# OBSERVATIONS ON THE SPREAD OF ASIATIC SCHISTOSOMIASIS.*

[WITH SPECIAL PLATE.]

BY

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*With a note on "Katayama nosophora" by*

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FROM 1852, when Bilharz announced the discovery of *Distomum haematobium*, down to 1904 no progress was made in the elucidation of the etiology of schistosomiasis.

In 1904 the London School of Tropical Medicine published as Cragg's Prize Essay an account by Catto of a new form of schistosomiasis in a Chinaman. Catto's disease was almost immediately shown to occur in the cat and dog. It then became possible for the first time to study in small susceptible animals the mode of infection with a human form of schistosomiasis.

Native tradition and the deductions of local practitioners had given rise in South Africa to the view that infection was acquired when bathing.

Looss, failing to find an intermediate host, and noting that the newly hatched embryo is killed in 1 in 1,000 dilution of hydrochloric acid, adopted the hypothesis that the infection took place through the skin, adding that the infective agent is the miracidium and that the metamorphosis into a cercarial form probably takes place in the liver.

In 1911 Matsuura and Yamamoto showed that in animals experimentally infected with *Schistosoma japonicum* by exposure in water from infected rice fields short ciliated larvae occurred in the skin.

In 1913 J. A. Kay asserted that miracidia kept in water for days lost their ciliated covering, but underwent further development to form cell masses, which he believed resulted in the infective stage.

Commenting upon Miyawa's statement that the infecting form is markedly different from the miracidium, Looss maintains that if it be correct the *S. japonicum* must differ in its development from *S. haematobium*.

Numerous workers have, however, failed to obtain infection with either species experimentally by application of miracidia to the skin. It may also be observed that the effect of weak acid upon a ciliated body like the miracidium need not apply to a cercaria with cuticular covering.

In 1913 Katsurada, in a summary of research on Japanese schistosomiasis, abandoned his adhesion to the Looss hypothesis in favour of a relatively simple metamorphosis of the miracidium prior to skin infection. This paper, published in December, 1913, has a note to the effect that he is informed in a private letter from a colleague that Mr. Miyairi of Kiushu had just found a reproductive stage of schistosoma in a *Lymnaeus* species.

*Work of Special Commission.*

In November, 1913, the Colonial Office made a special grant from the Tropical Diseases Research Fund to the London School of Tropical Medicine to enable the Wandsworth Scholar to proceed to the Far East and elsewhere to study the mode of spread of bilharziosis and to obtain if possible definite experimental evidence on this subject. In view of the importance of the inquiry to the navy in the Far East the Admiralty seconded Surgeon Atkinson for the duration of the investigations.

The Commission left England in February, 1914, and was engaged upon the work until the outbreak of war in August, when the investigation had to be abruptly concluded.

Our head quarters were established at Shanghai, partly on account of the ready access from this large shipping centre to both Chinese and Japanese endemic areas, and partly because the most generous facilities were granted there by the medical officer of health and the municipal authorities.

In view of the negative results of previous attempts made in London by the Wandsworth Scholar and elsewhere by others, the Looss hypothesis of direct infection was set aside in favour of one to the effect that the schistosome conformed in essentials to the life-cycle of other digenetic trematodes.

The "blunderbuss" method, already used for *Filaria loa* and other investigations, was again relied on. This is, briefly, to submit all likely hosts to an overwhelming infection. The proper host will show a marked, even fatal, susceptibility, while other even closely allied hosts will remain uninfected. For this purpose it was necessary, first, to obtain an animal with such a heavy infection that the eggs could be separated from the faeces with little contamination. None of the cases of schistosomiasis in man approximated this stipulation. After a search lasting nearly three months, and involving a river journey of over a thousand miles, we secured a dog ideal for the work. The motions consisted almost entirely of mucus and blood, crowded with eggs. Dilution with water, a shake, then rapid decantation, left abundant eggs which hatched upon the second addition of clean water.

We observed that in highly acid faeces the eggs were almost moribund, with the cilia on the surface of their embryos characteristically pointing cephalad. Under the most favourable conditions, and in stiff stools, the embryos showed movement when hatched by the addition of water up to the tenth day.

Our second necessity was to localize a small village with a fairly high percentage of infection amongst the inhabitants, and then study the local molluscan fauna and submit the various species to the "blunderbuss" test. Further, by dissection of the various molluscs from such a defined area, naturally infected specimens might be found, and the nature of the infection diagnosed:

(*a*) By certain peculiarities that the cercaria of the schistosome should reveal; and

(*b*) By a second "blunderbuss" test to infect a susceptible mammalian host with material from the suspected intermediary host.

Although the disease is widely sporadic, we failed to localize a village that would meet our requirements in the lower Yangtse Valley. At Soochow and Kashing we saw a number of cases of schistosomiasis in the various dispensaries, but these occurred in peasants who came in from outlying districts and villages to which we could obtain no guidance or which in other ways proved inaccessible. Nevertheless, throughout the whole region we collected, dissected, and compared the molluscan fauna. Of the several developmental forms and cercaria found, none presented the one morphological character—"absence of pharynx"—which would have established in our mind a strong presumption in favour of a hypothetical schistosome larva. We noted, too, that the molluscan species collected were alike over infected and non-infected areas—for example, Kashing, Shaohsing, and Henli.

The up-river hospital records indicated that cases were few, and none attributable to the present season. Examination of numerous dogs gave like results, save in the exception which, as noted above, proved our sole efficient source of eggs. The local explanation of the paucity of cases was that the summer was one of the hottest and driest on record.

All species collected were, however, submitted to a biological test—namely, each was placed in a cylindrical jar containing water swarming with miracidia, and watched with a hand lens to see if the mollusc had a definite attraction for the miracidium, care being taken in large forms to discount results really due to the violent inhalation of water.

While the experiments with the Chinese molluscs were proceeding we continued to explore new areas and decided to include Katayama, where Fujinami's early experimental infections of animals by brief immersion in paddy field water had been carried out, and indicated an intense local infection. From this visit the Wandsworth Scholar brought back to Shanghai large numbers of various species, including *Vivipara* and the form described below by Mr. Robson as *Katayama nosophora* n.g., n.sp. The little village of Katayama is easily reached by ricksha run of about three-quarters of an hour from Fukuyama station on the main line from Shimonoseki to Tokio; it is the centre of a highly infected area, and gives the name "Katayama disease" to Asiatic schistosomiasis. Professor

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Fujinami not only kindly instructed our interpreter in Kyoto as to the best means of reaching Katayama, but also advised where the most suitable assistants for the collecting might be got. He also informed us of Miyairi's views, already referred to above.

The molluscs from Katayama were submitted to the biological test in Shanghai, and a small brown form with eight spirals and an operculum, named *K. nosophora* (Fig. 7), showed an extraordinarily marked attraction for the miracidia, as contrasted with the other species. The small dark head and foot speedily became festooned with little white specks, and it was obvious from the agitated manner in which the snail repeatedly attempted to brush them off that their presence was a cause of considerable irritation. As further numbers attacked, the snail hastily left the water or suddenly closed the operculum and dropped to the bottom.

In many specimens the liver was found ramified with long intertwining delicate tubes bluntly rounded at the extremities and containing cercariae with bifid tails. Similar tubes with like contents had already been found in a species of mollusc near Kashing, but the tubes in the Katayama mollusc were longer and more slender, while the cercariae were smaller, showed a gut very short and slightly developed, and there was a complete absence of pharynx (compare Fig. 1, *a* and *b*, with Fig. 6, *a* and *b*).

The adult *Schistosoma japonicum* has a bifurcated gut which reunites much posterior to the ventral sucker, but the young larva, even when it has entered the final host, shows two simple lateral gut branches which unite only after some days' growth. Thus a simple short bifurcated gut was to be expected in the cercaria.

In consequence of the satisfactory result of these experiments a second visit was paid to Katayama, and in a short space of time a large supply of this mollusc was collected by the ricksha boys; owing to transport delays a large number died before reaching Shanghai, but sufficient survived to enable the second series of experiments to be carried out. The livers of a number of these molluscs were teased in fresh water, and the miracidia allowed to become free and to swim about. Laboratory-bred mice, obtained from the Shanghai Municipal Laboratory, were then immersed, none of the fluid being allowed near the mouth. In view of the outbreak of war, a start was then made for home.

The first part of the voyage through the Formosan Channel was very rough, and three of four mice died within the first few days at sea. Just before reaching Hong Kong the animal of our earliest experiment, a month old, also died. It became putrescent before it could be examined, but a single male schistosome was found. This led one to sacrifice at Aden the few molluscs that were still alive. The last remaining mouse was then submitted to infection. This animal was safely transported to London and killed in the laboratory of the London School of Tropical Medicine a month later. Live male and female schistosomes *in copula* were found in the portal vessels. Some were removed, and a permanent preparation was made of the gut with the mesentery undamaged. This, reproduced in Fig. 10, shows the paired worms *in situ* in the mesenteric veins.

The marked attraction of the mollusc for the miracidium, the peculiar morphological characters of the cercaria and the successful infection of a laboratory-bred mouse from cercaria obtained from Katayama molluscs after several weeks' captivity at sea leave no room for doubt that the schistosome has a life-cycle similar to that of other digenetic trematodes.

*Developmental Stages.*

The thin-walled tubes found in the liver are undoubtedly sporocysts. These tubes are cylindrical, and contain the cercariae usually in single file (Fig. 1, *a*). The ends are bluntly rounded; sometimes an end presents a knob-like constriction. There are here also very fine transverse rugae which appear to bear spines, but these do not extend to any distance along the sporocysts (Fig. 4). The sporocysts in the liver of a single mollusc often appear to be about the same stage of development. This fact, taken with the minute spines, would indicate that these sporocysts are not those originally developed from the infecting miracidia, but are probably daughter sporocysts. We were not able in the time at our disposal to settle this point. The knob-like extremities (Fig. 5) occasionally seen at the tips of the sporocysts might lead one at first sight to suspect that these were really rediae. The muscular sucker, the walled gut, and the "limbs" which should characterize a redia are, however, absent.

This coincides also with our findings in the case of the bifid-tailed cercaria (Fig. 6, *b*) found at Kashing, as well as those of Looss in *Cercaria vivax* and of other observers.

The cercariae (Figs. 2 and 3) measure 0.25 mm. in length with a greatest width of 0 04 mm. The body is 0.1 mm. long by 0.04 mm. broad. The tail is 0.1 mm. by 0.01 mm. The prolongations of the tail both measure 0.05 mm. by 0.006 mm.

The whole cercaria is covered with minute spines. There are no cilia. The oral sucker is enormously developed, occupying almost the anterior third of the body.

Fig. 11.—*Katayama nosophora.* (*a*) A single half row; (*b*) second marginal as seen when folded over medians and admedians. × 1/12 in. oil imm.

It is urn-shaped, and on its lip there is a series of small tubercles. The dimensions are 0.04 by 0.02 mm. From the oral sucker a delicate tube, representing the oesophagus, passes backwards for 0.01 mm. There is no indication of pharynx; the oesophagus bifurcates into two wide, thin-walled lateral branches, 0.02 mm. in length, which end blindly at the level of the anterior margin of the ventral sucker.

The ventral sucker is small, but very muscular. The lumen is reduced and triradiate. The sucker has a uniform diameter of 0.01 mm. and is slightly protuberant just behind the greatest width of the body, while here, too, the body attains a dorso-ventral thickness equal to the greatest width. On either side of the ventral sucker extending backwards towards the root of the tail and forwards between the two lateral gut branches are oval gland masses, five or more in number, on either side. From these there pass forward, slightly dorsally and laterally, paired ducts which discharge into the oral sucker near the mouth.

In the middle line, immediately in front of the ventral sucker, a clear, pear-shaped vesicle is sometimes visible.

*Conclusion.*

It would appear that the above results confirm Miyairi's main conclusion as to the transmission of *Schistosoma japonicum*. Unfortunately, his paper is inaccessible, in Japanese and in a journal, *Nissin Igaku*, which leading Japanese booksellers have been unable to procure.

A comparison of the detailed conclusions is for the present therefore impossible. The only information at present available to workers is in an annotation by Kumagawa in the *Troipcal Diseases Bulletin* for March 30th, 1914. We find from this that, according to Miyairi and Suzuki, "the miracidium, after penetrating the cuticle of the snail's body, proceeds to the gills and the walls of the digestive canals. After twelve days the first rediae appear and gradually concentrate to the hepatic ducts, elongating, and a number of the second rediae are seen. The authors put mice into the vessel in which the full-grown snails were fed for three hours every day for four days. After three weeks they found a great many *Schistosoma japonicum* in the livers of the mice." The snail, which the authors conclude is the intermediate host, has a dark-coloured shell with seven spirals. This is common in the waterways or ditches.

It will be noted that there are said to be redia stages in the course of the life-cycle, and that the snail shell has seven spirals. No diagnosis of the snail is given, or of the infective agent.

In conclusion, we have to acknowledge the kind assistance given to the expedition by the chairman and secretary of the Shanghai Municipal Council, the cordial help and advice of the principal medical officer of health for Shanghai, and of Drs. Moore and Noel Davis in the Health Laboratory. In our search for hosts we were greatly helped by Drs. Aird, Skinner, Fujinami, Goddard, Jackson, and many others, to whom our grateful thanks are due.

## NOTE ON "KATAYAMA NOSOPHORA."

By G. C. Robson, B.A.

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The mollusc used in the experimental transmission of *Schistosoma japonicum* and now described was reported by Dr. Leiper to occur in damp moss and grass on the sides of the irrigation ditches and also on growing plants in the rice fields in very great quantities. It was therefore a matter of surprise to the author, on making a search through the literature of Japanese land and fresh-water mollusca, that no description of the form in question was to be discovered. A very careful study of all the available literature of Chinese land and fresh-water forms (together with those of adjacent countries) was made also, and the author had the advantage of Mr. E. A. Smith's assistance. The result was to confirm the preliminary experience, and in consequence it became necessary to regard it as a new form. That a fresh-water mollusc occurring in such great profusion should to all intents and purposes be undescribed is indeed very extraordinary. Excluding the possibility of its having been described in some inaccessible Japanese publication, we have to bear in mind that it may have been recorded, through ignorance of its anatomical characters, on conchological grounds as referable to some other family. A second and possibly more likely solution may be sought in a suggestion that it may have only recently attained this plentiful development. Mr. E. A. Smith reminds me that *Paludestrina jenkinsi* when first found in England was obtained in large quantities though no previous record had been made of it in the already copious records of the British occurrences.

With regard to the systematic position, it has to be admitted that until more anatomical knowledge is forthcoming the generic position here assigned to this interesting form must be regarded as temporary, as the material was not preserved suitably for dissection.

The radula has been very kindly compared by the Rev. H. M. Gwatkin with those of various hydrobiid genera in his collection. He is of opinion that it is nearest akin to *Pyrgulopsis* and (less nearly) to *Pachydrobis*. Other genera (for example, *Littorinida*) offer a basis for comparison in single teeth, but as far as the material available for study and comparison goes, it appears to be distinct from all the known hydrobiid genera.

### Katayama, gen. nov.

*Radula:* Central tooth with three basal denticles and a cutting surface composed of a large median and two lateral cusps a side. The admedian tooth large, with a prominent cusp and five smaller ones; the succeeding teeth having eight and seven cusps respectively (Fig. 11, *a*). The outer marginal has a strongly arcuate extremity when seen in profile (Fig. 11, *b*).

*Shell,* with eight whorls (Fig. 7) (the last two usually eroded), increasing gradually in size, and exhibiting a moderately convex profile and a fairly well marked suture to correspond. The general shape is acuminate. The peristome is continuous, of a rich chocolate-brown colour, thickened and reflected upon the ventral and columellar lips. In the region of the peristome the body-whorl is abruptly extended and the transverse growth lines tend to assume the character of ribs. The colour is light olivaceous brown, the body-whorl being occasionally straw-coloured and the two apical whorls very dark purplish-black owing to erosion. The texture is horny and fairly solid. Irregular transverse growth lines cross the finely and irregularly granulated surface which in place occasionally exhibits, under a high power, a faint spiral sculpture.

*Dimensions of Shell.*—Maximum height 8.5 mm.; maximum width 3.1 mm.; maximum width of the aperture 2.75 mm.

*Operculum* (Fig. 9) spirally coiled, with the nucleus of the spiral markedly eccentric being placed towards one extremity in a lateral position.

*Katayama nosophora,* n. sp.; with the characters of the genus.

*Locality of types:* In irrigation ditches and rice fields at Katayama.

The types are deposited in the British Museum (Zoological Department).

## ON THE ALLEGED RESPONSIBILITY OF THE MEDICAL PROFESSION FOR THE REINTRODUCTION OF THE RUM RATION INTO THE BRITISH ARMY.

By Sir Victor Horsley, F.R.S., F.R.C.S.,
Captain R.A.M.C.(T.F.).

In former years the soldier was the victim of various forms of extortion and deception. His life, already very hard, was made harder by his being cheated in his pay, his clothing, and his food.

His pay is still subject to numerous deductions called "stoppages," the infliction of which practically render nugatory many of the promises made to him as a recruit, and, though his clothing is now, on the whole, good and his food greatly improved, he is again being cheated in his dietary by the recent reintroduction into the King's Regulations of the old pernicious rum ration, which is given him as a deceptive substitute for real food, reduces his efficiency, and injures his health.

This issue of rum on a regular and gigantic scale is naturally at the present moment a most serious evil to the country in its struggle against Imperial piracy, but it is also a matter of the highest importance to the members of the medical profession because an attempt is being made to place the responsibility for this national injury upon their shoulders. Therefore, for the protection of our soldiers as well as the defence of the interests of the empire in its strenuous life and death struggle, this matter must be dealt with at once, as one of vital concern and for which also some degree of technical information is necessary.

First, we must begin with tradition, for although the rum ration is now admittedly given to the troops as an intoxicant,* and for this purpose is supplied, not by the Army Medical Service, but by the quartermaster, it is still absurdly supposed (according to the Army Regulations, Allowances 34) to have singular powers of making the soldier dry and warm when he has been "drenched and chilled." How this dangerous nonsense became established as a military tradition, and is still for obvious reasons cherished by some persons, we must now consider in the light of history.

The spirit drinking habit was first contracted by the British army in Flanders during Marlborough's campaign at the beginning of the eighteenth century, and no doubt it gained some hold, because the fatal notion that spirits have some sort of medicinal value had come down through the Commonwealth wars from the Tudor period, when spirits were prepared and sold by apothecaries alone, under the curiously mendacious title of *aqua vitae*.

The spirit distilling and drinking widely introduced into this country in the first twenty-five years of the eighteenth century led to the awful development of the gin trade, which Hogarth vividly illustrated and against which the College of Physicians issued to the Government their celebrated appeal which led to restrictive legislation against this new popular disaster.

It is more than a national misfortune that this miserable story of 200 years ago is being repeated, in spite of the expressed opinions of Lord Kitchener, and that our army in Flanders is again being taught (by the issue of rum from home this time) to become victims of the spirit drinking habit, thus undoing the great work of Lord Wolseley and of Lord Roberts during the past forty years for army reform and, above all, army efficiency. At this point it must also be remembered, for the sake of our honour as a profession, that the Army Medical Service, though an absolutely essential part of His Majesty's forces, has not only never been accorded a proper place in the administration of military affairs, but even now has no representative on the Army Council, consequently the medical profession cannot be held to be primarily responsible to the nation for errors in the vital question of army hygiene and the medical and surgical care of the soldier.

In fact, the army is still, even in 1915, constitutionally, and in spite of the efforts of the British Medical Association, in a similar state to that of the days of Queen Anne,

* As Parkes said of the issue of rum, "It was one of those incredible mistakes only made worse by the explanation that it was done to please the men."

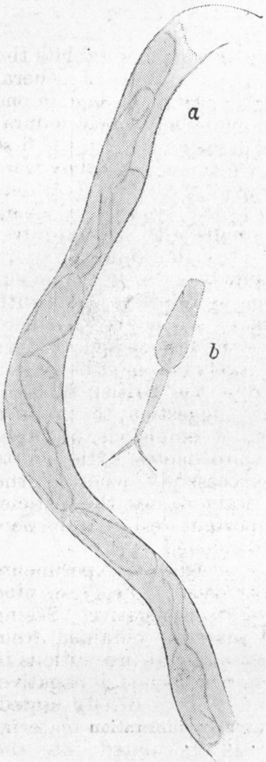


Fig. 1.—(*a*) Sporocyst from liver of *Katayama nosophora*. × 100. (*b*) Cercaria from the sporocyst. × 100.

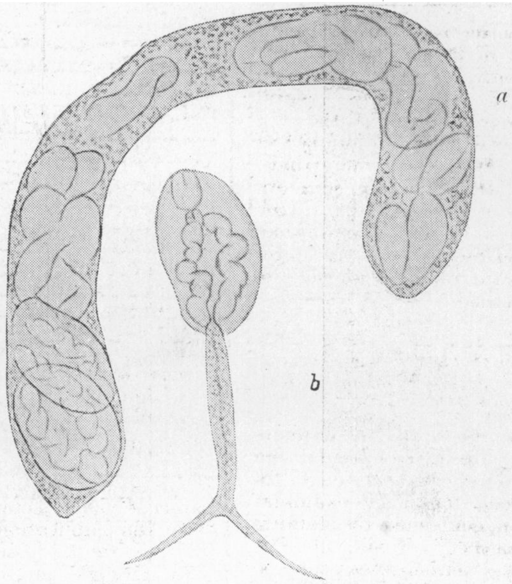


Fig. 6. — (*a*) Sporocyst resembling *Cercaria vivax* Sonsino. × 100. (*b*) Bifid-tailed cercaria from sporocyst Fig. 6 (*a*). × 100.

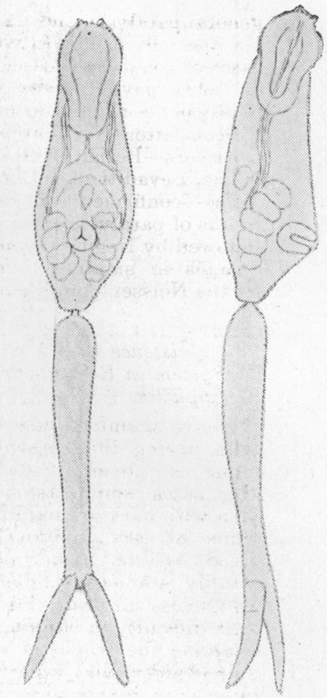

Fig. 2. Fig. 3.

Fig. 2.—Ventral view of cercaria showing anatomical details. × 300.
Fig. 3.—Lateral view of cercaria. × 300.

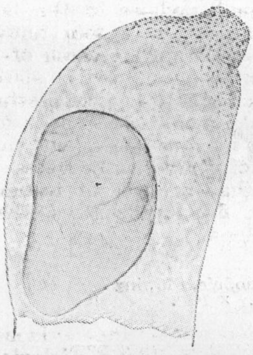

Fig. 4.—Rounded extremity of sporocyst from *K. nosophora*, showing transverse folding, with indications of spines. × 300.

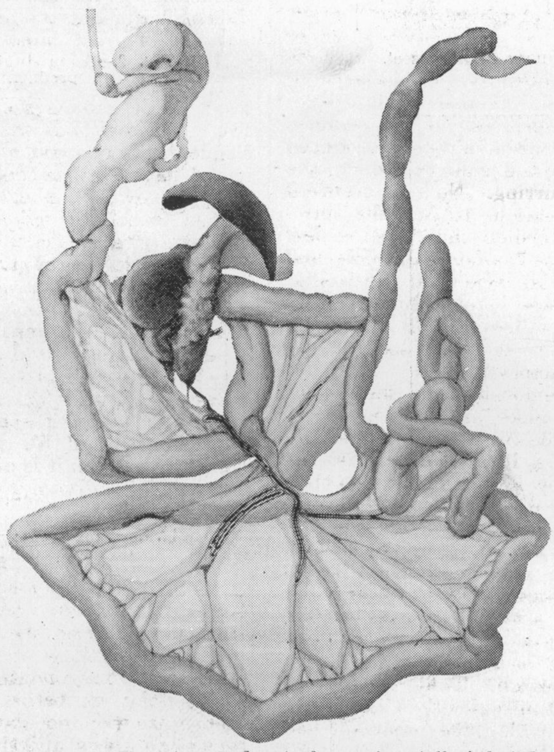

Fig. 10.—Mesentery and gut of experimentally infected mouse, showing paired schistosomes in the portal veins. (From a preparation now in the Museum in the London School of Tropical Medicine.) × 2.

Fig. 9.—*Katayama nosophora*. Operculum, × 12, drawn semi - diagrammatically to show scheme of coiling.

Fig. 7.

Fig. 8.

Fig. 7.—*Katayama nosophora* (n.g., n.sp.). Shell, oral aspect. × 4.
Fig. 8.—*Katayama nosophora*. Shell, lateral view, showing labial swelling. × 4.

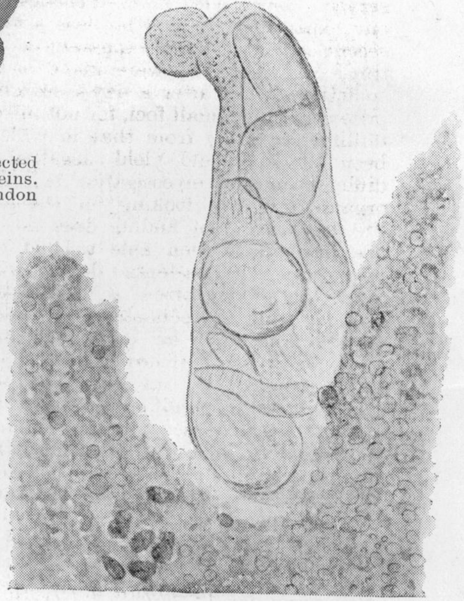

**Fig. 5.—Rounded bulbous end of sporocyst extruding from liver substance. × 300.**