

sinense Cobbold 1875; *D. spatulatum* Leuckhart 1876, nec Rudolphi 1819; *D. hepatis endemicum* s. *perniciosum* Baelz 1883; *D. hepatis innoecum* Baelz 1883; *D. japonicum* R. Blanchard 1886; *D. endemicum* Ijima 1886.) Length 9-15 or even 18 mm.; breadth 2.4-4 mm.*

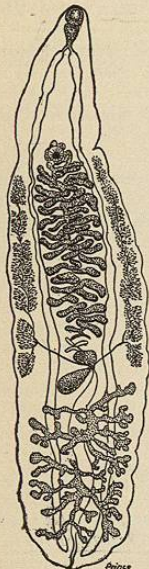


FIG. 4787.—*Opisthorchis sinensis* (Cobb.). Moderately extended specimen from man in California. Case of White. Magnified. (Original.)

It has been found abundantly in Japan, but occurs also in Corea, Formosa, Tonquin, China, India, and Mauritius. A single case has been reported from New York City by Biggs; the host was a Chinaman. Recently White has found eighteen cases of infection with this parasite (Fig. 4787) in San Francisco. All were detected at necropsies, and of the cases sixteen were

pest infected, one had beriberi, and one valvular heart disease. White was inclined to believe that some of the cases were infected in California, though no evidence has yet been published to show that the species has actually established itself on this continent. In Japan the population is widely infected; the parasite is sporadic in some regions, but in other localities in several provinces it is endemic; in some districts of the province Okayama, according to Katsurada, from fifty-six to sixty-seven per cent. of those subjected to faecal examination were infected. Of the development the ciliated embryo alone is known. This is formed when the eggs (Fig. 4788) are passed in the faeces of the host; but, according to Ijima, it does not desert the shell spontaneously, even after five months. The intermediate host is probably a mollusk, and the rice fields, which are often fertilized by human excrement, are centres of infection. The mode of transmission can only be conjectured.

The parasite occurs either in the gall ducts and gall bladder or in the pancreatic ducts. It is present also in the duodenum and rarely in the stomach and spleen. The pathological changes are of a mechanical type, and apparently generally proportionate to the duration of the disease and to the number of worms present, which may reach ten thousand or more in a single host. In cases of severe infection the death of the patient follows; this occurs in about fourteen per cent. of the sick. Two hundred and twenty fatal cases were recorded in twelve years in the province of Okayama. Like other species, this parasite has been found outside the liver in pus of a phlegmon on the right side of the abdomen, and in a second case on the diaphragm.

Pathology.—The hepatic lesions produced by flukes * According to previous reports the worm varies widely in size with hosts and number of individuals present. Even yet it may be questioned whether two or more species are not confused under this name by different observers.

were first accurately determined by Schaper for *Fasciola hepatica* in cattle and sheep, and subsequently confirmed by Katsurada and Blanchard, both of whom studied the changes in the human liver produced by *Opisthorchis sinensis*. The results show essential similarity in all cases studied. The lesions are of two sorts; the first, due to the occlusion of the biliary ducts by the parasites, is largely mechanical, and consists in stasis of the bile and dilatation of the ducts with resulting effects on general nutrition. At the same time the resulting inflammation leads to desquamative catarrh accompanied by thickening of the mucosa and glandular hyperplasia. There is also a proliferation of the connective tissue together with increase in blood capillaries and cellular infiltration, which aids in the reduction of liver tissue and in the obliteration of bile ducts. Atrophy of the parenchyma and granular degeneration bring about the destruction of the capillaries, and ultimately the transformation of a larger or smaller portion of the liver into a mass of cicatricial tissue containing only metamorphosed gall ducts.

The effects upon the circulatory system are primarily mechanical in the injuries to capillaries producing multiple hemorrhages, and where these discharge through gall ducts resulting in anemia. The inflammation produced by the movements of the flukes affects the walls of the blood-vessels and renders it possible for the flukes to gain entrance to the system, and thus be carried to various parts of the body. The growth of connective tissue serves ultimately to compress branches of the portal system, or even partially to obliterate them, and the circulatory stasis is followed by ascites or oedema. Enlargement of the spleen, pathological changes in the pancreas, when that organ also becomes infected, and chronic gastro-intestinal catarrh have been recorded. In fluke disease among animals it has also been noted that the blood is poor in hæmoglobin and subnormal in number of corpuscles.

Opisthorchis noveca Braun 1902.—(Syn.: *Distoma conjunctum* Lewis and Cunningham 1872, McConnell 1876, nec Cobbold 1859.) Body lancet-shaped, spinous, 9.5-12.7 mm. long by 2.5 mm. broad. Suckers close together, the oral being larger than the ventral. Pharynx spherical, intestinal crura extending far posterior. Genital pore immediately in front of acetabulum; testes round or only slightly lobed, at limit of posterior third of body and nearly opposite. Germarium slightly lobed, in front of bifurcation of the Y-shaped excretory reservoir. Uterus in loops through central area from germarium to genital pore. Vitellaria lateral, from testes anteriorly nearly to acetabulum. No cirrus sac. Eggs oval, 0.034 by 0.021 mm.

Found in a necropsy in Calcutta in large numbers in the gall ducts of two Mohammedans by McConnell. Similar parasites were discovered a few years earlier by Lewis and Cunningham in the liver of street dogs in the same city. No doubt these forms were both the same species, but Braun has shown clearly that they cannot be the species which Cobbold had found earlier in the liver of an American fox that died in London, and to which the discoverers had assigned them.

Heterophyes Cobbold 1866.—Body without distinct separation into anterior and posterior region. Oral sucker without crown of spines. Pharynx close to oral sucker, intestinal crura extend to posterior end of body. Genital orifice lateral, near acetabulum, surrounded by prominent muscular genital sucker with circle of branched chitinous spines. Vitellaria near posterior margin, scantily developed.

Heterophyes heterophyes (v. Siebold 1852).—(Syn.: *Distomum heterophyes* v. Siebold 1852; *Mesogonimus heterophyes* Railliet 1890; *Cenogonimus heterophyes* Looss 1900; *Cotylogonimus heterophyes* Lühe 1900.) Length 1-1.7 mm., breadth 0.3-0.6 mm. Limit between anterior mobile and posterior regions often indistinct in alcoholic material (Fig. 4789). Acetabulum very powerful, thick-walled, about



FIG. 4788.—Egg of *Opisthorchis sinensis* (Cobb.). ×500. (After Katsurada.)

two and one-half times and genital sucker about one and one-half times as large as oral sucker; average diameter of oral sucker 0.09 mm., of ventral sucker 0.23 mm., of genital sucker 0.15 mm. Intestinal crura thin, terminating posteriorly at excretory bladder. Lateral acini of vitellaria outside intestinal crura, sometimes even extending on to ventral surface. Testes near posterior end, just anterior to tips of intestinal crura. Germarium median in posterior region, uterus covering nearly entire posterior end. Eggs light brown, thick-shelled, 0.03 by 0.017 mm.; ciliated miracidium fully developed when egg is deposited (Fig. 4790).

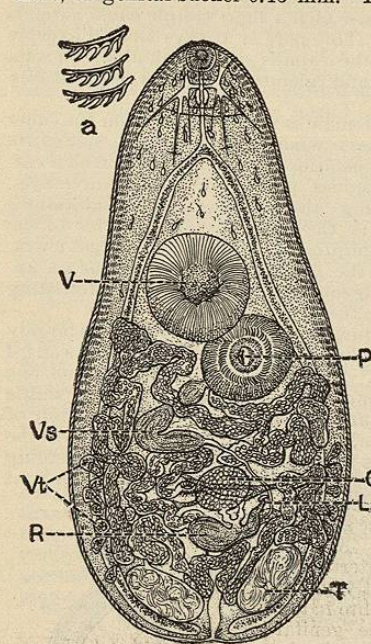


FIG. 4789.—*Heterophyes heterophyes* (v. Sieb.) in Ventral Aspect. a, Cuticular spines from margin of genital sucker, P, Other letters as before. ×42. (After Looss.)

in Japan needs confirmation. The species was discovered in 1851 by Bilharz in the intestine at the necropsy of a boy in Cairo. The belief that the species was rare in man has been dispelled by the studies of Looss, who finds it rather common; on account of its diminutive size, however, it is easily overlooked. This author has also recently differentiated some closely related species which have been found in other hosts and listed heretofore under the same name. Its seat is the middle third of the duodenum, and it is often found by the hundreds. It usually moves about freely in the chyle, but may remain attached to the wall or concealed in the folds of the mucosa. The parasite feeds on the contents of the intestine, and neither blood corpuscles nor epithelial cells could be found in its alimentary canal. This accounts for its apparently harmless character even when present in large numbers. In spite of the prominent spines on the skin Looss was unable to recognize in any case alterations in the mucosa of the host, which could be attributed to the work or presence of the parasite. According to Looss also the parasite affects particularly the country population and is wanting in those who live in the cities as well as in Europeans.

Dicrocoelium Dujardin.—Body delicate, semitranslucent; form elongate, foliate, tapering toward both ends, with smooth cuticula; oral and ventral suckers separated by less than one-fourth total length. Pharynx small; oesophagus short; intestinal crura long but not extending to posterior end. Cirrus sac anterior to acetabulum, enclosing coiled seminal vesicle and long slender cirrus. Genital pore between pharynx and fork of intestine. Testes compact, forming with the smaller compact germarium a median series directly posterior to acetabulum. Laurer's canal and receptaculum seminis present. Uterus in transverse coils, filling region posterior to germarium. Vitellaria lateral to intestinal crura,



FIG. 4790.—Egg of *Heterophyes heterophyes*. ×500. (After Looss.)

only moderately developed. Eggs dark brown, numerous.

Dicrocoelium lanceatum Stiles and Hassall 1896.—(Syn.: *Fasciola lanceolata* Rudolphi 1803, nec Schrank 1790; *Distomum lanceolatum* Mehlis 1825; *Dicrocoelium lanceolatum* Dujardin 1845.) Length 4, usually 8-10 mm., breadth 1.5-2.5 mm. Body flattened, lanceolate, attenuated toward both extremities, especially the anterior (Fig. 4791). Suckers separated by about one-fifth total length; diameter of oral sucker about 0.5 mm., of ventral about 0.6 mm. Intestinal crura terminate one-fifth of total length from posterior end. Genital pore at intestinal fork. Testes slightly right and left of median line. Vitellaria from posterior testis through about the middle fifth or fourth of body. Loops of uterus extending laterally beyond intestinal crura. Eggs 0.038-0.045 by 0.022-0.030 mm., thick-shelled, dark brown when deposited, and containing a spherical or oval miracidium ciliated only at anterior end and supplied with rudimentary intestine and boring spine.

Parasitic in gall ducts of herbivorous and omnivorous mammals very generally, often in common with *Fasciola hepatica*. Among the hosts given are sheep, cattle, horse, ass, deer, goat, hare, rabbit, pig, and man. The records in accordance with which this species occurs in dog and cat rest on confusion with *Opisthorchis felinus*.

The development of the species is unknown. Leuckart found that the miracidia spontaneously desert their shells in the intestine of certain slugs (*Arion*, *Limax*), but that no further development could be induced here or in other snails. On the basis of a single feeding experiment, however, he considered small species of *Planorbis* from fresh water to be the larval host. Piana conjectured that land snails were more probably responsible. No further evidence has been obtained.

The distribution of this species is less extended than that of *Fasciola hepatica*, though in general, much the same. Leuckart believed it more abundant in southern Europe than in the north. It is wanting in England, but has been recorded among extra-European countries in northern Africa, Siberia, Turkestan, North and South America.

Seven cases of human infection are on record. They come from Germany, Bohemia, Italy, France, and Egypt. With possibly a single exception the parasite was not the cause of any apparent trouble. In view of this absence of dangerous symptoms Braun conjectures that mild infections may be much more frequent than is known.

The family of the Schistosomidae Looss contains flukes of separate sexes with the male shorter and thicker than the slender female, and having a canal formed by the ventrally turned margins of the body. The acetabulum is stalked and the intestinal crura unite posterior to it. Only one genus is important here.

Schistosoma Weinland 1858.—Female filiform; male very broad with body rolled together ventrad to form completely closed *canalis gynacophorus*. Suckers near together. No pharynx. Intestinal crura in male join

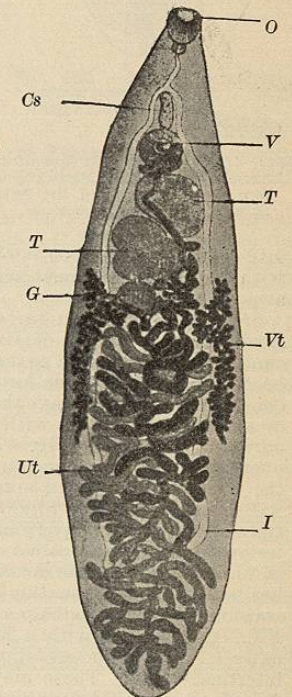


FIG. 4791.—*Dicrocoelium lanceatum* Stiles and Hassall. ×12. (After Braun.)

often far back. Genital pore in both sexes median, post-acetabular, no copulatory organs. Testes of five to six vesicles. Seminal vesicle small. Uterus of female very long, at times with large numbers of eggs. Eggs tapering equally to both ends with small terminal spine at posterior end, without lid. In venous system of mammals.

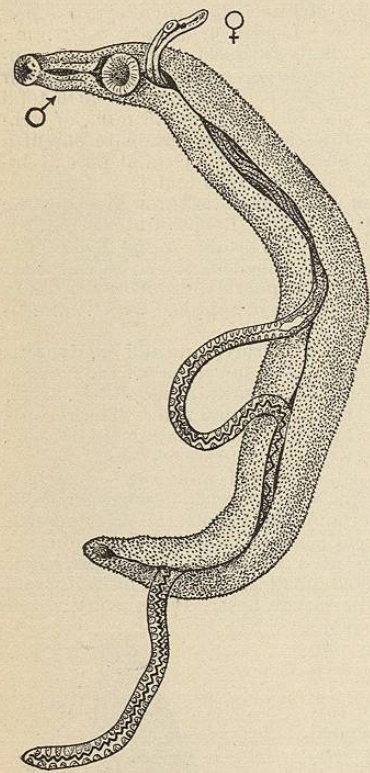


FIG. 4792.—*Schistosoma haematobium* (Bilharz). Male and female in copula and before the beginning of the production of eggs. $\times 12$. (After Looss.)

0.12-0.19 mm. long, 0.05-0.073 mm. broad, spindle-shaped with median enlargement and with rudimentary filament at posterior end.

Structure.—Through the admirable recent studies of Looss the earlier work of Leuckart and others has been confirmed and extended so that a precise account can now be given of this unique form. The two sexes must be considered separately save that both agree in the delicacy of structure consonant with their existence in the blood current. The male (Fig. 4792) shows papillae or warts over the entire dorsal surface, except near both ends of the body. Fine dermal spines cover the suckers both within and without. Slightly larger spines cover ventral surface of the body from the genital pore to the posterior tip, i.e., the so-called *canalis gynaeophorus*, as well as form a zone on the dorsal margin of that side which lies within in the formation of the canal. A pharynx is wanting and the oesophagus with two expansions (A, B, Fig. 4794) covered with a layer of salivary cells terminates at or near the acetabulum, branching to form the intestinal crura. These may join soon to form the unpaired caecum, which extends in the median line nearly to the posterior end, or their junction may not occur until the posterior fifth of the body is reached; one also finds the crura separating for short intervals in the course of the unpaired caecum. The food mass in the alimentary canal of the parasite consists chiefly of leucocytes with pigment from the liver and a few erythrocytes.

The reproductive system departs widely from that of other Trematoda described in general above, first in that the sexes are separate, but secondly and equally strikingly in its structure. In the male (Fig. 4794) the testes, four or five in number, lie alternately right and left of

the median line not far behind the acetabulum. As the apparent common duct is in reality a part of the organ, the group represents rather a very deeply lobed single testis. The short duct joins this to the sausage-shaped seminal vesicle, from which a short simple canal extends to the sexual pore. This pore is always located exactly at the entrance to the *canalis gynaeophorus*. Special copulatory organs and glandular adnexa are entirely wanting.

The body of the female is smooth except on the inner surface of the suckers, where extremely fine spines are numerous and the posterior tip of the body, which carries much stronger spines, pointed in various directions. A pharynx is wanting; the oesophagus with dilatations and gland cells, as in the male, divides anterior to the middle of the acetabulum, to form the intestinal crura, which unite behind the germarium to proceed as an unpaired caecum in a zigzag line, with regularly alternating lateral diverticula to the posterior end.

The female reproductive system (Fig. 4793) lies largely between the acetabulum and the posterior junction of the intestinal crura. Just anterior to this junction one finds the median, elongated oval germarium. The single vitellarium with symmetrical follicles right and left of the intestinal caecum, occupies the posterior end of the body. Its duct lies parallel to the germ duct coming from the posterior end of the germarium, and joins it at the shell gland, which is located a short distance anterior to the germ gland. After a short ootype the uterus extends nearly directly as a tube of uniform calibre in the median line to the genital pore which lies immediately behind the acetabulum.

The egg (Fig. 4795) has the form of a compressed spindle somewhat inflated at the middle. At the posterior pole one finds a short irregular tip, homologous to the filament on the eggs of ectoparasitic trematodes. In those eggs which are discharged in urine this process is terminal, in such as remain in the body of the host it is slightly lateral. The egg shell contains a mature embryo, cylindrical in form with conical anterior tip, or papilla, and covered by a coating of fine cilia. A rudimentary alimentary canal, cephalic gland, and the usual masses of germ cells in the posterior end are easily distinguishable.

All authorities, save one, agree that the embryos do not hatch out if the eggs are left in unaltered urine, but that the addition of fresh water, especially if warm, brings about at once the opening of the shell and escape of the embryos. If left in urine the embryos die in the shell in from six to twenty-four hours. The further fate of these embryos is entirely unknown, as also the manner of infection. It has been conjectured that the sporocyst stage also occurred in the human host, but the experiments of Looss on apes were without result.

This species occurs as a parasite in the portal system of man, perhaps also in the Sooty monkey and in cattle.

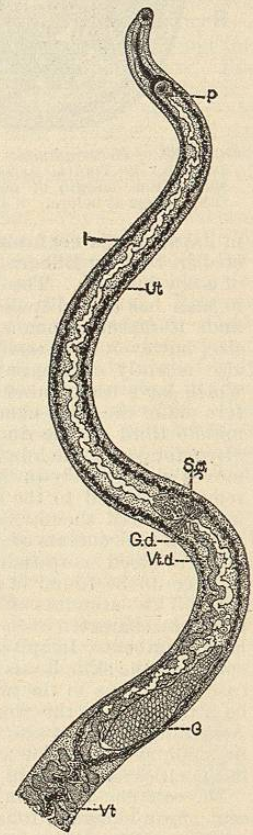


FIG. 4793.—*Schistosoma haematobium* (Bilharz). Anterior region of female in ventral aspect. The uterus does not contain as yet any developing ova. Letters as before. $\times 19$. (After Looss.)

It is widely distributed in Africa, records being at hand of its occurrence in Egypt, along the eastern coast, at Cape of Good Hope, and at points on the western and northern shore as well as in the interior. It is very common among the Egyptian laborers, and boys and youths seem to be particularly susceptible to its attacks. One-third or more of those examined by different observers were found to harbor the parasite. The centre of infection at Mecca (Arabia) is regarded as introduced, and that recently discovered on the island of Cyprus is probably similar.

A case has just been reported by Manson in which the eggs were found in the faeces but not in the urine of an Englishman in the West Indies, who had never been in any country where the parasite is known to exist. On account of its peculiar features the case needs confirmation, but it correct demonstrates the existence of a new centre of infection near our shores.

Stiles says that the human blood fluke has been found twice in this country; once in a foreigner on the "Midway" during the Columbian Exposition and once in New York City. I have found another case recorded from Georgia. All these cases were certainly infected elsewhere, and there is no evidence to show that the parasite has been able to gain a footing as yet in this country.

Pathology.—The females apparently go into the venous plexus of the pelvis to oviposit, and the eggs are carried thence by the blood current into various organs. Here they accumulate, occluding the vessels and causing various symptoms according to the organ affected. Such accumulations have not been found as yet in spleen, stomach, or pancreas. In the lungs they determine lesions which simulate those in miliary tuberculosis, and though rarely recorded as yet are believed to be common. Tumors of similar origin have been rarely met with in mesenteric ganglia, on the peritoneum and in the skin.

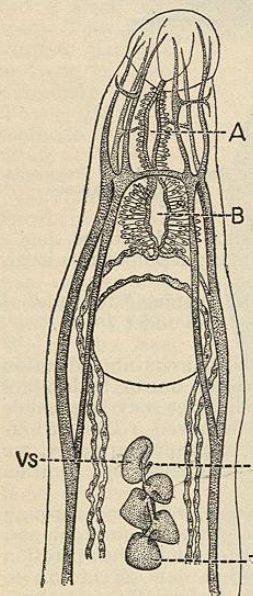


FIG. 4794.—*Schistosoma haematobium* (Bilharz). Anterior end of male showing male genital organs and also in part nervous and alimentary systems; A, B, enlargements of oesophagus with glands; P, sexual pore; T, testis; VS, seminal vesicle. $\times 48$. (After Looss.)

The disease may continue for some time, even six to eight years, and eventually terminate without more extended symptoms.

Renewed or reinforced infection, however, intensifies the cystitis and often brings about urethritis as well. Frequently one finds urinary calculi, in many of which the nucleus of the calculus can be shown to consist of one or more fluke eggs. In Egypt one series of observa-

tions showed the coincidence of bilharziosis with lithiasis in eighty per cent. of observed cases. In more severe cases the changes may extend to the ureters, kidneys, and colon. The urine contains larger amounts of blood and eggs, and the faeces present a similar appearance. The symptoms then resemble tropical dysentery, and Bilharz, the discoverer of this parasite, originally connected the two in a causal way. As a result of the changes outlined, nutrition suffers and finally death ensues from uraemia, pyaemia, pyelonephritis, or general marasmus. The wall of the bladder shows under these conditions excessive thickening, together with the formation of excrescences, 1-2 cm. in diameter, filled with the eggs of the parasite; the cavity of the organ is diminished materially, and also the elasticity of its wall. Extensive ulcerations are not uncommon, and in connection with the rupture of small vessels determine the characteristic hematuria.

The disease cannot be regarded as necessarily fatal; its severity depends in general upon the degree of infection. In cases of moderate intensity appropriate treatment of a general character effects a noteworthy amelioration, and in many cases at least the disease is self-terminating. Anthelmintics and other medicaments have been employed with variable results.

Infection is generally attributed to the use of impure water from pools and canals. It has been observed that those villages supplied directly from the Nile are badly infected, while in those using filtered water the parasite is almost unknown. Looss has urged strong reasons in favor of the view that bathing affords the opportunity for the parasite to enter the body through the skin. Both the means of infection and the subsequent course of the parasite in reaching its location in the portal system are, however, entirely conjectural. Henry B. Ward.

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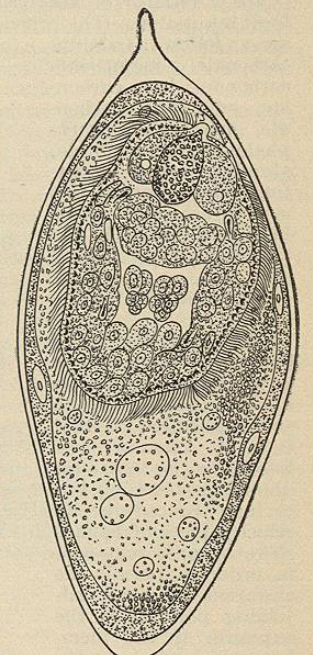


FIG. 4795.—Egg of *Schistosoma haematobium* (Bilharz). $\times 500$. (After Looss.)

PRINCIPAL ARTICLES CONSULTED.

Blanchard, R.: Lésions du foie déterminées par la présence des douves. Archives Parasitol., iv., 581, 1901.
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