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SYNCÆLIDIUM PELLUCIDUM, A NEW MARINE TRICLAD.

WILLIAM MORTON WHEELER.

THE Triclad which I propose to describe in the following pages was found in the gill-books of *Limulus polyphemus*. My material was collected and in part studied at the Marine Biological Laboratory at Wood's Holl, Mass., during August, 1892. I gladly seize this opportunity of thanking the director, Professor C. O. Whitman, for the many privileges which I have enjoyed at the laboratory, and for his continued interest in my work. I am also indebted to Professor J. S. Kingsley, who has kindly helped me to some of the literature on our native Dendrocœla.

THE TRICLADS PARASITIC ON LIMULUS.

Girard ('50) first gave the following brief description of the common Triclad parasite of *Limulus*:—

“ *Vortex candida*, Girard. Body elongated, tapering away towards the posterior extremity;¹ head rounded; sides entire; almost transparent, of a pale rose color. From Chelsea beach,

¹ Girard evidently mistakes the head for the tail end, a blunder into which Ryder has also fallen.

found attached to the Horse-shoe Crab. Length, a quarter of an inch."

The generic position of this species was regarded as doubtful, "the genus *Vortex* not being as yet well circumscribed."

A year later Leidy ('51) gave the following description of a planarian from *Limulus*:—

"PLANARIA, Müller.

Subgenus nov. Bdeloura.¹

Characters same as Planaria, without tentaculæ, and the posterior extremity of the body separated by a constriction serving as a disc of attachment.

5. BDELLOURA PARASITICA, *n. sp.*

Body milk-white, with a faint yellowish intestine showing through the translucent integument, smooth, thin, lanceolate, or spatulate; anteriorly narrowed, obtuse; lateral margins, thin, undulating; constricted portion posteriorly truncated, nearly as broad as the middle of the body. Eyes two, reniform. Œsophagus simple, cylindrical, campanulate when protruded.

Length from 3 to 10 lines; breadth 2-5 to 2¾ lines. The longest may contract to 6 lines by 3½ lines.

Habitation.—Parasitic upon the King Crab, *Polyphemus occidentalis*, Lam."

The year following, Girard ('52), while remarking on *Fovia*, says: "*Vortex candida*, described at the same time, has been described since by Dr. Leidy under the name of *Bdeloura parasitica*. The genus *Bdeloura* I adopt, but the species must retain its prior name and be called *B. candida*, Girard."

Notwithstanding this identification of *B. parasitica* with *Vortex candida*, Stimpson in his *Prodromus* ('58) retained Leidy's specific name.

These early descriptions were unknown to v. Graff, who in 1879 again described a Triclad from *Limulus* as *Planaria*

¹ βδέλλα, a leech; ουρα, tail; because the animal adheres by the tail like a leech.

limuli. v. Graff's paper is a brief but valuable anatomical contribution, to which I shall have occasion to refer again.

It is my opinion that there are at least three distinct species of Triclad to be found on *Limulus*. All the descriptions to which I have alluded are, I believe, referable to the commonest and largest of these species, and for it I shall retain the name *Bdelloura candida*, following the example of Verrill ('73, p. 634). Another species, which I propose to call *Bdelloura propinqua*, is about 8 mm. long, being about half as large as the full-grown *B. candida*. A third species, still smaller (only 2-3 mm. long and .3-.4 mm. broad when fully expanded), differs considerably from the species of *Bdelloura*, so that I have concluded to erect a new genus for its accommodation—the genus *Synœlidium*.¹ When not otherwise stated, the description in the following paper applies to this last species, to which I give the specific name *pellucidum*.

The existence of more than one species of planarian on *Limulus* was first suspected by Ryder ('82^a). He inferred that there might be three species, from three well-marked types of egg-capsules which he found on the gills. That he saw one of the species of *Bdelloura* (probably a half-grown *candida*) is shown by his Fig. 8. His Fig. 10 is undoubtedly taken from a specimen of *Synœlidium pellucidum*, as is shown by the fusion of the posterior gut-rami. In concluding his article, Ryder says: "I do not propose to name the species, as these supposed distinct life-histories may, after all our endeavors to separate them, be only phases of the same thing."

S. pellucidum was also seen by Gissler ('82), as is evident from his Fig. 1. He regarded it as the young of *B. candida*, an error into which he need not have fallen, had he carefully examined the reproductive organs. He seems, however, to have had no clear conception of these organs in Triclads, for he designates the two uteri as sexual glands in his Fig. 1, and in the text remarks: "From analogy I infer the latter to be the male organs, the female glands having escaped my obser-

¹ From *συν*, together, and *κοιλιδιον*, a little intestine, in allusion to the confluence of the posterior gut-rami.

vation." That *Synœlidium* cannot be the young of *B. candida* is at once apparent from the fact that the former species, when fully grown and sexually mature, is considerably smaller than the latter species at the time of hatching!

The appearance of *S. pellucidum*, when resting fully extended on a dark background, is reproduced in Fig. 2 under a low magnification. In the middle the sides of the body are parallel, but towards either end they converge uniformly. The intestine shows through the pellucid body-wall as a flesh-colored mass. Anteriorly the brain is easily seen as a pair of transparent swellings, which form haloes around the two black eyes. Other structures which may be seen with a low power are the pharynx, penis, and the two rosette-like uteri.

Like the species of *Bdelloura*, *S. pellucidum* is very active in its movements, creeping with a steady, rapid motion over smooth surfaces, or swimming at the surface of the water after the manner of the fresh-water Triclad and Pulmonate Mollusca. Rapid movement appears to be very common in the marine Triclads; Lang ('81^b) mentions it in his description of *Gunda segmentata*, and I have observed it in a pretty little *Fovia* which occurs sparingly under the stones between tides at Wood's Holl, but which my friend, Dr. E. O. Jordan, collected for me in great numbers on Monhegan Island, Me.

Synœlidium occurs only between the leaves of the gill-books of the *Limulus*, never migrating to the bases of the cephalothoracic legs like the young and sexually immature *Bdelloura*.

THE ANATOMY OF SYNCÆLIDIUM.

1. *Integument.*

The rather dense cilia covering the whole body are somewhat longer on the ventral than on the dorsal surface (Fig. 10); measuring on the former $.4\ \mu$, on the latter $.2\ \mu$ — $.3\ \mu$. They are borne by a compact membrane (*z*) which stains quite deeply in the various carmines. In cross-section it appears to be homogeneous and somewhat thicker on the ventral ($.3\ \mu$) than on the dorsal surface ($.25\ \mu$). No nuclei could be detected in this membrane, but when the planarian was dried

over a flame—either in the fresh state or after long preservation in alcohol—a beautiful net-work appeared on its surface (Fig. 6). The net itself is dark-colored, but the polygonal spaces enclosed by its meshes are much paler. In sections, when the knife skims off the surface of the body, the same structure is apparent, but with the tones of color reversed: the net being colorless while the spaces take the stain. The same structure is also visible in sections of large specimens of *B. candida*. The ciliated membrane so closely resembles the pharyngeal epithelium of fresh-water Tricladæ after treatment with silver nitrate (see the Figs. of Woodworth, '91, and Chichkoff, '92), that I take the net-work to be an indication of cellular structure. Each polygonal area probably represents a cell. The lack of any traces of nuclei in these areas puzzled me at first, but I believe that they are to be found just beneath the longitudinal muscles (Fig. 10 *ly*). Occasional processes from these hypodermal cells may be seen extending out between the muscle-strands and joining the plaque-like polygonal pieces of the ciliated membrane. Sometimes the nuclei lie between the muscle-strands or even nearer the surface. From these conditions I conclude that the hypodermal cells of *Syncolidium* are mushroom-shaped, the cell-body being represented by a polygonal ciliated umbrellar portion with a stem in which the nucleus is lodged and which extends in some distance below the surface and between the muscle-strands. The portion of the hypodermal cells which I have called the ciliated membrane—and which, if my interpretation be correct, is really no membrane at all—is liable to separate from the underlying muscle layer in specimens killed in hot sea water (Fig. 10).

2. Musculature.

Immediately beneath the ciliated portion of the hypodermis—providing I have not overlooked some structure corresponding to the basilar membrane of the fresh-water Tricladæ—lies a very delicate layer of transverse muscles, which may be detected in thin tangential sections. The smooth fibres, of which this layer is composed, vary somewhat in

width. Between them lie minute and much elongated nuclei, which, I believe, belong to them, notwithstanding the almost unanimous assertion of writers that the adult muscles of the Dendrocoela are enucleate. As I have made no macerations of these muscles, I can make no definite statements in regard to their method of termination and attachment. They do not pursue a very long course as discrete fibres, but appear to anastomose at intervals, thus forming a net with very much elongated meshes.

Beneath the delicate transverse muscles lies a very thick layer of longitudinal muscles (Fig. 10 *ml*), which consist of distinct and quite regular bundles. These extend from one end of the body to the other, without or with very rare anastomoses. They appear as clear strands in stained preparations. On an average they are about $1.3\ \mu$ in breadth, with a dorso-ventral diameter of $3\ \mu$. Measurements, of course, vary greatly according to the state of contraction of the fibres. In many of my preparations a peculiar striated or lamellated appearance may be observed in the muscular substance (Fig. 10). It seems to be due to an alternation of dense and stainable with an unstainable and more liquid plasma. The lamellæ are usually arranged parallel to the surface of the body or at a slight angle to it. I fail to find any nuclei in the longitudinal muscles; the nuclei which lie between the strands, often in very regular rows, and immediately beneath them, belong, as I have said, to the hypodermis.

In *B. candida* the longitudinal muscles are very poorly developed as compared with those of *S. pellucidum*. The dorsoventral muscles, so well developed in the former species, are so difficult to resolve in the latter that I am not sure that I have seen them. Owing to its small size, *Synœlidium* is not a very favorable object for the study of the various muscle-layers of the pharynx and penis.

3. *Parenchyma.*

So much space in the body of *Synœlidium* is taken up by the longitudinal muscles and viscera, that the parenchyma—abundant in many other Triclad— is here very much reduced

and difficult to analyze. A complete lack of pigment adds to the difficulty of locating the cells peculiar to this interesting tissue.¹

On the other hand the glands are very easily studied. In specimens stained with Weigert's picrocarmine and mounted in glycerine they take on a deep yellow or orange color, in Czokor's alum cochineal they are colored a dull brick red. In both cases they contrast strongly with the surrounding tissue.

At first sight the glands appear to have a very diffuse distribution, but closer study enables one to separate them into the following groups (Fig. 7) :

1. There is a narrow zone of slime-glands completely surrounding the body just within the lower ventral edge. This zone, which appears to be common to many other Triclad's (*vide* Lang, '81b, Iijima, '84, Woodworth, '91), is broad in the head region, distinctly narrower in the tail, and very narrow along either side of the middle of the body.

2. A large group of slime-glands in the head region. These have an anterior trend and open on the dorsal surface. In the region of the eyes they separate into three bundles, one of which passes between the eyes and over the brain, while the two others pass laterally to the eyes. The three bundles again intermingle in the præocular region.

3. A somewhat smaller group of slime-glands at the opposite end of the body with a posterior trend and openings on the dorsal surface.

4. A cluster of glands corresponding to the salivary glands of Iijima ('84), and Chichkoff ('92). They are found in the parenchyma just in front and on either side of the pharynx, to which they converge, and into which they open near its tip.

5. A cluster of glands surrounding the vaginal opening in the genital atrium (Fig. 7 and Fig. 4gg1).

So far as their reaction to the stains is concerned, the glands of these five groups are identical in *Syncælidium*. In *B. candida*, however, the salivary glands have a specific reaction: they take on a very intense blue stain with alum

¹ In this lack of pigment *Syncælidium* resembles the fresh water *Dendrocælum lacteum*.

cochineal, while the glands of the other categories stain dull brick red like their homologues in *Synœlidium*. So deep is the stain that full-grown specimens of *B. candida* mounted *in toto* in clove-oil or balsam show the salivary glands as a mass of nodulated fibres radiating from the pharynx into the body. v. Graff ('79) supposed that the lesions in the gill-lamellæ of *Limulus* were produced by some chitin-solvent in the secretion of the slime-glands of *Bdelloura*. May not the differential stain of the salivary glands in this form point to the pharynx as the organ which emits this chitin-solvent?

v. Graff describes in *Bdelloura* two acinose glands, opening one on either side into the pharynx. I fail to find these unless they be the "salivary glands." In that case the word acinose ("traubenförmig") is certainly ill-chosen. Moreover, these glands are not separable into two clusters in my specimens.

In regard to the slime-ducts and their openings in Triclads, I am unable to share the view recently advanced by Chickoff ('92). According to this author (p. 485) there are no determinate ducts or orifices; in order to reach the surface of the body the mucus makes a way for itself through the parenchyma and hypodermis. "L'excrétion," he says, "se fait sur différents points, suivant les besoins; selon que l'excitation se produit sur la face dorsale ou ventrale, la substance se dirige vers l'une ou vers l'autre, pour être expulsée. Ce que Iijima désigne dans ses figures sous le terme de 'Ausmündungsstelle der Schleimdrüsen' n'est rien d'autre que des traînées de mucosité sur le point de s'échapper du dehors. Leur présence, observée presque toujours sur les coupes, est due uniquement aux conditions dans lesquelles l'animal a été fixé." And again at p. 486-487 he adds: "Les 'Ausmündungsstellen' disparaissent complètement, si l'on fixe l'animal en évitant la présence de la substance muqueuse dans le parenchyme, autrement dit, si on lui donne le temps d'expulser tout ce que ses glandes ont sécrété, du moment où la spatule l'a pris."

Granting that all preceding observers have mistaken the products of secretion for portions of the glands, does it follow that the slime-glands have no determinate ducts and openings? Not in the least. Such delicate structures as these ducts

must be, would, of course, be very difficult to resolve in specimens killed just after the momentary supply of mucus had been exhausted. In *Synœlidium* it is no difficult task to trace the irregular slime-ducts, or at any rate the "traînées de mucosité," to the spaces between the polygonal areas of the ciliated membrane. I believe the little widenings occurring at intervals in these spaces are the openings of the ducts. I cannot, therefore, agree with Chichkoff, and must hold to the views of Lang, Iijima and Woodworth, though I am not prepared to agree with the last mentioned observer in homologizing the slime-glands with the "Stäbchenstrassen" of the Rhabdocœles.

4. Digestive Tract.

The pharynx does not differ in its form or function from that of other Triclad's so far as I can observe. It is a thick-walled muscular tube (Fig. 10 *ph*) contained in a special chamber and opening into the trifid gut.

The gut, or intestine, deviates somewhat from the Triclad type (Figs. 3 and 4 *coe*). The unpaired anteriorly directed ramus does not extend up to the brain, much less beyond it as in *Gunda* and *Phagocata*. Its lateral diverticula are few in number (five to seven on a side) compared with such forms as *Dendrocœlum lacteum* or even *Bdelloura candida*. The diverticula show little tendency to subdivide, except at their tips, where they are sometimes bi- or even trifurcate. The two posterior gut-rami pass back, one on either side of the pharyngeal chamber, and give off a few stunted diverticula, which have even a less tendency to subdivide than the diverticula of the anterior ramus. Behind the genital atrium the two rami converge and fuse. From their point of union an unpaired stem with a few diverticula on either side extends posteriorly a short distance. The diverticula usually alternate so that the stem has a zigzag appearance.

This curious fusion of the posterior rami is constant in all the specimens of *Synœlidium* which I have examined (about 75 in number) with two exceptions. These were just hatched young (.5-.6 mm. long). One of these (Fig. 1) shows the

rami separate, that of the right side being considerably longer than that of the left. I conjecture that in the fusion, which must take place very soon after hatching, the tip of the shorter ramus unites with its fellow in such a way that the whole tip of the primitively longer ramus is left as the unpaired stem of the adult.

The fused condition of the posterior rami of *Synœlidium* was described and figured by Ryder ('82^a, Fig. 10). v. Graff says of *B. candida*: "Die beiden hinteren Darmschenkel sind in der Jugend getrennt, bei erwachsenen Thieren aber (immer?) durch eine Queranastomose verbunden." This condition I have also noticed in three adult specimens of *B. candida*, but the fusion is of a very different nature from that obtaining in *Synœlidium*. In the former species the posterior rami are of equal length and extend into the tail. In the cases which I have examined, the fusion occurs between two mesial diverticula, thus forming a connection between the rami, like the horizontal bar which joins the two upright pieces in the letter H. This vinculum does not occur in the young or half-grown specimens of *B. candida*. In *B. propinqua* I have seen no trace of it.

Only one other Triclad is known to me which exhibits a union of the posterior rami — a species of *Dendrocœlum* (*D. nausicæ*) from Corfu and Cephalonia, long since described by Oscar Schmidt ('61). His Fig. 1, Pl. II, shows that the union is brought about by a confluence of a pair of mesial diverticula, and not by a fusion of the rami themselves. The species is interesting as presenting a condition intermediate between *Synœlidium* and *Bdelloura*, for one of the posterior rami is distinctly shorter than the other.¹

Histologically, the gut of *Synœlidium* does not differ from that of other Triclads as described by Lang, Iijima, and Chichkoff.

¹ In Boas' Text-book of Zoology ('90, p. 150), there is a figure of *Dendrocœlum lacteum* attributed to Oscar Schmidt, and showing several anastomoses between the posterior gut-rami. In N. American specimens which I regard as belonging to this species I can detect no such conditions, the two posterior rami being quite separate.

5. *Excretory System.*

In hardened specimens and in sections I have looked for the water-vascular system in vain, but in the living animal more or less extensive portions of it were readily detected when just the right amount of compression was applied. It consists of a rather stout and somewhat zigzag main trunk on either side of the body (Fig. 4 *tex*), running just lateral to or immediately over the tips of the gut-diverticula. The trunks arise near the anterior end of the body and fade away in the caudal region. Into the main trunks open at very irregular intervals, and often by twos and threes, jagged and ramified branches. No flame-cells were seen in the main trunks, but at intervals in slight dilatations of the larger branches (Fig. 11 *wf*) the play of the flagella could be watched for minutes at a time. The movements of the flagella are very rapid, and resemble an endless chain moving behind a slit-shaped opening in a direction parallel to the long axis of the slit. I have not seen the funnels figured by Lang and Chichkoff. The two main trunks are connected with each other at the posterior end of the body by means of anastomosing smaller branches. A similar connection at the anterior end could not be made out. I do not lay much stress on this negative observation, since Iijima figures an anterior connection between the main trunks in the young *Dendrocælum lacteum* (Pl. XX, Fig. 2), although he seems not to have found a posterior connection. Chichkoff also gives an excellent figure of the anterior anatomoses in the same species (Pl. VIII, Fig. 38).

The pharyngeal excretory system so beautifully figured by Chichkoff (Pl. VIII, Fig. 41) was not seen in *Syncælidium*. Nor have I seen anything which might be interpreted as an opening of the water vascular system to the exterior, either on the dorsal surface (dorsal pores of Iijima) or in the pharynx, where the occurrence of an opening is suspected by Chichkoff.

6. Nervous System.

The great transparency of *Synœlidium* makes it a very favorable object for the study of the nervous system. The brain and main nerve-trunks may be readily seen in the living animal, but this method is insufficient for a study of details. It is, however, only necessary to stain with alum cochineal, extract as much of the stain as possible with water, dehydrate and mount directly from absolute alcohol in gum sandarac to obtain a diagrammatically clear picture of all but the very finest details of the nervous system.¹ The nerves stand out as white lines on a darker background. Fig. 3 is a camera-drawing from such a preparation, the color of the nervous and non-nervous tissue being reversed for the sake of greater clearness.

The two longitudinal trunks (Fig. 3 *mv*) gradually widen anteriorly and unite to form the brain (*br*) which, like the brain of *Gunda* (Lang, '81^a) and other Triclad, may be divided into an anterior and superior, or sensory, and a posterior and inferior, or motor portion. From the former portion arise, on either side of the median line, three sensory (?) nerve trunks, which run forward and outward. The two inner trunks (*an*¹, *an*²) break up into a plexus before they reach the marginal nerve (*mnv*) which runs around the entire periphery of the body. The third nerve on either side remains undivided. The marginal nerve is very poorly developed between the tips of the mesial branches arising from the first sensory nerve on either side. Behind the brain each longitudinal nerve is connected with the marginal nerve of its own side by means of a very regular series of lateral nerves (*lv*). I am not sure that the number of these lateral nerves is always constant; in the specimen from which the figure was taken there were twenty-one, exclusive of the third and undivided sensory (?) trunk. Twenty of the lateral nerves on either side are connected by transverse nerves (*tnv*), which bridge the space between the longitudinal trunks. Their points of insertion in the longi-

¹ Sandarac is preferable to balsam on account of its lower refractive index.

tudinal trunks correspond exactly to the points of exit for the lateral nerves. At the posterior end of the body, where the longitudinal nerves unite, a small plexus of somewhat variable character connects their fused ends with the marginal nerve.

This I take to be the typical arrangement of the main nerve-trunks. In a few cases, however, I observed a marked deviation from this schema; some of the transverse nerves in the retro-pharyngeal region had broken up into a rude plexus, much like the plexus which occurs in fresh-water Triclad throughout the whole area between the longitudinal cords.

The marginal nerve has a clearly defined outline along its inner border, but along the outer edge it is quite irregular, and breaks up into an indistinct plexus of smaller fibres not easily resolved in *Synœlidium*. In specimens of *B. candida*, which had been hardened in a much flattened condition, I found no difficulty in tracing this plexus for some distance externally to the marginal nerve as a pretty net-work of fibres with rather uniform meshes. I have no means of telling how extensive this plexus may be. A long series of experiments with methylene blue, undertaken for the purpose of establishing this point, failed completely. I am, however, inclined to believe with Woodworth, that the plexus, of which the marginal nerve is only a condensation, extends through the longitudinal muscles, especially in *Synœlidium*, where this system is so powerfully developed.

In young specimens, a ring-nerve may be seen in the walls of the œsophagus (Fig. 3, *phr*) connected with two lateral pharyngeal nerves (*phl*). The innervation of the pharynx thus resembles that of *Gunda* as described by Lang ('81^a, '81^b). I have been unable to make out a connection between the lateral pharyngeal nerves and the longitudinal trunks, but I doubt not that such a connection exists.

On the histology of the nervous system I have little to add to the accounts of other writers (Iijima, Lang, and Chichkoff). In *B. candida*, where the histological elements are more robust, I have found spindle-shaped ganglion cells in the marginal nerve similar to the ganglion cells which occur in the longitudinal nerves of the same and other Triclad. These cells

were not seen in the marginal nerve of *Syncælidium*. In regard to the brain, I must dissent from Woodworth, who regards the "Substanzinseln" as consisting of connective tissue, and the mass of closely-packed cells with large nuclei surrounding the fibrous portion of the brain as mesenchymatous. In *Syncælidium* it is possible to entertain some doubt in regard to the exact nature of these cells, because of their small size; but in *B. candida*, both the "Substanzinseln" and the enveloping cells are undoubtedly ganglionic. It is even possible in this form to trace the single process of each ganglion cell into the felted mass of brain-fibres.

In *B. propinqua*, the brain with its ganglionic covering is separated from the surrounding tissues by a layer of peculiar fibrous tissue. In specimens mounted *in toto*, this layer appears as a pale halo surrounding the brain, and considerably increasing its apparent size.

The eyes of *Bdelloura* and *Syncælidium*, always two in number, consist of oval refractive bodies set in pigment-cups, the latter being confined to the inner and lower surfaces of the bodies. The eyes lie, one on either "Substanzinsel," and appear to be innervated by very short fibres from this region of the brain.

7. Male Reproductive Organs.

The testicular follicles (Fig. 4 *ts*) are a series of oval, or, very rarely, lobed bodies which lie on either side of the body between the successive gut diverticula. They extend from the second or fourth diverticulum of the anterior ramus to the second or third diverticulum of the unpaired stem. They vary considerably in number; in twenty specimens in which they were counted, there were 8-20 on either side of the body, the average number being 14. In the same individual the number on both sides is rarely equal; one side usually exceeds the other by from one to four follicles.

In *B. candida* the testicular sacs are much more numerous (60-100 on either side), and each sac is relatively very much smaller. Moreover, they lie outside the tips of the gut diverticula rather than between them. In *B. propinqua* the testicular

sacs are of about the same relative size as in *B. candida*, but nearly twice as numerous; in one specimen I counted 170 on one side of the body and this is probably below rather than above the average number for this species. Here, too, the sacs extend in between the gut diverticula as compact rows, especially in the anterior ramus.

In sections of *Syncælidium* the wall of each follicle consists of a single layer of cuboidal cells with large, round nuclei (Fig. 10 *tsf*). Towards the lower inner edge of the sac the cells flatten out, and are continued into a thin string-like duct, which I have succeeded in tracing for some distance towards the vasa deferentia. I have no doubt that Woodworth and Chichkoff are correct in regarding these ducts as preformed and determinate paths by which the spermatozoa reach the vasa deferentia.

The testicular follicles are normally packed full of spermatozoa in various stages of maturation. With alum cochineal the fully developed male elements take an intense indigo blue tint, which contrasts strongly with the purple color of the follicular cells and younger spermatozoa. This intense blue is very probably an expression of their powerfully cyanophilous character, and is of interest in connection with the recent researches of Auerbach ('91a, '91b) and Watasé ('92).

The vasa deferentia (Fig. 4 and Fig. 10 *vd*) lie on either side of the pharyngeal chamber, and extend from the region of the fourth or fifth diverticulum of the anterior gut-ramus to the keg-shaped penis. In mature specimens they are always distended with spermatozoa and sharply marked off from the surrounding tissues. Their anterior ends are thread-like, but posteriorly they widen out considerably and finally take a short and abrupt turn headward, only to turn back again and run as very delicate tubules into the penis. These delicate ejaculatory ducts widen towards their tips and open by discrete ostia very near the orifice of the penis. There is, therefore, no unpaired ejaculatory duct in *Syncælidium* as in many other Triclad.

The penis lies in the genital atrium (Fig. 3 *gat*), which is provided with a small opening on the ventral surface of the body.

8. Female Reproductive Organs.

The ovaries are a pair of round translucent bodies, one on either side of the anterior gut-ramus, between its first and second, or second and third diverticula (Fig. 4 *ov*). They appear to be simple sacs consisting of small, flattened cells enveloping the maturing ova. I can detect nothing which may be regarded as a parovarium in *Synœlidium*.

The oviducts (Fig. 4 *ovd*) leave the posterior outer surfaces of the ovaries as thin tubes. At first they run a little within and then along the dorsal surface of the longitudinal nerve trunks (Fig. 10 *ovd*) till they reach a point in front of the confluence of the posterior gut-rami. Here they converge and unite in the median line to form a very short vagina, which opens on the posterior wall of the genital atrium (Fig. 4 *vg*). The vagina is supplied with a number of slime-glands (*ggl*), which are undoubtedly homologous with the glands figured in a similar situation by Iijima for *Planaria polychroa* ('84, Fig. 5, Pl. XXI *dr*), and *Dendrocœlum lactentm* (Fig. 1, Pl. XXI *edr*), and by Lang for *Gunda segmentata* ('81b, Fig. 56, Pl. XIV).

The vitellaria are granular cell-cords which in the sexually mature *Synœlidium* fill all the available interstices between the gut diverticula medially to the testicular sacs. Their general arrangement may be gleaned from Fig. 4 *vt*; their cytological structure from Fig. 10 *vt*. In sections the cell-cords are found attached to the walls of the oviducts, but on the method of their opening into the latter I have made no observations.

In his account of the anatomy of *B. candida* ('79) v. Graff makes the following statement: "Auffallend erscheint dagegen die Duplicität des Uterus, der jederseits zwischen 7. und 8. Darmmast (von hinten gezählt), durch je eine besondere Mündung rechts und links vom hinteren Ende des Schlundrohres sich nach aussen öffnet." Before I had seen this statement I was surprised to find two uteri in *Synœlidium* (Fig. 4 *u*). They are spheroidal bodies conspicuous in the living animal as translucent foam-like masses on either side of the genital atrium and forming apparent interruptions in the posterior gut-

rami. The center of each mass is usually, although by no means always, filled with a more opaque substance (*sp*) immediately surrounding which there is a pale halo (*us*). In carefully stained specimens each uterus is seen to possess an independent opening on the ventral surface (*ou*). The relations of these openings to the longitudinal nerve-cords are seen in Fig. 3 *ou*. The apertures occupy the posterior inner edges of uteri. In preserved specimens the apertures themselves are very small, but there is a pale enucleate halo surrounding each, so that they may be readily found.

In sagittal section (Fig. 8) the uterus is seen to take up nearly the entire thickness of the body. Externally its wall is sharply defined, but internally it is very ragged, at least in certain stages of its physiological activity, the single layer of cells composing it being frayed out at their inner ends. The nuclei of these cells (*x*) are few in number and stain very faintly. The mass in the center (*sp*), which shows as an opaque body in specimens studied *in toto*, is a compacted ball of spermatozoa, and the pale halo surrounding it (in the section Fig. 8 represented by two fragments only, *us*) is a glairy coagulum which usually envelops the mass of spermatozoa, and which I take to be the secretion of the cells of the uterine wall. The opening of the uterus is shown in section at *ou*. The walls of the delicate lumen, which appear to consist of a chitinous substance, are very thick and concentrically striated. A small nodule (*vl*), perhaps a kind of valve, seems to occlude the lumen. Then follows a more dilated cavity communicating with the cavity of the uterus proper.

In *B. candida* the conditions are similar, but more easily studied on account of the much greater size of this Triclad. The duct runs to the exterior from the anterior instead of the posterior inner surface of the uterine sac. In section (Fig. 9) the epithelial character of the wall is easily studied. It agrees in all essential respects with the uterine epithelium of the fresh-water forms. The duct has a very distinct lumen (*ou*) which is ciliated up to the valve (*vl*). There is also a slightly dilated portion connecting the duct with the uterine cavity proper as in *Synœlidium*. Contrary to v. Graff's

supposition, I find no connection between the oviducts and the uteri.

Bdelloura and *Synœalidium* appear to be the only Tricladæ which have two uteri and a distinct duct and opening for each uterus on the surface of the body.¹ The gap between these ectoparasitic planarians on the one hand and the fresh-water and land planarians on the other, is partially bridged by a series of forms representing the gradual emancipation of the oviducal opening from the duct of the uterus (vagina of authors).² In the land Tricladæ and in *Gunda lobata* (O. Schmidt) the oviducts unite with the hind portion of the uterus; in *Haga plebeja* they open into the lower end of the uterus; in *Gunda segmentata* and *G. ulvæ* the unpaired portion of the oviduct opens into the duct of the uterus; in the common fresh-water species it can hardly be said to open into the duct of the uterus, but has a separate opening into the genital atrium. In all these forms, however, the duct of the single uterus opens directly into the genital atrium; in *Bdelloura* and *Synœalidium* the ducts of the *two* uteri appear to have no connection with the oviducts and are entirely removed from the genital atrium. I fail to find any traces of yolk cells or ova in the uteri and I have seen nothing to indicate that the egg-capsules are formed in these organs. Spermatozoa are nearly always present in considerable quantity. In a specimen of *B. candida* I found spermatozoa in either oviduct for some distance up towards the ovaries. In a specimen of *Synœalidium* I found an egg about to be discharged into the genital atrium. These few observations are calculated to render the vexed question of the function of the uterus in Tricladæ still more perplexing. The great variation in the position and shape of the uterus — in other words, its morphological instability — in Tricladæ points to considerable variety of function. For the present I am inclined to believe that the uteri of *Synœalidium*

¹ Unless, indeed, this latter peculiarity obtain also in Bergendal's *Uteriporus vulgaris*. I have not seen his description of this form, but I conclude that its single uterus has an opening on the outer surface of the body from a remark in his recent paper ('92 p. 313).

² What I have called the vagina in *Synœalidium* is not, of course, homologous to the vagina of other Tricladæ.

and *Bdelloura* have nothing to do with forming the egg-capsule, but function only as receptacula seminis. On this supposition it is difficult to explain the presence of a secretion in the uterus unless it serve as a nutrient medium for prolonging the activity of the spermatozoa. It would seem, either that the duct of the uterus must function as a vagina, the penis being inserted in its orifice during copulation, or that the spermatozoa must be attracted into the uterine cavity. This may perhaps be accomplished by positive chemiotactic properties resident in the secretion of the uterine epithelium. I take this suggestion from Jordan's interesting paper on the spermatophores of the newt ('91); he believes that the spermatozoa of this amphibian may be enticed into the recesses of the cloacal glands by the glandular secretion.

9. *Breeding Habits.*

B. candida, *B. propinqua* and *S. pellucidum* all deposit their egg-capsules on the gill-lamellæ of their host, *Limulus*. The first species seems to show no preference for a particular region of the gill-leaf, but scatters its egg-capsules over the whole surface. *B. propinqua* selects the basal, or proximal region of the leaf, while *Syncælidium* prefers a small area near the edge and just lateral to a small marginal callosity which forms a brown line with the callosities of the adjacent leaves when the gill-book is closed.

The egg-capsule of *Syncælidium* (Fig. 5) is about .75 mm. long, of an oblong shape and somewhat compressed. It is attached by a slender pedicel .5 mm. in length, in such a way that one of the flattened sides of the capsule is applied to the surface of the gill-leaf. Usually the capsules are arranged with their long axes parallel to one another in a little cluster near the marginal callosity. The chitinous wall of the capsule is thin and transparent, but grows thicker towards the poles. Through it the two opaque white eggs or larvæ may be distinctly seen. I have never found more than two eggs in a capsule.

Many of the capsules bear at their outer ends one or more of the deep blue thecæ of an infusorium (Fig. 5). These

were regarded by Gissler ('82) as pneumatic tubes, but Ryder ('82b) showed that they were the thecæ of "Protozoa of the genus *Epistylis* or *Zoothamnion*."

Both Ryder ('82a) and Gissler ('82) figure the egg-capsules of *Synœlidium*. After describing the capsules of *Bdelloura*, Ryder says: "The second form, represented in Figs. 5-7, enlarged 16 times, is much smaller, but similar in structural features to the preceding. The capsules measure about $\frac{1}{25}$ of an inch in length and contain usually 2 eggs or embryos. At first the ova occupy each one of the ends of the capsule, as shown in Fig. 5; but after the young worms have developed somewhat, they usually lie alongside of each other lengthwise of the capsule. They frequently change positions, however, at this stage and it sometimes happens that there is but one embryo in a capsule."

Gissler's Fig. 2^b is evidently the capsule of *Synœlidium*, as shown by its size relatively to the infusorial thecæ attached to its summit.

For a description of the egg-capsule of *B. candida* I would refer the reader to the papers of Leidy ('51), v. Graff ('79), Ryder ('82a) and Gissler ('82).

What I take to be the egg-capsule of *B. propinqua*, is considerably smaller than that of the allied *B. candida*, measuring only 1.25 mm. It appears to contain only one ovum, instead of 2-7 as in *B. candida*, but on this point I cannot be positive. I am unable to identify this form of capsule with any of those described by Ryder ('82a).

The three *Limulus*-infesting Tricladæ differ also in their time of breeding. *B. candida* oviposits during May and early June, when the *Limuli* return from the deep water to the sandy beaches to breed. The passage of the Tricladæ from one crab to another must be favored by the prolonged coitus of the latter. *Synœlidium* oviposits in the latter part of July and the early part of August, when the gills are deserted by the half-grown young of *B. candida* for the basal joints of the cephalothoracic appendages. As the *Limuli* have laid their eggs and begin to return to deep water by the first days of July, it is necessary in order to study *Synœlidium* and its

habits, to collect a number of the crabs early in the season and to confine them in a large fish-box or similar receptacle. *B. propinqua* appears to breed at the same time as *Synœlidium*.

10. General Conclusions.

In conclusion two questions on which the foregoing anatomical study of *Synœlidium* has a bearing may be briefly discussed. The first relates to the origin of metamerism, the second to the systematic position of the three Triclad parasitic on *Limulus*.

A careful study of the strikingly regular anatomical features of *Gunda segmentata* led Lang ('81b) to attempt a derivation of the Hirudinea from Turbellaria-like forms. Such a derivation involves *implicite* the view that metamerism in the Annelida and higher forms is not derived from a process of budding like that observed in such forms as *Microstomum*, but from a condition like that which obtains in *Gunda*, where the testes, vitellaria, gut-diverticula and transverse portions of the nervous system have a segmental arrangement. This view has many attractions and I was inclined to give it great weight when I began my study of *Synœlidium*. Here, too, the nervous system has an arrangement quite as regular as that of *Gunda*, and preliminary observation pointed to a pair of gut-diverticula, a pair of testes and a pair of vitellaria to each transverse and each pair of lateral nerves. But the examination of a great number of specimens of all ages soon convinced me that the gut-diverticula are very variable in number and arrangement, that they are not paired and do not coincide with the lateral nerves. The testes and vitellaria accommodate themselves closely to the gut-diverticula, and vary correlatively. The water vascular system and musculature, of course, showed no signs of metamerism, so that I was left with the nervous system as the only apparently metameric organ in the body of *Synœlidium*. Hence, providing Lang's Fig. 1 is not unduly schematized, — and I am not willing to believe this, — I am forced to admit that *Synœlidium* falls far short of *Gunda* in the metameroid arrangement of its parts. The *Limulus*

parasite is interesting as representing a condition intermediate between *Gunda* and the fresh-water Triclad, a condition in which the nervous system is quite as regular as that of *Gunda*, while the other organs are scarcely more regular than their homologues in the fresh-water species.

The most striking peculiarity of the Triclad parasites of *Limulus* is the duplicity of the uterus and the independent openings on the surface of the body. v. Graff, who first observed this curious character ('79), does not appear to have given it due weight. This character combined with another, *viz.*, the complete absence of rhabdites, seems to me to be of sufficient magnitude to isolate these Triclad as a distinct family — Bdellouridæ — coördinate with the families Planariidæ and Geoplanidæ. Certainly the characters which distinguish this proposed new family from the remaining Triclad are as important as those used in the delimitation of many of the families of Polyclads. As a purely tentative arrangement of the group, subject, of course, to modification in the future, I would propose the following:

Family Bdellouridæ.

Ectoparasitic marine Triclad without auricular folds at the cephalic end; without pigment, except in the two eyes; without rhabdites; with two uteri opening by discrete ostia laterad to the longitudinal nerves; ejaculatory ducts opening separately very near the tip of the penis. Egg-capsules, elliptical or oblong, flattened, attached by a slender pedicel.

* Large species, with typical Triclad gut; the posterior rami united by a fusion of two of the mesial diverticula only in old specimens (always?); anal end of the body widened into a glandular disc; anterior end narrow and tapering to a point when the animal is expanded; ducts at the anterior edges of the uteri; penis acuminate, with a broad base. BDELLOURA, Leidy.

† Testicular sacs small, about 60–100 in number on either side of the body, lying laterad to the gut diverticula; brain relatively small, not contained in a fibrous capsule: Length

when fully grown, 15 mm. Egg-capsule elliptical, length 2.5-4 mm.

B. candida, Girard (*B. parasitica* Leidy; *Planaria limuli* v. Graff).¹

†† Testicular sacs small, about 170 in number, lying on either side of the body, but extending inward a considerable distance between the gut-diverticula, especially in the anterior region of the body; brain enclosed in a fibrous capsule. Length when fully grown, about 8 mm. Egg-capsule elliptical, length 1.25 mm. *B. propinqua* nov. sp.

** Small species, with the posterior rami of the gut uniting soon after hatching and forming an unpaired stem; both ends of the body alike, tapering, when the animal is fully extended. Ducts at the posterior inner surfaces of the uteri. Penis keg-shaped. SYNCÆLIDIUM, nov. gen.

† Testicular sacs very large, the average number being 14 on either side of the body; lying between the simple gut-diverticula; brain relatively large, not enclosed in a fibrous capsule. Length, 3 mm. Egg-capsule oblong, length .75 mm. *S. pellucidum*, nov. sp.

THE UNIVERSITY OF CHICAGO,
March 1, 1893.

POSTSCRIPT.

My attention was not called to Verrill's paper on the Marine Planarians of the New England coast (Trans. Conn. Acad., Vol. VIII, January, 1893) till after I had handed in my manuscript for publication. Verrill has anticipated me in founding a family for the reception of *Bdelloura candida*—the only species which he recognizes; but the characters which he assigns to this family are not in all respects satisfactory.

¹ Leidy ('51) describes another species as *Bdelloura rustica*, from Egg Harbor, N. J., where it was found on *Ulva latissima*. I do not include this in my table, because I doubt that it belongs in the genus *Bdelloura*. Equally doubtful is Stimpson's allocation ('58) of *Planaria longiceps* of Dugès ('30) in the same genus.

Thus he omits the double uterus, in my opinion the most distinctive character of the group. The posterior acetabulum, or sucker, must be dropped as a family character, because it is lacking in *Synœlidium*, a form too closely allied to *Bdelloura* to be relegated to any other Triclad family.

In Verrill's anatomical sketch of *Bdelloura candida*, I would criticise a remark on the uterus. At page 123, he says: "Each one (uterus) is connected with the genital duct by a convoluted tube"; and in his Fig. 8, Pl. XLIV, he clearly depicts this structure. When the uteri are much shrunk, their irregular edges may perhaps simulate a convoluted tube, but as Verrill has not studied sections of the Planarian in question, and as I feel quite confident that I have not overlooked this tube leading to the "genital duct," I doubt its existence, at least in *Synœlidium*.

April 2, 1893.

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EXPLANATION OF PLATE VIII.

<i>an</i> ¹ .	First sensory nerve.	<i>sp.</i>	Spermatozoa.
<i>an</i> ² .	Second sensory nerve.	<i>tex.</i>	Main trunk of water vascular system.
<i>br.</i>	Brain.	<i>dvml.</i>	Dorsoventral muscle.
<i>coe.</i>	Gut.	<i>trnv.</i>	Transverse nerve.
<i>e.</i>	Eye.	<i>ts.</i>	Testicular sacs.
<i>ggl.</i>	Glands opening into the vagina.	<i>tsf.</i>	Follicular epithelium of testis.
<i>hy.</i>	Hypodermal cells.	<i>u.</i>	Uterus.
<i>lnv.</i>	Lateral nerve.	<i>uep.</i>	Epithelium of the uterus.
<i>ml.</i>	Longitudinal muscle.	<i>us.</i>	Secretion of the uterus.
<i>mnv.</i>	Marginal nerve.	<i>vd.</i>	Vas deferens.
<i>ou.</i>	Ostium of the uterus	<i>vl.</i>	Valve-like nodule in the uterine duct.
<i>ov.</i>	Ovary.	<i>zmv.</i>	Longitudinal nerve.
<i>ovd.</i>	Oviduct.	<i>vt.</i>	Yolk-glands.
<i>p.</i>	Penis.	<i>wf.</i>	Wimperflamme.
<i>ph.</i>	Pharynx.	<i>x.</i>	Nucleus of the uterine epithelium.
<i>phl.</i>	Longitudinal nerve of the pharynx.	<i>z.</i>	Ciliated membrane.
<i>phr.</i>	Ring-nerve of the pharynx.		
<i>sgl.</i>	Slime-glands.		

FIG. 1. Just hatched *Syncalidium*, showing the still separate posterior gut-rami.

FIG. 2. Adult living *Syncalidium* as seen in reflected light on a dark surface ($\times 10$).

FIG. 3. Nearly adult *Syncalidium* viewed as a transparent object, showing the disposition of the nervous system.

FIG. 4. Adult *Syncalidium* viewed as a transparent object, but slightly diagrammatic, showing the gut, reproductive organs, and water-vascular system.

FIG. 5. Two egg-capsules of *Syncalidium*, showing their method of attachment to the gill-lamellæ, etc.

FIG. 6. Fragment of the ciliated membrane, showing its polygonal areolation; from a desiccated specimen.

FIG. 7. Adult *Syncalidium* viewed as a transparent object, to show the distribution of the glands.

FIG. 8. Portion of a sagittal section through one of the uteri of *Syncalidium*, showing the duct and external opening.

FIG. 9. Portion of a transverse section through one of the uteri of *Bdelloura candida*, showing the duct and external opening.

FIG. 10. Transverse section of *Syncalidium* through the middle of the body.

FIG. 11. Fragment of the water-vascular system of a living *Syncalidium*.