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On the structure of *Taenia confusa* Ward.

By

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(Studies from the Zoological Laboratory, the University of Nebraska, Lincoln, under the direction of HENRY B. Ward, No. 27.)

With Plate 28.

The specimens representing the above named form were obtained through a Lincoln physician; the first one, in 1894, and the second a year later. On account of the external appearance, which is noticeably different from that of the two previously known human *Taeniae*, *Taenia saginata* and *Taenia solium*, they were set aside for a more careful examination at some future time. The generally peculiar appearance of the body, the dissimilarity in internal structure, and the extremely modified head preclude all possibility of classifying them with either of the common forms. In view of these differences the name *Taenia confusa* was proposed by Dr. HENRY B. WARD, who first recognised the specific rank of the form. He briefly mentioned the same in the report of the Zoologist (WARD, 1896, p. 258) and later, in the report for 1896 (WARD, 1897, p. 180—182) gives a fuller general statement in regard to it. The only other literature which refers to the new species is the report of the preliminary announcement made before the Nebraska State Medical Society (WARD, 1896a). A systematic study of the form was taken up by me in Sept. 1895 and has been carried on in connection with my studies on other forms of *Taenia* to the present date [June 1897]¹⁾.

The anatomy has been worked out about as thoroughly as the

1) A recent note referring to this species and to this paper is WARD, 1897 a.

material, which was poorly preserved for histological purposes, would permit. In the following description of the structure of the new worm no great amount of histological detail is given for the reason already stated¹). Two specimens only, were obtained; the one entire and the other, unfortunately, lacking the head. The last mentioned has been largely used up in making sections, the other remains intact in the private collection of Dr. HENRY B. WARD.

Because of the ease with which specimens of *Taenia saginata* may be secured for study, and also on account of the more abundant supply of literature describing this species, the new form has been compared principally with it although in many such as the general delicacy of structure, the small head, and the branching of the uterus, there is more of a similarity to *Taenia solium*. In the minute details of structure, however, it resembles neither.

General structure. In general the form is from 5 to 8 m long, consisting of a very small head and between 700 and 800 proglottids. The proglottids are, with very few exceptions, longer than broad (Fig. 1); this being especially characteristic of the terminal ones (Fig. 1 *f*), which measure in some cases, as much as 35 mm long by only 4 or 5 mm broad. At no time do they have the peculiar pumpkin-seed shape, so characteristic of the terminal proglottids of *T. saginata*. The uterus, in the ripe proglottids (Fig. 2) consists of a median stem with from 14 to 18 irregularly branching offshoots, which in general appearance often resemble somewhat the branches as seen in *T. solium*. The sexually mature segments (Fig. 1 *c*) are longer than broad and are characterised particularly by the long kidney-shaped lobes of the ovary (Fig. 3 *o*). The whole body is in general much thinner and more fragile than that of *T. saginata*. The eggs (Fig. 11) are oval in shape, 39 μ long by 30 μ wide, of a white color and without a pyriform apparatus.

In the following detailed account, the description of the internal

1) To Dr. HENRY B. WARD, my highly esteemed instructor, I am greatly indebted for his kindly aid and valuable suggestions. Not only has he supplied me with literature from his own library, but also, with very valuable material for study and comparison from his private collection, to which, in fact, the specimens under discussion belong. His wide acquaintance with zoological literature, and his familiarity with the special methods so essential to a successful pursuit of this kind of research work, have been of inestimable service to me.

structure is based mainly upon observation made on the headless specimen.

External characteristics. The total length of the headless worm is 8.5 m; of the other 5.2 m. Beyond the noticeably long and narrow structure of the proglottids the body does not differ much in general appearance from the ordinary forms. The genital pores are rarely very prominent except in the segments immediately succeeding those sexually mature; as regards the general arrangement in the successive proglottids, there is no anomaly, the pores being arranged alternating irregularly in the usual manner. The body is of slight structure with much less powerful musculature than *T. saginata* possesses, and is incased in a very delicate thin cuticula. The extreme length of some of the segments is the first thing to strike the attention as being unusual and upon measurement it is found that, in the larger worm, at only one point in the chain, just anterior to the sexually mature proglottids, are they wider than long. Here they measure on an average about 3 mm wide by 2.1 mm long, this excess of width over length being present throughout about 80 proglottids. In the smaller one, the predominance of length over breadth although still considerable, is not so marked, and many proglottids measure somewhat wider than long. The general proportions of this worm may be seen from the second table below. In this case, however, most of the segments that are shorter than broad, show by their slightly wrinkled appearance that they are more or less contracted lengthwise.

The following measurements will give some idea of the relative size of different parts of the first worm:

Posterior proglottids . . .	35 mm long by 3.5 to 4 mm wide
About 1 m further forward . . .	26 " " " 5 "
About the middle . . .	15 " " " 4.5 "
Showing first branch of uterus . . .	5 " " " 4.5 "
Sexually mature	4.5 " " " 3.5 "
Near the anterior end . . .	1 to 1.2 " " " 0.8 to 1 mm "
The smallest present . . .	0.9 " " " 0.6 "

From the above data it will be seen that the proglottids are broadest somewhat back of the middle of the worm, and that from the smallness of the anterior segments there could not have been a very great number with the missing head. The whole number of proglottids present is 762.

The second specimen is the one which bears the head¹⁾. The total length is 5.2 m and the whole number of proglottids, about 775. The proglottids extend quite up to the head and no special, unsegmented neck region is present. The first few are broader than long but change after about the twelfth. The following table gives the measurements of the various parts of the body.

Head	to	50	cm, number of	proglottids	290,	the last	3.2	mm long	by	4.6	wide
50	"	100	"	"	"	"	"	6	"	"	7
100	"	150	"	"	"	"	"	7	"	"	8.2
150	"	200	"	"	"	"	"	10	"	"	9
200	"	250	"	"	"	"	"	10	"	"	10
250	"	300	"	"	"	"	"	13.5	"	"	7.8
300	"	350	"	"	"	"	"	15	"	"	7
350	"	400	"	"	"	"	"	17	"	"	5.4
400	"	450	"	"	"	"	"	29	"	"	5
450	"	483	"	"	"	"	"	27	"	"	4.8

In general contour the proglottids have somewhat the shape of a flattened cylinder, with the exception of some near the anterior end, and the ones immediately following the sexually mature. The former in many cases show considerable tendency to taper toward the head, and in the later, where the branching of the uterus is well

1) A description of this structure has been purposely omitted for reasons given elsewhere (WARD, 1897a) from which the following remarks are quoted:

"The head which was attached to the one specimen of *T. confusa* was cut off and after having been stained was mounted in balsam in the ordinary manner. There was, furthermore, a label accompanying the specimen throughout the entire series of transfers and it is difficult for me to believe that it could have been confused with any other specimen, especially since to my knowledge there were no other tape-worms on the table at the same time. . . . It has not escaped any who have examined the figure and description that there exists between the head as described and that of *Dipylidium* a great similarity. . . . However, the general form appeared to us remarkable on first study, and I am able to say positively, from having studied the head under a lens when still attached to the entire chain, that the head of *T. confusa* was remarkably small, approximately of this same size and shape, and that there was within the head and beneath the apex, a dark object corresponding to the general position of the inverted rostellum with hooks, which was figured from the specimen as mounted and now in my possession. . . . But since a confusion may possibly have arisen and since I do not wish to prejudice the work of my student by allowing him to incorporate in it any doubtful particulars, I have had him complete his paper omitting any reference to the structure of the head."

under way, the genital pore becomes quite prominent so that the outline takes on a somewhat pentagonal form (Fig. 1 *d*). The proglottids following these begin to lengthen rapidly and broaden gradually until the extreme breadth is attained; in this state they are more or less quadrate in shape (Fig. 1 *e*). The terminal or ripe proglottids do not show in any case the pumpkin-seed form so characteristic of *T. saginata*, and are very slightly smaller at the anterior end, the tapering being almost imperceptible.

The extreme posterior end flares out more or less and forms a broad base for the attachment of the next succeeding segment (Fig. 1 *f*). One striking thing in the ripe proglottid is the prominence of the vagina which persists from its first formation throughout the entire chain. This, however, is not characteristic for this form only but occurs also in *T. saginata* in a less marked degree.

The cuticula. The cuticula is very delicate as compared with of *T. saginata* and can scarcely be detected under the low power of the microscope. It splits or cracks rather easily and is generally thrown into slight folds or wrinkles. On cross section, the body shows a much more irregular or wavy outline than that of *T. saginata*, due doubtless, to the thin cuticula. The cuticula varies slightly in thickness in different proglottids and in various parts of the same proglottid, being somewhat heavier in the posterior ones and very slightly thicker in the neighborhood of the pore. On the dorsal side of a sexually mature proglottid of *T. saginata* it measures $10.5\ \mu$ in thickness and correspondingly in *T. confusa* $4.5\ \mu$, in the latter it appears to be homogeneous and in cross section no vertical striations are visible. Nothing resembling cilia or processes of any kind are found on the exterior.

Just beneath the cuticula and seemingly almost a part of it, is a double layer of very minute fibres lying at right angles to each other. The layers are extremely thin and are best seen in frontal section. The transverse fibres are outermost. In neither case is a solid sheath formed, small interspaces remaining between the fibres.

The sub-cuticular layer. Directly under the cuticula, or perhaps more properly, the above mentioned systems of fibres is seen a border or fringe of more or less spindle-shaped cells, at right angles for the most part to the surface. There is a greater or less quantity of intercellular substance present which prevents one from making a very definite study of the cells. They all have prominent nuclei which seem to lie at about the center while one end of the

cell lies against the cuticula and, in many cases, the other is seen to be in direct continuity with the single wavy muscle fibres which extend down toward the middle of the proglottid. In most cases, these fibres pass on directly through the band of transverse muscle fibres, but in some instances they seem to run into, and turning, becomes a part of the same.

The body parenchyma. The mass of the body within the cuticula, as in all Cestodes, is made up largely of parenchymatous tissue, which, inasmuch as it differs in no way from that of the ordinary forms, will require no particular description. The whole mass is divided by the transverse and longitudinal muscle fibres, according to the usual manner, into a cortical and middle layer. The middle includes nearly all the organs of the proglottid, and the outer layer, many muscle fibres and calcareous bodies so common to *T. saginata*. The latter, however, are not so plentiful nor so large in this form, measuring only up to $11\ \mu$ in diameter. It was suggested that the smaller size might be due to some particular stain used which had partially disintegrated the bodies, but inasmuch as I have used a great variety of stains and find little if any change in the size or structure of these bodies in different preparations, I think the smallness of size can hardly be attributed to the action of the stains.

Muscular system. As has been mentioned the muscular system is much less powerful than that of *T. saginata*; but all three systems of muscles, viz. longitudinal, transverse and sagittal, are present (Fig. 4 *l.m.*, *t.m.*, *s.m.*). The layer of longitudinal muscles is much the thickest of the three and the individual muscle fibres the largest.

They are of especially large size toward the inner edge of the cortical layer and show a tendency to run in bundles; numbers of these bundles lying side by side give the section a marked streaked appearance. In most cases the bundles do not run in exactly straight lines but take a more or less wavy course. Moreover they do not stop at the ends of the proglottids and become attached to the walls, but unquestionably, run on directly from one proglottid to another (Fig. 5 *l.m.*). This, then, is very different from the structure found in *T. saginata*, which, according to LEUCKART (1886, p. 293) has certain spindle-shaped cells lying between the end of some of the longitudinal fibres in the successive proglottids, connecting them through the isthmus or neck; the fibres themselves always terminating at the end of the proglottid. In *T. confusa* no cells answering to

such a description were found. The isthmus contains in addition to the longitudinal fibres, some parenchyma and usually a few transverse and sagittal fibres. This point was verified in sagittal, frontal and transverse sections of proglottids in different stages of development. Some of the fibres near the surface it is true attach to the ordinary spindle cells lying next to the cuticula, where it dips down slightly between the proglottids, but the main mass extends on through into the next segment.

The connection between the various proglottids seems to be the most firm at the sides near the inner edges of the longitudinal excretory canal, these points often being tied together by the longitudinal muscles fibres when all the remaining tissues are free. The proglottids do not in all cases separate along the line marked out on the exterior of the worm, but not infrequently break at the cross excretory canal, which in this form lies very near the posterior edge of the proglottids (Fig. 5 *t.e.c.*). This fact was noticed many times in pulling the proglottids apart.

The transverse muscles do not show so much of a tendency to run in bundles as the longitudinal, and are in general smaller. They form two plates (Fig. 4 *t.m.*) between which the sexual organs are located. Under the low power they have the appearance of a continuous band but under the higher power they are found to spread at the ends near the edges of the proglottid and for the most part attached to its walls. In the neighborhood of the pore especially their spreading and attachments become very plain. The large central plug in the pore is well supplied with them. Occasionally they may be seen entirely outside the plate and lying in the cortical layer.

The sagittal fibres (Fig. 4 and 5 *s.m.*) cross the proglottids from dorsal to ventral surfaces and are scarcely visible under the low power. Those lying in the middle portion of the proglottid have the appearance of connecting the two transverse muscles plates but the higher powers of the microscope show that in reality they pass on, for the most part into the cortical layer. It is due largely to the direction of these fibres that the ends of the transverse plates seem to unite or bend around into one another. These fibres are the smallest of the three kinds mentioned and show little tendency to run in bundles. Often they may be traced across the middle field, through the transverse bands and on into the cortical layer, where in some cases, they attach to the spindle-shaped cells which abut on the cuticula. Near the center of the proglottid they seem to be some-

what more numerous and are crowded together at intervals into band-like masses, appearing to form sheath-like structures around the various internal organs. They persist in the neighborhood of the pore but seem to undergo no modification in structure.

Excretory system. The excretory system does not differ materially from that of *T. saginata*. In some of the very anterior proglottids it is seen at four longitudinal vessels but these soon merge into two, one on either side, which extend through the remainder of the body (Fig. 3 *l.e.c.*). The canals are of larger size and near the posterior edge of each segment are joined by a cross vessel (Fig. 3 *t.e.c.*). They pass ventral to the genital ducts and between the general inner field and the longitudinal nerves.

Nervous system. On account of the condition of the material, which was not suitable for working out histological detail, but little can be said of the nervous system beyond its location and gross structure. Two main branches extend throughout the body along the outer edge of the large longitudinal excretory canal (Fig. 3 *l.n.s.*). They do not exist as single cords, except at the very anterior end but run for the most part in strands of three and occasionally five (Figs. 4—6 *l.n.s.*). Where three are present the middle one is usually considerably the largest. The strands are for the most part more or less oval in cross section but may spread out until they are almost band-like in appearance. In the neighborhood of the genital ducts they separate, some going to one, and some to the other side of the same, commonly two pass dorsal and one ventral to the ducts. The strands seem to have no distinct sheath of their own, but a sort of surrounding case is formed by the muscles fibres. All are traversed and divided up into minute facets by a connective tissue network. They are almost invariably larger and better developed on the same side with the genital pore.

Sexual organs. In this form as in all other Cestodes, the sexual organs are well developed. They do not differ essentially in their general plan of structure from those of *T. solium* or *T. saginata* but show many minor variations.

Any one of the several more important of these would be almost sufficient alone to show the specific rank of the new form. The proglottids showing full development of the sexual organs measure 4 mm to 4.5 mm long by 3.5 mm wide in the headless worm, and about 4 mm long by 4.5 mm wide in the other; in the first case being longer than broad and in the second somewhat wider than long. In

these both male and female systems are well developed, and by means of sections their structure and relationship may readily be made out. As is the case in kindred forms the male organs occupy largely one surface of the body and thus provide means for distinguishing dorsal and ventral side. Following the well established precedent, the side bearing the testes (Fig. 4 *t*) is designated as dorsal.

Male System.

Testes. The testes (Fig. 3 *t*) are present as numerous more or less round bodies distributed throughout the entire upper field of the segment between the excretory vessels, with the exception of a limited area just anterior to the ovarian lobes. They are more abundant toward the borders and anterior end of the inner field. They seem to differ little from those of *T. saginata* except for their smaller size (0.089 to 0.096 mm in diameter). No vasa efferentia are visible but this fact is due probably to the poor histological condition of the material.

Vas deferens. This organ (Fig. 3 and 4 *v.d*) is present as a greatly coiled tube which extends from the genital pore in a line at right angle to the antero-posterior axis of the proglottid, and ends near the center of the segment. The coiling is very pronounced and complicated, and occupies a space from 0.13 to 0.16 mm wide. This area has a sheath-like boundary formed principally of surrounding muscle fibres. The tube itself measures about 0.045 mm in diameter but becomes smaller before it enters the cirrus pouch where it again springs abruptly to a greater diameter forming a special enlargement for storing the innumerable spermatozoa with which it is filled. There are usually from one to three of these bulb-like swellings, which form a sort of Vesicula seminalis.

Vesicula seminalis. This structure (Fig. 6 *v.s*) seems to be modified in no way particularly from the remainder of the Vas deferens, except for the enlargement of the cavity. The diameter of the enlargement varies somewhat in different proglottids, and slightly in the different bulbs, where more than one are present. In general the diameter is about 49.7 μ . The increase in size seems to be principally dorso-ventral, consequently the bulbs can be seen in transverse sections to the best advantage. They are present in all the transverse sections through the pore but in several series of frontal sections they appeared to be lacking until their presence was proven by means of measurements. In a few cases there seemed to be no trace

of them in the frontal sections. Occasionally, certain modifications are met with in which the round bulbs show a tendency to merge into one another and form a long vesicle.

Cirrus and cirrus pouch. The cirrus (Figs. 6 and 7 *c*) is simply the modified end of the Vas deferens which, after it reaches the cirrus pouch, becomes much straighter, of less diameter (29 μ) and shows but very few coils. The tip is usually slightly enlarged although occasionally it is conical. It often lies thrust slightly out of the sac and except for the smaller diameter seems to be but little modified from the Vas deferens. A trimming or border of fine chitinous points, similar to those already described for *T. saginata* by LEUCKART (1886, p. 440) cannot be definitely made out. In one or two cases very delicate markings were discernable, but whether they were points or simply wrinkles could not be determined. The representation in the drawing (Fig. 7 *c*) is somewhat exaggerated. The cirrus is so arranged that in extension the seminal duct is evaginated or turned inside out for a short distance, forming the copulatory organ. To be more explicit, the outer end of the cirrus pouch is reflected back, forming a pit which is continuous with the seminal duct.

When the muscular wall of the sac contracts a regular prolapsus of the duct results and its inner side is forced out to the exterior. This process is well illustrated by beginning at the base of a gloved finger and gradually turning it inside out; although of course in the case of the worm the pressure is distributed over what corresponds to the entire outer surface of the glove finger, thus forcing the tube to double back upon itself and turn inside out. This arrangement is also found in *T. saginata*.

The cirrus pouch (Fig. 7 *c.p*) is somewhat pear-shaped and measures 0.31 mm in length. Its walls are made up largely of muscular, web-like structure in which the fibres run diagonally. On the inside are retractor muscle fibres (Fig. 7 *r.m.c*) which attach the cirrus to the wall, and also, many connective tissues fibres. Numerous deeply staining bodies, which for want of a better name are called free nuclei* (Fig. 7 *f.n*) are present and are distributed throughout the inner network of fibres. In addition to the nuclei, numerous other minute bodies which resemble them very closely are present. Upon close examination the latter are seen to be the cut ends of small muscle fibres. These small bodies (both nuclei and small muscles fibres) are found also along the edge of the pore plug and

the border of the vagina (Fig. 7). The seminal vesicle, as described above, also lies inside of the sac.

The genital pore. The genital pore (Fig. 4 *p*) or generative cloaca as it is sometimes called, is very different in structure from that of either *T. saginata* or *solium* (compare Figs. 7, 8). The pore in the majority of cases is distinct but not prominent and measures in the sexually mature proglottids about 0.45 mm in diameter by only 0.05 to 0.08 mm deep. This extreme shallowness is almost sufficient ground in itself to exclude this form from belonging to the above named species; for example, *T. saginata*, according to LEUCKART (1886, p. 440), has a wide pore or a funnel-like cavity, 0.22 mm deep (Fig. 8 *p*). The pore in *T. confusa*, contains a large plug-like projection (Fig. 4 *pp*) at the outer extremity of which the seminal duct opens. This plug is so large in fact that the cloaca is almost obliterated (Fig. 7) being only a slight depression left between the edge of the plug and the lip of the pore, due to the rounding off at the end of the former. It generally extends out even with the edge of the proglottid and sometimes a trifle beyond. As mentioned above, the cirrus opens out about its center and when not protruded there is a slight invagination or pit at the end of the plug. The cirrus when thrust out, is wholly outside the cavity, judging from which, one is inclined to think that copulation between the organs of the same proglottids does not normally occur. The vagina, to be described later, opens back of the plug, between it and the posterior edge of the cloaca.

The various muscles layers of the wall are little if any changed in the region of the pore. No special sphincter muscles for the whole pore is present. The slight pit which forms the cloaca, is dipped into by the cuticula (Fig. 7 *c.u*) which then turns up the side of the plug and finally down into the cirrus opening. Thus the cirrus and Vas deferens are lined by a continuation of the body wall.

The pores are not regularly alternating on the proglottids but in the main, in a given number, they about balance (Fig. 1). They always lie back of the middle of the segment, this arrangement becoming more pronounced as the proglottids increase in length. They increase but slightly in size with the increasing age of the proglottid and in the long ripe segments, in which the central plug has about disappeared, they are more or less shrunk or collapsed internally, still however, possessing a distinct outer lip or ring.

In a few cases, in segments where the uterus is just beginning to branch, the pore is a trifle deeper than in most of the sexually mature ones, measuring about 0.09 mm. It is also deeper in transverse section than longitudinal (compare Figs. 6 and 7), thus showing that there is more of an indenture on the dorsal and ventral sides of the plug than on the anterior and posterior sides. The following measurements will give some idea of the relative size of the pore and plug in sexually mature proglottids. Dorso-ventrally the plug measures 0.2 to 0.4 mm in diameter, the pore, 0.26 to 0.60 mm. Longitudinally the plug measures 0.3 to 0.4 mm, the pore 0.5 to 0.6 mm in diameter.

Female Organs.

Vagina. The pore in addition to receiving the male duct is also the terminus for the female canal, or vagina, which opens directly behind the plug (Fig. 7 *v*). The vagina is seen as a long thread-like structure, more or less sinuous but showing little tendency toward the formation of complicated coils like those so characteristic of the Vas deferens (Fig. 3 *v*). It extends into the proglottid some distance parallel to the last mentioned organ, and then makes a quarter circle to the rear, where finally, after undergoing some modifications of structure, it terminates in the shell-gland. The terminal end which opens into the pore is also considerably modified, being much enlarged in diameter. At this point, it springs rather abruptly from its normal narrow state (about 24.5μ) to a breadth of 0.04 to 0.06 mm, and then gradually tapers to the outer opening. The narrowing of the canal again, which varies considerably in different proglottids is due probably to the state of contraction of the pore itself. The enlargement begins about 0.25 to 0.60 mm back from the outer opening and has scattered along its walls, a great number of free nuclei (Fig. 7 *f.n*) similar to those of the cirrus pouch. These are also present along the entire length of the vagina.

A short distance from the exterior, a well developed sphincter muscle (Fig. 7 *sp.m*) is found, which in section measures from 0.02 to 0.035 mm across the cut end. It extends as a band or ring, completely around the vagina and is present in all proglottids. It serves, probably, to hold the cirrus firmly during copulation. In the sexually mature proglottids, the lumen of the vagina is usually considerably narrower at the point where the sphincter surrounds it.

Since the presence of such a muscle in either of the other human

Taeniae, has never been mentioned, to my knowledge, I considered this structure at first, as characteristic only of *T. confusa*, but upon examining my specimens of *T. saginata* I found a prominent sphincter muscle present in relatively the same position (Fig. 8 *sp.m*). It differs from that of *T. confusa* in being broader and more band-like, and like the other muscles of *T. saginata* is coarser and more powerful. As in *T. confusa* the vagina is narrower in its immediate vicinity.

Such a muscle as the above, has been found in two of the other than human *Taeniae* but its presence in *T. saginata*, I think, has never before been recognized. In preparations from a very large specimen of a peculiar human *Taenia*, which I have in my possession, a vaginal sphincter muscle is very distinctly seen; but whether this tapeworm is merely a highly modified form of *T. saginata* or a different species, I am as yet unable to say.

The greater part of the vagina, the canal connecting the modified ends is, in appearance, much like that of *T. saginata* with the exception of the cilia, if, indeed, cilia are present in the new form. As a matter of course, on general principles, one expects to find the vagina of the *Taeniae* ciliated, but that such is the case in this form, I am by no means assured. Certain structures are present which at first sight appear to be cilia, but upon very close examination their interpretation becomes decidedly doubtful. They do not have the characteristic fringe-like appearance that cilia usually possess, and instead of pointing toward the receptaculum as do cilia in the ordinary forms these point outward toward to pore (Figs. 7—9 *v*). In fact, they have more the aspect of numerous tiny folds in the wall of the vagina than of cilia and I am rather inclined to think that they are such. Although I have carefully examined all my preparations, I find it impossible, without further evidence, to affirm positively either that the structures are, or are not, cilia.

Like the Vas deferens the vagina is lined by a continuation of the cuticle, which, however, is considerably thicker than in the former organ. The tube, as above indicated, measures about 24.5μ in diameter, the lumen about 19.5μ . More or less of a special case or sheath-like structure (Fig. 7) surrounds it, inside of which is a sort of connective tissue network or system of fibres very similar to those surrounding the cirrus, and likewise having free nuclei plentifully distributed throughout. As the proglottids grow older, the deposits of pigment, which are not very plentiful in the younger proglottids,

increase, rendering the vagina more and more prominent. It is plainly visible in the very terminal proglottids.

Receptaculum seminis. A short distance before the vagina enters the shell gland, there is a noticeable increase in the diameter and the walls are slightly modified in structure. This enlarged portion is the seminal receptacle (Fig. 9 *r.s*) and is for storing the spermatozoa which pass up through the vagina from the genital pore. In this species it is almost circular in frontal section (0.135 mm in diameter) and of a lenticular shape in transverse section (0.078 mm in diameter).

Before leaving this point, there is a peculiar structure connected with the receptaculum which should be mentioned. LEUCKART in his description of *T. saginata* (1886, p. 444) pictures a slightly modified structure just anterior to the receptaculum, but beyond mentioning the fact that the latter is rather peculiarly connected with the vagina anteriorly, gives no description or explanation of the same. In my own preparations of *T. saginata*, however, I find no such modification. The structure referred to in *T. confusa* lies immediately in front of the seminal receptacle (Fig. 9 *x*). Shortly before reaching the receptacle, the vagina becomes slightly enlarged and then abruptly narrowed or rather, the narrow part seems to be of almost entirely different structure, and projects forward into the slight swelling in the vagina just mentioned. The walls of the new structure are thicker and the lumen much narrower than those of the vagina proper. The interior is apparently of the same structure as that of the latter. The walls are surrounded by what appear to be great numbers of small sphincter muscles (Fig. 9 *sp.m*), which are very distinctly seen in the longitudinal sections. The free nuclei mentioned several times heretofore, are very numerous in this vicinity. This constricted part of the vagina continues back a distance of about 0.11 mm to the easily recognized receptaculum, which is always filled with spermatozoa in the sexually mature proglottids.

The continuation of the vagina, if we regard the seminal receptacle as an enlargement of it, is a wide thin walled canal, comparable in structure to the "Befruchtungs"-canal of LEUCKART (1886, p. 442) in *T. saginata*. This extends back to the shell gland (Fig. 10, *s.g*), an oval body located about midway between the lobes of the ovary. Before it reaches the shell gland, however, it receives a short canal (0.1 mm long) from the cross band connecting the two lobes of the ovary (Fig. 10 *z*).

Shell gland. The shell gland, as above mentioned, is an oval body measuring about 0.25 mm long by 0.2 mm wide, and is the common center for all the canals of this region. The peculiar radiate appearance it has in section is due to the granular cells which are packed together, side by side, with their narrow ends or ducts pointing in toward the center of the organ. Extending vertically through its middle is a narrow duct which slightly enlarges near the center (Fig. 10 s.g). This enlargement measures 0.02 mm wide by 0.068 mm long. The duct is a direct continuation of the above mentioned wide thin-walled modification of the vagina connecting the receptaculum and shell gland. From the anterior ventral side of the shell gland, after being joined by the duct from the vitellaria (Fig. 10 vl) which comes in from the posterior side, it bends directly upward, passes through the center of the gland and after reaching the dorsal edge, doubles back very slightly upon itself and extends forward as the canal which bears the eggs to the uterus (Fig. 10 y). Unlike the case in *T. saginata* or *T. solium*, this canal does not enter the posterior end of the uterus, but extends along above it for some distance, gradually declining until it finally enters the dorsal side of the same.

The ovary. This is a paired organ of about the same general structure as that of *T. saginata* or *T. solium*, but differing very much from either in form (Fig. 3 o). The wing-like expansions or lobes are greatly elongated, kidney-shaped and larger than the corresponding structures of the other Taeniae. They include between them the area containing the receptaculum seminis, the shell gland and the end of uterus. As stated, they are much longer than broad, the larger one, which lies always on the opposite side from the vagina measuring in general about 1.4 mm long by 0.56 mm broad. This makes it about two and one half times as long as broad. The one lying on the same side as the pore is generally about 0.1 mm shorter than its mate, measuring only about 1.3 mm in length.

The lobes are connected by a broad (0.2 mm) transverse band (Figs. 9 and 10 b) which springs from about their median inner edges and passes across the intermediate field just under the posterior edge of the receptaculum. This arrangement of the cross canal is the same as that of *T. saginata* or *T. solium* according to the statements of SOMMER (1874, p. 26) for the latter forms, but different from what is given for *T. saginata* in the translation of LEUCKART (1886, p. 444) where is said that the cross canal passes over instead of under the receptaculum. This statement attributed to LEUCKART is probably

simply a mistake in translation, inasmuch as in the German editions he speaks of the canal in question as passing under (ventral to) the vagina. At about the middle of the band, a small duct is given off as already described, which runs only a short distance till it connects with the modified parts of the vagina extending from the seminal receptacle to the shell gland (Fig. 10 *z*). It is very slightly coiled and generally enters the vagina somewhat from the side.

The vitellarium. The vitellarium or yolk gland (Figs. 3–10 *vt*) is a triangular, unpaired organ, extending out laterally about even with the edge of the ovarian lobes, and presenting no new or unusual modifications of structure. It shows a more or less scalloped edge posteriorly, but anteriorly wedges in between the ovarian lobes and tapers off toward the shell gland. Its duct finally enters the gland at the ventral posterior edge (Fig. 10) and immediately joins the vertical canal through the same. As for the contents of the vitellaria they may be easily recognised from those of the ovary, because of their much more finely granular nature.

The uterus. The connection of the uterus with the shell gland has been explained already, but as yet little has been said of the structure of the uterus itself. It has, however, an exceptional structure, which defeats beyond all doubts any attempt to classify its possessor as one of the common forms of *Taenia*.

In the proglottids ready for fertilization the uterus is a median unbranched tube ending blindly near the anterior end, and extending back posteriorly between the lobes of the ovary to the shell gland (Fig. 3 *u*). The very great difference in structure in the neighborhood of the shell gland, between it and *T. saginata* or *T. solium*, has already been pointed out. The latter have uteri which are very similar in the unbranched state. They extend back and end near the anterior edge of the lobes of the ovary, each connecting with the shell gland by means of a slender canal which opens into its posterior end. In the case of *T. confusa*, the canal (Fig. 10 *y*) opens into the dorsal side of the uterus, and the latter extends back until it lies directly against the shell gland (Fig. 10 *u*). This arrangement may be seen in the proglottids from the time that they become sexually mature until the disappearance of the shell gland. In its primitive unmodified form (Fig. 3 *u*) the uterus is about 0.15 mm in diameter.

As the uterus fills with eggs it begins to bud out thickset and stubby side-branches which usually persist in the ripe segments as heavy, arborescent members (Fig. 2). In a few of the terminal pro-

glottids from which a part of the eggs have escaped the branches often become thin near the point of attachment to the main stem.

The branching begins first at the anterior end of the uterus and gradually extends backward, the eggs seeming to pass down the tube and mass at the anterior end. As the branches increase in number and size, the proglottids lengthen and the generative organs, for the most part, gradually disappear. Finally, the uterus with its offshoots comes to occupy the entire field within the limits of the excretory canals (Fig. 2).

In the ripe proglottids, the uterus consists of a main stem with from 14 to 18 lateral branches which are generally very irregularly disposed throughout the parenchyma, rarely running out perpendicularly to the main stem, as is the common method in *T. saginata*. Usually they extend only a very short distance before they split up into two and sometime three branches which again often divide in a similar way. They seldom extend in a straight line but have a more or less pronounced sinuous outline. More resemblance to the proglottids of *T. solium* is shown, than to those of *T. saginata*, but the uterus extends forward to the anterior end of the proglottid, and the number of branches is greater than in *T. solium*. The ends of the branches are usually swollen into large, irregular, club-shaped masses, which border on the excretory canals. At the anterior end, there are usually from three to seven peculiar tassle- or vase-shaped branches, which extend forward to the very edge of the proglottid. They are so arranged that when two proglottids are separated, the end of the uterus is torn open and the eggs set free. According to LEUCKART (1886, p. 424), the eggs are set free at the anterior border of the proglottid in *T. saginata* also. At the posterior end as in *T. saginata* the uterus falls short of the edge of the proglottid by from 2 to 3 mm.

The branches at the anterior and posterior ends, especially the latter, are longer than the others and lie more obliquely to the long axis of the segment. The posterior ones are also usually more highly branched and fuller on the outer side, in consequence of which, they have the appearance of bending or drooping into a sort of plume-like shape. This is especially marked in the detached ripe proglottids. In these also, the central stem is sometimes very thin and the branches, as already mentioned, of very small diameter at their points of attachment. There seems to be no omission of branches on the side occupied by the pore, although the ones lying in its vic-

nity are ordinarily not so heavy as the corresponding ones on the opposite side.

Sexual development. The first definite appearance of the sexual organs occurs in the small anterior proglottids measuring 0.8 mm long by 0.6 mm wide.

The first indication seen is a transverse streak about the middle of the proglottid, extending from near the median longitudinal line to within a short distance of the edge, and bearing at the outer end a club-like swelling. The streak is the "Anlage" of the vagina and vas deferens, and the enlarged end will ultimately develop into the sexual pore. The development goes on very rapidly, for in proglottids a very short distance further back, the streak has grown to form a quarter circle, the inner end of which extends toward the posterior end of the proglottid. Soon, in proglottids measuring 1.2 mm long by 0.84 mm wide, a sort of a Y is formed with the short arm extending forward. In this stage the largest diameter of the developing organs is at a point near the edge where the future pore will develop. Here also, the first indications of the differentiation into the vagina and vas deferens are seen, the intermediate substance becoming gradually thinned out. In proglottids measuring 1.6 mm long by 1.9 mm wide, an almost complete separation of vas deferens and vagina has taken place. They still, however, remain in contact in the deeply staining, club-like portion which is the Anlage of the pore. In this stage the uterus has extended forward as far as it ever does before branching, but has not yet attained the width it reaches in the sexually mature proglottids. It bends somewhat out of its course to pass around the end of the vas deferens, and then back at a sharp angle resuming its former course until it finally connects posteriorly with the ending of the vagina, which shows two enlargements in about the region where the receptaculum and shell gland will appear. By this time the joined end of the vagina and vas deferens have reached the lateral edge of the proglottids.

In proglottids measuring 1.7 mm long by 1.8 mm wide the ovary first makes its appearance, as a granular bean-shaped area. The testes have also put in appearance and are very little if any older than the ovary. In these proglottids the pore has established its connection with the exterior and the cirrus pouch is formed. The vas deferens has somewhat the appearance of a thread within an outer tube or case. The sheath around the vagina is also discernible. At

this period, as in all the later, the uterus extends back entirely to the shell gland, and the dorsal and ventral sides of the proglottids can be readily distinguished.

As for the sexually mature and ripe proglottids, since they have been rather fully treated already, little more need be said about them in this connection. The branchings of the uterus begin as bud like projections from its sides and as these increase the sexual organs gradually disappear; the testes first, followed by the ovary and the vitellaria. As has been stated already, the vas deferens and the vagina, more especially the later, persist for a much longer time (Fig. 2 *v.d.*, *v*). The shell gland usually remains for a considerable time, leaving here as in *T. saginata*, upon its disappearance a vacant area free from branches.

Eggs. The eggs in the ripe proglottids are oval in form and are made up of several different parts (Fig. 11). First on the outside, is a thin transparent membrane, and next a layer of little rods standing side by side. Just inside the rods comes a thin layer or space, the exact nature of which was not determined. The elongated inner portion is of about the same general outline as the outer covering of the egg, and is of different appearance in different eggs. In some there is a sort of dark cap-like structure at one end, in others it is present at both ends, and in others yet, the dark area extends along the side and one end, or often both ends. Usually the entire center is dark. In no case can the pyriform apparatus, or tail-like processes spoken of by LEUCKART (1886, p. 449) in connecting with the eggs of *T. saginata* be found. It is not unreasonable to, suppose however, that since they are very delicate, they may have been present, but were destroyed through the poor preservation of the material. The eggs measure in general about $39\ \mu$ long by $30\ \mu$ wide.

The development of the same has not as yet been worked out. For comparison with eggs of *T. solium* and *T. saginata* see the table below.

It has been suggested that possibly this species is the same as that, from a North American Indian, which WEINLAND described in 1858. If, however, the descriptions of the two forms are compared, it will be found that they agree in scarcely any particular. The head, neck and whole anterior half of his specimen were wanting. The following summary is taken directly from WEINLAND's description of the form in his possession (1858, p. 44).

- 1) Joints very thin, nearly transparent, equally narrow, transverse diameter about 4 mm, longitudinal about 12 mm.
- 2) Genital openings very small and without external lips.
- 3) No pigment in either vagina or spermatic duct.
- 4) Uterus more regular than either *T. solium* or *T. medicanelata*, yet more resembling the latter.
- 5) Branches of uterus, about 30 in number start from the main stem, either at right angles or at angles of about 45 degrees.
- 6) Branches of uterus always quite parallel, and generally straight; but whenever bent, all makes the same angle.
- 7) Branches of uterus never arborescently divided, nor furcated at the ends, except the foremost and hindmost in each joint.
- 8) Eggs 0.033 mm long by 0.030 mm broad.

Comparing the above summary with the following which embraces corresponding anatomical points in the structure of *T. confusa*, but little similarity between the two forms is seen to exist.

- 1) Joints thin, not transparent, equally narrow, transverse diameter 3.5 to 5 mm, longitudinal 27 to 35 mm.
- 2) Genital openings not exceptionally small and with very distinct external lips.
- 3) Deposits of pigment, plentiful in both vagina and spermatic duct, the former being especially prominent in most of the ripe proglottids.
- 4) Uterus less regular than that of either *T. solium* or *T. medio-canellata*, yet more resembling the former.
- 5) Branches of the uterus from 14 to 18 in number, which start from the main stem very irregularly as regards angles.
- 6) Branches of uterus rarely parallel or straight, whenever bent, they exhibit no regularity in the shape of the angles.
- 7) Branches of uterus often arborescently divided, and often furcated at the ends throughout the entire proglottid.
- 8) Eggs 0.039 mm long by 0.030 mm wide.

The following table is a summary of the principle points of difference between *T. confusa* and the two common forms of *Taenia* found in the human alimentary canal. The measurements for *T. saginata* and *T. solium* are quoted for the most part from LEUCKART (1888):

	<i>T. saginata</i>	<i>T. solium</i>	<i>T. confusa</i>
Total length of the worm	4—8 m	2—3.5 m	5—8 m
Total no. of proglottids	1300	850	750—800
Size of terminal proglottid	12—19 mm long, 5—6.5 mm wide	10—12 mm long by 5 mm wide	27—35 mm long by 3.5—5 mm wide
Change of form in the terminal proglottid at anterior end	very considerably	slight	very slight
Greatest breadth of chain	12—14 mm	7—8 mm	8—10 mm
Length of proglottids exceeds breadth	only in last 100	in last half	in nearly the entire worm
Proglottids 35 cm behind the head measure	1.5—2.6 mm long, 5—10 mm wide	0.8 mm long, 1.3 mm wide	1—2.5 mm long, 0.8—3 mm wide
Sexually mature proglottids measure	4—6 mm long, 8—10 mm wide	2.5—3 mm long 4.5—5 mm wide	4—4.5 mm long, 3.5—4.5 mm wide
Sexually mature proglottids show	disproportionate increase in breadth	o.	an increase in length with slight increase in breadth
Diameter of head	1.5—2 mm	1 mm	unusually small
Necks	unsegmented	unsegmented	segmented
Thickness of cuticle	* 0.0105 mm	—	0.0045 mm
General musculature	powerful	delicate	delicate
Longitudinal muscle fibres	not continuous between proglottids	do.	continue from one proglottid to the next
Calcareous bodies	plentiful, measure up to 0.018 mm	sparse, measure up to 0.12 mm	sparse, measure up to 0.011 mm
Longitudinal nerve strands	dorsal to genital ducts	do.	divide, passing both dorsal and ventral to genital ducts
Seminal vesicle	absent	absent	present
Diameter of testes	0.15 mm	0.12—0.15 mm	0.089—0.096 mm
Diameter of vas deferens	0.025 mm (0.040)	†	0.045 mm
Length of cirrus pouch	0.4—0.5 mm	†	0.31 mm
Depth of generative cloaca	0.22 mm	†	0.05—0.08 mm
Width of pore	1 mm	†	0.45—0.6 mm
Receptaculum seminis	0.1 mm long by 0.07 mm thick	†	0.135 mm long by 0.078 mm thick
Vagina	ciliated	† ciliated	doubtful, at least modified
Posterior part of vagina	little if any modified anterior to receptaculum	—	greatly modified anterior to receptaculum and provided with sphincter muscles
Ovary	lobes round	part of smaller one cut off by vagina. Lobes transversely oval	lobes kidney shaped
Connection of uterus with shell gland	thin duct opens into end of uterus	duct longer and connects same as in <i>T. saginata</i>	duct opens into the side of the uterus, posterior end of uterus lies against shell gland

	<i>T. saginata</i>	<i>T. solium</i>	<i>T. confusa</i>
Uterus in terminal proglottids	20—30 branches	7—10 branches	14—18 branches
Branches of uterus	branch at right angles and are slender	branch at right angles and are thick	often do not branch at right angles and are generally thick forked and crooked
Branches of uterus absent on pore side	usually 2	—	usually the same number on both sides
Size of eggs	slightly oval, 0.03 mm in diameter	almost round, 0.03 mm in diameter	oval, 0.039 mm long by 0.03 mm wide
Pyriform process	present	present in young proglottids	absent apparently
Eggs	escape at anterior border of proglottids	do not escape at anterior border	escape at anterior border
Color of eggs	rust-brown	usually brown	whitish or yellowish
Sexual development seen first in proglottids	0.3 mm long by 2.5 mm wide	1.5 mm long by 2.2 mm wide	0.8 mm long by 0.6 mm wide
On the first Anlage the club-like end of the newly forming vagina and vas deferens lies	inward, toward uterus	inward	outward

* According to my own measurements.

† In speaking of the reproductive organs of *T. solium* LEUCKART (1886, p. 526) says that they are smaller in dimensions than those of *T. saginata*.

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Explanation of the Plate.

<i>b</i>	band connecting two lobes of the ovary	<i>t</i>	testes
<i>c</i>	cirrus	<i>t.e.c</i>	transverse excretory canal
<i>c.p</i>	cirrus pouch	<i>t.m</i>	transverse muscle fibres
<i>cu</i>	cuticula	<i>u</i>	uterus
<i>f.n</i>	connective tissue nuclei	<i>v</i>	vagina
<i>l.e.c</i>	longitudinal excretory canal	<i>v.d</i>	vas deferens
<i>l.n.s</i>	longitudinal nerve strand	<i>v.s</i>	vesicula seminalis
<i>l.m</i>	longitudinal muscle fibres	<i>vt</i>	vitellaria
<i>o</i>	ovary	<i>x</i>	thick walled tube connecting the vagina with the receptaculum
<i>p</i>	pore	<i>y</i>	canal through which the eggs pass from the shell gland to the uterus
<i>p.p</i>	pore plug	<i>z</i>	canal which carries the ovarian eggs toward the shell gland
<i>r.m.c</i>	retractor muscle of cirrus		
<i>r.s</i>	receptaculum seminis		
<i>s.g</i>	shell gland		
<i>s.m</i>	sagittal muscle fibres		
<i>sp.m</i>	sphincter muscle		

Plate 28.

Fig. 1. *Taenia confusa* WARD (nat. size). *a* Anterior end a short distance back of head, *c* sexually mature proglottids, *f* terminal proglottids.

Fig. 2. Ripe proglottid ($\times 6$).

Fig. 3. Sexually mature proglottids ($\times 20$) showing the reproductive organs.

Fig. 4. Transverse section of sexually mature proglottid ($\times 40$).

Fig. 5. Sagittal section through the connecting isthmus of two proglottids ($\times 50$).

Fig. 6. Transverse section through the pore region of a sexually mature proglottid ($\times 50$).

Fig. 7. Frontal section through the pore region of a sexually mature proglottid ($\times 160$).

Fig. 8. Frontal section through the pore region of *T. saginata* ($\times 160$).

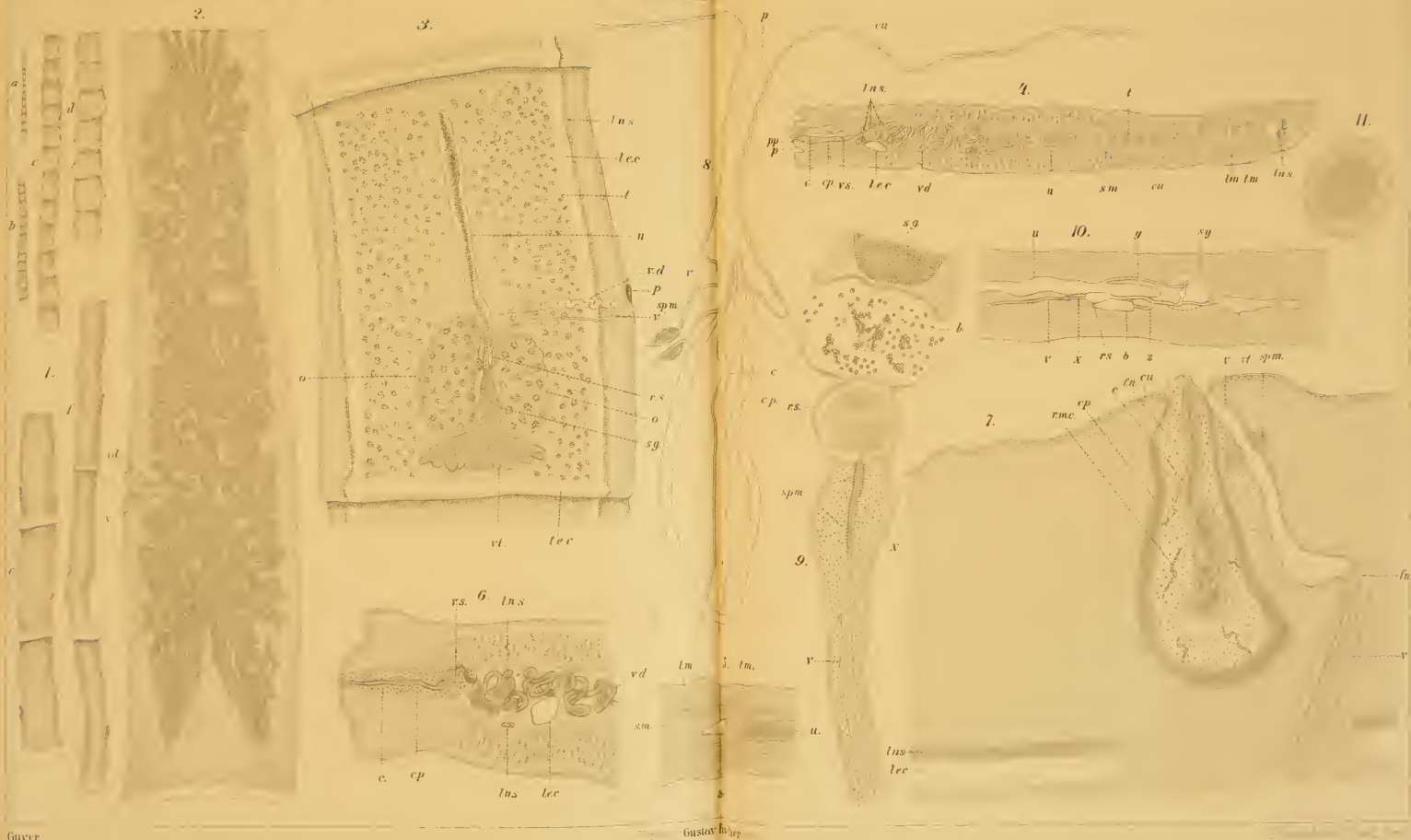
Fig. 9. Frontal section showing posterior modifications of the vagina ($\times 160$).

Fig. 10. A diagram built up by means of the camera lucida from consecutive sagittal sections showing the relative size and position of the female sexual organs ($\times 50$).

Fig. 11. Egg from ripe proglottid ($\times 660$).

Errata.

- p. 470, l. 11, after "it", add comma; after "many" add "respects".
 " " l. 3 from bottom of text, after "wide" add comma.
 " 471, l. 4, after "other" add comma; l. 5 after "proglottids" add comma.
 " " l. 9—10 omit "being arranged".
 " 472, l. 21 instead of "later" read "latter".
 " 473, l. 15 after "with" insert "that".
 " " l. 25 after "correspondingly" add comma; after " 4.5μ " add semicolon.
 " " l. 6 from bottom after "fibres" add comma.
 " " bottom line should read "the center. One end" etc.
 " 474, l. 9 from bottom after "moreover" add comma.
 " " l. 5 " " " "saginata" remove comma.
 " 475, l. 9 omit "the" at the end of line.
 " " l. 8 from bottom after "part" add comma.
 " 476, l. 9 for "larger" read "large".
 " " l. 15 for "cross" read "gross".
 " " l. 24 at end of line read semicolon instead of comma.
 " 477, l. 3 after "forms" insert comma.
 " " l. 17 for "Fig." read "Figs."
 " 478 middle, do not make a paragraph between "duct" and "When".
 " " l. 12 from bottom for "c. f." read "c. p."
 " " l. 6—7 from bottom instead of text read "which consists principally of connective tissue nuclei (Fig. 7 *f. n.*)".
 " 479, l. 26 for "muscles" read "muscle".
 " 480, l. 11 from bottom for "free nuclei" read "connective tissue nuclei".
 " 482, l. 13 " " " " " " "
 " 483 l. 12 for ("Fig. 10 *v. l.*") read "(Fig. 10 *v. t.*)".
 " " l. 2 from bottom after "where" insert "it."



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