cercariae (McMullen and Beaver 1945). A total of about 550-1400 cercariae were used

for each bird. Smaller numbers of cercariae were usually used for canaries and larger numbers for chicks. The author was able to infect one canary by exposing it only once to about 550 cercariae for 20 minutes. The feathers, if present, were removed from the abdomen and the bird was placed in infested water in 500 cc. or 1,000 cc. beakers. The beakers were covered and placed in a warm water bath. The infested water in the beaker was allowed to come in contact with the abdomen of the exposed bird. The exposure usually was for 20-45 minutes. At the end of each interval of exposure the bird was carried back to its cage and left to dry.

In nature one male goldfinch (Spinus tristis tristis) was found to be infected bisexually. Another male cardinal (Richmondena cardinalis) was found infected unisexually and only one female was recovered from the small veins around the intestine. No eggs were found in the intestinal wall or liver. The seminal receptacle of the female worm was empty.

The parasite eggs were found in great numbers in the lumen and mucous layer of the intestine of the goldfinch and it was possible to complete the life cycle from these eggs by infecting the snail host, canaries and chicks.

Technique: The adult worms, as was mentioned previously, were usually obtained from the small veins around the intestine of the infected birds from a region shortly posterior to the duodenum to the pyloric caeca. Occasionally worms were recovered from the pyloric caeca of chicks. Fine needles were used

for recovering the worms from the intestine. The needles were made of fine (No. 10) sewing needles, inserted in a soaked wooden rod. The blood vessels, containing the worms, were dissected carefully in a spot close to the middle of the body of the worm and the needle was inserted carefully in the loop made by the freed part of the body of the worm. The worm was then pulled out gently. It is not claimed that this is a perfect technique for recovering these fragile worms but it helped in recovering long pieces and sometimes the whole worm. The technique was more successful when the worm was in a larger vein and not penetrating deeply in the small veins of the muscular layer of the intestine. The recovered worms curled up outside the host blood. Neither cooling in the refrigerator nor the use of menthol were successful in relaxing the worms. At about the time of death the worms relaxed. The adult worms were fixed in hot Bouins or hot A. F. A. and the paraffin embedding techinque was followed for sectioning. Delafield's haematoxylin, Mayer's paracarmine and Mayer's HCl carmine were the stains used for the whole mounts. Mayer's HCl carmine and Heidenhain's haematoxylin were the stains used for the sectioned specimens. Eosin, fast green and indulin were the counterstains used. Graded ethyl alcohol and xylol were used for dehydration and clearing. However, terpineol was found to be useful as a clearing agent, since the body of the worm is fragile and cannot stand too much hardening caused by xylol. Measurements of the whole worms were

taken by drawing the outlines of the worm with the aid of a microprojector. By using a universal map measuring instrument the original length was calculated. Fine wire was applied instead of the universal map measuring instrument in cases where the latter was difficult to apply. One entire female was not measured because it was too badly looped.

The eggs were studied living in .940% saline solution, physiological saline solution and in spring water. The latter was used for studying hatching activities. The location of the eggs in the intestinal tissue was studied from sections of those tissues.

The miracidium was studied in living condition without stains or with vital stains. These were neutral red and nile blue sulphate. It was possible in this way to study most of the internal structures. Silver nitrate (LaRue's unpublished technique with modifications) was useful for studying the epidermal plates and some other external structures, i. e. excretory pore, bristle patches and papillae. Carnoy's was used for fixing and affising the miracidia on the slides (suggested by S. Hunt). Boiling formalin 10% was used for fixing specimens to be measured. Delafield's haematoxylin, Mayer's HC and Mallory's triple stain were used for staining permanent mounts of the miracidia for further anatomical structures. The miracidium also was studied both living and in serial sections after penetration into the snail tissue.

Mother and daughter sporocysts were studied living, in permanent mounts and in sections. Neutral red and nile blue

sulphate were used for living specimens. Delafield's haematoxylin and Mayers's HCl carmine were used for the permanent mounts.

The cercaria was studied, living, in dechlorinated tap water, for the excretory system. Saturated aqueous alizarin, neutral red and nile blue sulphate were the vital stains used in studying the living cercariae. Permanent mounts were made of cercariae shed from the snails and of those dissected from the snails. These cercariae were stained with Mayer's HCl carmine, Harris'haematoxylin and Delafield's haematozylin. The two latter haematoxylins were also used for staining sections of the cercariae inside the snails. Cercariae were measured after fixation in boiling formalin (10%).

TABLE 1

WILD BIRDS EXAMINED

Date	Birds	Sex	Number	Locality	Infection
7/22/49	Field sparrow (Spizella pusilla pusilla.)	-	1	Jackson Road	C
	Kingbird (Tyrannus tyrannus)	Male	1	Jackson Road	C
6/30/50	Song sparrow (Melospiza melodia)	Males (4) Female(1)	5	Livingston County	C
7/1/50	Cowbird (Molothrus ater ater)	Female	1	Delhi	C
	Robin (Turdus migratorius)	-	2	Delhi	C
	Wood pewee (Contopus virens)	-	1	Delhi	C
7/21/50	Goldfinch (Spinus tristis tristis)	Male	1	Delhi	+
	Catbird (Dumetella carolinensis)	-	2	Delhi	C
	Robin (T. migratorius)	-	2	Delhi	C
7/28/50	Cardinal (Richmondena cardinalis)	Male	1	Delhi	+
	Downy woodpecker (Dendrocopos pubescens)	-	1	Delhi	C

The total number of wild birds examined was 18. Two species were found to be infected with this particular parasite. Both infected birds belong to the family Fringillidae.

THE ADULT

Adult worms of Gigantobilharzia huronensis are elongate, filamentous and with fragile bodies. Males and females are almost alike in diameter and the females are longer than the males. Oral and ventral suckers are absent from both sexes (Figs. 20, 23) and very small papilae are present on the anterior end of both males and famales (Figs. 1, 3). Adult worms were never seen in copula. Both sexes were usually found scattered along the small intestine, in the small veins. Eggs were found in the feces of the definitive host as early as 31 days after the first exposure. However, two sexually matured worms, male and female, were found 26 and 27 days after the first exposure, but they might hot have reached their maximum length.

Specimens of the adult worms were catalogued as follows: U.S.N.M. Helm. Coll. No. 37334, paratypes, male fragment and a female, from chicks.

THE MALE: The thread-like male is attenuated anteriorly and ends bluntly posteriorly (Fig. 20). A short gynaecophoric canal is present (Fig. 1). No lateral expansions were observed at the posterior end (Fig. 2). The length of one young male (26 days old) is about 9.6 mm. The following measurements were taken from the anterior part of eight males recovered from intestinal veins of chicks; all the worms were fixed in hot Bouin's. The width of the body anterior to the gynaecophoric canal, in the region of the intestinal caeca,

averaged 51 μ, ranging from 42μ-54μ. The width of the body posterior to the gynaecophoric canal averaged 40μ, ranging from 34μ-47μ. The length of the canal averaged about 1084μ, ranging from about 795μ-1550μ and the width averaged 70μ, ranging from 54μ-82μ. The canal is short compared to the length of the body of the male but is, more or less, well formed and defined, and muscular in structure. The cuticle is devoid of spines. The brain is located about 188μ from the anterior end, on the dorsal side of the worm pushing the esophagus into a small curve in this region. The brain is usually seen as a lightly stained mass of very fine fibers (Fig. 1). Neurons were occasionally observed among the body tissue, darkly stained in sectioned specimens. The digestive system consists of a mouth, esophagus, short intestinal caeca and a long common intestine. The mouth is subterminal and opens into a shallow buccal cavity which extends to the anterior end of the body (Fig. 5). The esophagus averaged 478μ in length ranging from 375μ-690μ and is weakly muscular in structure. It attaches to the intestinal caeca through a sinus-like connection, made of the union of the intestinal caeca. Esophageal glands surround the esophagus for a short distance anterior to the junction of the esophagus with the intestine (Fig. 1). They usually take more stain than the surrounding tissues. The intestinal caeca bifurcate for a short distance and were difficult to see in many specimens. It was possible to see them clearly enough to measure in only five worms. The intestinal bifurcation of two

worms recovered from chicks measured 170μ and 289μ. The intestinal bifurcation of two worms from the intestinal veins of the canary measured 143μ and 323μ, and one from the goldfinch was 374μ. The large range in measurements, even among specimens from the same host, may be due to difference in the age of the worms. The intestine after the short bifurcation reunites and extends as a single common intestine following a zig-zag course and ends a short distance from the posterior end of the body (Fig. 2). The excretory pore is terminal posteriorly. The reproductive system of the male consists of a large number of testes, vasa efferentia, vas deferens, seminal vesicle, prostate, ejaculatory muscle, ejaculatory duct, cirrus pouch and a spiny cirrus (Figs. 1, 6). The testes are rounded to broadly oval in shape when fully developed, usually set close together in almost a lineal pattern, alternating with the wavy intestine. The testes are numerous in number (300± in a young male) and start shortly anterior to the posterior end of the gynaecophoric canal and extend posteriorly to a point near the posterior end (Figs. 1, 2). The greater diameter of 25 testes averaged 35μ. Each testis is connected dorsally to a fine vas efferens which passes around the posterior of the testis and connects with the single vas deferens (Fig. 1). The vas deferens is usually located ventrally in the region of the testes and is about 4.5μ in diameter. It extends anteriorly, passing dorsal to the seminal vesicle, to a point about 607μ from the anterior end of the worm where it turns posteriorly as a dilated

seminal vesicle. The seminal vesicle is a large, elongated, sac-like structure, extending posteriorly in a looping manner. It is about 750μ in length and is made of two parts, a short thin walled portion and a long thick walled posterior part. The seminal vesicle is weakly muscular. The prostatic part averaged about 170μ in length made of glandular cells surrounding the lumen of the sperm duct. The prostate glands are surrounded, and in direct contact with a thin wall-membrane which is differentiated directly at the beginning of the prostate region. This membrane constitutes the cirrus pouch, extending posteriorly and covers the ejaculatory muscle and the ejaculatory duct. There is a space between the cirrus pouch and the ejaculatory duct itself with nuclei of an undetermined function (Fig. 6). At the posterior end of the prostate is the ejaculatory muscle. This muscle is well-developed and was seen in almost every specimen. Its greater diameter averaged 22μ and is surrounding the sperm duct. The ejaculatory duct is a rather thick walled canal, extending to the genital pore and ends in a large spiny cirrus (Figs. 6, 21). The cirrus is usually situated on the left side at the beginning of the gynaecophoric canal. Sperms were observed coming out through the cirrus in great number in living specimens. This might be caused by the pressure of the cover slide.

THE FEMALE: Three entire females were obtained from chickens. Fixed in hot Bouin's, they measured 16 mm., 18 mm. and 24 mm in length. The worms were about 27, 30 and 46 days

old, respectively. A fourth female, about three months old, almost complete, obtained from a canary, measured 29 mm. The following measurements were taken from fourteen females recovered from chickens' intestinal veins and fixed in hot Bouin's. The width of the body anterior to the oötype averaged 51μ, ranging from 37μ–64μ. The body usually enlarges in diameter suddenly in the region of the oötype and stays large in the region of the ovary where it measured an average of 67.5μ, ranging from 57μ–78μ. The diameter of the body becomes smaller posterior to the seminal receptacle, averaging 51μ and ranging from 44μ–68μ. The body width near the posterior end averaged 37μ, not much variation was found. A slight enlargement in the posterior end of the body was occasionally observed (Fig. 4). This enlargement was believed to be caused by the fixation, since the living worm was observed to be flexible at this end and continuous contractions and extensions were usually taking place. The brain is 172μ from the anterior end and is not easily seen in the females because of the presence of the uterus, in addition to the esophagus. The digestive system consists of a mouth, esophagus, intestinal caeca and a long common intestine. The mouth, also subterminal, opens into a funnel-like cavity, but unlike the male, no anterior extension of the buccal cavity was observed. The esophagus, like that of the male, is weakly muscular and averaged 549μ in length, ranging from 379μ–750μ. The esophageal glands occupy the same spot around the esophagus as in the male near

the bifurcation of the intestinal caeca (Fig. 3). The intestinal caeca bifurcate as in the male but, in contrast with the latter, the intestinal caeca in the female are longer, extending posteriorly to the posterior end of the seminal receptacle where they reunite (Fig. 3). From here on the gut passes as a single common intestine in a zig-zag way and ends a short distance from the body end. One case of re-bifurcation in the region of the vitellaria was observed. This is believed to be an anomalous case. Odhner (1910) observed a similar case in G. acotylea but the bifurcation and the reunion were directly after the regular union of the intestinal caeca behind the seminal receptacle. The excretory pore is terminal and median like that seen in the male. The reproductive system consists of an ovary, oviduct, ootype, Mehlis' glands, uterus, seminal receptacle, Laurer's canal, vitellaria and vitelline duct. The ovary, located about 1.230 mm. from the anterior end of the body, is spiral in shape (Fig. 3, 23) and extends about 431μ posteriorly. Connected to the posterior end of the ovary is the oviduct. This extends posteriorly for a short distance where it joins a large seminal receptacle, then it turns anteriorly making a sharp angle. The oviduct extends anteriorly to a short distance posterior to the rear end of the ovary and then turns back where it is joined by Laurer's canal. The oviduct through this passage makes several loops. From the point of connection with Laurer's canal (Figs. 7, 24), the oviduct turns anteriorly passing ventral to the ovary and

extends anteriorly to a point about 112μ from the anterior end of the ovary where it becomes the oötype. Between the oötype and the anterior end of the ovary is the Mehlis' gland, mostly accumulating ventrally (Fig. 3). The oötype is a distinct structure with large epithelial cells surrounding its lumen and, occasionally, one ovum can be seen within it. From the oötype a simple uterus extends anteriorly and opens about 20μ posterior to the mouth opening (Fig. 3). The seminal receptacle is a large simple sac, often observed looped and, in bisexual infections, is filled with sperms. The extended seminal receptacle is spindle shaped averaging 136μ in length and 38μ at its greatest width. Laurer's canal is a well-developed organ in the female of this species. It opens on the dorsal side of the worm, between the ovary and the seminal receptacle, and with a protruding papilla bulging out through an atrium-like structure (Fig. 24). Laurer's canal is narrow near the external opening, and enlarges as it continues inside until it becomes as large as or slightly larger than the oviduct which it joins. Numbers of sperms were seen in Laurer's canal. The vitellaria occupy most of the body posterior to the seminal receptacle. The vitelline follicles are arranged around the intestines. A single vitelline duct passes anteriorly and ends shortly before the oötype. The connection between the vitelline duct and the oviduct was not observed, but it should be in thise area. Up to 7 eggs at a time were seen in the uterus.

DISCUSSION: Comparing the adults of this species with the described species of the same genus, they agree with the type species G. acotylea Odhner (1910) in the absence of oral and ventral suckers in both sexes. Also, both species are filamentous and elongated. However, this species differs from the type species in being much shorter and thinner than the latter. The female of G. huronensis differs from the type species, in being longer than the male, and neither sex shows lateral extensions of the posterior end, a prominent character which was described for G. acotylea. The digestive system of the adults in both species are generally alike but they differ in the situation of the mouth opening, which is subterminal in G. huronensis while it is terminal in the type species.

The male of G. Huronensis is slightly thinner than the female while the situation is reversed in the type species. The gynaecophoric canal is more defined and longer in this species. The esophagus is longer than in the type species. The male reproductive system agrees in the numerous testes in both species and also in the presence of a long seminal vesicle, ejaculatory duct, prostate and cirrus pouch; but they differ in the arrangement of the testes, which are almost lineally arranged in G. huronensis and are sizable compared to the width of the body while they are on both sides of the vas deferens in G. acotylea and look small compared with the width of the body. The long seminal vesicle in this species

differs in being made of two portions as previously mentioned, and the cirrus pouch encloses the prostate, ejaculatory muscle and the ejaculatory duct while the cirrus pouch in G. acotylea contains part of the seminal vesicle. There are well-developed ejaculatory muscles and a large spiny cirrus in the male of this species, but lacking in the type species. Finally, the terminal portion of the genital system (Endapparat) in G. acotylea is located between the bifurcation of the intestinal caeca while in G. huronensis only the anterior part of the seminal vesicle is located between the intestinal caeca.

The females of the two species differ in the presence of a well-developed Laurer's canal in G. huronensis and the attachments of the oviduct to the seminal receptacle and Laurer's canal. The seminal receptacle is only an enlarged portion of the oviduct in G. acotylea whereas in G. huronensis, it bulges from the side of the oviduct (Fig. 7). The esophagus of the male of this species is shorter than that of the type species. Comparing G. huronensis with G. monocotylea Szidat (1930), the male of the latter has an oral sucker, a terminal mouth, lacks a synaecophoric canal and is wider in body diameter. The terminal portion of the genital system (Endapparat) of G. monocotylea is located between the intestinal caeca and ends shortly anterior to the angle of the reunion of the intestinal caeca. The female of G. monocotylea can be differentiated by the absence of Laurer's canal and the attachment of the reproductive

system, which is similar to the type species. Szidat was not able to get an entire adult and so no comparison between the lengths of the adults can be made.

A male only was described from G. egreta Lal (1937) and this can be differentiated from the male of G. huronensis in being much longer and broader, and having no gynaecophoric canal. The esophagus of G. egreta is almost three times as long as the esophagus of the male of G. huronensis. It has a subterminal mouth similar to that of G. huronensis. The male of G. egreta is similar to G. monocotylea in having the "Endapparat" between the intestinal caeca. No cirrus pouch was seen clearly in G. egreta, and the author did not mention the presence of the prostate or ejaculatory muscle in the text or the figure.

The adults of G. huronensis can be differentiated from G. gyrauli Brackett (1942) by the presence of the oral sucker in both sexes of the latter species. The male of G. gyrauli is as long as the female and has no cirrus pouch, prostate or ejaculatory muscle and has only a long "sperm duct." The seminal vesicle is longer in G. huronensis and the "Endapparat" in general is more elaborated than in G. gyrauli. The females of the two species can be differentiated by the arrangement of the reproductive system, being like the type species in G. gyrauli. The latter also lacks a Laurer's canal.

G. huronensis can be differentiated from G. lawayi Brackett (1942) by the male of the latter, being wider and having generally

a longer gynaecophoric canal. Also in the latter species the distance is shorter between the anterior end and the beginning of the intestinal bifurcation. The seminal vesicle is shorter in G. lawayi and no prostatic portion nor ejaculatory muscle were reported.

The female of G. lawayi is shorter than the female of G. huronensis and the different organs are also proportionally so. Laurer's canal is absent in the former species and the attachment of the oviduct is similar to the type species.

The adults of G. huronensis, contrary to the other species of the same genus, were found in birds not considered as true water-birds, whereas the rest of the species were reported from water-birds from the United States and abroad.

THE EGG

The mature viable eggs of G. huronensis are spherical to very broadly ovoid in shape, without spines or indentation, straw colored and with well developed miracidia as seen through the shell. The miracidium is well packed inside the shell leaving only a narrow space between the embryo and the egg shell. This space is filled with granular material (Figs. 8, 25). Sometimes a few globules may be observed close to the embryo. The vitelline membrane is not easy to see unless the egg swells in water, in this case the vitelline membrane appears to be surrounding the embryo, leaving the granular material outside, between the vitelline membrane and the egg shell. The arrangement of the egg materials inside the shell, in contrast with what has been reported in human schistosomes, is in agreement with the observations of Price (1931) on S. douthitti, Wall (1941a) on Spirorchis elephantis and the same author (1941b) on Spirorchis parvus. From the drawings of Szidat (1930) of the egg of Gigantobilharzia monocotylea it seems that his observations also agree with this species.

The measurements of forty viable mature eggs passed out from a laboratory infected canary and placed in 0.940 percent saline solution (Prosser et al., Comparative Animal Physiology, Saunders, 1950) were as follows: the length averaged 93μ, ranging from 86μ-105μ; the width averaged 88μ, ranging from 82.5μ-90μ. Seventeen eggs of the forty were completely

spherical in shape. Up to seven eggs at a time can be seen, occasionally, in the uterus of female from laboratory infected hosts.

Examination of the infected intestine, in serial sections and smears, has shown that the eggs of this species are located in the mucosa and the submucosa of the intestine (Fig. 26). The eggs can be seen crowded together, scattered, or in linear rows and varying in size and development. Eggs were seen rupturing the intestinal villi of the infected bird and ready to escape into the lumen of the intestine (Fig. 27). The location of the eggs of this species in the intestinal tissues agrees with the observations of Faust and Meleney (1924) in S. japonicum, Szidat (1930) in G. monocotylea, Faust, Jones and Hoffman (1934) in S. mansoni and Szidat (1939) in Pseudobilharziella filiformis. However, McLeod (1940) reported the presence of the eggs of Ornithobilharzia filamenta in the lymphatic system.

The eggs of this species, compared with those of other schistosomes are: smaller than G. monocotylea and have no spines; larger than G. gyrauli (Brackett, 1942). No comparican be made with G. acotylae (Odhner, 1910) since the author, unfortunately, had lost the records of this stage and only one egg, in the uterus, had been measured. The egg of Pseudobilharziella filiformis Szidat (1939) with its compacted miracidium inside, shows some resemblance to the eggs of G. huronensis. However, the presence of the spine and the ovoid shape of

P. filiformis show the differences between the two. The eggs of Ornithobilharzia lari (McLeod, 1937) agree with those of this species in being "broadly oval to spherical in shape" but they are smaller. In fact, the eggs of G. huronensis can be differentiated from the rest of schistosome eggs by the size and by the fact that they are almost spherical, without spine and having a compact miracidium inside.

HATCHING: Hatching of the eggs of G. huronensis agrees, generally, with what has been described for the other schistosomes. The matured viable eggs swell when placed in water and the narrow space between the embryo and the shell becomes larger, a translucent fluid fills the newly formed cavity between the embryo and the vitelline membrane. The miracidium becomes active, the anterior cilia start beating and the apical papilla contracts and extends. Shortly afterwards the rest of the cilia start beating and the miracidium becomes very active. At least three major movements are usually observed: (1) rotating around the periphery of the egg, (2) twisting and inverting the body, (3) boring against the shell and, sometimes, spinning the rest of the body during the accomplishment of this movement. While all these activities are going on, suddenly the egg shell breaks open and the miracidium is set free, moving around immediately and actively. When the miracidium is forced out under pressure, the hatching embryo is usually sluggish and not very active.

To determine the time which is needed for hatching, a few drops of the feces of a laboratory infected canary were placed in a 75 ml. stender dish containing spring water. The eggs in this water were watched under a dissecting microscope until the first miracidium was observed swimming. The time of three observations averaged about twenty minutes from the time the feces was placed in water until the appearance of the first miracidium. However, in one case, using a side-arm distilling flask, one miracidium was observed swimming in the side arm in 11.5 minutes. It is not exactly known whether the amount of water made this difference or the handling of the feces. At any rate, it can be concluded that in spring water of 68° F. the eggs of this species hatch in a short time. Brackett (1942) working with G. gyrauli found the eggs of that species hatched within a few minutes, a situation which is somewhat similar to the condition here recorded for G. huronensis.

THE MIRACIDIUM

FORM, SIZE AND COVERING: The miracidium of G. huronensis is pyriform in shape with a peculiar "waist" around the middle of the body which is devoid of cilia (Figs. 9, 10, 28, 30).

Fifty miracidia from eggs passed by a laboratory infected canary were relaxed in the ice box for half an hour and fixed in boiling 10% formalin. They measured as follows: the length averaged 158μ, ranging from 140μ-180μ; the greatest width averaged 58μ, ranging from 48μ-68μ.

Specimens of the miracidium were catalogued as follows: U.S.N.M. Helm. Coll. No. 37336, miracidium.

The body covering of the miracidium consists of twenty-two ciliated epidermal plates. These plates can be seen clearly and with definite boundaries in specimens treated with silver nitrate (Figs. 11, 30). The distribution of the epidermal plates is: 6 plates in the first row, 9 in the second row, 4 in the third row and 3 in the fourth row. There is a characteristic gap or "waist" between the second and the third row, a region not covered with ciliated epidermal plates (Figs. 11, 30).

The shapes of these ciliated epidermal plates, in different rows, are clearly shown in the photomicrograph (Fig. 30). There is a notch in the middle of the base of each of the triangular-shape plates of the first row. These notches usually surround a small circle about 1.5μ in diameter. One

case of partial fusion of two neighboring epidermal plates has been observed in the second row.

The cilia of the first row of plates, as in the case in other schistosome miracidia, start short, near the apical papilla, elongate close to the lateral papillae and become posteriorly as much as about four times longer than those near the apical papilla.

The fate of the ciliated epidermal plates was determined by dissecting and sectioning a number of exposed snails after intervals of from 30-60 minutes. Examinations of such material showed that these plates are retained by the miracidia after penetrating the tissues of the snail host (Fig. 29) and will be lost inside the snail tissue starting, usually, with the posterior ciliated plates. These observations are generally in accord with those of Thomas (1883) on Fasciola hepatica. Faust and Meleney (1924) on S. japonicum, Wall (1941) on Sp. parvus, Maldonado and Acosta-Matienzo (1947) on S. mansoni and Anne Van der Woude Miller (1950, Thesis) on Megalodiscus temperatus. However, contrary observations were reported by Barlow (1925) for Fasciolopsis buski. The latter noticed that the miracidium of F. buski sloughs the ciliated epidermal plates during its penetration into the snail host.

Beneath the epidermal layer is a continuous subepithelial layer with ovoidal shape nuclei (Fig. 28). Reisinger (1923) observed in S. haematabium a similar arrangement and shape of nuclei, but he called this layer the nucleus bearing part of

the epithelial cells, which is actually the subepithelial layer. Ozaki (1951) observed a similar structure of this layer in the miracidium of Paramphistomum explanatum (Creplin).

THE PRIMITIVE GUT: The so-called primitive gut is a sac filled with granular material and extends from the tip of the apical papilla posteriorly to the anterior part of the brain. The primitive gut opens through a perforated dome-shaped tip of the apical papilla. There are four nuclei, observed usually together, in the lumen of the primitive gut when the miracidium is seen in a dorsal-ventral position. Observed in side view the gut appears to consist of two lobes. Mallory's triple stain was found to be selective for the nuclei of the gut. Nile blue sulphate also is useful for this purpose in the living miracidium. Reisinger (1923) observed the perforated opening of the gut (Porenkuppel) in the miracidium of S. haematobium. He also indicated the presence of the nuclei in the gut of the same miracidium. Faust and Meleney (1924) and Tang (1938) observed four nuclei in the gut of the miracidium of S. japonicum. The same number of nuclei were observed by Lynch (1933) working on the miracidium of Heronimus chelydrae. Faust and Hoffman (1934) observed only one nucleus in S. mansoni, but Maldonado and Acosta-Matienzo (1947) reported two nuclei in the gut of the miracidium of the same species. Wall (1941) observed three nuclei in the gut of the miracidium of Sp. parvus. Price (1931) did not mention the presence of these nuclei in the gut of the miracidium of S. douthitti.

In an effort to determine the function of the gut, approximately a hundred snails were exposed to about a dozen miracidia each for intervals of 30, 45, and 75 minutes. The snails then were transferred to a clean container and dissected with fine needles and the miracidia recovered were stained with neutral red and nile blue sulphate stains. Some of these miracidia were in poor condition, some still retained the gut after penetration, while others had lost it completely. These cases were characteristically for each time group. This experiment showed that the primitive gut of this species is retained in some cases after penetration and may probably be used as an accessory penetration gland within the snail tissues. Reisinger (1923), Hunter and Hunter (1935) and Yamaguti (1940) were of the opinion that the primitive gut is a part of the penetration apparatus. Goodchild (1948) suggested that "the median structure is an adhesive gland." On the other hand, Thomas (1883), Maldonado and Acosta-Matienzo (1947) observed the presence of the gut after penetration of the miracidia into the snail tissues. Ozaki (1951), using different fixatives, decided the nature of these glands as of a lipoid nature.

THE PENETRATION GLANDS: On each side of the primitive gut is a large unicellular granulated gland. Each gland opens anteriorly on the side of the primitive gut and extends to the brain posteriorly. They are used by the miracidium during penetration and are not seen in penetrated miracidia.

THE LATERAL PROCESSES AND THE LATERAL PAPILLAE: The lateral processes are balloon-shape structures, two on each side of the miracidium in this species (Fig. 10), located between the first and second row of the ciliated epidermal plates. No opening to the outside, nor any secretions were observed from these structures. A duct was observed in a few specimens leading inward from each process. Each duct terminates in a slightly enlarged vesicle which rests on the anterior part of the brain. A similar duct was observed in S. douthitti by Price (1931). The observations of Sewell (1922) Tang (1938) and Wall (1941 a, b) are in general agreement with this. However, in the miracidium of G. huronensis there are two lateral processes on each side instead of one.

Anterior to the lateral processes on each side is a papilla about 3μ in length. Price (1931) reported a pair of lateral papillae on each side of the miracidium of S. douthitti in the same location as observed in this species. Wall (1941 a, b) agreed with Price in his observations on Spirorchis elephantis and Sp. parvus. However, in G. huronensis only one lateral papilla was observed on each side.

THE BRAIN: The brain is located in the anterior third of the body of the miracidium. The structure and shape of the brain does not differ essentially from that described in other schistosomes. It was broadly ovoidal and may appear bilobed. Cells were observed over its surface and they usually stain deeply. Two lateral, forked nerve fibers have been

noticed extending to the sides of the miracidium. On each side of the brain, apparently attached to the lateral nerves is a large cell (Fig. 9). These cells are thought to be nerve cells.

BRISTLE PATCHES: Bristle patches were observed in the living specimens attached to the periphery of small circles (3μ-4μ in diameter). The circles are situated between the first and second row of the ciliated epidermal plates, and can be seen clearly in specimens treated with silver nitrate (Figs. 11, 30). No definite arrangement could be noticed for these circles, but they were mostly arranged in threes, twos, or singly. Brock (1893) working on S. haematobium made good observations on the bristles in the miracidium of that species, but he still called them cilia. He stated "one circular row of them, [speaking about the cilia] which is placed at the junction of the zones beside the posterior series of apertures, has the peculiarity of frequently standing straight out from the body, vibrating slightly or quite motionless, whilst all the other cilia are moving rapidly." Price (1931) studied these bristle patches in S. douthitti and their connection with the central nervous system.

A few circular areas similar to those of the bristle patches described above were observed in the apical papilla of the miracidium of G. huronensis (Fig. 11). The circles can be seen in specimens treated with silver nitrate and also in preparations stained with Mayer's HCl carmine and fast green.

In the living miracidia, as well as in permanent mounts, short bristles were observed on each side of the apical papilla. These bristles are subterminal and can be seen only on the sides (Fig. 10). Yamaguti (1940) reported the presence of these bristles and their arrangement on the "Terebratorium" of several miracidia naming two types of arrangements, a sub-apical ring and a uniform covering of the whole surface. To the first type he referred the representatives of Fasciolidae, Echinostomatidae and Paramphistomidae. To the second type he referred the representatives of the Strigeidae and Schistosomatidae. The present observations, although they confirm the presence of the bristles in the apical papilla in this miracidium, do not agree with the arrangement referred to by Yamaguti in the family Schistosomatidae of which G. huronensis is a member.

STRUCTURES OF UNDETERMINED NATURE: Very small circles (1.5μ in diameter) were observed in the apical papilla of this miracidium (Fig. 11). These circles are few in number, almost the same size as those usually observed in the notches at the base of the first ciliated epidermal plates. As to the function of both groups of small circles, Coe (1895) describing similar circles in both locations, on the miracidium of Fasciola (Distomum) hepatica, considered the apical circles as openings of glands. Yamaguti (1940) reported the presence of the six circles on the first epidermal plates and referred to as "Sinnespapillae." Ozaki (1951) reported both the apical

circles and the circles of the first epidermal plates. He considered the apical circles as excretory pores and the small circles of the first epidermal plates as sense organs. Whether these circles, in the miracidium of G. huronensis, are gland orifices or nerve terminations or both needs more study.

There are two groups of cells, each group being triangular in shape and located posterior to the brain on each side of the miracidium (Figs. 9, 28). The anterior end of each group tapers for a short distance and may be seen turning toward the body wall of the miracidium where it apparently ends. No opening to the outside was definitely seen and so whether this structure is the lateral gland or some other structure was not determined.

THE EXCRETORY SYSTEM: The excretory system of the miracidium of this species is in general agreement with those described for other schistomes. It is composed of two pairs of flame cells, an anterior pair and a posterior pair (Fig. 10). The anterior pair is located at the sides of the brain, one cell on each side. The posterior pair is usually found in the vicinity of the third row of epidermal plates. The anterior and the posterior tubules from the flame cells join the convoluted collecting ducts around the middle of the body of the miracidium. Each collecting duct, after complicated loopings, ends in a bladder which opens through the excretory pores on each side between the cells of the third row of epidermal plates (Fig. 11, 30).

THE GERM CELLS: The germ cells are found in the posterior part of the body of the miracidium (Fig. 9), extending sometimes to the anterior half of the body. The so-called "fiber-like extensions" can be seen extending from the cell body of some cells to the body wall of the miracidium. These fiber-like extensions are usually seen in cells which are isolated from the rest of the group.

THE LONGEVITY OF THE MIRACIDIA: A simple experiment was carried on in the laboratory to show the longevity of the miracidia of this species. The temperature was about 70° F. and unnecessary light was avoided during the night. Thirty miracidia were separated among eleven 10 ml. stender dishes as is shown in (Table 2). The miracidia were obtained by placing feces containing eggs in spring water in a 75 ml. stender dish, and left to hatch. The water was checked for the hatched miracidia every ten minutes after the first miracidium hatched. The miracidia were recovered by decanting the water of the main dish to another dish and replacing it with fresh water and examining the decanted water for miracidia. Checking the living miracidia continued for 24 hours; at intervals of 1 hour for the first 14 hours with an interval of 2 hours between 9-11 hours. After 14 hours the checking was made every 2 hours until the end of the twenty-fourth hour. Part of the water had been replaced 2 times after 2 and 9 hours. After 24 hours only 5 miracidia were left. Three miracidia appeared active while 2 showed very little activity. A young snail host

TABLE 2

THE LONGEVITY OF THE MIRACIDIA OF G. HURONENSIS

Dish Number	Number of Miracidia in each	Time of Hatching	After 7 hours	After 9 hours	After 11 hours	After 12 hours	After 13 hours	After 14 hours	After 16 hours	After 18 hours	After 20 hours	After 22 hours	After 24 hours
1	1	9:30 a.m.	1	1	1	1	1	1	1	1	0	0	0
2	2	9:40	2	2	2	2	2	2	2	2	2	2	2 One active
3	3	9:40	3	3	3	3	3	3	3	1	0	0	0
4	3	9:50	3	3	3	3	3	3	3	3	2	0	0
5	3	9:50	2	2	2	2	1	1	1	1	1	0	0
6	3	9:50	3	3	2	2	2	2	2	2	1	1	1 Can hardly move
7	3	9:50	3	3	3	1	1	1	1	0	0	0	0
8	3	10:00	3	3	3	3	3	3	3	2	2	2	1
9	3	10:00	3	3	3	3	3	3	3	3	3	1	1 Can hardly move
10	3	10:00	3	3	3	3	3	3	3	1	1	0	0
11	3	10:00	3	2	2	2	1	1	1	1	0	0	0
Total	30		29	28	27	25	23	23	22	17	12	5	5

was placed in the dish with these active miracidia and watched for 30 minutes. The miracidia moved actively, hit the snail several times, came into contact with the foot and head regions but no attempt to penetrate was observed.

Under the above mentioned conditions the mortality among the miracidia of this species, after 24 hours, was about 83 percent. Even the active miracidia which have survived after this time were unable to continue the life cycle of the parasite. Faust and Meleney (1924) reported that the "infective stage" of the miracidium of S. japonicum lasts from 60 to 72 hours. Lampe (1927) working on S. mansoni found "the duration of the life of the free swimming miracidia estimated at two to three days." Christopherson (quoted from Lampe, 1927) found the longevity of the miracidium of S. haematobium, at the most, nine hours. Faust and Hoffman (1934) found the longevity of the miracidium of S. Mansoni was less than 24 hours. Maldonado and Acosta-Matienzo (1948), working on the same strain of S. mansoni, found that at the end of 9 hours the mortality had reached 100 percent. Short (1950-thesis) found for the miracidium of S. douthitti that "no miracidia survived for 23 hours; only 2 lived 21 hours, and after 20 hours these 2 swam slowly, appearing feeble and largely exhausted."

The disagreement in results reported by the investigators mentioned, who considered the duration of life of these several miracidia, even in the same species, is due probably to the differences in methods and conditions under which each

experiment was done. However, the result of this experiment is in close agreement with that of Short on the miracidium of G. douthitti which was studied in the same laboratory.

THE PENETRATION OF THE MIRACIDIUM: The actual penetration of the miracidium of G. huronensis into the snail host was observed and at the same time attention was paid to see whether or not there is any attraction between the miracidia and the snail host.

The process of penetration does not differ generally from what has been described for some other schistosomes. The miracidia anchor on the soft part of the snail and, as soon as they become firmly attached, they start boring. If about half of the body of the miracidium gets in, the rest will follow within a few seconds. Unsuccessful attempts were also observed and some miracidia failed to penetrate. Some became exhausted and were not able to re-attack. The miracidia were observed to attack almost any exposed soft part of the snail. The actual penetration was much easier to observe on the anterior part of the snail and the elongated foot of the host. Very rarely were the tentacles of the snail attacked by the miracidia. The average time of ten cases of penetrations into ten snails of different sizes (from 2 mm. - 6 mm.long) was 150 seconds with the extremes ranging from 90-210 seconds. The time of penetration of the miracidium of this species seems close to that found by Faust and Meleny (1924) in S. japonicum and by Faust and Hoffman (1934) S. mansoni. Gordon and co-workers (1934) found that 5-15 minutes were needed for the

miracidia of S. haematobium and S. mansoni to penetrate their snail hosts. Longer time (10 min. to 1 hr.) was reported by Wall (1941b) for the miracidium of Sp. parvus.

There was no confirmation of the idea of attraction between miracidia and the snail hosts, and it seemed that the miracidia meet their snail host by chance. Thomas (1883) working on the life history of the liver fluke was in accord with this observation. He stated "when the embryo, in moving through the water, comes in contact with any object, it pauses fro a moment, and feels about as it trying to test its nature, and, if not satisfied, darts off hastily again. But if the object be a Limnaeus truncatulus it as once begins to bore." Wall (1941b), Abdel-Malek (1950) on S. mansoni, Stirewalt (1951) on S. mansoni were also in general agreement with these observations. However, Faust (1924b) and Faust and Meleney (1924) sustained the idea that the relation between the miracidia and the snail host is a chemotactic one and as the latter authors stated; "that the source of stimulus is the mucous secretion of the mollusc." Maldonado and Acosta-Matienzo (1947) partially support this latter contention.

DISCUSSION: The unciliated area around the middle of the body of this miracidium is a character which, as far as can be ascertained, is not found in any other schistosome miracidia. Since the miracidium of this species agrees closely with other known schistosome miracidia in the number and arrangement of epidermal plates, the gap around the middle of its body is

apparently the result of shortening in the length of the plates, especially those of the second row. The plates of this miracidium were easily counted in well flattened preparations treated with silver nitrate. A small amount of the mounting material was used in order to allow the cover glass to flatten the specimens, otherwise it was difficult to determine the right number of the plates.

Looss (1892), working on the miracidium of Amphistomum subclavatum (Rud.), found that the gut differentiates in early stages of embryonic development. It starts as a few cells in the fore body of the miracidium and later forms a flat layer of cells surrounding a space inside. The cells break up and their cytoplasmic material fills the entire lumen. This situation also probably occurs in the miracidium of G. huronensis and the nuclei which are present in the lumen of the gut, like those of A. subclavatum, are the remains of the broken cells.

The location of the bristle-patches in this miracidium is similar to that of the miracidium of S. douthitti studied by Price (1931). Nevertheless, the location of these structures in the miracidia G. huronensis is different from the arrangement of the bristle-patches in some human schistosome miracidia. The observations of Looss (1886-1901) and Brock (1893) on the miracidium of S. haematobium agree on the presence of interruption in the body cilia. According to Looss this interruption is caused by two circles of fine papillae. The papillae are arranged around the body shortly behind the

head and slightly posterior to the middle of the body. The observations of Brock indicate the presence of the bristles, apparently, in the region behind the middle of the body. My observations on the miracidium of S. mansoni, both living and in silver nitrate preparations, confirm the observations of Brock (1893). It was found that the majority of the bristle-patches are posterior between the second and third row of epidermal plates. However few circles were seen, in silver nitrate preparations, between the first and second row. These few circles, which look similar to the bristle-patch circles, were not determined in the living specimens because of the death of the only mouse infected. It is believed that these few circles in S. mansoni probably represent a few bristle-patches in this area.

THE MOTHER SPOROCYST

The shape of the mother sporocyst of G. huronensis does not differ from that described for other species of schistosomes, all of which have a comparatively simple, elongate, sac-like body. The anterior end is attenuated, the posterior is blunt (Fig. 12). The wall of the developed mother sporocyst is composed of a very thin cuticle and stellate cells. These cells have a rather large nucleus and conspicuous nucleolus (Fig. 13). The germinal materials occupy the lumen of the mother sporocyst and the protoplasmic extensions can be seen across the body lumen.

The majority of the mother sporocysts of this species are located in the mantle near its edge. Occasionally they are found also around the anterior part of the esophagus. One case was recorded where one mother sporocyst was recovered from the tissues of the foot eight days after exposure.

Mother sporocysts of the same age varied in size and development as did even those recovered from the same snail. specimens from 13-15 days old usually showed almost all the stages of development from single germ cells to the sausage-shaped immature daughter sporocysts. The immature daughter sporocysts were usually the predominant elements in such matured mother sporocysts, and only a small amount of undeveloped germinal materials was found scattered among the immature daughter sporocysts. The latter are found free in the lumen of the mother sporocyst.

The living mother sporocysts do not show much activity and usually stick to the bottom of the container. The only detectable movement was a weak contraction of the anterior end of the young mother sporocysts. In the matured mother sporocyst it was even harder to detect such movement and the only activity seen was among the immature daughter sporocysts.

The longevity of the mother sporocysts was not determined but usually daughter sporocysts could be found in the liver of the snail after 14-15 days following exposure at laboratory temperature (60° F.). The shortest time (13 days) was recorded during a spell of warm weather. The period of maturation of the mother sporocyst of this species seems to be the shortest compared to other schistosomes. Faust and Meleney (1924) in S. japonicum reported the "secondary" sporocysts in the liver after 29 days. Price (1931) in Schistosomatium douthitti removed the daughter sporocysts from the liver after 36 days. Maldonado and Acosta-Matienzo (1947) in S. mansoni recovered the daughter sporocysts from the liver in 18 days. Olivier and Mao (1949) working also on S. mansoni reported a similar period (19 days).

A birth pore was observed in the mature mother sporocyst 15 days old. An active well differentiated daughter sporocyst was observed once near the anterior end making its way out. A canal leading from the birth pore to this embryo was clearly seen. Cort and Olivier (1943) reported the presence of the birth pore in the mother sporocysts of Trichobilharzia

stagnicolae (Talbot, 1936) McMullen and Beaver, 1945. Cort, Ameel and Olivier (1944) also reported a birth pore in the mother sporocysts of Schistosomatium douthitti.

Measurements of the mother sporocysts were made from permanent mounts at different stages of development. All the specimens were taken from laboratory infected snails and stained with Mayer's HCl carmine. They measured as follows: two mother sporocysts (10 days old) fixed in hot A. F. A. were 1.218 mm. and 1.562 mm. in length. Their width was 0.068 mm. and 0.105 mm. A third mother sporocyst (13 days old) fixed in hot Bouin's measured 1.245 mm. in length and 0.060 mm. in width. A fourth mother sporocyst (15 days old), fixative not recorded, measured 1.387 mm. in length and 0.071 mm. in width.

It is not claimed that these measurements are conclusive since the number of specimens examined was so limited. These figures are given only to present in a general way the size of these mother sporocysts, which were obtainable entire and without damage.

THE DAUGHTER SPOROCYST

The daughter sporocysts make their appearance in the lumen of the matured mother sporocyst around the thirteenth day after exposure. They are elongate, sausage-shaped bodies, blunted posteriorly, while the anterior is attenuated and covered with spines (Fig. 14). The daughter sporocysts are found usually in the liver 14-15 days after exposure. In an 18 day old daughter sporocyst one may notice immature cercariae. The body wall of a 22 day old daughter sporocyst (Fig. 15), is covered with a thin layer of cuticle. Two kinds of nuclei were differentiated, small ovoid nuclei differing in size and a second kind with more or less rounded nuclei and a visible nucleolus. When most of the lumen contents of the daughter sporocyst turn to well-developed cercariae the body wall becomes thin and the small ovoid nuclei of the body wall are predominant. These usually were close to the interior edge of the wall. All the above mentioned daughter sporocysts were taken from snails infected during the summer months.

The shortest time for the cercariae to leave laboratory infected snailed was 24 days after exposure during the summer time and 30 or more days during the winter (Najim, 1950). However, it was possible to shorten the period of time during the winter season by placing the snails near a heater continuously after exposure. The snails were exposed to a 60 watt electric light 2-3 hours a day during cloudy days. By this method cercariae would leave the snail within 24 days in January. In one

case three snails were exposed in May and did not liberate cercariae until July when they were crushed and examined. All were found to be infected and well-developed cercariae were seen in the daughter sporocysts. Whether for unknown reasons development slowed down or the developed cercariae held back is not known.

A well-developed birth pore (Fig. 16) can be seen in mature daughter sporocysts. The anterior end including the birth pore is usually active and shows continuous contractions and movement in the living specimens. Eight daughter sporocysts (15 days after exposure) were recovered from the liver of a snail. They were fixed in hot Bouin's, stained with Mayer's HCl carmine and fast green, and averaged 0.500 mm. in length, ranging from 0.238 mm. to 0.930 mm. The width averaged 0.038 mm., ranging from 0.030 mm. to 0.051 mm. The longest daughter sporocyst showed large germ balls.

The oldest daughter sporocyst recovered complete was 18 days old (Fig. 14). It was fixed in hot Bouin's and stained with Mayer's HCl carmine. It measured 1.500 mm. in length and 0.050 mm. in width. Many pieces of different ages from 15-59 days were also recovered and studied living or as permanent mounts.

THE CERCARIA

The cercaria of Gigantobilharzia huronensis is an apharyngeal furcocercous, brevifurcate, Distome with pigmented eyespots (Fig. 17). The following measurements were made on fifty cercariae from laboratory infected snails, fixed in a 10% solution of boiling formalin. The body length averaged 240μ, ranging from 195μ-270μ; the body width averaged 72.5μ, ranging from 63.7μ-105μ; the tail stem length averaged 268.5μ, ranging from 255μ-300μ; the tail stem width near the body averaged 30μ, ranging from 22.5μ-45μ; the furca length averaged 146.8μ, ranging from 102.5μ-172.5μ; the furca width averaged 15μ, with not much range; the head organ length averaged 92μ, ranging from 75μ-105μ; the head organ width averaged 49.5μ, ranging from 45μ-60μ; the diameter of the acetabulum averaged 28μ, ranging from 22.5μ-30μ; the distance between the acetabulum to the anterior end of the body averaged 150μ, ranging from 120μ-180μ.

The tail is muscular with muscle cells similar to those in the cercaria of Schistosomatium douthitti as described by Price (1931). The furcae have fin folds. The excretory canal projects beyond the main body of the furca terminating in a slightly extended thimble-like structure (Fig. 17).

A specimen of the cercaria was catalogued as follows: U. S. N. M. Helm. Coll. No. 37335, cercaria, from Phyra gyrina (Say).

THE SPINES: Spines cover almost the whole body, tail stem and the tail furcae. These spines are directed backwards and those on the body differ in distribution and size from those on the tail, being crowded on the dorsal side of the anterior part of the head organ. Following this area is a characteristic small area with scattered spines, which is followed by evenly distributed spines over the remainder of the body (Fig. 18). On the ventral surface the spines are, practically, evenly distributed (Fig. 19). Those on the tail are stouter, longer and more sparsely distributed than those on the body. The spines on the furcae are even less numerous than those on the tail stem. Such difference in the distribution of the spines over the body and tail has been noticed by Joparkar (1921) who worked on the cercaria of Schistosomum spindalis. R. B. S. Sewell (1922) reported a similar condition in "C. Indicae XXX." Blacklock and Thompson (1924) have noticed in the cercaria of S. haematobium that "the spines are longer and more sparsely distributed on the base of the tail stem." H. H. Miller, Jr. (1927) who worked on C. tuckerensis noticed the same condition in that "both tail stem and furcae are sparsely covered with retrose spines which are longer than those on the body." Later, Annie Porter (1938) in C. isundlwesii, and Wall (1941) in cercaria of Sp. elephantis, reported a similar condition. However, as far as I am aware, the small area with the scattered spines on the dorsal surface of the head organ is a characteristic not previously described for schistosome cercariae.

THE HEAD ORGAN: The head organ occupies almost the first third of the body. It is preceded on the ventral surface by an oral sucker. The posterior part of the head organ is strongly muscular and occupying the center of this muscular portion is a heavy muscle which often contracts and appears as a separate ovoidal muscle surrounding the esophagus which might be mistaken for a pharynx. It is possible that the structure which T. Oiso (1927) described as a pharynx in the cercaria of Bilharziella yokogawai is this muscle structure, since as LaRue (1938) stated: "The pharynx according to Miller (1926) is a character of considerable value. Its absence characterizes the entire group of blood flukes, both adults and cercariae."

The line of attachment of the posterior part of the head organ to the body wall is present and visible. The cystogenous gland or oral gland occupies the center of the head organ and reacts like the posterior group of penetration glands with HCl-carmine (Fig. 32). No opening could be seen from this structure to the outside, nor any extrusion noticed in the living cercariae. The head organ seems to disappear in the adult in which no oral sucker is present.

VENTRAL SUCKER: The ventral sucker or acetabulum exists only in the cercaria and disappears in the adult. It is situated slightly posterior to the middle of the body and is more or less protrusible. Occasionally, it could be seen extending outward in a side view of the cercaria. There are strong

radiating muscles attached to the sucker. The sucker is very active in the measuring-worm-like movement of the cercaria.

PENETRATION GLANDS: There are five pairs of unicellular penetration glands in the emerged cercaria (Fig. 17). The glands are set close together starting from the area immediately anterior to the acetabulum and extending to the posterior part of the body. The first pair is located directly anterior to the acetabulum; the second pair more or less elongated partly surrounds the acetabulum and each gland is made up of three lobes. These two pairs together make up the first group. Similarity in staining reaction suggests the acidophilic nature, i. e. stain selectively with the alizarin vital stain (Gordon, et al., 1934). Also, they usually take the eosin stain in permanent mounts. The nuclei in the two parts are generally spherical. The second group of glands is made up of the third, fourth, and fifth pairs of glands. They react similarly to stains suggesting the basophilic nature, i.e., stain blue with Delafield's hematoxylin and take the carmine stain. Harris' heaatoxylin (1:10 ammonium alum) was not satisfactory in this respect. It might be because of the presence of a high percentage of ammonium alum. The nuclei of this group are rather oval in shape compared with the first group of glands.

The glands could not be differentiated into fine and coarse granulated groups as they all appear to be almost alike in the living specimens. In specimens stained with Delafield's and eosin the three posterior pairs show coarse granules.

Cercariae sectioned inside the infected snails show similar reactions, i. e. the suggestive oxyphily of the anterior group and the basophily of the posterior group. Faust and Hoffman (1934), working on S. mansoni in Puerto Rico, noticed that the differentiation between the anterior acid-fast and the posterior base-fast may occur only with complete maturity of the cercariae and "the glands are all originally basophilic in reaction; oxyphily in the anterior two pairs develops with maturity." They mentioned also that these observations correspond with those made by Faust and Meleney (1924) on the cercaria of S. japonicum. In the same year Gordon, Davey and Peaston, working on the cercariae of S. mansoni and S. haematobium in Sierra Leone, noticed the differentiation between the acidophilic anterior group of glands and the basophilic posterior group of glands in the cercariae sectioned inside the livers of infected snails which were discharging cercariae and they stated: "It was possible by careful staining with Delafield's haematoxylin and eosin to produce selective staining of the cephalic gla nds in the sectioned cercariae." My findings in this respect agree wit h their contentions. A sixth pair of penetration glands in the unemerged cercariae was not seen, not even in a good permanent stained specimen of this stage. Five pairs of ducts connect the penetration glands to the anterior part of the body with each duct ending in a separate, spined cup.

DIGESTIVE TRACT: The digestive tract consists of a mouth opening a nd a tubular esophagus which ends about halfway between the eyespots and the acetabulum. The esophagus ends in a bulb-like structure produced from the incomplete bifurcation of the esophagus. In side view, the mouth opening could be seen in front of the muscular part of the head organ on the ventral surface. The pharynx is absent.

EXCRETORY SYSTEM: The excretory system, usually, consists of five pairs of flame cells, four pairs are in the body and one pair in the anterior part of the tail stem (Fig. 17). The body flame cells are distributed as follows: one pair lies anterior to the eye spots, the second is between the acetabulum and the eyespots, the third and the fourth are posterior to the acetabulum.

There are two collecting ducts, one on each side of the body extending from the posterior end to the level of the acetabulum where they turn to the sides and then make another turn toward the posterior where they meet the anterior and posterior lateral collecting tubules. Before doing so the collecting ducts are provided with two ciliated patches each (Fig. 17). These can be differentiated from the flame cells by the flickering and the difference in structure. The collecting ducts unite in the posterior end of the body forming a small bladder. T he structure generally known as the island of Cort could not be seen in this cercaria.

The anterior tubules each have two flame cells and the posterior tubules extend posteriorly to the anterior part of the tail stem. Attached to each of the posterior tubules are two flame cells in the body and one in the tail stem. The flame cell pattern can be formulated as 2 [(2) + (2 + 1)]. The excretory system opens by a tubule protruding outward at the tip of each furca. Variations in the position of the flame cells and the looping of the tubules were noticed quite often. This might be caused by pressure from the cover slide and contractions of the body of the cercaria. A few cases of shifting of the position of the flame cells have been observed during this study. The second pair of flame cells were observed anterior to the eyespots beside the first pair, also the third and fourth pairs might come closer together in position. A few cases were observed of an extra pair of flame cells beside the third pair. However these casses were rare and thought to be abnormal.

NERVOUS SYSTEM: The nervous system consists of what is generally called the brain. This consists of two lobes connected by a commissure. The brain is situated ventral to the eyespots and stains deep blue with Delafield's hematoxylin.

The eyespots are found between the head organ and the acetabulum on the dorsal side. Each eye spot consists of a single lens directed toward the side, the pigmented granules, and the nerve cord which attaches to the eye. The nerve cord can be seen with nile blue sulphate stain.

A few hairs have been observed on each side of the body of the cercaria, attached to papila-like structures (Fig. 17). Szidat (1929a) described corresponding structures in the cercaria of B. polonica and called them sense bristles, "sinnesborsten." Gordon, et al. (1934) described similar structures in the cercariae of S. mansoni and S. haematobium. Wall (1941a) described the same structure in the cercaria of Sp. elephantis.

PRIMORDIUM OF THE REPRODUCTIVE SYSTEM: A mass of cells easily seen in stained specimens appears posterior to the acetabulum. The development of these cells into the reproductive system in S. douthitti was studied in detail by El-Gindy (1950—Thesis).

BEHAVIOR: As soon as the cercaria emerges from the snail it moves actively for a short time and then becomes more or less quiet on the surface of the water. The cercaria attaches to the surface film of the water with the body parallel to the surface and the tail hanging downward at various angles. The cercaria moves with tail forward which is the usual method followed by similar cercariae. The forward motion is, apparently, effected by the rapid flapping of the furcae and the vibratile movement of the tail stem, which is more pronounced near the center while the ends are relatively stationary. The body of the cercaria seems to follow by a relatively more limited vibration. The cercaria also agrees with the other schistosome cercariae in the measuring-worm-like movement.

In its behavior the cercaria of G. huronensis resembles that of the cercaria of B. polonica (Kow) described by Szidat (1929a) the cercaria of Schistosomatium douthitti (Cort) described by Price (1931), the cercaria of G. gyrauli Brackett (1940b) and the cercaria littorinalinae Penner (1950). When resting all the above species come to the surface of the water in the containers.

EMERGENCE: The cercariae emerge from the snail host in the early morning around 5:30 A.M. (in a shaded and heated room in January). The majority of the daily shedding takes place within about 4-5 hours, sometimes continuing until noon, in heavy infections. The liberating time of this cercaria resembles that of C. elevaé Miller, C. physellae Talbot and C. stagnicolae Talbot, as stated by Brackett (1940a).

Immediate emergence of the cercariae from the infected snails sometimes occurs as soon as the old water in the wide-mouth bottles is replaced by new water. This agrees with the observations of Soparkar (1921) on the cercaria of Schistosomum spindalis. He noticed the stimulating action of fresh tap water on the infected snails and stated: "The cercariae are shot out by the snail in puffs containing fifty or more individuals and this action appears to be stimulated by contact with fresh tap water." Taylor and Baylis (1930) who worked on C. ocellata, and Brackett (1940a) in his studies on the behavior of Schistosome cercariae noticed a similar reaction. The latter author stated: "if the water was changed on a snail infected with larval schistosomes, an immediate

emergence of cercariae might occur." This phenomenon has been interpreted by the same author as being the effect of "the rapid change in temperature which occurs with the addition of fresh water." This reaction appears also to be caused by a renewal of water in the present observations. R. E. Kuntz (1946) working on the effect of light and temperature on shedding of S. mansoni cercariae has noticed, "It would appear that any sudden alteration of temperature of the water in which snails are immersed will induce a release of cercariae of S. mansoni."

As to the mechanism of emergence, the cercariae were observed to emerge with the anterior part of the body coming first. This region contracts continuously back and forth until it frees most of the body. Then, with a rapid vibrating movement it will free the tail. As soon as the whole body and the tail are liberated the cercaria turns over and moves with the tail forwards. This method was used exclusively in all observed specimens. Faust and Meleney (1924) have stated for S. japonicum that, "In all of our observations these cercariae have always emerged tail first." Faust and Hoffman (1934) have stated for S. mansoni that "Cercariae of S. mansoni emerge, tail first, from the infected snail, almost exclusively." No case was observed in the cercariae of G. huronensis that compared with the method observed by the above authors.

THE CERCARIA AS A DERMATITIS PRODUCING AGENT: Tests were made to determine whether the cercaria of G. huronensis

is a dermatitis producing agent. About twenty-five cercariae were placed in a 6 inch petri dish and the author's left arm with the flexor surface down, was immersed in the water containing cercariae. After five minutes the arm was removed to dry. at the same time six cercariae were pipetted separately on six different dry spots of the same arm. After about twenty minutes strong itching was felt on several places of this arm. Ten minutes later five red spots became apparent. In addition four reddish spots appeared shortly afterwards in the area of the six pipetted drops. The spots enlarged in size and two days later they became nodular in shape. After two weeks they were still detectable. A repetition of this experiment some nine weeks later but using the right arm produced a similar reaction as shown in (Fig. 31). No pus was produced in either case.

These tests proved that cercariae of G. huronensis are a dermatitis producing agent and so a new member has been added to the dermatitis cercariae group in the United States. A survey of the area around Ann Arbor should be conducted to establish the distribution of this cercaria since the present work covered only a limited area.

DISCUSSION: The cercaria of G. huronensis falls in Sewell's (1922) "spindalis" group and H. M. Miller (1926) group B of the furcocercous, apharyngeal, brevifurcate distome cercariae. Sewell listed two cercariae under the "spindalis" group, namely C. spindalis and "C. Indicae XLVII." H. M. Miller

(1926) added Cercaria B (Kemp) to Sewell's spindalis group on the basis of similarity of the number and the character of the penetration glands and changed the name spindalis to group B in his classification.

The cercaria of G. huronensis can be differentiated from the cercaria of Schistosomum spindalis in being larger in size; no differentiation of the penetration glands in the living specimens of the cercaria of G. huronensis; absence of the eyespots in G. spindalis. In behavior, C. spindalis hangs in water with the head down and the tail turned upwards while C. huronensis hangs with body parallel to the surface.

C. huronensis differs from cercariae "Indicae XLVII" in being slightly smaller than the latter and also in the proportional size of the parts, i. e. the tail in C. indicae being shorter than the body; in C. indicae the penetrstion glands are differentiated into coarse and fine granulated groups; the first anterior pair of flame cells starts from a point posterior to the eyespots; the body being armed with spines in the anterior two thirds, but the posterior third appears to be devoid of armature and finally differs in the mollusc intermediate host which is an aperculate, Melanoides tuberculatus Müller, for "C. Indicae XLVII," while G. huronensis has a pulmonate intermediate host.

E. L. Miller (1935) reported C. pteractinota from Physa gyrina and Helisoma trivolvis. The author did not give the number of the penetration glands, neither did he give the

pattern nor the number of the flame cells of the cercaria, However, Miller's cercaria differs from the cercaria of this species in that its tail is three times as long as its body. C. pteractinota also possesses prominent pigmented masses one on either side of the oral sucker near its posterior end, it hangs in the water with its head downward, and, finally, it possess two germ masses instead of one.

Porter (1938) described C. elandsiae from South Africa and determined it as a longifurcous cercaria. But Porter's elandsiae is rather a brevifurcate since its furcae are slightly less than half the length of the tail stem. C. elandsiae possesses 2 (4 + 1) flame cells and its size is generally close to the size of the cercaria of this species. However, C. elandsiae has only four pairs of penetration glands, the arrangement of the flame cells are different, it does not hang to the surface film of the water, and, finally, the intermediate host is Lymnaea natalensis.

The cercaria of G. huronensis, in fact, could be easily confused with the cercaria of S. douthitti (Cort) Price, 1931 and the cercaria of G. gyrauli (Brackett, 1940b). The three cercariae are similar in behavior and size. The cercaria of G. huronensis can be differentiated from the cercaria of S. douthitti by the number of flame cells. The penetration glands, in S. douthitti are differentiated into anterior coarse granular group and a posterior fine granular group. Also in S. douthitti the absence of the fin folds from the furcae and

the emerging time in the evening in contrast to G. huronensis which emerges in the morning.

In comparison, the cercaria of G. gyrauli has more flame cells with a pattern of 2 (3) + (3 + 1) . The penetration glands are of two kinds, fine and coarsely granular, but they are reversed from the arrangement of S. douthitti as indicated by Brackett (1940b). The digestive system is more developed in gyrauli, the intestinal caeca extend posteriorly to the level of the acetabulum.

It is not difficult to differentiate the cercaria of G. huronensis from the cercaria of B. polonica (Kow), Szidat (1929a). The latter cercaria is larger in size, has six pairs of penetration glands consisting of two groups, coarse and finely granulated, and finally the number of flame cells is "2 (6 + 1)" in C. polonica.

C. littorinalinae Penner (1950) shows similar behavior to that of the cercaria of G. huronensis, but it can be differentiated by size with the former the larger and also in that C. littorinalinae has more flame cells. The digestive system is more developed, and, finally, the cercaria develops in a marine snail Littorina planaxis philippi.

HOST-PARASITE RELATIONSHIPS

During these studies some interesting phenomena were observed in the relations between parasite and hosts. Starting with the miracidium and the snail, it was observed that the miracidia were phototropic. Physa gyrina were usually found in nature on the bottom of the pool or were attached to dead leaves and logs in the water. Thus the interrelation seemed to be reversed. However, the shallow water of the pool and the fact that the miracidia do not remain still in the water but usually are in continuous movement wandering up and down might give chance for contact between parasite and snails. Yet, the chances in nature seem to be less favorable to high infections as compared to experimental infections. From general observations in the laboratory a majority of the eggs were found to hatch during short intervals. This concentration might be true in nature and so would provide a group of miracidia at one time instead of single individuals which also might increase the chances of infection. Death of young infected snails was observed up to about 50%. It is not claimed that this mortality was due entirely to parasitism but parasitism has certainly some lethal effect especially in heavy cases of infection.

The cercariae are released in the morning and at this time the bird hosts were observed to visit the same area. The birds may become infected when they enter infested water for

bathing and drinking. One male cardinal was observed hopping in the pool and drinking the water.

The adult worms live, in the case of warm-blooded animals, in the veins of the final host. The mature adults of this species are usually found in the small veins around the intestine, sometimes deeply penetrated in the muscular layer of the intestine, while larger species of blood flukes are reported to live in the portal vein or other relatively large mesentric veins. Apparently the adult of this species can penetrate into the small veins becasue of their extremely slender body.

The parasite had no serious effect on the final host in the laboratory infected birds and the birds seemed to get along quite well with their parasites. Two cases of death were recorded in infected canaries after two and three weeks of exposure. But, these cases were probably caused by mistakes in feeding and exposure to cold weather.

DISCUSSION

The species G. huronensis is placed under the subfamily Bilharziellinae Price, 1929 and the genus Gigantobilharzia Odhner, 1910 because of the similarity in form between the male and female, i. e., both having slender bodies. It has also short paired intestinal caeca, long common caecum, numerous testes situated along the course of the common caecum, gynaecophoric canal reduced to a short groove situated in anterior part of body, no suckers, and the uterus may contain one or several eggs.

Odhner (1912) gave a diagnosis of the genus Gigantobilharzia, which he based on his description of a single species, G. acotylea Odhner, 1910. Price (1929) gave the generic diagnosis stated erroneously "cirrus pouch absent," which should read, "cirrus pouch present," because the same author in the species description stated; "terminal portion of genital system (Endapparat) consists of a cirrus pouch containing. . . ." This statement agrees with the original description.

Mehra (1940) raised the genus Gigantobilharzia to subfamily rank without giving reasons for doing so. Although there may be a need for a re-evaluation of the subfamily Bilharziellinae, it seems better to follow the old classicication until more information is obtained.

Since five more species of the genus Gigantobilharzia have been described, the existing generic diagnosis is no longer valid and a revised diagnosis should replace it. It

is difficult to define precisely the genus Gigantobilharzia because of inadequate descriptions of some species. This apparently is due to failure of some authors to secure sufficient specimens for detailed studies.

In almost all of the known species of the genus Gigantobilharzia the body was described as long, filamentous or thread-like. Male and female are, more or less, similar in form with the exception of G. actoylea Odhner, 1910, in which the male is somewhat flattened. None of the species have spines or any kind of cuticular armaments. However, small papillae were observed on the anterior end of both sexes in G. huronensis. Also, in the same species small wart-like protuberances were observed scattered irregularly along the body of both sexes. These protuberances might be caused by the fixative. The acetabulum is absent from both sexes in all the described species of the genus. The oral sucker is present in one sex (apparently only the male of G. monocotylea Szidat, 1930) or in both sexes (in G. gyrauli Brackett, 1942) or the oral sucker is absent (G. acotylea Odhner, 1910, G. egreta Lal, 1937 and G. lawayi Brackett, 1942, and G. huronensis, Najim, 1950). Brackett (1942) erroneously indicated the presence of an oral sucker in the type species, G. acotylea Odhner, 1910.

The digestive system is generally similar in all the species where this system was described. Paired intestinal caeca in male are anterior to gynaecophoric canal or anterior to this level when the gynaecophoric canal is absent. The

intestinal caeca in the female unite directly posterior to the seminal receptacle. Mouth is terminal or subterminal. The seminal vesicle and the adjacent organs (Endapparat) show wide differences from a simple sac to a more or less complicated structure as was previously mentioned.

The gynaecophoric canal is absent or imperfectly formed, a situation which is not unfamiliar among the members of the subfamily Bilharziellinae. McMullen and Beaver (1945) in discussing this structure in the subfamily Bilharziellinae referred erroneously to Pseudobilharziella filiformis Szidat (1939) while, it appears, they wanted to refer to G. monocotylea Szidat (1930), because the gynaecophoric canal is present, without doubt, in P. filiformis Szidat (1939) and the statement and argument of the two authors rather apply to G. monocotylea Szidat, 1930. Whether there is a gynaecophoric canal in G. monocotylea which Szidat might have overlooked, as McMullen and Beaver (1945) pointed out, or whether it is just an enlargement in the body as the figure showed, can not be determined unless the specimens themselves are re-examined. Szidat's statement of the lack of a gynaecophoric canal in his species G. monocotyles will have to be accepted.

The male genital pore opens at the beginning of the gynaecophoric canal or at this level when the gynaecophoric canal is absent. In some species the opening is described on the left of midline.

The testes of the species of Gigantobilharzia differ in shape, size, and arrangement. The testes in G. acotylea are

small, oval-shape, start shortly posterior to the gynaecophoric canal and are set on both sides of the vas deferens. Szidat (1930) did not mention much about this structure in G. monocotylea, nor do his diagrams show clearly these structures. In G. egreta Lal, 1937 the testes are rather large, round to oval in shape, and lie on both sides of the common caecum. The testes of G. gyrauli Brackett (1942) show no regular shape and start shortly posterior to the gynaecophoric canal. In G. lawayi Brackett, (1942) the testes are wider than long, arranged in tandem, and start farther forward than the posterior end of the gynaecophoric canal. The shape of the testes in G. huronensis is, more or less, like those in G. egreta Lal, 1937 but the latter are much larger in size. The testes of G. huronensis start from a point farther forward than the posterior end of the gynaecophoric canal. The testes in all the described species occupy the greatest portion of the body length and extend posteriorly to a point close to the end of the body. From the above discussion it may be concluded that the testes are different in shape, being round to broadly oval, oval and irregular in shape. The testes start from a point shortly posterior to the posterior end of the gynaecophoric canal (when this structure is present) or farther forward than the posterior end of the gynaecophoric canal. In all species the testes are numerous.

The ovary of the described species of Gigantobilharzia is in accord with what has been described for the subfamily

Bilharziellinae, being an elongated, more or less, spiral organ. The connection of the ovary to the oviduct and the latter to the seminal receptacle has been discussed previously. However, similar connections to that of G. huronensis are found in Ornithobilharzia emberizae Yamaguti, 1941 but in the latter species Laurer's canal is located posterior to the seminal receptacle while in G. huronensis, the canal is found between the seminal receptacle and ovary. The female genital pore opening is close to the mouth opening, shortly posterior to the latter opening in almost all the described species. McMullen and Beaver (1945) suggested re-examination of the location of the female genital opening in Gigantobilharzia. This work confirms the previous observations on other species of the genus and it can be stated that the female genital opening is located in a characteristic position in almost all the members of the genus Gigantobilharzia.

The posterior end ofthe body is blunt, with the exception of G. acotylea Odhner, 1910 which has elaborated lateral expansions. However, some species show a sort of flattening at this end. Tanabe (1951) designated cercaria sturniae as Gigantobilharzia sturniae Tanabe, 1948 n. comb. Since Tanabe's description of the new species is scanty and inadequate, not much can be done with this species. However, concerning the presence of an acetabulum Tanabe stated that there was"an anteriorly placed genital pore and acetabulum, the latter being very indistinct or possibly absent." Since the absence of

the acetabulum is one of the determining characters in the genus Gigantobilharzia, in which it has not been reported in any of the other described species, Tanabe's species should be re-examined. From the above discussion the following generic diagnosis is submitted:

GENERIC DIAGNOSIS: Gigantobilharzia Odhner, 1912 (emended) Bilharzellinae: Male and female elongated, filiform; or the male may be somewhat flattened. Cuticle without spines, acetabulum absent, oral sucker present or absent.

Male: Gynaecophoric canal, if present, short, situated in anterior part of body; digestive system similar to that of Bilharziella; testes originate posterior to or anterior to the posterior end of the gynaecophoric canal. Cirrus and cirrus pouch present or absent. Genital pore situated at anterior end of gynaecophoric canal or at about this level when the gynaecophoric canal is absent.

Female: Ovary moderately long and spiral; vitelline follicles occupy most of the body length. Uterus contains a single or several eggs; genital pore shortly posterior to the mouth opening; eggs oval to almost spherical. Adults found in birds.

Type species: G. acotylea Odhner, 1910.

KEY TO THE SPECIES

1. Gynaecophoric canal present. 2
   Gynaecophoric canal absent. 5
2. Oral sucker present . . . . . G. gyrauli Brackett, 1942
   Oral sucker absent. 3
3. Male somewhat flattened 140 mm.-160 mm. long by 0.25 mm.-0.35 mm. wide, female filamentous 30-35 mm. long by 0.1 mm.-0.20 mm. in diameter . . . . . G. acotylea Odhner, 1910
   Male and female filamentous, female longer than male. 4
4. Esophagus in male 0.22 mm.-0.30 mm. long; female about 10 mm. long . . G. lawayi Brackett, 1942
   Esophagus in male long; female 18-29 mm. . . . . G. huronensis Nojim, 1950
5. Male and female described, oral sucker present in male. . . . . G. monocotylea Baidat, 1930
   Male only described, oral sucker absent . . . . . G. agreta Lal, 1937

SUMMARY

1. The life-cycle of Gigantobilharzia huronensis Najim, 1950 was determined experimentally and detailed morphological studies were made on each stage of the life cycle.
2. The snail, Physa gyrina (Say), served as the intermediate host.
3. The natural definitive hosts were goldfinches (Spinus tristis tristis) and cardinals (Richmondena cardinalis). Chicks and canaries served as susceptible hosts in the laboratory.
4. The shortest time recorded for the hatching of eggs in water is about 20 minutes. Cercariae were liberated from the snail as early as 24 days after exposure. Eggs were found in the feces of the definitive host 31 days after the first exposure to the cercariae.
5. The adult worms are elongate and filiform. Females are longer than males and in both sexes the oral and ventral sucker are absent. The cuticle has no spines. A short gynaecophoric canal is present. Up to 300±testes are present in the male and the cirrus is spiny. Laurer's canal is present and vitelline follicles fill most of the body of the female. The uterus contains from one to several eggs at a time and the genital pore is located shortly posterior to the mouth opening.
6. The eggs are spherical to very broadly ovoid in shape and averaged 93μ in length by 88μ in width.

7. The miracidium has a peculiar wide gap between the second and third rows of epidermal plates. The body covering consists of twenty-two epidermal plates arranged in four rows of 6: 9: 4: 3.
8. The mother sporocyst has an elongate, sac-like body. A birth pore is present in the mature mother sporocysts.
9. The daughter sporocyst has also an elongate body but unlike the mother sporocyst, the anterior end is covered with spines. A birth pore is present in the mature daughter sporocysts.
10. The cercaria is an apharyngeal, furcocercous, brevifurcate, distome with pigmented eyespots; the body averaging 240μ in length by 72.5μ in width; the tail stem averaging 268.5μ in length by 30μ in width; the furca averaging 146.8μ in length by 15μ in width. The furca have fin folds. The body and the tail are covered with spines. There are five pairs of penetration glands and an oral gland. The excretory system is usually 2[(2) + (2 + 1)]. The cercaria attaches to the surface film of the water with the body parallel to it and the tail hanging downward at different angles. The cercaria is a dermatitis producer in human skin.

LITERATURE CITED

References marked with asterisk not read in the original.

Abdel-Malek, E. T. 1950. Susceptibility of the snail Biomphalaria boissyi to infection with certain strains of Schistosoma mansoni. Am. J. Trop. Med., 30 (6): 887-894.

Barlow, C. H. 1925. The life cycle of the human intestinal fluke Fasciolopsis buski (Lankester). Am. J. Hyg., Monogr. Ser., (4): 1-98.

_____. 1936. Is there dermatitis in Egyptian schistosomiasis? Am. J. Hyg., 24 (3): 587-599.

Bilharz, Th. 1852. Ein Beitrag zur Helminthographia humana nebst Bemerkungen von C. Th. von Siebold. Ztschr. F. Wiss. Zool., 4:53.

Blacklock, D. B. and Thompson, H. G. 1924. Human schistosomiasis due to S. haematobium in Sierra Leone. Ann. Trop. Med. and Parasitol., 18 (2): 211-234.

Brackett, S. 1940a. Studies on schistosome dermatitis. VI. Notes on the behavior of schistosome cercariae. Am. J. Hyg., 31 (Sect. D): 64-73.

_____. 1940b. Two new species of schistosome cercariae from Wisconsin J. Parasitol., 26 (3): 195-200.

_____. 1940c. Studies on schistosome dermatitis VIII. Notes on the biology of the snail hosts of schistosome cercariae in Wisconsin and epidemiological evidence for the life cycles of some avian schistosomes. Am. J. Hyg., 32 (Sect. D): 85-103.

_____. 1942. Five new species of avian schistosomes from from Wisconsin and Michigan with the life cycle of Gigantobilharzia syrauli (Brackett, 1940). J. Parasitol., 28 (1): 25-42.

Braun, M. 1901. Zur Revision der Trematoden der Vogel. Centr. Bakt., Abt. 1. 29: 941-948.

Brock, G. S. 1893. Anatomy and physiology of the bilharzia ovum. The Lancet, 2: 622-625.

Brumpt, E. 1931. Cercaria ocellata, determinant la dermatite des nageurs, provient d' une bilharzia des canards. Comp rend. Acad. Sci., 193: 612-614.

Chapin, E. 1924. Helminth. Soc. Wash., 36th meeting, J. Parasitol., 10 (4): 208.

Chentum, E. L. 1941. Dendritobilharzia anatinarum n. sp., a blood fluke from the mallard. J. Parasitol., 27 (2): 165-170.

Christenson, R. O. and Greene, W. P. 1928. Studies on biological and medical aspects of "Swimmer's" itch. Schistosome dermatitis in Minnesota, Minn. Med., 11 (9): 573-575.

Coe, W. R. 1896. Notizen über den Bau des Embryos von Distomum hepaticum. Zool. Jahrb., Abt. f. Anat., 9: 561-570.

Cort, W. W. 1919. Notes on the eggs and miracidia of the human schistosomes. Univ. Calif. Publications in Zool., 18 (18): 509-519.

_____. 1928. Schistosome Dermatitis in the United States (Michigan). J. Am. Med. Assoc., 90 (13): 1027-1029.

_____. Ameel, D. J. and Oliver Louis 1944. An experimental study of the development of Schistosomatium douthitti (Cort, 1914) in its intermediate host. J. Parasitol., 30 (1): 1-17

_____. and Olivier, L. 1943. The development of the sporocysts of a schistosome, Cercaria stagnicolae Talbot, 1936. J. Parasitol., 29 (3): 164-176.

Ejsmont, L. 1929. Uber zwei Schistosomatidengattunger der Vögel. Acad. Polonaise Sc. Math. et Nat., Ser. B: 389-403

El-Gindy, M. S. 1950. Biology of Schistosomatium douthitti (Cort, 1914) Price 1931, (Trematoda) in its hosts. Unpublished thesis, Univ. of Michigan.

Faust, E. C. 1924a. Notes on Ornithobilharzia odhneri n. sp. from the Asiatic Curlew. J. Parasitol., 11 (1): 50-54.

_____. 1924b. Schistosomiasis in China: Biological and practical aspects. Proc. Roy. Soc. Med., 17: 31-43.

_____. and Hoffman, W. A. 1934. Studies on Schistosomiasis mansoni in Puerto Rico. III. Biological studies. I. The extra-mammalian phases of the life cycle. Puerto Rico J. Pub. Health and Trop. Med., 10 (1): 1-97.

_____. and Meleney H. E. 1924. Studies on Schistosomiasis japonica. Am. J. Hyg., Monogr. Ser. (3), 339 pp.

* Gogate, B. S. 1934. On the trematodes from wild ducks in Rangoon. Rec Ind. Mus., 36.

Goodchild, Ch. G. 1948. Additional observation on the bionomic and life history of Gorgodera amplicava Looss, 1899 (Trematoda: Gorgaderidae). J. Parasitol., 34 (5): 407-427.

Gordon, R. M. Davey, T. H. and Peaston, H. 1934. The transmission of the human bilharziasis in Sierra Leone, with an account of the life-cycle of the schistosomes concerned, S. Mansoni and S. haematobium. Ann. Trop. Med. and Parasitol., 28: 323-418.

Hunter, W. S. and Hunter, G. W. III 1935. Studies on Clinostomum. II. The miracidium of C. marginatum (Rud). J. Parasitol., 21(3): 186-189.

Johnston, S. J. 1917. On the trematodes of Australian birds. Jour. and Proc. Roy. Soc. N. South Wales, 50: 187-261.

Kowalewski, M. 1896a. . Studya helmintholog1czne III. Bilharzia polonica sp. nov. (Helminthologische Studien III. Bilharzia polonica sp. nov.) Mit 1 Taf., Anzeiger Akad. Wissenschaften Krakau, 2: 63-72.

_____. 1896b. . Studya helmintholog1czne iv. Sprostowania i uzupetnienia do pracy mej o Bilharzia polonica sp. nov. (Etudes helminthologiques iv. Amendements et supplements au travail de l'auteur sur le Bilharzia polonica sp. nov.). Avec 1 planche. Anzeiger Akad. Wissenschaften Krakau, 3: 145-148.

Kuntz, R. E. 1946. Effect of light and temperature on shedding of Schistosoma mansoni cercariae. Research Project X-535, Report No. 7, Naval Medical Research Institute, 16 April.

Lal, M. B. 1937. Studies on the trematode parasites of birds. Part II. Morphology and systematic position of some new blood-flukes of the family Schistosomidae. Proc. Ind. Acad. Sci., 6 (5): 274-283.

Lampe, P. H. J. 1927. The development of Schistosoma mansoni. Proc. Roy. Soc. Med., 20: 1510-1516.

La Rue, G. R. 1938. Life history studies and their relation to problems in taxonomy of digenetic trematodes. J. Parasitol., 24 (1): 1-11.

Linton, E. 1928. Notes on trematode parasites of birds. Proc. U. S. Nat. Mus., 73, Art. 1,1-36.

Looss, A. 1886-1901. Beobachtungen über die Eir und Embryonen von Bilharzia, in: Leuckart Parasiten des Menschen. Leipzig, Bd. 1 Apt. 2: 521-234.

_____. 1892. Ueber Amphistomum subclavatum Rud. und seine Entwicklung, in: Festschrift zum siebenzigsten Geburtstage Rudolf Leuckart, Leipzig: 147-167.

_____. 1899. Weiter Beiträge zur Kenntnis der Trematoden-Fauna Aegyptens, zugleich Versuch einer naturlichen Gliederung des Genus Distomum Retzius. Zool. Jahrb. Syst., 12: 521-784.

Lynch, J. E. 1933. The miracidium of Heronimus chelydrae MacCallum. Quar. Jour. Mic. Sci., 76 (1): 13-33.

Maldonado, J. F. and Acosta-Matienzo, J. 1947. The development of Schistosoma mansoni in the intermediate host, Australorbis glabratus. Puerto Rico J. Pub. Health and Trop. Med., 22 (4): 331-373.

Maldonado, J. F. and Acosta-Matienzo, J. 1948. Biological studies on the miracidium of Schistosome mansoni. I. Hatchability, Longevity, and infectivity of the miracidium of S. monsoni. Am. J. Trop. Med., 28 (5): 645-657.

Mehra, H. R. 1940. A new distome Entrohaematrema n.g. and a new blood fluke Hemiorchis bengalensis n. sp. belonging to the family Spirorchidae Stunkard, and a new species of the genus Dendritobilharzia Skrjabin and Zakharow belonging to the family Schistosomatidae Poche, with remarks on the evolution of the blood flukes. Proc. National Acad. Sci. India, 10 (4): 100-118.

Miller, Anne Van der Woude 1950. Germ. cell cycle of Megalodiscus temperatus (Stafford, 1905) Harwood, 1932 (Paramphistomidae: Trematoda). Unpublished thesis. U. of M.

Miller, E. L. 1935. North American Cercariae. Ill. Biol. Monog. 14 (2): 1-125.

Miller, H. M. Jr. 1926. Comparative studies on furcocercous cercariae. III. Biol. Monogr., 10 (3): 1-112.

_____. 1927. Furcocercous larval trematodes from San Juan island, Washington. Parasitol., 19: 61-83.

McLeod, J. A. 1936. Further notes on cercarial dermatitis. Trans. Roy. Soc. Can., Sect. V; 39-48.

_____. 1937. Two new schistosomid trematodes from water-birds. J. Parasitol., 23 (5): 456-466.

_____. 1940. Studies on cercarial dermatitis and the trematode family Schistosomatidae in Manitoba. Can. J. Research, D, 18: 1-28.

_____. and Little, G. E. 1942. Continued studies on cercarial dermatitis and the trematode family Schistosomatidae in Manitoba part 1. Can. J. Research, D, 20: 170-181.

McMullen, D. B. and P.C. Beaver 1945. Studies on schistosome dermatitis IX. The life cycles of three dermatitis-producing schistosomes from birds and discussion of the subfamily Bilharziellinae (Trematoda: Schistosomatidae). Am. J. Hyg., 42 (2): 128-154.

Naegeli, A. 1923. Ueber einen beim Baden entstehenden Hautausschlag, die sog. Hundsblattern (Exanthema caniculare). Schweiz med. Wochschr., 49: 1121-1122.

Najim, A. T. 1950. Gigantobilharzia huronensis sp. nov., a bird blood-fluke from the goldfinch. J. Parasitol. 36 (6-Sec. 2):19.

Odhner, T. 1910. Gigantobilharzia acotylea n.g.n.sp., ein mit den Bilharzien verwandter Blutparasit von enormer Lange. Zool. Anz., 35 (12/13): 380-385.

_____. 1912. Zum natürlichen System der digenen Trematoden. V. Zool. Anz., 41 (1):54-70.

Oiso, T. 1927. On a new species of avian schistosoma developing in the portal vein of the duck, and investigation of its life-history. Taiwan Igakkai Zasshi, Taihoku Sept. English summary, pp.1-3.

Olivier, L and Mao, C. P. 1949. The early larval stages of Schistosoma mansoni Sambon, 1907 in the snail host, Australorbis glabratus (Say, 1818). J. Parasitol., 35 (3): 267-275.

Ozaki, Y. 1951. Studies on the Miracidium of Trematodes. I. The Miracidia of Paramphistomum explanatum (Creplin), P. orthocoelium Fischoeder and Gastrothylax cobboldi Fischoeder. Jour. Sci. Hiroshima University, 12 (Series B, Div.1):99-111.

*Parona, C. and Ariola, V. 1896. Bilharzia kowalewskii n.sp. nel Larus melanocephalus. (Nota preventiva) Atti Soc. Ligust. di sc. nat. e geogr., Genova, 7: 114-116.

Penner, L. R. 1950. Cercaria littorinalinae sp. nov., A dermatitis-producing schistosome larva from the marine snail, Littorina planaxis Phillippi. J. Parasitol., 36 (5):466-472.

Poche, F. 1907. Einige Bemerkungen zur Nomenclatur der Trematoden. Zool. Anz. 31 (4):124-126.

Dou[illegible], A. [illegible]. The [illegible] trematodes found in certain South African [illegible] with special reference to the histology of the [illegible] (Distomidae). Publications S. African Inst. Med. Research, [illegible] (40): [illegible]-460.

Price, E. W. 1936. A synopsis of the trematode family Gorgoderidae with descriptions of new genera and species. Proc. U.S. Nat. Mus., 83: [illegible]-30 pls. [illegible]-15.

Price, E. W. 1937. Notes on Neorchilarynx Travassos. Helminth. Soc. Wash., 4: 34-36 [illegible]. J. Parasitol., 23 (4): [illegible]-23[illegible].

Price, E. W. 1937. Life history of Deliotocoelium (Dist.). Am. J. Hyg., 25 (3): [illegible]-[illegible].

[illegible]r, H. 1913. Untersuchungen über Bau und Entwicklung der Amphistomen-Larven aus den Gattungen Paramphistomum und Diplodiscus. I. Die Entwicklung der Miracidium-Larve von Paramphistomum cervi (Zeder) Fischoeder. Zeitschr. wiss. Zool. Abt. A., 107: (1, 2.): [illegible]-[illegible].

[illegible]i, S. A. [illegible]. Entozoorum Synopsis cui praemittuntur Monita [illegible] Diesingii et Leuckartii [illegible] Mantissa. pp. [illegible]. Vindobonae.

[illegible]ov, V. L. 1917. Trematody ptits [illegible] (Vogel-Trematoden des westlichen der Union d. [illegible].) Chor. [illegible] [illegible]. Petrograd, [illegible]-[illegible].

[illegible], [illegible] B. [illegible]. 1921. Gorgoderina Linton. Index C. Med. Helminthol., [illegible] (Suppl.): [illegible]-[illegible].

[illegible], I. B. 1930. Studies on some Deliotocoelium (Dist., [illegible]) Price, 1931 (Trematoda: Schistosomatoidea). Unpublished thesis. Univ. of [illegible].

[illegible]rjabin, K.I. 1924. Etiudy po izucheniiu parazitich. chervei ptits Rossii. Trudy Gosud. Inst. Eksper. Vet., Moskva, 1:140-177.

*_____. 1924. K faune parazitcheskikh chervei Turkestanskikh pelikanov (Pelecanus onocrotalus L.). 8 pp. 26 cm. Moskva (Reprint of above, pp. 149-154.)

*_____ and Zakharow, N.P. 1920. Dva novykh roda trematod iz krovi ptits. (Materialy k poznaniiu gelmintofauny ptits Rossii) (Zwei neue Trematoden-Gattungen aus den Blutgefässen der Vögel. (Beitrag zur Kenntniss der Helminthenfauna der Vögel Russlands). Izviest. Donsk. Vet. Inst. 2:1-5; German summary, pp. 5-6

Soparkar, M. B. 1921. The cercaria of Schistosomum spindalis (Montgomery). Indian J. Med. Research, 9 (1): 1-22.

Stirewalt, M. A. 1951. The frequency of bisexual infection of Schistosoma mansoni in snails of the species Australorbis glabratus (Say). J. Parasitol 37 (1): 42-47.

Szidat, L. L929a. Zur Entwicklungsgeschichte des Bluttrematoden der Enten Bilharziella polonica Kow. 1. morphologie und biologie der cercarie von Bilharziella polonica Kow., Centr. Bakt., Abt. I. 111: 461-470

_____. 1929b. Die Parasiten des Hausgeflügels. 3. Bilharziella polonica Kow., ein Blut schmarozender Trematode unserer Enten, seine Entwicklung und Uebertragung. Arch. f. Geflügelk.,3: 78-87.

_____. 1930. Gigantobilharzia monocotylea n. sp., ein neuer Blutparasit aus Ostpreussischen Wasservögeln. Ztschr. Parasitenk., 2:583-588.

_____. 1939. Pseudobilharziella filiformis n. sp., eine neue Vogelbilharzie aus dem Höckerschwan, Cygnus olor L. Ztschr. Parasitenk., 10: 535-544.

Talbot, S.B. 1936. Studies on schistosome dermatitis. 11. Morphology and life history studies on three dermatitis-producing schistosome cercariae, C elyae Miller, C. stagnicolae n. sp. and C. physellae n. sp. Am. J. Hyg., 23: 372-384.

Tanabe, A. 1951. Cercaria segmentinae Tanabe 1948, A Homonym of Cercaria sturniae. J. Parasitol., 37 (3): 321.

Tang, C. C. 1938. Some remarks on the morphology of the miracidium and cercaria of Schistosoma japonicum. Chinese Med. J., Suppl., 2: 423-432.

Taylor, E. L. and Baylis, H. A., 1930. Observations and experiments on a dermatitis-producing cercaria and on other cercariae from Lymnaea stagnalis in Great Britain. Tr. Roy. Soc. Trop. Med. and Hyg., 24 (2): 219-244.

Thomas, A. P. 1883. The life history of the liver-fluke (Fasciola hepatica). Quar. Jour. Mic. Sci., 23: 99-133.

Travassos, L. 1922. Informacoes sobre a fauna helminthologica de Matto Grosso. A folha Medica, Rio de Janeiro, 3 (22): 187-190.

Wall, L. D. 1941a. Life history of Spirorchis elephantis (Cort, 1917), a new blood fluke from Chrysemys picta. Amer. Midl. Nat., 25 (2): 402-412.

_____. 1941b. Spirorchis parvus (Stunkard), its life history and development of its excretory system (Trematoda: Spirorchiidae). Tr. Am. Micr. Soc., 60 (2): 221-226.

Watson, J. M. 1950. Studies on Bilharziasis in Iraq. Part IV. The National Anti-Bilharzia Campaign. J. Royal Faculty Med. Iraq, 14:25-37.

Weinland, D. F. 1858. Human cestoides. An Essay on the tapeworm of Man. pp. 93., figs. 12. Cambridge (Mass.)

Wetzel, R. 1930. A new species of trematode worm of the genus Ornithobilharzia from Canadian goose. Proc. U. S. Nat. Mus., 78, Art. 3: 1-4.

Yamaguti, S. 1940. Vergleichend-anatomische Studien der Miracidien. Ztschr. Parasitenk., 11: 657-668.

_____. 1941. Studies on the Helminth Fauna of Japan Part 32. Trematodes of Birds, V. Japanese Jour. Zoology, 9 (3): 321-341.

Young, R. L. 1937. Another record of ovian schistosomes in North America. J. Parasitol., 23 (3): 295-296.

EXPLANATION OF PLATES

All the drawings in plates I, II and III were made with the aid of a camera lucida.

ABBREVIATIONS

B	Brain
BP	Bristle patch
C	Cirrus
CP	Cirrus pouch
EJM	Ejaculatory muscle
ESG	Esophageal glands
EXP	Excretory pore
GJ	Gynaecophoric canal
GP	Genital pore
LG	Laurer's canal
MG	Mehlis' gland
O	Ovum
OC	Oötype
OV	Ovary
OVD	Oviduct
P	Prostate
SR	Seminal receptacle
SV	Seminal vesicle
T	Testis
VD	Vas deferens
VE	Vas efferens
VI	Vitellaria
VTD	Vitelline duct

EXPLANATION OF PLATE I

All the drawings were made from whole mounts.

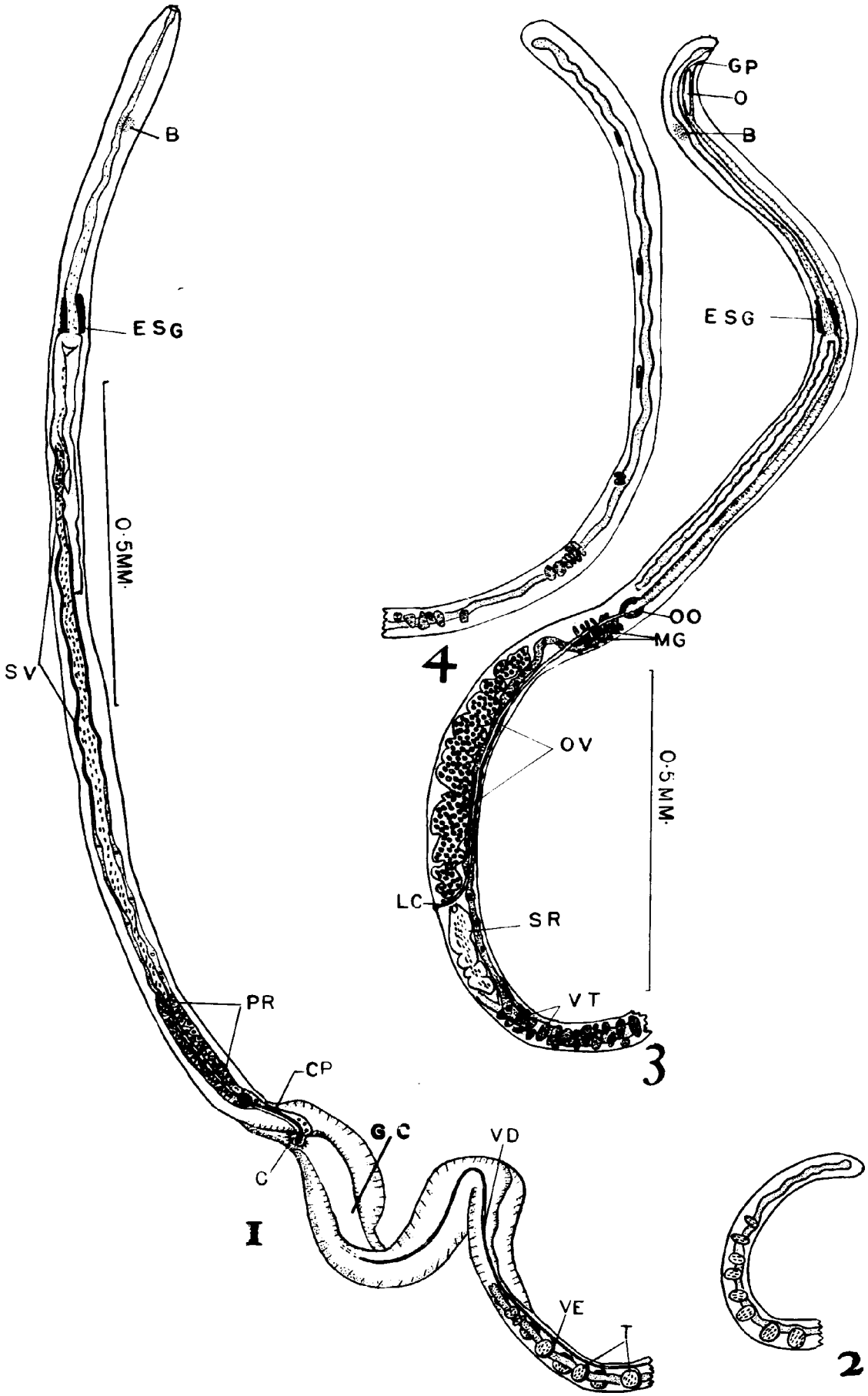
Fig. 1-Anterior part of an adult male including gynaecophoric canal and a short portion of the testes region.

Fig. 2-Posterior end of an adult male.

Fig. 3-Anterior end of an adult female.

Fig. 4-Posterior end of an adult female

PLATE I



EXPLANATION OF PLATE II

Fig. 5-A longitudinal section of the anterior end of a male showing the anterior extension of the buccal cavity.

Fig. 6-The end part of male "endapparat", highly magnified.

Fig. 7-Connections of the ovary, seminal receptacle and Laurer's canal; constructed from several specimens.

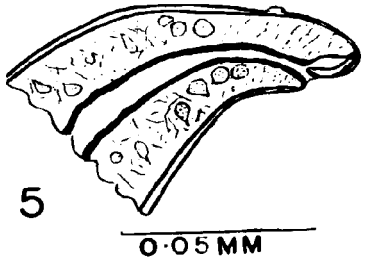
Fig. 8-A matured viable egg from the feces of a canary.

Fig. 9-A miracidium showing the primitive gut, penetration glands, brain, triangular bodies and germ cells.

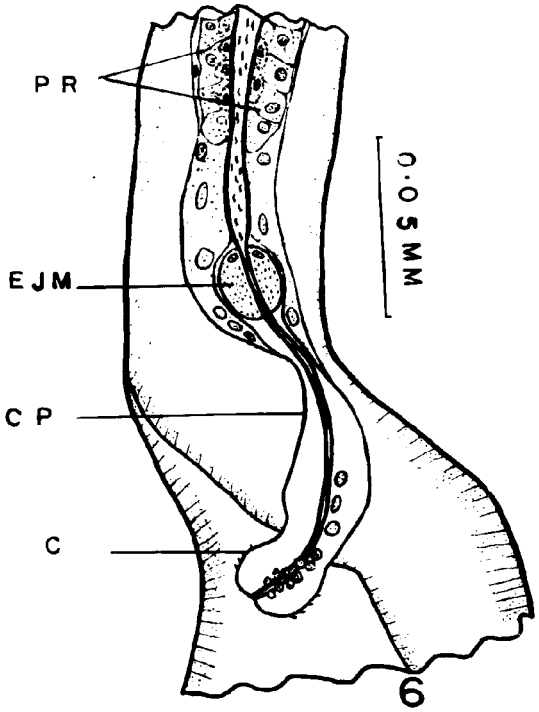
Fig. 10-A dorsal ventral view of a constructed miracidium showing one side of the excretory system, bristles in the anterior papilla, the lateral papillae and the lateral processes.

Fig. 11-A miracidium treated with silver nitrate showing the epidermal plates.

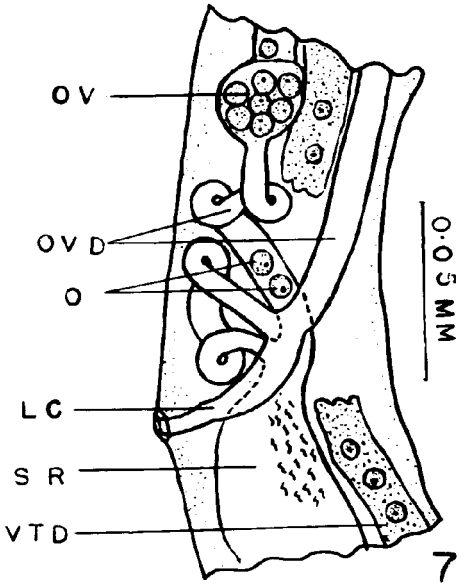
PLATE II



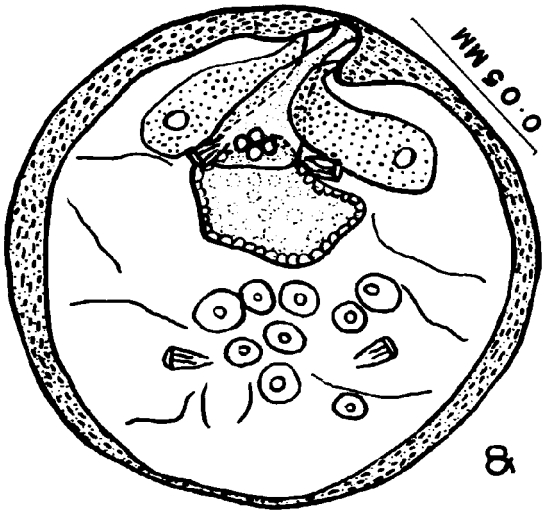
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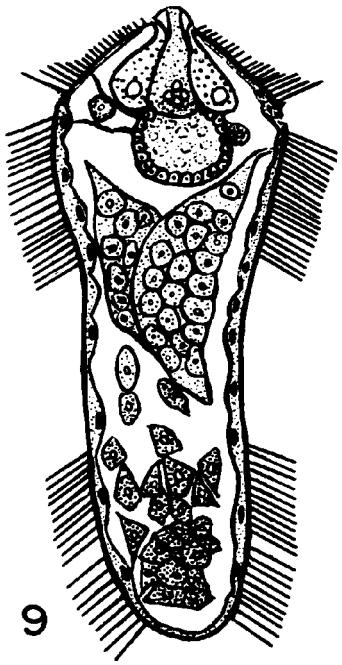
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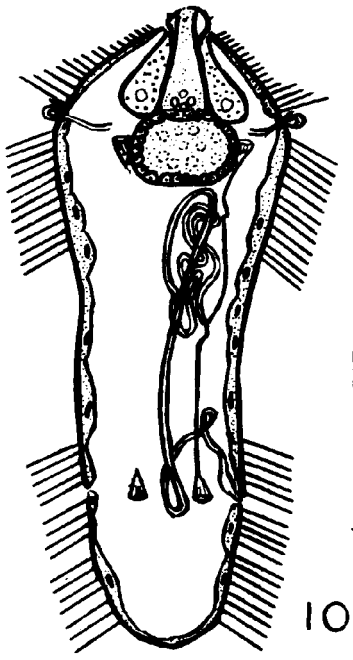


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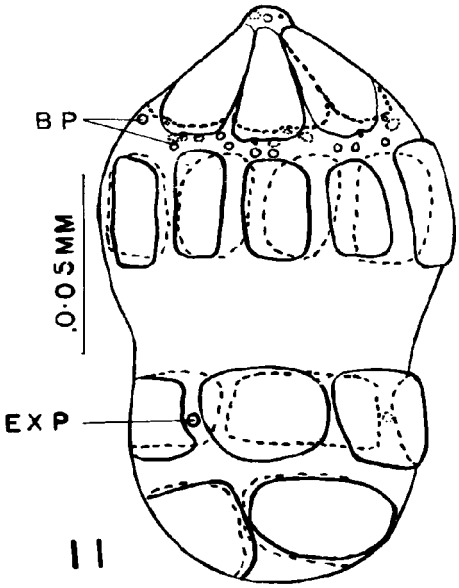


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EXPLANATION OF PLATE III

Fig. 12-Mother sporocyst, 15 days old

Fig. 13-Body wall and some of the germinal materials in the lumen of a 14 days old, mother sporocyst.

Fig. 14-Daughter sporocyst, 18 days old showing the spined anterior end.

Fig. 15-Body wall of 22 days old daughter sporocyst.

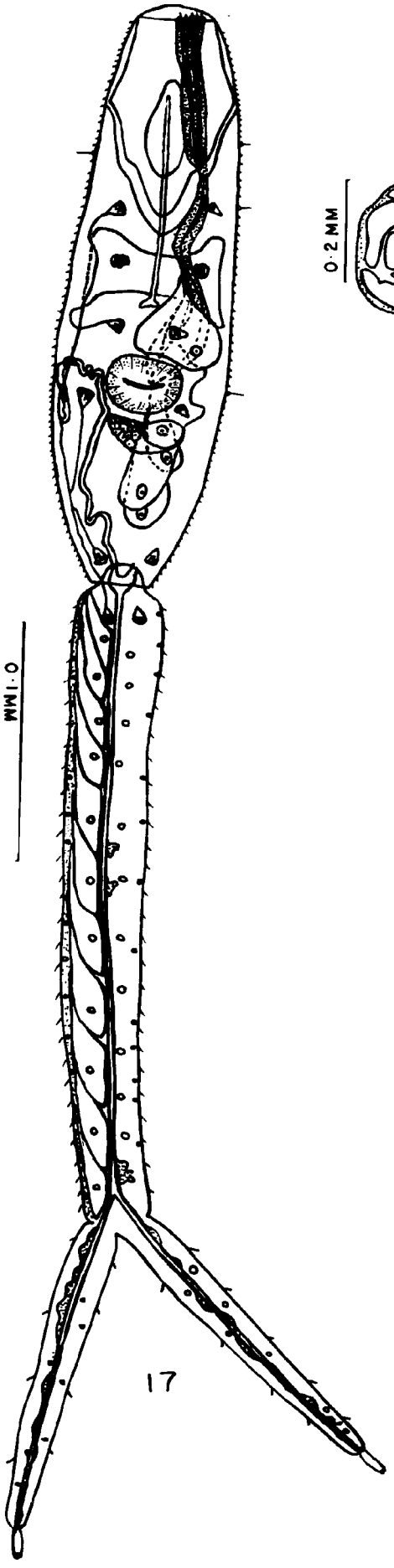
Fig. 16-Birth pore of a 59 day old daughter sporocyst.

Fig. 17-A cercaria constructed to show different structures. On the left showing excretory system and muscle cells in tail stem, on the right showing the penetration glands.

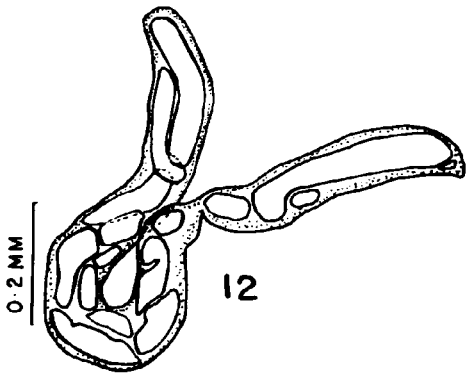
Fig. 18-Dorsal side of the anterior end of the cercaria showing the distribution of the spines.

Fig. 19-Ventral side of the same portion showing the distribution of the spines and mouth opening.

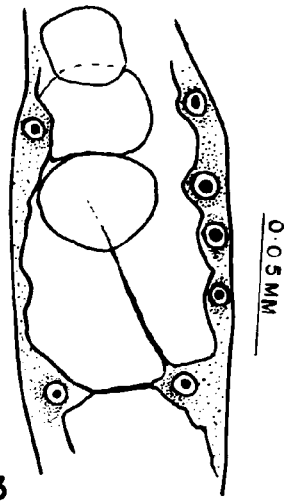
PLATE III



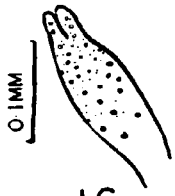
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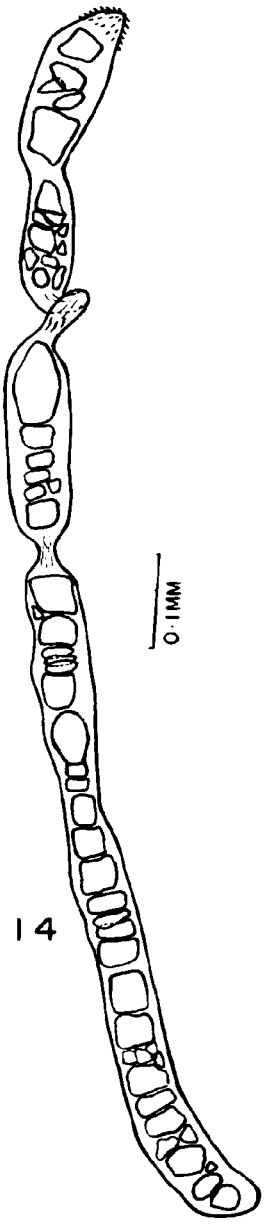
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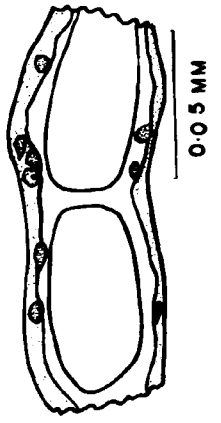
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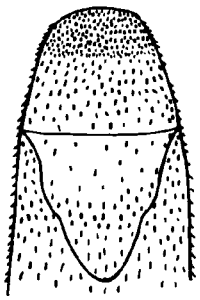
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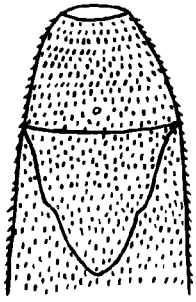
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EXPLANATION OF PHOTOMICROGRAPHS

PLATE I

Fig. 20-A whole mount of male, 26 days old, about 2.5 m.m. long.

Fig. 21-A longitudinal section of male showing the glans.

Fig. 22- A whole mount of female, 27 days old, about 5 m.m. long.

Fig. 23-Anterior part of the same female.

PLATE IV

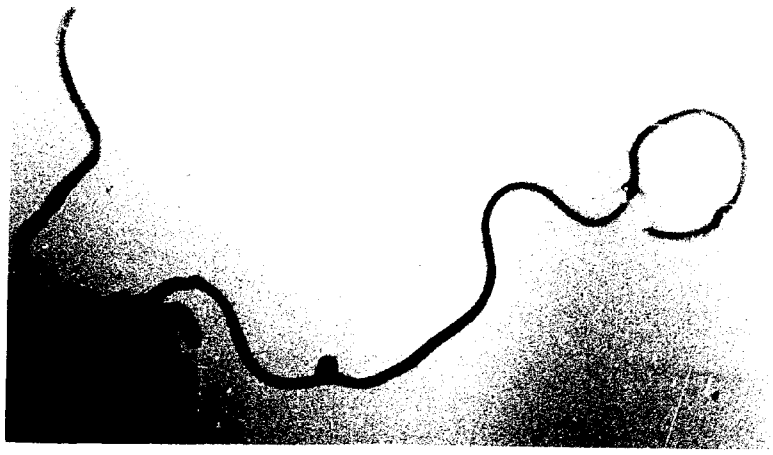


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EXPLANATION OF PHOTOMICROGRAPHS

PLATE V

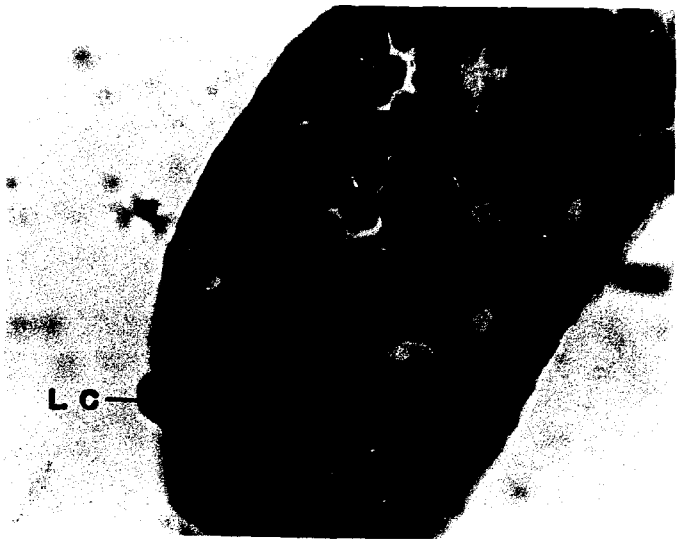
Fig. 1- Longitudinal section of a female Ascaris lumbricoides.

Fig. 2- Diagram from a section of a carmine stained whole mount.

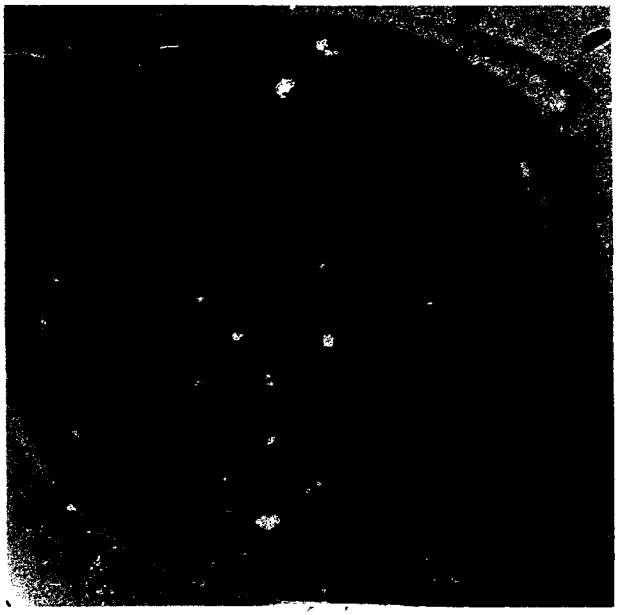
Fig. 3- Cross section of the intestine of an infected Ascaris lumbricoides showing the location of the eggs.

Fig. 4- Cross section of the same organism showing invasion of the intestinal villi by eggs, in the region of the liver.

PLATE V



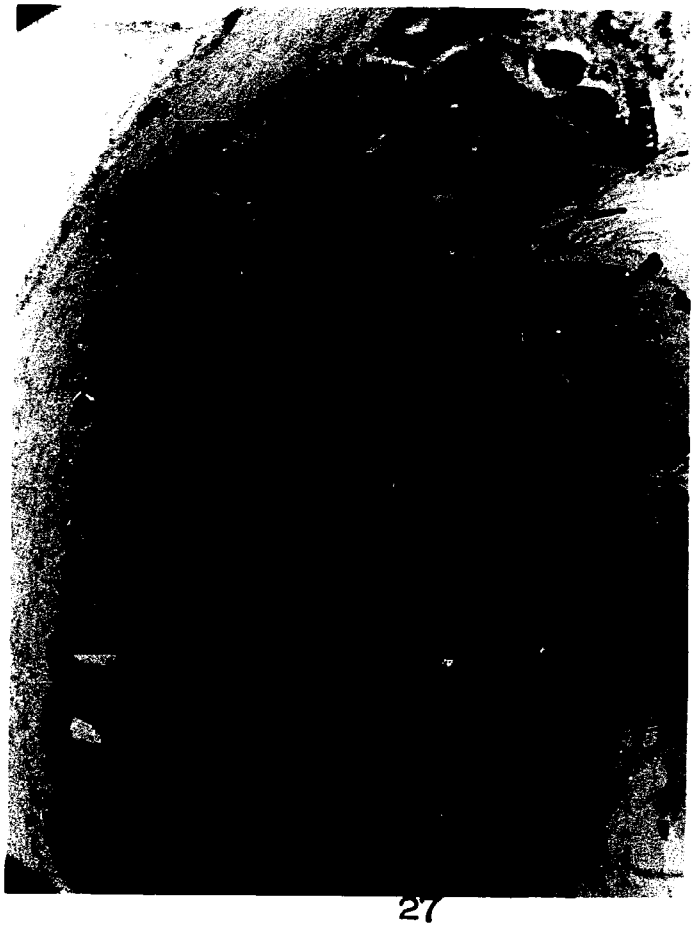
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EXPLANATION OF PHOTOMICROGRAPHS

PLATE VI

Fig. 28-A whole mount of a miracidium.

Fig. 29-A section of a snail 45 minutes after exposure to miracidia showing a miracidium still retaining its cilia on the anterior end, in the foot-head region of the snail.

Fig. 30-A miracidium treated with silver nitrate showing epidermal plates.

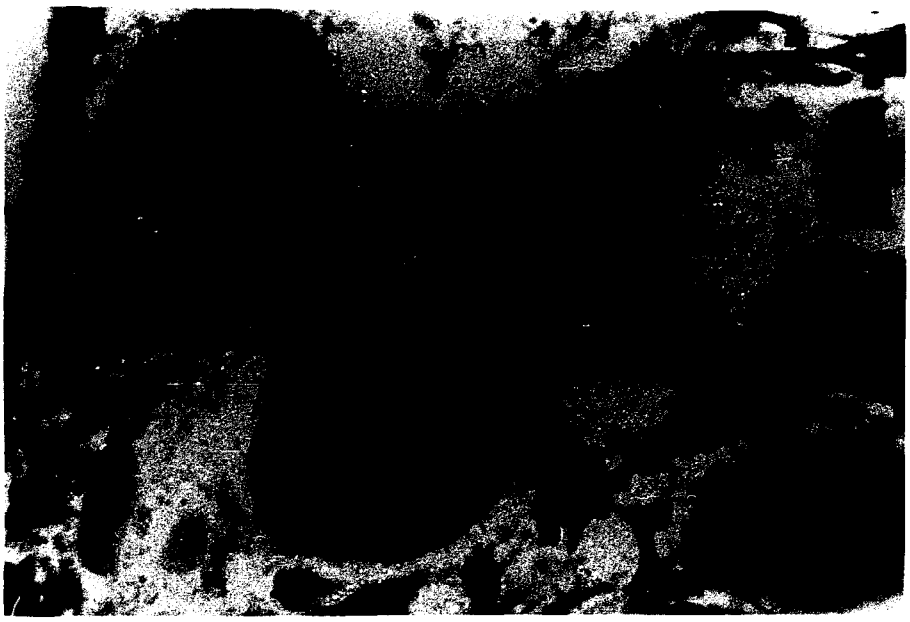
Fig. 31-Dermatitis infection caused experimentally by the cercariae of this species on the arm of the author.

Fig. 32-A whole mount of cercaria stained with Mayer's HCl Carmine. The two anterior pairs of penetration glands do not show clearly while the three posterior pairs and the cystogenous gland take the stain.

PLATE VI



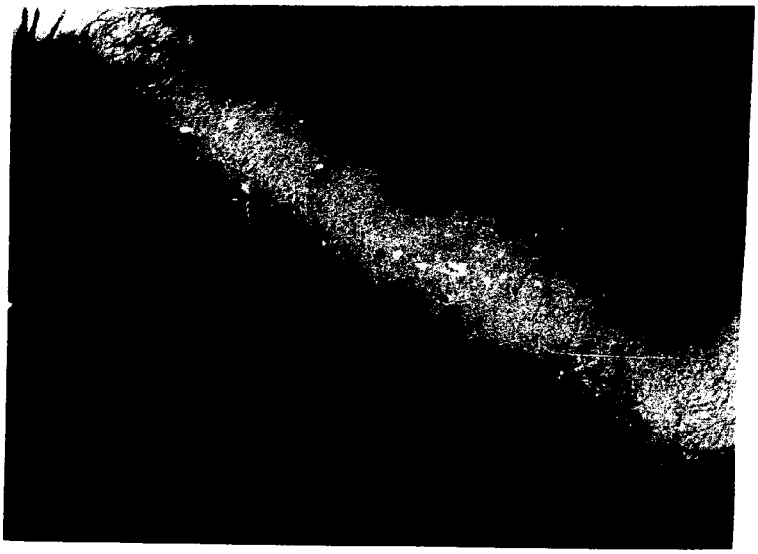
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