Notes on Distoma Endemicum, Baelz.

By

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With Plate VII.

Since 1883 it has been known that in certain districts of Okayama-Ken a species of Distoma often infests the liver of the natives, causing deplorable diseases or even deaths. The parasite has been described in no less than two papers, but not quite satisfactorily, a fact which induced me to apply to the Science Department of Tōkyō Daigaku for permission to visit infected districts, in order to obtain an exact knowledge of the parasite, preliminary to an attempt at the elucidation of its life-history. Experiments for attaining the latter purpose are being carried on. As I have however no expectation of bringing them soon to a close, I wish to fulfill my duty in submitting the following report to the authorities of the Imperial University. I venture to believe that my notes will put the characters of our Distoma in a clearer light than heretofore and hope that they may be of some service for future investigations by our naturalists and physicians.

As already referred to, there exist to my knowledge two published accounts of the Distoma parasitic in the liver of Japanese. The one is contained in the joint-work of Messrs. Kiyono, Nakahama, Suga and

Yamagata, acting-physicians in the hospital of Okayama. It appeared in January 1883 under the title of 肺臓及肝臓ジストマノ實驗 (*"Observations on Distomæ of the lung and liver"*). This pamphlet contains a series of observations on numerous cases of the Distoma-disease, which are no doubt of great importance to physicians, together with a short anatomical account of the liver-distome.—In *"Berliner Klinische Wochenschrift,"* published on April 16th of the same year, Prof. Baelz gives some accounts of Japanese human-parasites (*"Ueber einige neue Parasiten des Menschen"*). Of liver-distomes he describes two new species, viz., Distoma hepatis endemicum s. perniciosum and Distoma hepatis innocuum. To me it is exceedingly doubtful whether these are to be regarded as really distinct species. At any rate it is certain that the species which I myself examined is identical with Dist. endemicum. The two species described by Baelz are very closely allied to Distoma spathulatum Leuckart (= Dist. Sinense Cobbold). The latter parasite, as described and figured by McConell*, is by no means satisfactorily known, and I should not be surprised if further investigations should show its identity with either or both of Baelz's species. Kiyono &c., as well as Baelz, mention the absence of seminal receptacle in the Japanese liver-distome as a chief point of difference between it and Dist. spathulatum ; but I believe this is a mistake, for I have seen a distinct seminal receptacle in Dist. endemicum.—I remember that a few years ago Prof. Leuckart of Leipsic was engaged in the study of human Distomes from Japan. The publication of his results may bring the above mentioned identity or non-identity of the several species to a definite settlement.

I wish here to express my thanks to the medical staff of Okayama-hospital, especially to Messrs. Yamagata and Matsuwo, for giving me every facility in collecting information. The last named

* Lancet, 1875.

gentleman kindly supplied me with a number of Distomes from two sources. Those from human-liver could easily be identified as Dist. endemicum Baelz, while those from the liver of cat showed slight differences inasmuch as they possessed very fine spines in the skin (= cuticula) and were of smaller size than the former. Perhaps this cat-distome from Okayama is to be considered as a distinct species, but I firmly believe that in Tōkyō, Dist. endemicum does sometimes inhabit the liver of cats. During December of last year I have had occasion to dissect three cats. In one of them, I found the gall-bladder and hepatic ducts unusually enlarged. They were almost filled up with Distomes, which agreed in every respect with Distoma endemicum from Okayama. I counted over 600 of them. In the second cat, the gall-bladder and hepatic ducts were of normal appearance and only a single specimen of Distoma was found within. It is probable that some more were left undiscovered. The third cat did not seem to be at all infested.

It thus stands beyond doubt that Dist. endemicum infests not only the human-liver but also cats. This fact affords a great convenience in experimentally ascertaining its life-history, since the mode of infection must be the same in both cases. Again, it is clear that conditions requisite for the development of Distoma endemicum do also exist in Tōkyō, the cats examined having been reared up in this city or in its environs. But as yet no one has ascertained the occurrence of our Distoma in the inhabitants of Tōkyō. Notwithstanding, the possibility or even the probability of its occurrence is not to be denied. Perhaps it may be that the parasitic worm owing to some local circumstances, does not become introduced into the human-body in a number enough to cause any calamitous influences, and thus passes unnoticed. Baelz also assumes the occurrence of human liver-distome eleswhere than in Okayama-Ken, since he met with cases in Tōkyō,

analogous to the Distoma-disease of the above mentioned Ken. Recently some cases of Distoma-disease have been reported from a certain district in the neighborhood of Lake Biwa.

According to Kiyono and his colleagues, there are no less than 21 localities in Okayama-Ken and 1 small village in Hiroshima-Ken where the Distoma-disease has been observed. I could visit only a few of the infected villages in Kojima-Gōri, about 7 hours' voyage on steamer from Kōbe and about 8 miles distant from the town of Okayama. Amongst them a small village by the name of Nakaune was pointed out to me as the place suffering most from the disease. On the authority of Dr. Yamagata and of a local physician, there are about 10 *o/o* of inhabitants affected with the disease (Baelz gives as much as 20 *o/o*). The nature of the locality and its situation has been described by Kiyono &c. and also by Baelz. It is a strip of low land along the sea-shore, lying beneath the sea-level during high-tide. The sea-water is kept out by means of a dam, constructed some sixty years ago. The land is traversed by a broad ditch with sluggishly flowing water. The villages in which the Distoma-disease occurs are all situated along this ditch. There is no well in the whole strip of land and drinking water is brought from the adjoining hills. The ditch-water is drunk, according to the information I received, only in exceptional cases, if ever it is so taken. Its main use is for washing purposes. It is important to mention however that amongst other things kitchen-utensils, vessels of all sorts, and vegetables to be eaten half-raw, are always washed in the ditch. Moreover this ditch-water is usually resorted to in watering vegetables growing on farms and also in irrigating rice-fields which remain dry during uncultivated seasons.

It is a settled fact that the eggs of Distoma endemicum are discharged like those of other Distomes together with the fœces of patients In those villages as in other parts of Japan, human excrements are

used for manuring purposes. I frequently observed farmers transporting manure in boats on the ditch and unrestrainedly cleaning their manure-tubs in the water. Here are undoubtedly chances enough for millions of Distoma-eggs to reach the ditch-water, in which ciliated embryos would hatch out. Indeed it admits of hardly any doubt that the ditch-water stands in intimate relation with the development of our parasite; and one can not be going too far in asserting that the establishment of a new system of water-supply would ensure the annihilation of Distoma-disease, so far as the above mentioned villages are concerned.

The question into what animal those ciliated embryos next find their way must remain unanswered for the present. After the analogy of those Distomes whose life-history has been worked out, I naturally fixed my attention on molluscs. I found in abundance Limnæa japonica Jay, Melania libertina Gould, and a small species of Paludina. Less abundant were a large species of Paludina, and species of Planorbis, Cyclas, Corbicula and Anodonta. Land-snails were said to be exceedingly rare. Notwithstanding the special search made, I failed to discern any trace of Sporocyst, Redia or Cercaria in any one of these molluscs. Dr. Kiyono informed me that some years ago he found Sporocysts or Rediæ, whichever they were, in almost all Melania of the same locality that he examined. Unfortunately I was unable to verify this fact myself. It is less probable, although the possibility should not be excluded, that the ciliated embryo should first enter into some other invertebrates. At any rate it requires no comment to assume that somehow broods of Cercaria would finally be formed. As to the way in which these Cercariæ become introduced into the human body, one might think of four alternatives. Firstly, they may enter it together with water that is drunk. Baelz does not hesitate to assume this as *the* way of infection ; but I am inclined to put some doubt on this point,

for the ditch-water, as I have already said, does not form the usual drink of the natives. A number of patients whom I saw assured me of never having drunk the ditch-water. I do not mean however to exclude all chances of infection directly from the water. Secondly, they may be taken in together with the host in which the Cercariæ have developed. In this case the Distoma would have but one intermediate host. In this connection I should mention that Paludina and Corbicula are eaten but never in a raw condition. Oysters are abundantly cultivated in the neighborhood, but they are clearly above suspicion since most of them are sent to markets in Okayama where the Distoma-disease is unknown. Thirdly, they may be eaten together with vegetables in an encysted condition after the manner of Distoma hepaticum. I did not observe any edible plants in the ditch, but the fact that the ditch-water is often used for watering vegetable-farms must not be forgotten. Fourthly, they may enter the human body together with the second intermediate host. In this respect shrimps and small miscellaneous fishes as well as molluscs fall under suspicion. Eels and Carassius vulgaris are sent to Okayama markets and are probably harmless. If the words of villagers are to be trusted, symptoms of the Distoma-disease generally manifest themselves late in Summer or at the beginning of Autumn. This is suggestive of the fact that the immigration of young Distoma-broods takes place about that time. In the case of sheep-rot, it is known that symptoms appear in the interval from July to September in consequence of the immigration of young Dist. hepaticum, which attains maturity in 2—4 months.

With these remarks I proceed to give the description of the mature worm.

In the fresh state the worm is translucent, colorless or with a slight reddish shade. The dark-colored uterus is very conspicuous and other organs such as the testes, the seminal receptacle, the vas deferens, the

ovary and vitellarium can be discerned as whitish objects.

The total length of the body averages $11\frac{3}{4}$ mm. The largest measured 13 mm. and the smallest 8 mm. in length. At about the middle of the body, the breadth measures 2—$2\frac{3}{4}$ mm. (Kiyono &c. give 8—20 mm. × 4—5 mm. and Baelz 8—11 mm. × 3.5—4 mm. for the dimension). It has thus an elongated form resembling Dist. lanceolatum in shape. In *fig. 1* I have endeavored to reproduce the shape as exactly as possible. The anterior portion occupying about $\frac{1}{4}$ of the whole body-length tapers toward the blunt apex where the mouth is situated. This portion of the body is marked off from the hinder portion by a slight curving in of the sides. At the level of these notches is situated the ventral sucker (*v. s.*), at which point the breadth of the body measures $1\frac{1}{4}$—$1\frac{4}{5}$ mm. Behind the ventral sucker the body is broad and flat. The ventral side is more convex than the dorsal, while in front of the ventral sucker the cross-section of the body presents an oval form. The hind end does not taper away so gradually as in front, but forms a rounded angle of about 90° or less.

The skin ("*Cuticula*") is smooth, very thin and without spines. Its substance is finely granular. Much controversies were held as to the nature of "*cuticula.*" Biehringer* and Schwarze† have lately shown that it originally constitutes a layer of nucleated cells (ectoblast), an opinion that I can fully corroborate.

The peripheral system of muscles (*Hautmuskelschicht*) is weakly developed. It consists of a layer of exceedingly fine circular fibers lying in immediate contact with the skin, a middle layer of strong longitudinal fibers, and an innermost layer of less developed diagonal fibers. Dorso-ventral fibers are rather abundant.

The mesenchymatous connective tissue presents the usual aspect.

* Beitr. z. Anat. ü. Entwickl.-gesch. d. Trematoden. Arbeiten aus dem Zool. Inst. zu

A number of large branched cells formerly taken for ganglionic cells and lately explained by Looss‡ as elements of the connective tissue, are distributed in the mesenchymatous mass, especially in the anterior portion. I have observed besides a number of large cells in the neighborhood of the pharynx. They are probably of a glandular nature.

The mouth opens on the ventral side at the anterior end. The oral sucker (*fig. 1, o.s.*) is slightly larger than the ventral sucker (*v. s.*). Baelz mentions numerous cuticular hooks as being present in the buccal-cavity, but I did not find any trace of them.

The cask-shaped muscular pharynx (*ph.*) is a well-marked organ closely following the oral sucker. The œsophagus (*œ.*) is very short. Only this portion of the alimentary tube is supplied with circular and longitudinal muscle-fibers on its wall.

The bifurcation of the intestine occurs a considerable distance in front of the ventral sucker. The blind ends of intestinal tubes lie near the posterior end of the body.

The unpaired terminal portion of the excretory vessel (*ex.*) extends from the minute excretory pore (*p. ex.*) anteriorly to the region of the seminal receptacle (*s. r.*), pursuing an irregular course. It runs in the middle of the body, on the dorsal side of the testes. Being a relatively wide canal, it can easily be seen in either fresh or hardened specimens as a transparent streak. I could not distinctly make out the point where this median vessel was continuous with the lateral vessels. The latter can be easily traced in the anterior two thirds of the body. On each side a clear vessel runs anteriorly just outside the intestine. Reaching the height of the point of intestinal bifurcation it turns on itself and traces back its former course posteriorly, its caliber gradually thinning out. I have observed a number of ciliated funnels

Würzburg. VII.

† Die postembryonale Entwickl. der Trematoden Z. f. wiss. Zool. XLIII.

‡ Beitr. zur Kenntniss der Trematoden. Z. f. wiss. Zool. XLI.

(*Wimpertrichter*) but no ciliary patches in the lumen of the vessels.

The brain (*br.*) is situated, not above or in front of pharynx as is usual, but immediately behind it forming a bridge over the œsophagus.

Sexual organs. The ovarium (*ov.*) is a lobed organ of no definite configuration, situated at the beginning of the last $\frac{1}{3}$ of the body. It lies nearer the ventral side than the dorsal. A very fine oviduct arises from its dorsal side (*vide fig. 2*) and soon turns forward in order to become continuous with the uterus. At the turning-point it is joined by the Laurer's canal and soon afterwards by the median duct of the vitellarium. The oviduct does not show any special widening that might be designated as ootyp. Unicellular shell-glands (*sh. g, fig. 2*) are grouped together in front of the ovarium. They do not color very strongly and seem to have been hitherto entirely overlooked.

The Laurer's canal (*l. c.*) opens on the dorsal surface by means of a minute pore, after it has pursued an irregular course posteriorly and dorsally.

Shortly before its junction with the oviduct the Laurer's canal stands in connection with a large oval or pear-shaped seminal receptacle (*s. r.*), usually lying to the right of the median line. I always found it filled with spermatozoa. In preserved specimens the mass of spermatozoa has contracted, thus leaving a space between it and the receptacular wall. It is this organ that has hitherto been taken for the ovary.

The vitellarium (*vit.*) on each side of the body consists of numerous small groups of yolk-cells, presenting a clustery appearance. It extends through all that part included between the ovary and the ventral sucker, along the body-margin outside of the intestinal tube. Sections show that it is confined to the dorsal side of the body. I did not happen to notice it arranged in separate coils, nor did I perceive any

segmentation of the body such as Baelz mentions.

Among the vitellarium, branched efferent ducts filled with yolk-cells may be seen here and there. From the hind portion of the organ a main efferent duct (*vit. d.*), one from each side, proceeds posteriorly and towards the median line over the intestine. Above the ovary the two ducts meet, and from this point a short unpaired duct descends ventrally and opens into the oviduct at the place already indicated.

The Uterus (*ut.*) makes manifold convolutions in the region bounded laterally by intestinal tubes and situated between the ovary and the ventral sucker. The approximate number of uterine loops along the lateral border varies from 16 to 24. On account of innumerable eggs contained within, the uterus forms, as is generally the case, a most conspicuous organ. The eggs have in the anterior portion a dark-brown color, which gradually passes into brown in the middle and then into white in the posterior portion of the uterus. The anterior and much narrowed end of the uterus passes over the ventral sucker and opens externally just in front of the latter on the ventral median line. This opening, which is minute and not recognizable except in sections, is the genital pore common to both male and female products. Two distinct sexual openings have been described, but this must be an error.

There are always two testes (*t.*) situated in the hind quarter of the body. They lie one after the other, ventrally to intestinal tubes. Their shape is varying, being irregularly lobed or branched. One might estimate the number of main lobes at 6 or 7. Each testis sends out a very fine vas deferens (*v. d. fig. 2*) from its central portion. The vasa deferentia run anteriorly above the seminal receptacle and the uterus but beneath the transversal efferent ducts of the vitellarium. At about the middle of the region occupied by the uterus and above it the vasa deferentia unite and form a single duct (*v. d. fig. 1*) of a

considerable calibre. This portion is always filled with spermatozoa and might be termed the seminal reservoir. After an irregular winding course, it reaches the ventral sucker, assumes a position to the right of the median line and finally joins the front end of the uterus a short distance within the sexual opening.

It remains yet to say a few words about the eggs. They are unusually small, measuring 0.028—0.03 mm. in length and 0.016—0.017 in breadth. In those eggs contained in the hind end of the uterus the shell is colorless and transparent. Each encloses an egg-cell and a number of yolk-cells, the nuclei of which can easily be demonstrated by coloring. In the anterior portion of the uterus, where the egg-shells have assumed a dark-brown or dark-olive color, embryos are already formed. Such an egg is represented in *fig. 3*, magnified 640 times. In the interior 3 distinct bodies beside some yolk-granules are seen. One of these bodies is a granular mass of triangular or irregular shape. Behind this body, away from the operculum, there is a second mass of larger size and clearer appearance. The third body lies mainly on the side of the second and has the form of a rod, slightly curved and often showing constrictions. This elongated body does not form a part of the embryo ; it is probably the remnant of yolk-matter.

Embryos can be forced out of shells by a sharp tap on the cover-glass. In *fig. 4* I have drawn an embryo as examined in weak acetic acid. It has an elongated oval shape, measuring 0.025 m.m. in length. The body slightly tapers toward the hind end. I believe I have seen an indication of head-papilla. The delicate skin is covered all over by cilia, which are turned posteriorly. The anterior portion of the body is made up of a few large cells with granular contents. The hind portion contains small cells of clear appearance, probably germinal cells. These two groups of cells apparently correspond with the two granular bodies that we have seen within the egg-shell. There are no eye-spots.

Embryos artificially pressed out remain perfectly quiet. Only once I saw an embryo moving slowly by means of its cilia, after a preliminary pause.

Eggs from the gall-bladder and intestine of a cat have been kept from December last until this day for over five months, but I observe no changes in them. Nor did the artificial warmth of an incubator enhance the hatching out of embryos.

Tōkyō, June 5th, 1886.

EXPLANATION OF FIGURES.

br., brain.
ex., median excretory vessel.
int., intestine.
l. c., Laurer's canal.
o., dorsal opening of Laurer's canal.
œ., œsophagus.
o. s., oral sucker.
ov., ovary.
ph., pharynx.
p. ex., excretory pore.
s. r., seminal receptacle.
sh. g., shell-gland.
t., testes.
ut., uterus.
v. d., vasa deferens.
vit., vitellarium.
vit. d., efferent duct of vitellarium.
v. s., ventral sucker.

Fig. 1. Distomum endemicum Baelz, magnified 12 times. Seen from the dorsal side.

Fig. 2. Female sexual organ, half-diagramatically represented. Seen from the dorsal side.

Fig. 3. An egg, containing an embryo. Magnified 640 times.

Fig. 4. En embryo, examined in weak acetic acid. Magnified 640 times.

Fig. 5. Distomum endemicum, natural size.

Fig. 1.

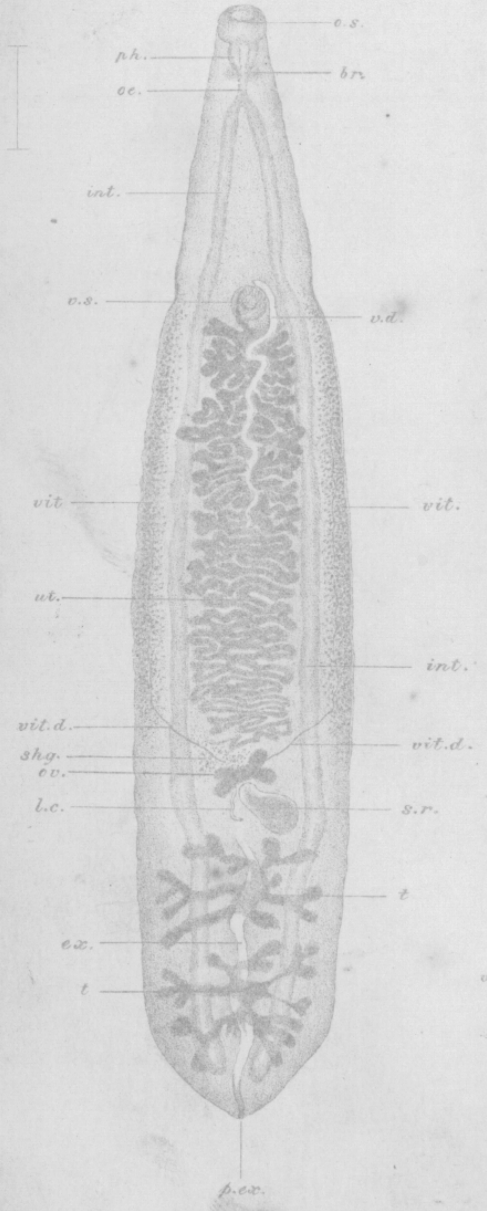


Fig. 3.

Fig. 4.

Fig. 5.

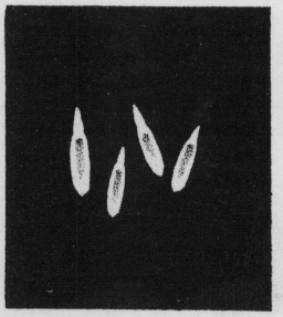
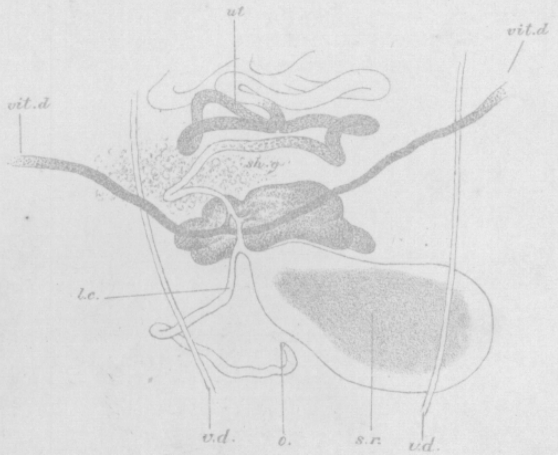


Fig. 2.



Nomura et Ijima del