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On a New Cestode Larva Parasitic in Man

(*Plerocercoides prolifer*).

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With one plate.

The remarkable Cestode larva to be described in this paper probably belongs to the Bothriocephalidæ. It may be called a Plerocercoid and the name, *Plerocercoides prolifer*, is given simply because it is desirable that there should be a distinctive name for practical use.

For the opportunities of studying this most interesting parasite I am indebted to Dr. J. KONDŌ, Professor of Surgery in the College of Medicine, Tōkyō Imperial University, and also to his assistants, Drs. H. SHIODA, M. YAMAMURA and K. SUGI.

The patient who harbored, especially in the subcutaneous tissues, enormous numbers of the worm in question, was a woman, YAE TANAKA by name, and resident either in Tōkyō or in its immediate vicinity. Her occupation had been that of a weaver until she was married to a dealer in old furniture, occupations which place her decidedly in the lower class of society. In the spring of 1904, she came to the University hospital for the treatment of an in-

guinal hernia. Dr. SHIODA tells me that the cause of the hernia, which was on the left side, was traceable to the presence of the parasites in the region of the Ligamentum Poupartii. The patient was then thirty-three years of age. Aside from the affliction complained of, what at once attracted the attention of the medical attendants was the peculiarly swollen state of the integument which bore scattered spots of acne-like appearance. This abnormal state of the skin extended over nearly the entire body, except, so far as I could roughly observe, on the face and the upper extremities, but was most strikingly noticeable on the left thigh. This was excessively swollen and had very much the appearance of elephantiasis, though the skin and the underlying tissues were quite soft so that they hung down by their own weight and could be grasped in a flaccid mass by the hand.

Of the statements made by the patient I will refer to only a few points. When twenty-five years old, she had had a tapeworm; but that surely had nothing to do with the present parasitic disease. The dermal ffection was said to have been first felt in her thirty-first year, i.e., about two years previously to her coming to the hospital. It had apparently given the patient no trouble beyond that imposed upon motion by the swollen thigh and the itching of the skin in parts where a pimple-like hardening made its appearance. Scratching with the nails in order to appease the itching had led to breaking of the skin at the spot, from which could then be pressed out a soft whitish mass together with some fluid. A number of small scars, seen more especially on the breasts, attested to abrasions thus effected apparently not long before. Details of clinical and pathological observations will doubtless be given in a forthcoming report by Professor KONDŌ.

In the examination of preparations made of the skin taken from the left thigh, I was taken in consultation by Mr. YAMAMURA. It was not long before I was convinced of the presence, in the connective tissue, of numerous encapsuled worms, the Cestode character of which was evident from the calcareous bodies contained in the parenchyma.

Subsequently on two occasions, July 9th and 24th, 1904, I was present at surgical operations undertaken to relieve the patient of the superfluous tissues and to procure fresh material for study and experiments. Each time a very large piece of the skin and the underlying tissues was excised from the left thigh. I should think that altogether several pounds' weight of them was removed during the patient's stay in the University hospital.

Of quite an unusual appearance were the subcutaneous tissues when freshly taken from the affected limb. At places several centimeters thick, they were moderately rich in panniculus adiposus and extraordinarily so in lymph. The latter swelled the connective tissue between the panniculi, giving it a slimy or gelatinous appearance and consistency. The slimy character seemed to be more manifest in the deeper parts. The lymph exuded copiously from the cut surfaces. The numerous capsules with the worm within were observable as whitish objects isolated or in clusters, in all parts of the tissues.

In fig. 1 (Pl.) I have shown, in natural size, a vertical slice of the skin and subjacent parts taken from the lateral side of the thigh and hardened in spirit. In the large piece, from which the slice was taken, is represented nearly the entire thickness of the tissues between the skin surface and the underlying muscles. I may say that this thickness measures 30–60 mm., notwithstand-

ing the fact that the hardening process has contracted the subcutaneous connective tissue, through loss of the lymph, into dense fibrous bundles, so that it no longer bears a semblance of what it was in the fresh state. The corium in the same piece may be said to be 3–6 mm. thick; it seems to be on the whole considerably thicker than in the normal state. In the figure above referred to, the lightly shaded subcutaneous spaces represent the adipose tissue, which, when blackened with osmic acid, stood out in sharp contrast to the connective tissue bundles and the capsules containing the worm.

The Worm Capsule.—The worm capsules of various sizes occur in abundance in all parts of the subcutaneous tissues and less abundantly in the corium. They were also observed in some numbers in the intermuscular connective tissue but not in the muscles themselves, so far as such observation could be made on parts incidentally exposed during the surgical operation. In the corium the capsule may be situated so close to the epidermis that the latter is externally raised into an acne-like prominence. On a piece of the preserved skin about 2 inches square I find at least four such prominences, which, as seen on the surface, appear smooth and less pigmented than the surrounding parts. Capsules in so superficial a position might without difficulty be caused to break through the epidermis by force applied from the exterior. The "soft whitish mass" which the patient pressed out after scratching certain itchy spots, could have been nothing else than the parasite which was present in the ruptured capsule.[1)]

1) The escape of the worms from the host, in the manner indicated, is to be looked upon as merely an accidental occurrence dependent upon the exceptionally superficial situation of their capsules; it was surely not an event natural to the species' life-history.

In shape the capsules are generally subspherical or ovoid. While the smallest of them are considerably less than 1 mm. in diameter, others measuring 1–2 mm. or more across are of quite common occurrence. One of the largest I have taken was of an elongate shape, 2½ mm. broad and 8 mm. long. Another measured 3 mm. by 6 mm. The larger capsules are found only in the subcutaneous parts, not in the corium. In the fresh state I could isolate the capsules without much trouble by tearing and cutting them off from the surrounding loose tissues.

The capsular wall (fig. 23), consisting of a dense feltwork of connective tissue fibers of the host, may reach nearly ⅓ mm. in thickness. In sections the capsules may appear not unlike a transversely cut blood-vessel on account of the tough and compact looking wall. Seen under the hand-lens, the internal surface of the wall looks smooth. In some large cysts the internal cavity was seen to be traversed by a branching pillar-like trabecula, the presence of which may be explained by supposing an enlargement of the cavity to have taken place around a strong connective tissue bundle or bundles. Under the microscope the internal surface of the wall either shows no special limiting structure or is lined with a deposit of what may be considered to be a granular coagulum or some tissue debris, the same as that which is found free in the cavity together with the worm.

Abundance of the Parasite.—An approximate idea of the enormous numbers of the parasite which infested the patient may be obtained from the fact that in the vertical section of fig. 1, presenting a surface of about 11 sq. cm., there can be counted nearly 60 capsules which had been cut by the knife. So far as concerns the most thickly infested parts of the patient's left

thigh, I should consider it a moderate estimate to allot on an average one capsule to every 20 sq. mm. of such cut surface or to every 100 cu. mm. of the infested tissues. This would give 1000 capsules to a mass of 100 cu. cm. of the same, in other words, to a mass of the subdermal tissues represented on the skin-surface by an area of 25 sq. cm., assuming the depth to be 4 cm. At any rate, I believe it to be in no way an exaggeration to say that there must have been considerably over ten thousand capsules in the left thigh alone.

Worms without Capsule.—Here I may mention that not all the worms were found in the encapsuled state. During the surgical operation a number of them were discovered free, so to say, in the connective tissue. This mode of occurrence was placed beyond doubt by observations of cases in which some worms, with moderately extended body and without a trace of an enclosing capsule, were found lodged right within a film of the fresh connective tissue when the latter was carefully distended between the fingers. It is noteworthy that these free worms were always small and of the simple slender shape, — typical Plerocercoids such as those represented in fig. 2 *a–c*; they were never so plump-bodied as are many confined within capsules. This fact indicates that it is only the comparatively younger individuals that are sometimes found free in the connective tissue.

Movements of the Worm; the Head.—Living worms liberated from the capsule by cutting this open and left in the warm lymph, showed slow movements, alternately extending and contracting, but effecting little or no change in position. On cooling the movements subsided, leaving the worm in a more or less

contracted condition. So likewise with all the worms which I have thrown into the cold (summer temperature) physiological fluid. However, for some time afterwards, motion could be restored by imparting a little warmth to the medium they were in. With such worms as I had kept in the physiological fluid, after about four hours had elapsed, my attempt at reviving them into motion was only partially successful; many of them then seemed to be nearly or quite dead, showing on the surface pustule-like swellings due to imbibition of the fluid into the parenchyma.

Observing the moving worms under the microscope, the narrower end of the body—undoubtedly the head—showed most motion. This consisted chiefly in evagination and invagination of the extreme end as well as in a shortening and lengthening of the parts. In the more active individuals the head-end was seen now and then to evaginate and elongate to the fullest extent, exposing the rounded extreme tip of the head (as in fig. 18). At other times there was perceivable on the tip a small depression or concavity, which, especially when the terminal parts of the head was somewhat broadened after a narrow neck-like part as was frequeutly the case for the time being, reminded me of the single terminal sucker known from the fish Bothriocephalid *Cyathocephalus* KESSL. But that depression was evidently simply due to invagination of the extremity of the head, for I have frequently seen it gradually but totally disappear as the head-end prolonged itself into a simple finger-like shape, losing the terminal broadening which might be observed so long as the invagination was present. The completely everted, slender head-end moved about as if feeling for something and at the same time generally started a rather lively peristaltic motion which traveled backwards for some distance. Altogether the movements are such

as would effectually assist the worm in penetrating into and shifting through the tissues of the host. In several cases I have succeeded in killing the worms with the head completely or nearly completely everted and protruded, by suddenly pouring on hot corrosive sublimate (figs. 18, 21).

The broad posterior parts of the body showed at most slow vermiform movements, keeping up nearly all the time a more or less strong indentation or invagination at the extreme hind end. Attempts to bring fresh worms into full extension by applying pressure between glasses, invariably failed.

From what I have seen of the moving head I must say that this is entirely destitute of any definitely formed and permanent organ of attachment. Examinations of well extended heads laid out into serial cross-sections have failed to reveal anything like bothria or suctorial grooves characteristic of the Bothriocephalidæ. It can certainly not be denied that the terminal invagination, an inconstant and temporary condition though it be, may under circumstances play the part of a sucker.

Division of the Worm within the Capsule.—With the smaller capsules it is the rule that they contain each a single worm. The same may sometimes be the case with the larger capsules also, but these more frequently contain two or more worms or pieces of the worm. From one of the largest capsules I have seen, five worms were obtained, and in another case seven (fig. 2). This increase in number is explained by the propensity of the worm to divide by transverse fission at a certain stage of its growth. Very frequently the worm body shows a constriction or constrictions at which places it is easily torn apart. In many cases I could not prevent this separation of the body taking place

during the process of removal from the capsule, however carefully this was done. In other cases a slight pressure between glasses sufficed to effect the separation at the constricted place. After all I have observed, there can be no doubt that the worm has the power of dividing and multiplying on its own account within the capsule. Thus the worm shown in fig. 5 may be looked upon in the light of one which is about to divide into two in the middle. I return to this point again soon.

Size and Shape; Budding.—While many of the worms are very small and filiform, measuring not over 0.3 mm. in breadth and 3 mm. in length, others (such as those of figs. 4 and 5) in a moderately contracted state are nearly 12 mm. long and 2½ mm. broad. The latter, when fully extended, would probably double in length but diminish considerably in breadth.

To illustrate the various shapes presented by the worms I have given in figs. 2–15 a selection of specimens, all killed with sublimate solution while living and moving in a watch-glass. In some specimens the body is distinctly flattened, without doubt in the dorso-ventral direction (figs. 4 and 5). In other cases this is not so apparent or is even scarcely perceptible; but then the body in transverse sections generally presents a more or less oval outline (figs. 16 and 17). There exists no clue whatever to decide which of the flattened sides is dorsal and which ventral.

The shape of the worm in the simplest case is that of a typical Plerocercoid (fig. 2 *a–c*; figs. 3 and 13). It is simply thread-like in the fully outstretched state or may consist, in a moderately extended state, of the narrow, highly retractile head-end and of the broader hind region, or when strongly contracted may be of an irregularly cylindrical form, transversely folded on

the sides and broad at both ends which show each a depression due to invagination of terminal parts (figs. 2*d*, 9, 12). When the head is withdrawn to the utmost degree it may be difficult to distinguish that end from the hind end, and moreover it may happen that such a worm is but a fragment constricted off from the hind parts of the Plerocercoid and is thus devoid of the parts which may be called the head.

The simple Plerocercoid I regard as the original form of the larva, which, as will soon be shown, may acquire a widely different shape in a later larval stage. I regard it also as the form the larva would be in just before it begins strobilation after introduction into the final host.

Now a remarkable fact about the present Plerocercoid is that it is capable, at a certain advanced stage of its intracapsular life, of proliferating by a process of budding coupled with the before mentioned division of the body. We seem to have here to do with a process of which counterparts are known in the well known Echinococcus and Cœnurus as well as in *Cysticercus longicollis* and certain Cysticercoids, but which presents some peculiar features standing probably in connection with the Plerocercoid form of the proliferating larva. So far as my knowledge goes, a budding Plerocercus or Plerocercoid seems not to have been known before, at least not with certainty.

Among a large number of the specimens freed from capsules, those bearing from one to several buds or supernumerary heads in addition to the original terminal head of the simple Plerocercoid, are of quite common occurrence. The buds are found only on the larger-bodied specimens and therefore on those taken from the larger capsules. This shows that the budding takes place only after the Plerocercoid has grown to a certain size.

Facts observed warrant the statement that the worms in the early period of encystment, and therefore when still small and solitarily confined in the cyst, are simple Plerocercoids with the terminal head only. The budding may occur in any region of the broad posterior parts, but not on the narrow retractile head.

The specimens of figs. 4, 6 and 14 bear each a bud in different states of contraction and looking much like a lateral branch. The specimen of fig. 5 is in possession of two unmistakeable supernumerary heads; in this specimen, as also in that of fig. 4, the buds are situated plainly on lateral edges of the flattened body. This situation of the buds may in fact be the rule in the earlier period of proliferation; but as they increase in number and the mother-body assumes an irregular shape, the rule loses applicability in that they then appear to arise from quite indefinite parts of the external surface. Of specimens with numerous buds I have represented two in figs. 7 and 8. The original of the latter figure bore considerably over a dozen thread-like buds.

The structures referred to above as buds, differ in no way, except in situation and perhaps also in size, from the original, terminally situated Plerocercoid head. They manifest exactly the same shape and movements as the latter. The numerous buds in the specimens of figs. 7 and 8, at the time of killing, were almost all in vermiform motion while the mother-piece showed little or no movement. I think there can be no doubt whatever that the buds are to be looked at in the light of heads, secondarily produced but quite equivalent to the single terminal head. In the end it is quite immaterial to distinguish this original head from those formed later by budding.

Since now the larva is capable of transverse fission, it follows that the heads, irrespective of the manner of their origin, may

separate off from that body part with which they were originally continuous and may thus represent in themselves new independent individuals of the typical, though at first comparatively small, Plerocercoid shape. In this way can be explained the origin of the two or more Plerocercoids, occasionally found together in the same capsule.

Division alone or in combination with budding gives rise to various shapes of the worm-pieces which in various combinations may occur together in the same sapsule. To give a few illustrations from a number of cases observed:

On several occasions a typical Plerocercoid with head was found together with a plump, nearly cylindrical and headless piece or with two such pieces (like fig. 9 or 12). All the two or three pieces must have been derived by division from an original Plerocercoid that at first singly occupied the capsule. In these cases the division of body had evidently taken place before the worm had commenced budding.

From a large cyst were once obtained: a Plerocercoid with a supernumerary head on one side and looking very much like fig. 4 and two nearly barrel-shaped headless pieces (like fig. 12), both of which must have originally been continuous with the hind end of the first.

Another large cyst gave two small Plerocercoids of typical appearance and a large apparently headless body (like fig. 9). One of the former I take to be original Plerocercoid head and the other, an individual which has been budded off.

The specimen of fig. 5, bearing two buds and showing a strong constriction in the middle, was the sole occupant of a cyst. Should that constriction give way, what the result would be needs no explicit mention.

Of the seven specimens shown in fig. 2, all from a single cyst, three (perhaps four, *a–d*) are simple-shaped Plerocercoids, while three others (*e–g*) are quite irregularly shaped pieces bearing each a number of budded heads. All these worms, in my opinion, must have arisen out of a single original Plerocercoid after its encystment.

Not infrequently the more plump-bodied specimens show on the surface rounded wart-like or papilla-like tubercles which are quite distinct from the buds (figs. 2*f*, 7, 8, 10, 11, 15). Their formation is due, partly at least, to the accumulation in the parenchyma of a peculiar reserve nutritive matter which will be described further on. The external tubercles, conjointly with the buds, greatly contribute towards giving the worm a remarkable irregular shape (figs. 7, 8), which is sometimes met with, especially among the plump and many-headed—therefore assumably old—pieces of the worm.

Here a word about the headless and budless pieces (like fig. 12) that are segmented off from the hind parts of the Plerocercoid within the capsule. They are probably not in all cases to be considered as parts thrown off in the manner for exampe of, the caudal appendage of *Cysticercus*. Presumably they are still capable of producing buds. At any rate, there is no reason whatever to think that the budding can take place only while the original terminal head is present and not after this is lost by fission. Whether at the end of the proliferation the entire mother-piece would be used up in that process or whether there would finally remain a residue comparable to the vesicular appendage of a Cysticercus, and whether or not the Plerocercoid sheds off the posterior parts before it begins strobilation in the

final host, are related questions on which my observations offer no clue to a solution.

The head-buds in the Plerocercoid were observed in various sizes, but I have not been able to trace them back with certainty to the earliest stage of their formation. Perhaps from an early period they are capable of active movements, now everting and then inverting, so that the little rudiment, when fixed, may take the form of an elevation or depression, which on sections might not be easily distinguishable from mere irregularities of the surface. An accumulation of parenchyma cells, such as might possibly occur at the spot where a bud is to arise, has not come under observation.

The enormous numbers in which the parasite occurred in the patient is explained, in large measure, by proliferation taking place in the host. A young and small Plerocercoid, after separation from the mother-body which produced it, may be assumed to find its way out of the capsular wall. That act has not been actually observed but seems to really take place from the fact before mentioned that a number of the smaller sized Plerocercoids were found free in the connective tissue. It is not to be doubted that these free worms are to a certain extent capable of wandering through the tissues by virtue of the power of movements with which they are endowed. Probably however the wandering ceases after the worm has grown to a certain size and then it would begin to give stimulus to the surrounding connective tissue to form the capsule around it. This stands entirely in harmony with the account of the patient that from time to time new acne-like elevations made their appearance on the skin.

Some Points in the Structure of the Plerocercoid.— The cuticula, sometimes 8 μ thick but usually much thinner, presents a homogeneous or finely granular appearance. In contact with it is the delicate dermal musculature which as usual consists of the external ring and the internal longitudinal fibers. As regards the subcuticula and the general parenchyma there seem to exist no points deserving special notice.

The calcareous bodies (*cal.*, figs. 17, 21, etc.), spherical or ellipsoidal in shape and measuring 7½—12 μ across, are abundantly present in all parts of the parenchyma except in the anterior body-parts. The head-end is always found to be free of them. (In fig. 19 the numerous black dots stand for the calcareous bodies.) Especially numerous are they in the bulky parts of the larger specimens. It may happen that very small Plerocercoids, such as seem to have been recently budded off, contain only quite a limited number of them in the hind parts. In stained sections the bodies appear sometimes pale and homogeneous, but more generally exhibit the usual concentric lamination; they are either stained or unstained.

Quite remarkable is the occurrence, in the parenchyma, of peculiar fat-like or yolk-sphere-like bodies of various sizes (*r. n.*, figs. 17, 19, 20, 22). They occur isolatedly or several together in groups, without regularity as to their number and position in the body. Sometimes they are numerously present and are often of a considerable size, forming conspicuous objects when the worms are observed under the microscope and giving the impression that they represent some internal organs (fig. 19). As a rule they are constantly found in a greater or less number in the

broad hind parts of the older specimens. Especially abundant are they in those irregularly shaped, independent pieces which bear a number of head-buds. The head or the anterior parts of the worm are generally devoid of the bodies in question; but this is not always the case, as sometimes a limited number of the bodies occur even as far as a position close to the tip of the head. A few cases in which a small group of them was situated at the head-end misled me for a time into thinking that I probably had suckers before me. Small and young Plerocercoids, evidently recently detached from the mother-body, mostly showed no trace at all of the bodies under consideration. In all probability they are something which develops and grows both in size and number as the worm gets older and which, I may add, begins to undergo a disintegrating process after a certain period of existence.

In an early stage of development the bodies are small, spherical or irregular-shaped masses appearing very much like yolk-granules,—homogeneous, refractive and strongly stainable. The circumstances of their occurrence and the shape of the larger ones were often such as suggested the formation of these by coalescence of several smaller ones. The bodies may grow to a size of 150 μ or more in diameter, retaining the original compact appearance, though in sections they usually appear more or less broken into irregular fragments separated by narrow fissures. As yet they seem to be imbedded directly in the parenchyma, exhibiting neither a vacant space around them nor a special enveloping membrane. As already mentioned, the same bodies after growing to a certain size begin to show signs of dissolution in that they, begining at the periphery, break up into finer or coarser granules as well as into conglomerate-like spherules that appear much like the white yolk-spheres of a hen's egg. Thus, the body may now

be, as it frequently is, represented by an unevenly granular substance inclosing a compact core of varying size, which core is the remnant of the original body in an unchanged condition. In a more advanced stage of disintegration the core disappears altogether and the body is entirely changed into a conglomerate-like mass consisting of granules and spherules of various sizes (*r. n.*, figs. 17, 20, 22). This change in character of the body is accompanied by a considerable increase in bulk. Moreover, after the setting in of the disintegrating process, the mass comes to lie in a vesicular space which is delimited from the parenchyma by a sharply defined, structureless membrane. The vesicle is generally roundish or oval, measuring 100–300 μ in diameter; occasionally it is found drawn out into a canalar shape of considerable length (as on the left of fig. 20). The bounding wall is at first thin but later so increases in thickness that it comes to resemble in a remarkable degree the cuticula of the worm. Now and then I have noticed on its inner surface fine hair-like processes, but this appearance I am inclined to regard as having been caused by a part of the contents sticking to that surface. The conglomerate-like mass either entirely fills up the internal space or leaves between it and the wall a peripheral space, which in sections is quite clear but may sometimes show traces of a very finely granular and faintly stained coagulum.

As to the significance of the body or substance described above, the most likely explanation seems to be that it represents a nutritive matter held in reserve, physiologically comparable to the fat of higher animals or to the amylum in plants. The storing up of the matter probably stands in relation with the high proliferating power possessed by the present worm. The reactions towards reagents indicate that the substance is not ex-

actly a fat but more probably an albuminoid. Similar, if not identical, bodies are known from certain other larval Cestodes. AUBERT[1] found in *Gryporchynchus pusillus*, a Plerocercus from *Tinca vulgaris*, a large number of refractive spherules massed together in the hind body; they were held by the describer to be fat, but this seems to require confirmation. The peculiar "Schollen," described by BARTELS[2] from the hind parts of *Cysticercus fasciolaris*, seem to closely agree with the bodies I have met with in *Plerocercoides prolifer*. In this relation might further be mentioned the clear drop-like spheres which are known to appear in *Cysticercus pisiformis*, etc. at the place occupied later by the internal cavity of the caudal appendage. This may be held to be an indication that there possibly may obtain a genetic relation between that cavity and the vesicular spaces containing reserve nutritive-matter in *Plerocercoides prolifer*.

An extensive system of excretory vessels traverses the entire body of the worm (*ex.*, figs. 16, 17, etc.). As in the Bothriocephalidæ generally, there exist several main vessels running in an approximately longitudinal direction. These frequently branch and anastomose with one another, thus bringing about an irregular network of the vessels. Those of largest caliber are seen in the posterior parts of the body, where they may be of a considerable width. As in *Bothriocephalus mansoni*, transverse sections through that region show them in section numerously in all parts of the parenchyma except in the peripheral zone (fig. 17). The external opening at the hind end could never be distinctly brought into view. Towards the anterior parts the network of

1) H. AUBERT. Zeitschr. f. wiss. Zool. Bd. 8. P. 284.
2) E. BARTELS. Zool. Jahrb. Abth. f. Anat. u. Ont. Bd. 16. P. 516.

the larger vessels divides into two, more or less clearly distinguishable lateral tracts, each of which, further anteriorly in the head, runs out into a single main canal on both sides. I have no observation on the capillary vessels.

On several occasions I have seen parts of the excretory vessels excessively swollen for a longer or shorter extent, apparently the result of an unnatural stowing of the fluid contents. In fig. 18 is shown the head of an individual with an abnormally swollen vessel, which at the extreme tip formed a loop and was continuous with another of much smaller caliber. I have been unable to exactly decide whether the vessels referred to were the two lateral vessels communicating with each other at the anterior end, or whether they represented ascending and descending parts of a lateral vessel of one side. Frequently, as the worms were observed under pressure between glasses, the swollen parts of the excretory vessels were seen to be filled with granules, apparently those of the reserve nutritive-matter that must have found its way into the vessels by rupture of tissues at some point.

Of the parenchymal musculature there exists in the first place a well developed system of longitudinal muscles, to the action of which should be ascribed the contractility of the body in length and the great retractility of the head. In them the fibers form anastomosing bundles, running from the tip of the head to the caudal end and present in all parts of the parenchyma except in the periphery (figs. 16, 17, 21, 22). The bundles are strongest and most numerous in the thick hind parts of the body. Where a head bud arises from the mother-body they give off branches into it as do also the excretory vessels.

Another, much less strongly developed system of the parenchymal musculature consists of fine muscular fibers which run singly, leaving wide spaces between, in various directions but mainly in the transverse plane of the body. In the narrow anterior parts (the head), as seen on cross-sections (fig. 16), there is observable a tolerable regularity in the arrangement of the fibers in that a set of them runs in an approximately transverse direction while another takes a dorso-ventral course. In the thick posterior parts (fig. 17), all the fibers run in quite an irregular manner, which fact is probably largely due to the crowded occurrence, in this region, of the wide excretory vessels and of the longitudinal muscular bundles. Transverse muscles in a continuous layer, dividing the parenchyma into cortical and medullary zones, do not exist.

With respect to the nervous system, all that I have seen is limited to the following facts. A pair of nerve trunks (*n.*, fig. 16) run in the usual position; they were observed with distinctness only in the anterior parts of the body. They seemed to unite at a position close to the tip of head. In the thick posterior parts of the body, they were not at all distinguishable.

Taken all in all, *Plerocercoides prolifer* shows a far-reaching structural agreement, especially in the musculature and the excretory system, with the Bothriocephalid larva *Sparganum* of DIESING, as well as with COBBOLD's *Ligula mansoni* so-called, which was provisionally referred to *Bothriocephalus* by LEUCKART. Indeed, it may be admitted to be nearly certain that the worm

is one of the Bothriocephalidæ, notwithstanding the fact that the head is found to be without bothria. Perhaps it is assumable that a definite suctorial organ or organs might yet develop at a later developmental stage of the worm than those I have had for observation. Equally possible it seems, on the other hand, that the head keeps up the observed simple condition even to the mature stage,—that we have here to do with a Bothriocephalid which has lost all trace of bothria. Perhaps these are wanting in the so-called *Ligula mansoni* also; at any rate they have never yet been seen with certainty in that larval Cestode. Accordingly it may possibly turn out that "*Ligula mansoni*" and *Plerocercoides prolifer* represent very nearly related forms, perhaps generically identical. A more exact systematic determination of the larval forms can not be made with certainty until they have been traced up to the sexually mature stage.

I consider it futile to enter here into speculations concerning the past and future life-history of the larval Cestode described in this paper. Great interest is of course attached to feeding certain animals (*e. g.*, cats, dogs, or pigs) with the larvæ for the purpose of raising the mature worm, and also to determining if they can be operatively transplanted into the connective tissue of animals and there made to proliferate. Experiments in these directions I have caused to be made by Professor KONDŌ's assistants, but unfortunately they have borne no fruit. As the patient's return to the hospital is held in prospect, I am in hope of obtaining a new supply of the material with which to renew the experiments.

PLATE.

Explanation of figures.

Plerocercoides prolifer.

Fig. 1. A vertical slice of the skin and subdermal tissues taken from the left thigh of the patient, showing numerous encysted *Plerocercoides prolifer* in situ. Hardened in alcohol. Above, the epidermis. From some of the cysts the worm had fallen out. Natural size.

Fig. 2 *a–g*. Seven separate pieces of the worm taken from a single large cyst. Magnified $1\frac{1}{2}$ times. Photographed after fixing with corrosive sublimate. *a–c*, simple Plerocercoids. *d*, a strongly constricted piece of the worm (with involuted head?). *e–g*, irregularly shaped pieces budding out heads.

Figs. 3–15. Worms in various shapes; all drawn from fixed specimens, magnified 4 times.

Fig. 3. A specimen of simple Plerocercoid shape, with the extreme head-end invaginated.

Fig. 4. Plerocercoid bearing a branch-like supernumerary head on one side.

Fig. 5. A similar specimen, bearing two supernumerary heads and strongly constricted in the middle.

Fig. 6. A specimen with a branch-like bud; the terminal head, either not present or strongly withdrawn.

Figs. 7 and 8. Irregular-shaped specimens with numerous heads formed by budding.

Figs. 9 and 10. Contracted specimens, either without the head or with the same strongly withdrawn.

Fig. 11. A specimen, irregularly coiled and with tubercle-like protuberances.

Fig. 12. A piece constricted off from the hind parts of a Plerocercoid. Invaginated at both ends.

Fig. 13. A Plerocercoid greatly stretched out, but with the extreme head-end still retracted.

Fig. 14. A Plerocercoid with the terminal head either lost or strongly retracted, but with a greatly outstretched head-bud.

Fig. 15. A Plerocercoid moderately stretched out and with irregularities of contour in the anterior parts.

Fig. 16. Cross-section through the anterior part (head region) of a Plerocercoid. Magnified 100 times. *n.*, lateral nerves. *ex.*, excretory vessels in section. The black dots represent partly nuclei and partly longitudinal muscular fibers in section.

Fig. 17. Cross-section through the posterior part of a Plerocercoid. Magnified 100 times. *cal.*, calcareous bodies. *ex.*, excretory vessels., *mus.*, bundles of longitudinal muscular fibers, which, in many other parts, are represented by the larger black dots. *r. n.*, reserve nutritive-matter in capsule.

Fig. 18. Head-end of a Plerocercoid fully stretched out, showing the simply rounded tip. Drawn from a specimen clarified with glycerine, 30 times magnified. Excretory vessel in part strongly swollen on account of the stowing of the liquid contents.

Fig. 19. A Plerocercoid pressed under glass; over-stained with carmine and afterwards bleached with caustic potash. Black dots represent well-stained calcareous bodies, which are absent in the head region. Reserve nutritive-matter (*r. n.*) in the form of numerous balls. A pair of excretory vessels (*ex.*) in the anterior parts. Magnified 30 times.

Fig 20. A section through an irregular-shaped piece bearing a number of buds or heads, parts of which are seen in two places (*h.*). Other lettering as in fig. 17. Magnified 50 times.

Fig. 21. A horizontal section through the nearly fully evaginated head-end of a Plerocercoid. Lettering as in fig. 17. Magnified 50 times.

Fig. 22. A horizontal section through the hind parts of a Plerocercoid. Lettering as in fig. 17. Magnified 50 times.

Fig. 23. Section of a worm-cyst lying in the subdermal connective tissue. About 8 times magnified.

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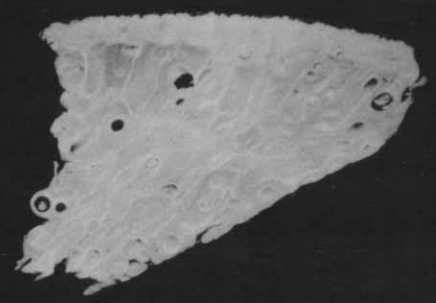

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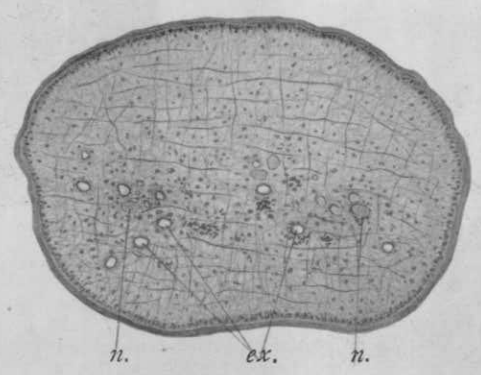

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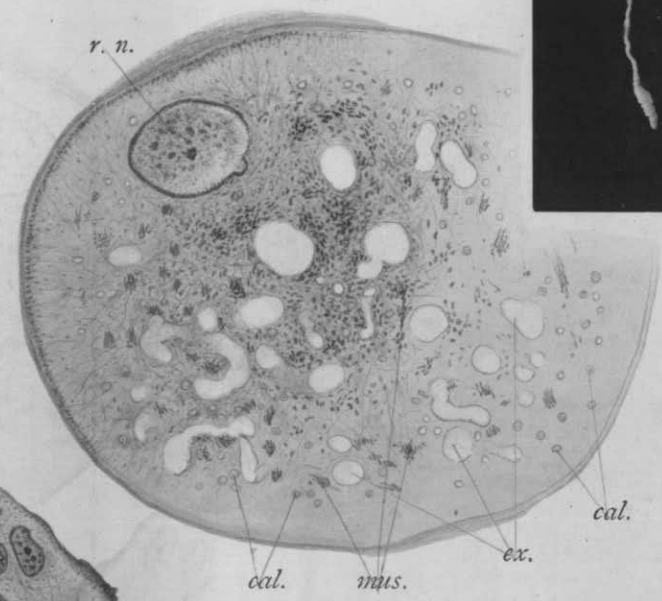

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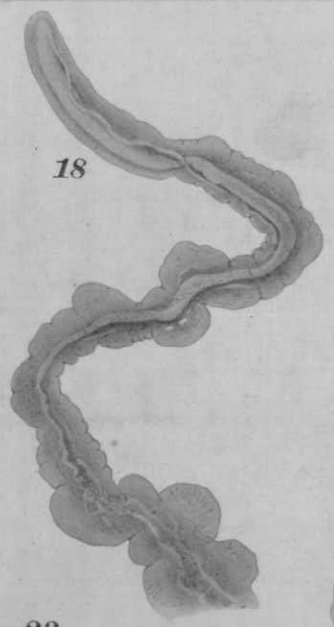

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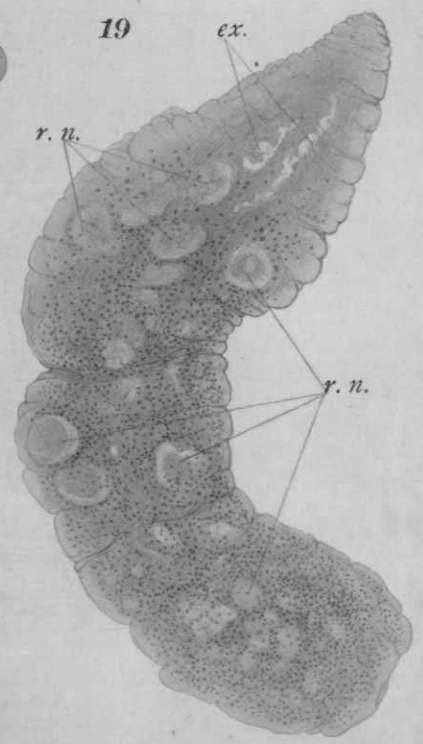

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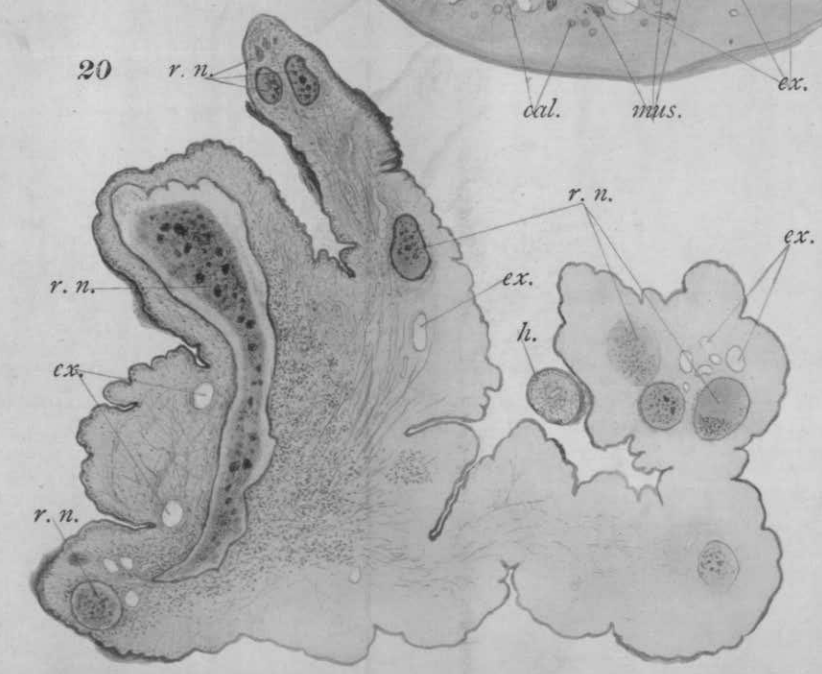

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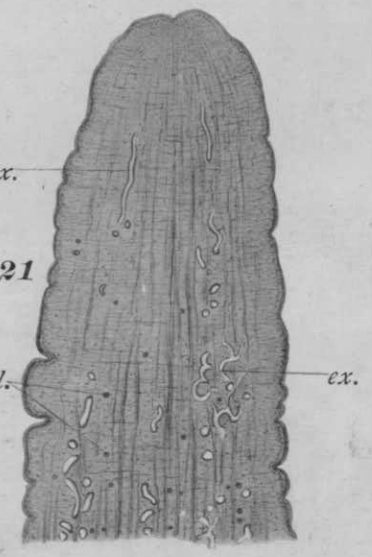

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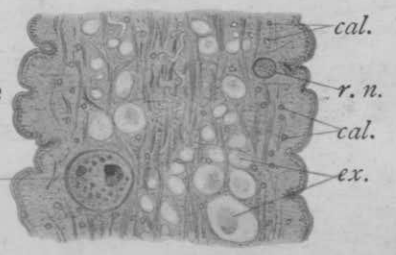

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