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On some Japanese Tricladida Maricola, with a Note on the Classification of the Group.

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With 1 plate and 6 text figures.

Introduction.

Up to the present, only three species of marine Triclads have been known to occur in Japanese territories, viz., *Procerodes lactea*, *Stummeria trigonocephala* and *Ectoplana limuli*. So far I have not, as yet, been able to obtain any other species. Doubtless more will be discovered in the Empire. In the present paper I shall try to describe the anatomy of these species as fully as I possibly can. Besides, I shall avail myself of the opportunity to propose a new classification of the marine Triclads.

Before proceeding further, I wish to express my sincere gratitude to the late Professor ISAO IJIMA, under whose kind supervision this investigation has been prosecuted. My best thanks are due to Mr. J. T. SAUNDERS of the Zoological Laboratory, Cambridge University, for looking over my manuscript. Also I gladly take this opportunity of thanking Baron HAMAO, former President of the Tokyo Imperial University, for the stipend, without which it would have been difficult for me to carry out the work.

Procerodes lactea Ij. et Kab.

(Pl. I., fig. 1.—Text figs. 1, 4.)

Numerous specimens of this species were captured by the late Professor Ijima beneath stones on the beach between Yukanki and Meleya in the Saghalin in July, 1906.

Form.—The shape of the body in the living condition is closely similar to that of *Pr. ulvae* (Oersted) in the same state. The frontal margin is subtruncate, usually slightly crenate and gently arched in the middle parts which spread on each side into an antero-laterally directed tentacle through a gentle concavity. The tentacles are moderately long and slightly rounded at the end. The head merges into the trunk, from which it is indistinctly separated by a slight neck-like narrowing. When fully extended, the trunk is elongated and slender, and is of a nearly uniform breadth throughout, beginning to taper gradually from the region of the copulatory organs to the rounded hind end.

Size.—The specimens in the preserved condition measure 2–4 mm. in length and about 1 mm. across in the broadest part of the body at the pharyngeal region.

Colour.—The body is almost translucent milky white, due to the entire absence of pigments, much as in *Pr. lobata* (O. Schm.) The intestine and the vitelline glands can be seen with more or less distinctness, being of a reddish or brownish colour. The pharynx and the copulatory organs are also discernible to a certain extent.

Eyes.—The crescentic eyes, two in number, are situated well behind the frontal margin and separated from each other by a space somewhat longer than the distance of either eye from the lateral body-margin of the same side.

Digestive Organs.—The mouth is placed somewhat behind the beginning of the posterior third of the body. The pharynx is inserted at about the end of the anterior third of the body, being somewhat longer than one-third the body-length. The unpaired anterior main trunk of the intestine usually sends out 7 or 8 pairs

of lateral branches, while the posterior trunks are provided with 14–18 outwardly directed branches.

Genital Organs.—The genital aperture is placed at a distance behind the mouth equal to about one-fifth that between the latter and the posterior body-end. The genital atrium is divided into the penis-sheath and the vestibulum by a constriction. Numerous testes, of a spherical shape, are dorsally situated in two lateral zones, beginning from the ovarian region and extending behind nearly to the end of the body. The vasa deferentia are united into a slender ejaculatory duct in the bulbous part of penis without showing any sign of vesicula seminalis. The penis is of a small conical shape, being vertically disposed in its sheath. The paired ovary is situated ventrally between the first and second pairs of the lateral branches of the anterior gut trunk. The oviducts open directly into a small outbulging of vagina at the postero-inferior aspect. The receptaculum seminis is a large spherical body, lying behind the penis. The vagina runs anteriorly and obliquely downwards to join the vestibulum from behind.

Remark.—This species seems to be nearly allied to *Pr. ulvae* and *Pr. lobata*, but may be readily distinguished from the former by the entire absence of pigments and the feature of the oviducts opening directly into the vaginal outbulging without uniting into an unpaired terminal duct, and from the latter by the different shape of the head and the absence of the seminal vesicle within the penis.

Stummeria trigonocephala (Ij. et Kab.)

(Pl. I., figs. 2, 4, 5.—Text figs. 2, 5.)

A single specimen of this species previously referred to the genus *Procerodes* was first collected by the late Professor Ijima in 1887 from the coast of Oginohama, Prov. Rikuzen. Later, numerous specimens were obtained by myself in the estuary of rivulets in the same locality (1915), and in Itsukushima, Prov. Aki (1916).

Form.—The head presents a nearly triangular shape and

merges behind into the trunk, being marked off by a gentle neck-like narrowing. The trunk gradually widens backwards to the region of copulatory organs, and then begins to taper to the posterior body-end which is somewhat rounded or bluntly pointed.

Size.—The large specimens are about 4 mm. in length, when alive and fully extended, and 1 mm. across in the widest part of the body.

Colour.—The translucent body is generally of a whitish or light brownish colour, but may present sometimes various sorts of hues—not infrequently smutty yellowish brown, yellow, orange, red, gray or green—according to the varying colouration of intestinal contents. The darkish pigments are well developed along the head-margin and most densely in the region of the eyes, bringing about a central clear space. The pharynx and the copulatory organs may fairly well appear as clear spaces. The ventral surface is of much lighter colour than the dorsal.

Eyes.—The two crescentic eyes are fairly closely approximated, but far removed behind the anterior end of the body, the distance being much larger than that of either eye from the lateral neck-margin of the same side, and the latter being a little longer than double the distance which intervenes between them ; each eye is surrounded by a small, oval, non-pigmented area.

Digestive Organs.—The mouth is situated at about the hind end of the middle third of the body. The insertion of pharynx takes place at a short distance behind the middle of the body. The anterior gut trunk is provided with 7–9 pairs of lateral branches, while the posterior trunks give off each about 10 branches on both sides, those of inner sides being very short.

Genital Organs.—The genital aperture lies nearly half-way between the mouth and the posterior body-end, and leads directly into the simple atrium. Numerous small testes, ventral in position, are arranged on both sides of lateral nerve-cords from close behind the ovaries to the pharynx-insertion, but farther behind only on the outer side of the same, ceasing altogether to exist at about the level of the mouth. The vasa deferentia fuse together in the penis bulb to form a short common duct which soon opens

into the moderately wide vesicula seminalis; the latter is narrowed inferiorly into the ejaculatory duct terminating at the tip of the penis, which is of a conical shape and is subvertically disposed. The paired ovary is placed ventrally between the fourth and fifth pairs of the lateral branches of the anterior gut trunk. The oviducts of both sides open separately into the vaginal canal. The receptaculum seminis holds a position posterior to the penis, giving rise at its antero-superior part to the vaginal canal, which runs down to open into the genital atrium from behind.

Remark.—The present species seems to be most nearly allied in the external features to *Pr. graciliceps* from Hongkong and *Pr. trilobata* from Avatscha in Kamtschatka, which were described in 1857 by STIMPSON (56) under the name of *Fovia*. To me it appears, judging from the description, that the worm in question stands somewhat at variance from both the species in a few respects. The head is in *Pr. graciliceps* of a triangular shape, much the same as in the present species, but is wholly devoid of any trace of pigments. In *Pr. trilobata* the head seems to present a similar appearance in shape, but a black transverse line exists at a point behind the eyes, unlike in *St. trigonocephala*.

Ectoplana limuli (IJ. et KAB.)

(Pl. I., figs. 3, 6–8.—Text figs. 3, 6.)

Numerous specimens of this species were collected in 1889 by Professor KISHINOUYE at Ajino, Prov. Bizen, and in 1916 by myself at Yobimatsu in the vicinity of the same place. The worms occur in abundance on *Limulus longispina*, attached mostly on the hard surface of the proximal segments of the cephalothoracic appendages as well as on the gill-books.

Form.—The body in the creeping state is elongate-slender, nearly uniformly broad almost throughout its length, and is narrowed at both its bluntly pointed ends. The tentacles are altogether absent.

Size.—The large specimens measure 4–6 mm. in length by 0·7–1 mm. in the broadest part when fully extended.

Colour.—The living animals are generally of a uniform milky white colour, but sometimes light brown, according to the character of intestinal contents. Any trace of pigments can nowhere be detected. In the hind region there usually exists a light spot which doubtless shows the position of the copulatory organs.

Eyes.—The two crescentic eyes are closely approximated and situated far behind the head end, the distance between them being about half that from the eye to the lateral margin of the head of the same side.

Digestive Organs.—The mouth is situated nearly between the middle and the posterior thirds of the body. The insertion of pharynx takes place at a short distance in front of the middle of the body. The anterior main trunk of the intestine is provided with 8–10 pairs of lateral branches, while the posterior trunks are usually united at the hind end, each giving off at least 16 lateral branches.

Genital Organs.—The genital aperture lies in front of the middle of the posterior third of the body. The genital atrium is divided into two chambers ; the vestibulum presents a vertically ascending and laterally outbulging and wide lumen. Numerous testes are situated ventrally along both sides of the anterior gut trunk, extending from the ovaries to the dividing point of the gut trunks. The vasa deferentia are united in the upper part of the penis bulb before opening into the vesicula seminalis, which is not wide, passing below into the slender ejaculatory duct. The intromittent part of the penis is of a conical shape and is subvertically disposed. The paired ovary is spherical in shape and occupies a ventral position between the first and second pairs of the gut branches. The oviducts open separately into the genital vestibulum at the upper end, where the small receptaculum also opens by a short stalk (vagina) from behind.

Anatomy.

Integument.

The epidermis consists, as usual, of ciliated cuboidal or cylin-

drical cells which vary in height not only in different species but also in different body parts of the same individual, largely depending upon the condition of expansion or contraction of the worm. It is generally thickest on the dorsal surface, and as it passes over to the ventral surface, gradually becomes thinner as far as the middle line, it measuring in *Pr. lactea* 12 μ dorsally, 8 μ ventrally ; in *St. trigonocephala* 8 μ dorsally, 5 μ ventrally, and in *Ect. limuli* 9 μ dorsally, 7 μ ventrally.

The protoplasm of the cell is generally fibrillated, as observed by a number of investigators. The courses of the fibrillae are more or less irregular, though in a general way perpendicular to the surface. Frequently, but not always, they form a network, in which the spherical or ovoid nucleus, as a rule, lies near the base or the middle of the cell, but not constant. The nucleus appears to contain a distinct chromatic network in a definite membrane. Besides, the epidermal cells are more frequently full of minute rhabdites.

The cilia covering all over the epidermis are much more strongly developed ventrally than elsewhere. In some preserved specimens the dorsal surface is often wholly destitute of them. In fixation, they become matted together to form a tangled mass, in which it is difficult to observe individual cilia. Where they are inserted in the epidermis, the characteristic basal swellings give the appearance of a very thin dense layer at the surface, which has been interpreted by some investigators as a cuticula. Although it is very difficult to determine the precise relation between the cilia and the protoplasmic striations of the epidermal cells, the basal extensions of the former may probably be continuous with the latter striations.

Generally the epidermis comprises a number of interstitial cells, usually known as Böhmig's "Klebzellen," which are characterised by the perforation of the glandular ducts as well as by the complete absence of cilia and rhabdites. The cells are more or less higher than the general epidermal cells, and form a narrow zone completely surrounding the body just within the lower ventral margin. This submarginal zone is broad in the anterior

region, distinctly narrower in the tail, and very narrow along either side of the body. The cells are not glandular, but perforated by the ducts of glandular cells which are deeply embedded in the parenchyma below the dermal musculature. Besides, there exist some similar cells here and there in scattered distribution, chiefly over the ventral surface of the body. By means of the secretion the worm is able to adhere with surprising firmness to a smooth surface, quite a strong jet of water being necessary to displace it.

Besides, the epidermis also holds in the tentacular and frontal regions special cells, designated under the name of sensory cells, which are provided with well developed cilia, but completely devoid of rhabdites. In the case of *Ect. limuli* they show no nuclei. As usual, the cells exhibit to a considerable extent a fibrillous structure, the fibrillae appearing to stand in connexion with nurofibrillae. Besides, any special sensory cells, demonstrated by Böhmig (5) in *Pr. ulvae* and *Planaria gonocephala*, could not be brought under observation.

Now as to the epidermis or epithelium of the Plathelminthes in general. In some Triclads there can frequently be recognised a special epidermis, in which no nuclei are present at all, much as in the Trematodes and Cestodes. Some authors [Seidl (55), Sabussow (51) and Böhmig] observed the case in the frontal sensory part of the body in several species (*Sorocelis stummeri*, *S. gracilis*, *S. lactea*, *S. sabussowi*, *S. rosea*, *Planaria wytegrensis* and *Procerodes ohlini*). Especially it is of great interest that in the hitherto known limulus-infesting *Bdelloura*- and *Syncoelidium*-species no trace of nuclei could anywhere be detected in the epidermis which is a homogeneous and ciliated layer, and is also wholly devoid of rhabdites, except in one species of *Bd. propinqua*. The nucleus containing parts are sunk into the parenchyma immediately below the dermal musculature. In vertical sections, it is impossible to distinguish cell-boundaries with ease, but in tangential ones, polygonal spaces are apparent, which probably represent the callular character. So far as my observations go, similarity can be demonstrated in the frontal sensory region only

in *Ect. limuli*. In the species examined there occurs no indication of the cuticular wall observed in several forms by WILHELMI (71) and others.

Turning attention to the variations, pointing out the resemblance between the insunken epidermis of the Turbellaria and the 'epidermis' of the Trematodes and Cestodes, the probable descendants of the former group, von GRAFF (24) has stated as follows:—"Berücksichtigt man, dass in der ursprünglichsten Familie (Geoplanidae). . . . . .ein normales Epithel angetroffen wird, so kann man in den eingesenkten Epithelien überhaupt und speciell in dem der Kriechleiste nur einen secundären Charakter erkennen—einen Charakter, der erst in den beiden am weitesten differenzirten Familien der Rhyncodemidae und Bipaliidae auftritt und bei letzterer seinen höchsten Ausbildungsgrad erreicht hat. Hier ergreift der Process der Einsenkung bei manchen Formen, wie *Plac. kewensis*, das gesammte Körperepithel und man könnte sagen, dass diese Species und die ihr im Bau des Epithels zunächststehenden Bipaliiden im Begriffe sind, die Epithelform der Trematoden und Cestoden zu acquiriren." In the endoparasitic Trematodes and Cestodes the body is generally invested by a cuticular wall, while in the ectoparasitic Trematodes regarding as the probable intermediate group of the former groups and Turbellaria there appear to be found some epidermal variations. The epidermis retains in some cases either the cellular or the cuticular feature over the whole surface of the body. Frequently there occur some species, in which the cuticular wall partly consists of the cells, or contain a number of nuclei at irregular intervals, as for example in the primitive cestode *Amphilina*—SALENSKY (52) as well as in several Trematodes (*Bucephalus*—ZIEGLER (76); *Cercaria*—SCHWARZE (54), HECKERT, 1889; *Monostomum mutabile*, BRAUM (8); *Nemathobothrium molae* and *Distomum*—MACLAREN (42); *Cotylogaster*—NICKERSON (46), etc.) In some specimens it is found that the cuticular wall, in its earliest stage, is composed of the cells which in later stages become the cuticula, the cytoplasma changing its character and the nuclei being obliterated gradually. To judge from the epidermal variations just mentioned, it seems that

the Turbellarian epidermis is homologous with the cuticular wall of the Trematodes and Cestodes, as pointed out by LÖNNBERG (40), ZIEGLER (77) and others. Further, the fact, which will be set forth in the paragraph concerning the atrium, probably affords a strong support for this view.

Rhabdites.—As is well known, the epidermal cells contain numerous rhabdites as a peculiar content, the rhabdites lying near the free surface of the cells and chiefly occupying the distal half. Some of the rhabdites may sometimes reach the basement membrane. Usually their major axis is approximately perpendicular to the surface and nearly parallel to one another, but they may sometimes assume any angle with one another. In *St. trigonocephala* they are found in a very small number, evidently situated between the epidermal cells. In *Pr. lactea* and *Ect. limuli* the epidermis is full of rhabdites usually within, and rarely between, the cells. Generally the rhabdites occur in great abundance, so that the epidermis appears at one glance to be composed of them, on the dorsal surface, up to the lateral margin of the body, where the body-glands open to the exterior, and where they abruptly cease. They are, however, altogether absent in the sensory regions, and become remarkably fewer in number on the ventral surface, disappearing altogether around the genital aperture.

As stated above, the epidermis is full of the rhabdites which are all of one kind, but vary in size. The variations occur wherever the rhabdites are found. Generally speaking, however, there is an interesting correlation between the thickness of the epidermis and the size of them, as mentioned by WOODWORTH (74). The rhabdites are invariably longer on the dorsal than on the ventral side, their length measuring on the average in *Pr. lactea* 6 μ dorsally by 4 μ ventrally, and in both *St. trigonocephala* and *Ect. limuli* 4 μ dorsally by 3 μ ventrally. Each is generally of a slightly curved fusiform shape, bluntly pointed at both ends, and more or less slender in the latter two species than in the former. In general, they are deeply stainable with borax-carmine, and when stained with haematoxylin-eosin, they take on a violet colour. They are of a perfectly homogeneous and strongly reflec-

tive nature, presenting no peculiar structure.

Of interest is the complete absence of rhabdites in the previously recorded limulus-infesting Bdellourid-species, except one form of *Bd. propingua*, in which they are but rarely found. However, they are in *Ect. limuli* very abundant on the dorsal side.

The formation of the rhabdites has long been a much debated question. By a number of investigators it was alleged that they originate only in cells, found scattered in the body-parenchyma directly inwards to the dermal musculature; while a few writers [Böhmig (5), Ude (55), Weiss (61)] assumed their formation to be partly in the subcutaneous cells and partly in the epidermal cells. Now I am apt to acknowledge the latter view. In the species examined, the rhabdite-forming cells are scattered in the parenchyma immediately near, or farther inwards to, the epidermis, as observed by some authors. The passage by which the rhabdites reach the epidermis through the parenchyma and the basement membrane could frequently be brought under observation. In both *Pr. lactea* and *Ect. limuli* the subcutaneous cells are found sparsely in the parenchyma, in spite of the abundant occurrence of rhabdites in the epidermis. To my mind, the fact probably stands in favour of the view that the formation of rhabdites takes place partly in the epidermal cells.

The question concerning the physiological meaning of rhabdites has also been long debated on by naturalists. Some writers considered the rhabdites as homologous to the nematocysts of Coelenterates, whereas more recent authors would ascribe them to the equivalents of gland secretions. I entirely concur with the latter opinon. The rhabdites are given off freely on the dorsal as well as on the ventral surface. When they are discharged a sticky gelatinous fluid is poured out with them. If the worm be placed in a dish with a very little water, or irritated in any way, a rapid discharge takes place, and the worm becomes enclosed in a whitish coating to protect itself. It is quite likely that the secretion being perhaps poisonous may have some effect in entangling or disabling the prey. As mentioned by Woodworth, Böhmig

and others, the rhabdites are, I believe, of use to the worm in securing food as well as for offensive and defensive purposes.

Basement Membrane.

Immediately inwards to the epidermis comes the basement membrane which is in most place a well marked layer, and varies in thickness according to individuals and to parts of an individual. Generally the membrane is somewhat thicker on the dorsal side than on the ventral and grows thinner as it passes over to the ventral side. Its thickness cannot be measured with any accuracy, the extremes, however, being 1 μ and 4 μ. It seems to be somewhat thicker in *Ect. limuli* than in other two forms, of which I have treated. Judging from the varying reaction to stains the membrane is apparently differentiated microchemically from both the parenchyma and the epidermis. In carmine or haematoxylin preparations it is always much more stainable than the epidermis and the parenchyma, and is distinctly marked off from both. The membrane appears in vertical sections nearly homogeneous, showing no granular feature, but it apparently presents in horizontal sections a fibrillated appearance. The course of the fibrillae, though more or less irregular, is, on the whole, parallel to the body surface and thus at right angles to the fibrillae of the epidermal cells. Externally the basement membrane presents a fine scalloped appearance, which may probably be due to the insertion of the epidermis; internally it is less sharply differentiated from the parenchyma, and fine striations, forming a loose meshwork, run out of the membrane to the latter.

Woodworth (74) believes the basement membrane of *Phagocata gracilis* to be a hypodermal product. However, my own observations of the fibrillous nature of the membrane seem to render more evident its probable continuity with the parenchyma. Genetically therefore it belongs to the parenchyma rather than to the epidermis, as mentioned by several authors.

Musculature.

The dermal musculature presents nothing peculiar, and consists, as is well known, typically of three sets of fibres, viz., the circular, the transverse and the longitudinal. The outermost circular muscles form a very fine layer directly beneath the basement membrane, and appear in sagittal sections of the worms as minute dots. In immediate contact internally with this there can be recognised a delicate layer, in which the fibres are arranged in two ways, one runs from the right to the left backwardly, the other from the left to the right backwardly. They cross perpendicularly with each other, and the fibres in the same ways are nearly parallel to each other with some distance. It is very hard to distinguish those fibres, though we are positively able to demonstrate them in horizontal sections. Inwards to the layer there exists a layer of the longitudinal fibres; which is the most developed of all the muscular layers of the body, and appears associated in distinct and quite regular bundles. The fibres in bundles extend from one end of the body to the other, without or very rarely with anastomosing system, and are much more strongly developed on the ventral than on the dorsal side. In the species examined, the musculature of *Ect. limuli* is much better developed than that of the others.

In our forms the body muscles, also calling parenchyma muscles, exactly coincide for the most part with those of the species studied by Böhmig. As usual, several kinds of fibres can be distinguished, viz., the dorso-ventral, the oblique dorso- and ventro-lateral and the oblique longitudinal. Of these the dorso-ventral muscles are very strongly developed in the species, with which I have dealt. In the lateral portion of the body there are also distributed two kinds of the oblique transverse muscles, the first running dorso-laterally, the second ventro-laterally. As stated by Böhmig, the oblique longitudinal fibres are present, confined to the frontal part of the body, but they are so weakly developed that I have not been easily able to demonstrate them. Besides, some fibres, regarded as the retractor or pro-

tractor of the pharynx, pass oblique longitudinally from the root of the latter organ, through the parenchyma to the dermal musculature. The numerous fibres are peculiarly distributed in *Ect. limuli* around the atrial chamber apparently without order, running irregularly and outwardly in the parenchyma (Pl. 1. fig. 8.)

In structural respects the muscle fibres show nothing peculiar, and consist, as usual, of the inner granular and the outer fibrillous layer. The latter is more strongly stainable than the former.

Parenchyma.

The parenchyma constitutes the greater portion of the body-substance, occupying all the interstices between the various organs. It generally consists of two sorts of cells, one of which, subject to considerable variation in form, is usually multipolar. In each there exists an ovoid or rounded nucleus. Processes of these cells come into connexion with one another, giving the appearance of the sponge reticulated fibrous connective tissue. The other is rounded or ovoid cells, the plasma of which is very finely granular and nearly homogeneous. They are usually designated under the name of "stamm" or "formative" cells, and are easily distinguished by a somewhat larger nucleus containing chromatin in noticeable abundance. They lie chiefly in the lateral parts of the body and take part in the regeneration or the formation of the tissue, as mentioned by several authors.

In *St. trigonocephala* the pigments, which are of somewhat coarse granules and of a dirty greenish colour, occur abundantly in the anterior region, as already stated. In the deeper tissue, below the dermal musculature, the granules are intercellular in position, never intracellular, and considerably well developed in the region of eyes. No sign of pigments was detected in the epidermis, unlike *Heterochaerus australis*, and also no special pigment cells are anywhere present.

Body Glands.

Embedded in the parenchyma are numerous glands, in which we are generally able to distinguish three groups of the body-, pharyngeal and genital glands, as I shall call them. As to the glands which stand in intimate relation with the pharynx and the genital organs, I would desire to give a note in the paragraph concerning those organs.

As usual, the body-gland is composed of two kinds, viz., the numerous eosinophil and the sparse cyanophil. The eosinophil glands are very diffusedly but not uniformly distributed in the parenchyma on each side of the body and open externally in the narrow submarginal zone of the ventral surface, as already stated. Of the species examined, in *Ect. limuli* they are most well developed. A large accumulation of the glandular cells exists near the anterior body-end. The deep ends of them are located behind the brain, and in passing over the latter they run downwards and forewards up to making their way to the ventral surface of the head close to its anterior margin. Again, such a similar but smaller cluster of the glandular cells is found at the posterior extremity of the body, and they open out on the posterior edge.

The glandular cells are, as usual, of a rounded or pyriform shape, and contain a homogeneous or finely granular substance. In haematoxylin-eosin preparations they stain violet in *Ect. limuli*, but deeply red in others. Each is prolonged on one side into a long slender duct; the ducts unite often with one another to form larger ones and then again to separate into numerous fine ducts near the dermal musculature just before opening submarginally on the ventral surface.

Between the eosinophil glands there occur the cyanophil, which are but rarely found. They are recognisable with more or less distinctness in *Ect. limuli*, chiefly in the brain region, as compared with those in *Pr. lactea* and *St. trigonocephala*, in which they cannot be found with ease. The shape of the cells varies to a considerable extent, but is, as usual, round or pyriform. In haematoxylin-eosin preparations they usually take on a somewhat

deep violet colour. They open to the exterior at various points of the entire body-surface.

The unicellular glands undoubtedly secrete mucus and help to attach the body of the worm more securely to objects or the host, as can be seen when one attempts to displace the worm from the latter. Moreover, it is very allowable to conclude that the mucus is used by the animal as a means of movement. The worms are able to move by the action of the cilia in the mucus layer between the ventral surface of the body and the substratum.

Digestive System.

The digestive system consists of the mouth, the pharyngeal chamber, the pharynx, the glands which come into connexion with the pharynx, and the intestine.

The mouth is a small opening situated on the ventral side nearly between the middle and the posterior thirds of the body, as already noted down, close to the termination of the pharyngeal chamber. It is lined with a definite one-celled layer, being somewhat higher than the epidermis of the ventral surface. The rhabdites are altogether absent around the mouth, and the cilia are confined to the outside of the mouth. Beneath the epithelium comes a basement membrane and layers of circular and longitudinal muscular fibres, of which the layer of circular muscles are remarkably well developed.

The mouth leads into the pharyngeal chamber, the lining of which is very flattened and rests on a very delicate basement membrane, next to which exist feeble muscular layers consisting of outer circular and inner longitudinal fibres. Towards the base of the pharynx these muscular layers gradually increase in thickness to a considerable extent and stand in direct continuation with the circular and longitudinal muscles of the pharynx. Unlike in *Bd. candida*, no evidence of the insunken epithelium was found in my own sections.

Pharynx.—The pharynx, protruding into its chamber, is as usual, a cylindrical body, of which the ratio to the body-length is

as follows : in *Pr. lactea* nearly 1: 3, in *St. trigonocephala* 1: 6 and in *Ect. limuli* 1:. 4·5.

So far as my observations go, there exists no essential difference in structural respect; nine layers can be clearly made out, as stated by Böhmig. For the sake of convenience they may now be distinguished into three zones, viz., the outer, the middle and the inner.

Outer Zone.—Externally the thin epithelial plate of the pharynx is, as usual, covered by a ciliary layer which disappears on the lip of the organ, where the ducts of the pharyngeal glands open out. Immediately beneath the epithelial plate is a delicate basement membrane and the musculature consisting of two layers of outer longitudinal and inner circular fibres. Generally the musculature is very well developed near the proximal portion of the pharynx and gradually diminishes in thickness towards the tip of the pharynx. The sets of fibres are much better developed in *Ect. limuli* than in the other species examined by me. Directly below the circular muscles there occur numerous nuclei which, in my opinion, seem partly to belong to the epithelium, and partly to be remnants of cells producing muscular fibres.

Middle Zone.—This part consists chiefly of parenchymatous connective tissue traversed lengthwise or crosswise by several elements, such as glandular ducts, nerve plexus and muscular fibres, which predominate generally to an extraordinary degree. Embedded in the parenchyma near the intestinal mouth are numerous pharyngeal glands in which, as is well known, two sorts can be distinguished, viz., the cyanophil and the eosinophil. The latter glands stainable violet with haematoxylin-eosin are abundantly distributed somewhat in front of the former which occur in a sparse number close near the pharynx-insertion and take on a deep red colour. These glandular cells vary in form, being usually pyriform. The efferent ducts of the cyanophil glands are formed into a strong compact bundle on entering the pharynx, and they run, immediately beneath the outer zone, the whole length of the pharynx and finally open into the pharyngeal chamber at the tip of the organ. Besides, they send out some fine

efferent ducts, which open here and there in scattered distribution over the external surface of the pharynx. Similarly the ducts of the eosinophil glands, forming a large bundle, proceed nearly parallel to the above with some distance between to open at the tip of the pharynx. Both the bundles of the ducts just mentioned are separated from each other by a zone of connective tissue traversed by plexus forming nerves.

The nerve plexus is much more conspicuous in the posterior half of the pharynx than in the anterior and for the most consists of several nerves connecting almost perpendicularly with one another. The longitudinal nerves run nearly parallel to the external surface of the pharynx. In *St. trigonocephala* there exists a strongly developed nerve ring nearly between the middle and the posterior thirds of the pharynx, much as in *Pr. lobata*. In *Pr. lactea* three fairly well developed nerves are seen, which probably represent the rings, but in *Ect. limuli* I have failed to recognise a similar ring.

Besides, this zone is traversed by numerous radial muscular fibres which run from the inner epithelium to the outer, but never occur in any definite bundle. Between these radial fibres there are a few nuclei which are exactly similar in appearance to those of the general parenchyma. Only in sections of *Ect. limuli* I have also been able to find out a few loops of excretory canals which were already demonstrated by some authors in the pharynx of any other forms.

Inner Zone.—In structural respects this zone is apparently analogous to the outer. The lining epithelium of the pharynx lumen is continuous with the external. In both *Pr. lactea* and *St. trigonocephala* the nuclei are displaced at about anterior one-third in the muscular layer of circular fibres immediately beneath the epithelium, while in *Ect. limuli* they are altogether absent in the whole internal epithelium. This muscular layer is developed to a considerable extent near the middle of the pharynx and is composed of numerous rows of fibres which are much more powerful in both *Pr. lactea* and *Ect. limuli* than in *St. trigonocephala*. Directly below this layer there exist longitudinal fibres in two or

more rows. Generally the thichness of the musculature diminishes towards either end of the pharynx. Quite similar to any other forms, retractor and protractor muscles pass from the pharynx through the parenchyma to the muscular layers of the body-wall, as already described.

Intestinal System.—The intestine shows a characteristic differentiation into an unpaired anterior and paired posterior trunks, but it deviates in *Ect. limuli* somewhat from the normal type, as will be described later. In general, the anterior trunk extends to a point in front of the brain and usually sends out some lateral branches on either side, numbering 7 or 8 in *Pr. lactea*, 6–9 in *St. trigonocephala* and 8–10 in *Ect. limuli*. The first branches occur in both *Pr. lactea* and *St. trigonocephala*, sometimes in front of the brain. In *St. trigonocephala* the branches are subdivided before reaching the lateral margins of the body ; while in the others they show little tendency to subdivide, except at their tips, where they are sometimes bi- or trifurcate. The posterior trunks proceed, one on either side of the pharyngeal chamber, towards the posterior body-end, where they unite together only in the case of *Ect. limuli*, but remain separate in others. They are provided with numerous diverticulae which have even less tendency to bifurcate than those of the anterior trunk, their number being 14–18 in *Pr. lactea*, 10–15 in *St. trigonocephala* and 14–16 in *Ect. limuli*.

Among the marine Triclads, *Syncoelidium pelucidum* HALLEZ is known to me as exhibiting a union of the posterior trunks, the trunks fusing behind the vestibulum. From the point of union an unpaired stem possessing a few minute diverticulae on either side proceeds towards the posterior body-end, much as in *Dendrocoelum nausicaæ*, a fresh-water species, in which the fusion is brought about by a confluence of a pair of mesial diverticulae, and not by a fusion of the trunks themselves. Behind the union, however, no unpaired stem is seen in *Ect. limuli*, in which the trunks unite together at the ends. Of course, the fusion is of a most different nature from that found in *Bd. candida*, in which it occurs between mesial diverticulae, thus forming a connection between the trunks,

like the horizontal bar which joins the two upright pieces in the letter H. Also the gut branches of *Micropharynx parasitica* JÄGERSKIÖLD are numerously subdivided and anastomose, quite similar to the appearance that occurs in some Polyclads (Pseudoceridae, Euryleptidae, etc.). Any sign of such an anastomosis could nowhere be found in *Ect. limuli*.

The intestinal cavity is lined by a continuous epithelium consisting of two sorts of cells, one of which constitutes the greater portion of the lining while the other is glandular. In most species the former cells are always either columnar or nearly conical and appear vacuolated at the distal portion. The nucleus always lies close to the basal portion, where the protoplasm is very finely granular and deeply stainable. Besides, the cells contain numerous granules of small size. In some specimens of *St. trigonocephala* the cells are found to contain various granules but in a sparse number. Between those cells just mentioned there exist the goblet-shaped glandular cells which are well known as MINOT's glands. They are full of coarse granules of homogeneous substance, deeply stainable with eosin and orange-G, and having strongly refractive powers. The cells occur more abundantly in the epithelium of the main trunk than elsewhere.

In the planarians digestion is regarded by IJIMA (29) and others as taking place intracellularly. According to ARNOLD (1), however, the food taken in is in all probability inter- and intracellularly digested. As to the intercellular digestion he says as follows: "The intercellular digestion is limited to fat. The fat is broken down in the lumen of the intestine by the secretion of the goblet-cells into fatty-acids, which are then absorbed by the columnar cells and synthesised again into neutral fat.

"Most of the fat is digested in the cytoplasm of the columnar cells, but some of it is extended into the parenchyma at their base, and appears in the yolk cells and in the wandering cells." Concerning this subject I have now little to add to what has been written. The digesting product can pass into the tissue only by osmosis and filtration.

Respiration is regarded as being carried on in these worms

by means of the digestive tract. However, the life and growth of the worm piece lacking either the mouth or the pharynx seem to me to suggest that it can breath with the whole extent of the skin.

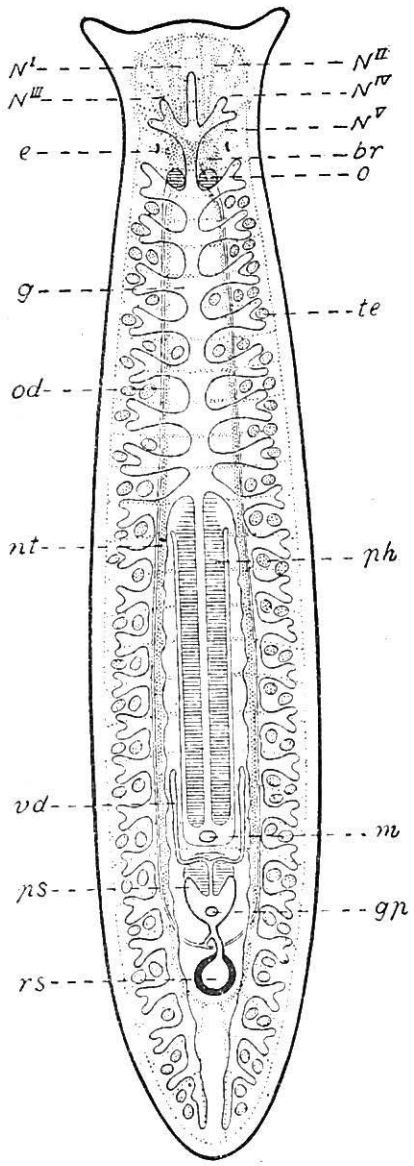
Excretory System.

Of the excretory canals I have been able to obtain no more insight than a few loops at some points in the dorso-lateral parts of body. So far as my observations go, the system in *Pr. lactea* appears to exhibit an arrangement that is generally characteristic of *Procerodes*. Dorsally there exist two main vessels on either side of tho body which are directly connected with one another by means of anastomosis, thus presenting an irregular network. The main vessels send out at various points numerous ducts generally perpendicular to the surface, which open to the exterior at between the epidermal cells. Generally an epithelium seems to be present in the ducts, but in some cases the wall is not sharply differentiated from the surrounding parenchyma. In sections I have seen no evidence of a definite epithlium.

Nervous System.

The nervous system of the species, upon which my observation was based, agrees in the main parts with that of other Triclads and is represented by the central parts consisting of the brain and the longitudinal trunks as well as by the peripheral part.

Each longitudinal nerve trunk gradually widens anteriorly and passes over a brain mass, those of both sides being connected by a number of strong commissures. So far as I have examined, the morphological point of distinction between both the central parts could not be ascertained with ease, but it seems probable that "die Abzweigungsstelle der sog. vorderen Längsnerven" presents such a point, as pointed out by Böhmig. The brain has the same appearance as that of other Triclads, but



Text fig 1. *Procerodes lactea*. Diagrammatic representation of the organization of an entire worm, as seen from the dorsal side.

br brain, *e* eye, *g* gut, *gp* genital pore, *m* mouth, N^I–N^V sensory nerves arising from the brain, *nt* longitudinal nerve trunk, *o* ovary, *od* oviduct, *ph* pharynx, *ps* penis-sheath, *rs* receptaculum semins, *te* testis, *vd* vas deferens.

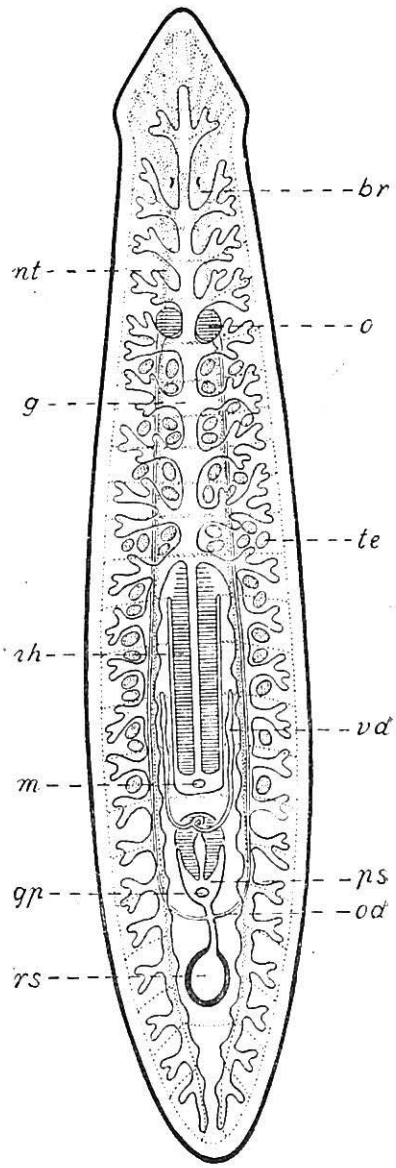
it is subject to variations to some extent in different species and genera.

Brain.—Pr. lactea (Text fig. 1). The brain is formed on the same plan as that of *Pr. ulvae*. Each half, connected with its fellow by three strong commissures, is nearly of a pyramidal shape, and consists, as usual, of three ganglia. From each brain mass arise some six sensory nerves directed forwardly and laterally. The innermost nerve (N^I), taking its origin at the anterior corner of the brain mass, proceeds forwards on the ventral side just inside the dermal musculature. Laterally following to this is present the second nerve (N^{II}) which proceeds forwards and appears to stand in connexion with the dorsal longitudinal trunk on the marginal nerve, much as in *Pr. ulvae*. The following third and fourth nerves (N^{III}, N^{IV}) branch repeatedly and extend anteriorly to the tentacular region. Besides, among the other two sensory nerves given off from the lateral part of the brain mass, the anterior (N^V) pursues a course laterally directed, and the posterior reach the eye. Furthermore, immediately below

the innermost nerve N^I, so that the definite distinction could not be demonstrated with any satisfaction to myself, there exists the fine anterior longitudinal trunk which is continuous with the posterior trunk. Those of both sides are connected together by three fine transverse commissures in the brain region. Anterior to these there are present at least four transverse commissures between the trunks. Lateral nerves are given off from the points of insertion of the commissures in the longitudinal trunk, and proceed, without branching, to the body-margin, where they join the marginal nerve plexus.

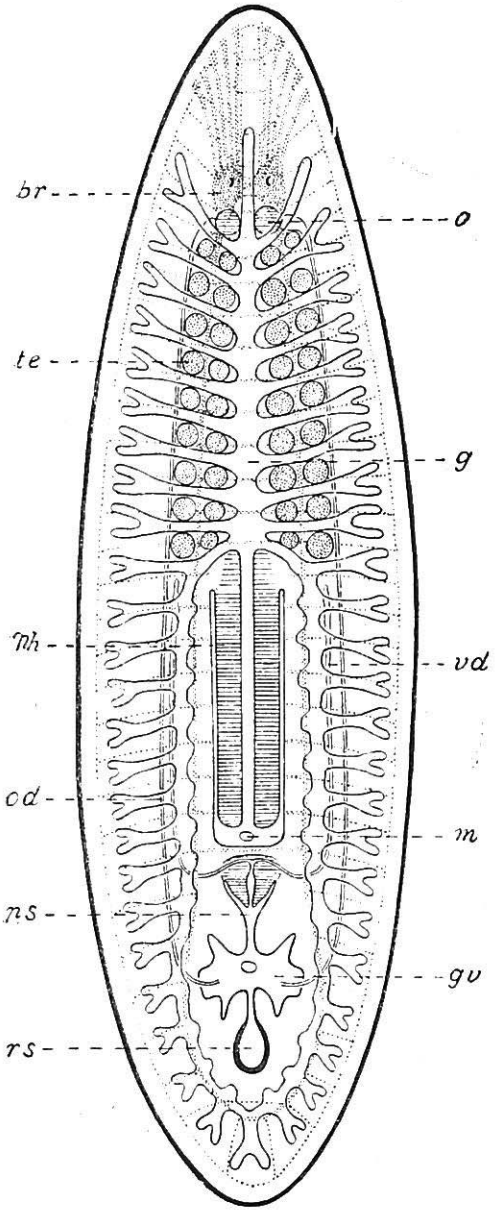
The dorsal nervous system seems to have in the brain region the same appearance as in *Pr. ulvae*. However, nothing more than three lateral nerves could be brought under observation.

St. trigonocephala (Text fig. 2). The material of this species is in a state unfit for close study, hence I will limit myself to a general appearance of the brain. The brain lies fairly far behind the anterior body-margin, unlike the other forms, and has the same appearance as in the preceding species. The right and left halves of the brain are connected by three strong commissures. Each brain mass gives rise to at least



Text fig. 2. *Stummeria trigonocephala.* Diagrammatic representation of the organization of an entire worm, as seen from the dorsal side.
Index letters as in text fig. 1.

five sensory nerves which break up into branches, as they proceed towards the anterior body-margin. Besides, from the postero-lateral region of the "Substanzinsel" arises a nerve extending to the eye. The arrangement of the anterior longitudinal nerve trunk seems to be quite similar to that of the preceding, and some, at least seven, fine transverse commissures occur between the trunks of both sides in front of the three commissures found immediately beneath the brain.



Text fig. 3. *Ectoplana limuli*. Diagrammatic representation of the organization of an entire worm, as seen from the dorsal side.
gv genital vestibulum.
Other letters as in text fig. 1.

Ect. limuli (Text fig. 3; Pl. I., fig. 6). The brain conforms closely to the type found in *Bd. candida*. Of interest is the presence of a fine transverse commissure (*nx*) immediately anterior to the ordinary strong commissures of the brain. From each brain mass arise five sensory nerves, excluding the optic nerve. The anterior longitudinal trunks (*na*) are connected together by a few transverse commissures (*nc*), at

least six in number, throughout their whole length, straight from trunk to trunk. Unlike the preceding two species there exist no three special transverse commissures in the brain region. From the main trunks, at points of insertion of the transverse commissures in the trunks, are given off lateral nerves (*nl*), which join the marginal nerve plexus (*nm*). The dorsal longitudinal nerve trunks appear to take their origin from the marginal nerve at points of exit for the ventral anterior longitudinal trunks, and pursue a backward course directly below the sheet of the dermal musculature. They are connected together by a number of transverse commissures and with the marginal nerve by the same number of lateral nerves, quite similar in appearance to the ventral anterior longitudinal nervous system.

Crowded around the fibrillous mass of the brain are numerous large nuclei containing ganglionic cells easily stainable. The cellular coating is generally much thicker on the ventral than on the dorsal side. The sensory nerves are also seen with their setting of ganglionic cells, which are generally either unipolar or more commonly bi- or multipolar. Each brain mass is invaded by a peculiar tissue well known as "Substanzinsel", which consists for the most part of the ganglionic cells beset with connective tissue and is traversed by some dorso-ventral muscular fibres.

Posterior Longitudinal Nervous System.—As usual, there exist three pairs of longitudinal nerve trunks, viz., ventral (*nt*), dorsal and lateral (*nl*). Of these the ventral trunks are the most important and are developed to a considerable extent. Behind the brain they generally proceed, running nearly parallel to each other, until near the copulatory organs and then gradually approach to each other. Only in *Ect. limuli*, however, they are separated in the region of the copulatory organs from each other, because of the remarkable enlargement of the vestibulum. The longitudinal trunks are connected together by a number of transverse commissures, straight from trunk to trunk, sometimes with, sometimes without branching in their passage, much like a rope ladder. Some of the commissures are much more well developed than others and these most frequently occur immediately behind the

pharynx and the copulatory organs. The longitudinal trunk of either side is also connected with the marginal nerve of the same side by means of a very regular series of lateral nerves given off usually from the main trunk at points opposite to the union of the latter with transverse commissures. The marginal nerve, forming a plexus, runs all round the body submarginally on the ventral side. Between the transverse commissures and the lateral gut diverticulae there exists no fixed relation in number, so far as my observations go. The number of commissures is, of course, never constant in the different individuals of the same species. In the specimens, from which the figures were taken, the number of commissures, exclusive of those bridging the space between the anterior longitudinal trunks, is shown in the accompanying table.

Species.	Number of commissures.	Length of worms in the preserved state.	Maturity.
Pr. lactea.	26	3.25 mm.	Sexually mature.
St. trigonocephala.	20	3.82 ,,	,, ,,
Ect. limuli.	28	4.53 ,,	,, ,,

The dorsal longitudinal nerve trunks, briefly noted down in the section concerning the brain, proceed towards the hind end just underneath the sheet of dermal musculature. Each is connected on the one hand with its fellow by a number of fine transverse commissures and on the other with the marginal nerve of the same side by means of lateral nerves given off from the trunk, quite like the ventral nervous system. Besides, the connexion between both the dorsal and the ventral nervous systems is effected by means of vertical nerves running dorso-ventrally, as was demonstrated in several species by Böhmig.

The nerves show the somewhat reticulated appearance so commonly described by various authors. Now I have little to add to what has been written in detail by Böhmig. Embedded in the nerves are numerous ganglionic cells at various points.

Sensory Organs.

The organs considered to be sensory organs are the tentacles or the corresponding anterior parts which are devoid of rhabdites as well as pigments and the eyes.

Tentacles.—The antero-laterally directed appendages projecting from the frontal margin are generally shown as tentacles, which are found only in *Pr. lactea* among the species examined by me. Unlike *Pr. ohlini*, the epidermis of this part is composed of normal ciliated cells which always contain no rhabdites and pigments. In *St. trigonocephala* also the epidermis has the same appearance at the anterior end of the body ; while in *Ect. limuli* it is wholly devoid of nuclei which have sunk into the parenchyma just beneath the sheet of the dermal musculature. The minute structure of the cells has already been described in the part dealing with epidermis. No peculiar sensory cell has come under my observation at all.

Eyes.—Generally two eyes lie on either side of the median line on the dorsal surface in the anterior region. They are embedded in the parenchyma. In *Pr. lactea* the eyes are situated at a little distance from the brain mass, but in *St. trigonocephala* and *Ect. limuli* either near or close to it. They are usually of an ovoid or crescentic shape. So far as my observations go, the structure shows no differenee in essential respects from that observed in *Pr. ulvae* by Hesse (28). We can distinguish two elements of which a single eye is formed, viz., the pigment cup and inside the pigment cup the retina cell (Pl. I., fig. 4, *rc*). The pigment cup is composed of only a single cell which shows a crescentic appearance, as recorded by Hesse. On the lateral side of it there exists an ellipsoidal, homogeneous or finely granular plasmic lens layer (*l*). This, in *Pr. lactea* and *St. triganocephala*, is developed to a considerable extent. The nucleus does not occur in the lens layer, but lying just outside the pigment layer, as is shown in fig. 4 (*n*).

In structural respests the retina cell has very nearly the same appearance as that previously observed in several

species. Close to the pigment cup there exist some ganglionic cells, the processes of which on one side proceed towards the brain and on the other pursue a course to connect with the retina cells. The cells number three or four? in *Pr. lactea* and *St. trigonocephala*, but two only in *Ect. limuli*. As stated by several authors, they exhibit generally the fibrillous structure. In the proximal part of the retina cones are seen very weakly stainable fibres, which show a decreasing affinity for stains as we recede from the proximal part. The fibres are at length connected with "Stiftchen" which is deeply stainable.

Reproductive System.

Male Organs.

The male organs are composed of the testes, the vasa deferentia and the penis.

Testis.—In the marine Triclads there is a wide degree of variation in the number of testes. Böhmig describes in *Pr. ohlini* and *Bd. candida* 100–150 on either side of the body; while Wilhelmi (71) records in *Cerbussowia cerruti* only a single pair of them, the smallest number of which I have found any record. Among the species examined, *Pr. lactea* bears 58 testes on either side, *St. trigonocephala* 30–35, the average number being 32, and *Ect. limuli* 18.

The testes show a considerable variation in position and arrangements. In *Pr. lactea* they are situated in the dorsal part of the body-parenchyma and are arranged in two lateral zones extending from the ovarian region backwards nearly to the body-end. In *St. trigonocephala* they are found lying ventrally not only on both sides of the longitudinal nerve trunks from close behind the ovaries to the insertion of the pharynx, but also posteriorly only on the outer side of the same, ceasing altogether to exist at about the level of the mouth. In *Ect. limuli* they are placed in the ventral part along both sides of the anterior unpaired gut trunk, extending backwards up to the dividing point of the gut trunks. Generally the testes are situated on either dorsal or

ventral side of the body between the successive gut diverticulae, presenting a somewhat metameric appearance.

The testes are usually ovoid or round in form, but sometimes polygonal or lobate, as the case may be, they being subjected to more or less pressure against one another. The fully grown testes are in every way like the typical follicles of the Triclads. In *St. trigonocephala* they are comparatively small. Each testis is bounded directly by a thin layer, the tunica propria, which assumes the character of fibrous tissue, and is beyond doubt to be differentiated from the parenchyma, as mentioned by Böhmig. In the first stage of development the testes appear as spherical clusters of cells, which by division increase in number and arrange themselves in the form of the follicles, normally packed full of sperm-mother-cells and spermatozoa in all stages of development. Numerous cells, each containing a large nucleus, are arranged in a single layer on the wall of the testis; they are loosely opposed to the parenchyma.

Vas Deferens.—The wall of the capsular testis gives rise to the epithelium of the fine duct, by which the spermatozoa reach the vas deferens. Generally two types may be distinguished in the mode of communication of the testes with the vasa deferentia, according to the position and arrangement of the testes. In the first type, the testes communicate almost directly with the vasa deferentia; while in the second type, they open into the latter by means of fine testicular canals.

In *Pr. lactea* each testis, occupying a dorsal position in the body, gives rise, on its lower side, to a fine testicular canal or vas efferens. The vasa efferentia proceed between the gut branches, frequently uniting together to form somewhat wider ducts, and then take a course directed towards either of the vasa deferentia. They are more or less distinctly visible only when filled up with spermatozoa. In *St. trigonocephala* and *Ect. limuli*, from each testis lying ventrally arises a short vas efferens which soon unites with its fellow of the opposite side to form vasa deferentia.

The vasa deferentia proceed backwards in *Pr. lactea* and *St. trigonocephala*, along the inner side of the longitudinal nerve-

trunks on the ventral side, while they run in *Ect. limuli* just outside the latter. Generally the two vasa deferentia pursue a somewhat winding course, gradually widening as they proceed, and finally uniting in the upper part of the penis-bulb. In their course they are always filled up with spermatozoa and thus are sharply marked off from the surrounding tissues.

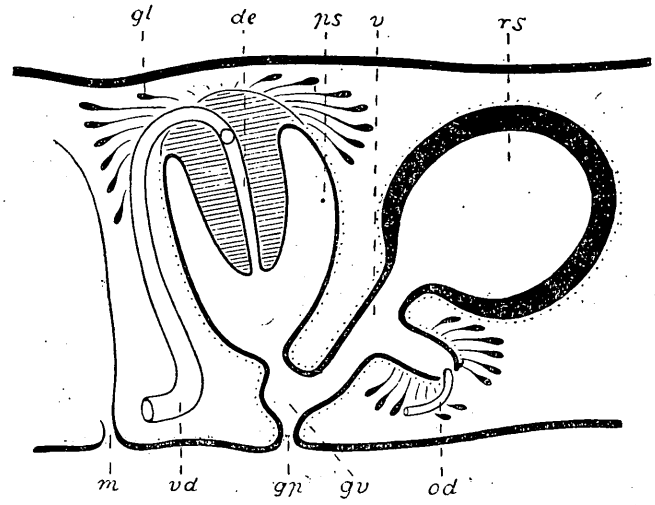
The inner wall of the vas efferens and deferens is formed by a single layer of definite epithelial cells which are usually cubic or flattened, and the protoplasm of which is very finely granular; but not vacuolated. As usual, the epithelium exhibits at intervals some ovoid nuclei deeply stainable. No trace of cilia could be detected at points of exit for the vas efferens from the testis. Directly external to the epithelium is a delicate layer of circular muscular fibres.

Penis.—The penis consists of the bulbous part and the conical intromittent part which is vertically or subvertically disposed in the penis-sheath. No chitinous stylet is present at all. The bulb is comparatively less developed in the species examined than in any freshwater planarians.

In *Pr. lactea* (Text figs. 1, 4.) the vasa deferentia unite in the penis bulb into a slender duct, the ejaculatory duct, which opens at the tip of the penis, without assuming the character of widening, much as in *Pr. ulvae.* In *St. trigonocephala* (Text fig. 2, 5) they fuse in the blub to form a single slender duct, the vas deferens impar, which stands in connexion, as in *Pr. jaqueti*, with a moderately distended and smooth-walled vesicula; the vesicula gradually narrows into the ejaculatory duct as it proceeds towards the apex of the penis. Such similar feature are also found in *Ect. limuli.* Beyond the point of union of the vasa deferentia, a short common duct enters at once into a wide lumen which is, however, more or less narrow as compared with that of the preceding species.

The lining of the penis lumen is an epithelium composed of cuboidal or cylindrical cells. As is well known, embedded in the parenchyma around the penis are a number of the glands which open into the penis-sheath over the surface. Directly external to

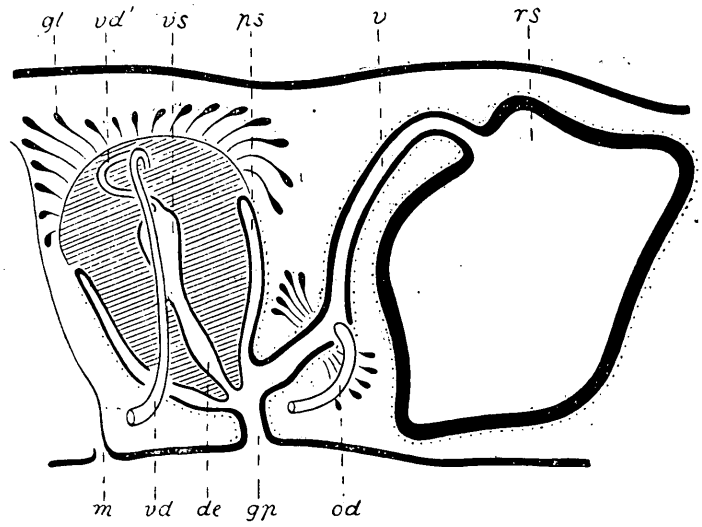
it there exists a muscular layer of circular fibres which are more well developed in the part of the ejaculatory duct than in the part



Text fig. 4. Diagrammatic copulatory organs of *Procerodes lactea* in sagittal section.
de ductus ejaculatorius, *gl* gland, *v* vagina.
Other letters as in text figs. 1 and 3.

of the vas deferens impar. Besides, the minute structure of the intromittent part shows no difference in any essential respects, from what has hitherto been described. As usual, the penis is externally covered with a thin layer of normal cells, which is continuous with the lining epithelium of the penis-sheath, while in *Ect. limuli* the epithelium is devoid of nucleus at all. Immediately beneath the epithelium there exist two muscular layers of strongly developed circular and longitudinal fibres. Between the external and the internal muscular layer there is a zone of a mass of the connective tissue, which is traversed by feeble radial muscular fibres. A number of nuclei regarding as either myoblasts or nuclei of the connective tissue lie arranged directly below the external muscles. These, I believe, for the most part, to be cells that have produced the muscular fibres. The penis bulb

consists generally of a reticulated, fibrous connective tissue which is traversed by variously directed muscular fibres. Embedded in



Text fig. 5. Copulatory organs of *Stummeria trigonocephala* in sagittal section, diagrammatically shown.
vd' vas deferens impar, *vs* vesicula seminalis.
Other letters as in text figs. 1 and 4.

the body-parenchyma around the penis are numerous penis glands which enter the penis at the base to open its cavity.

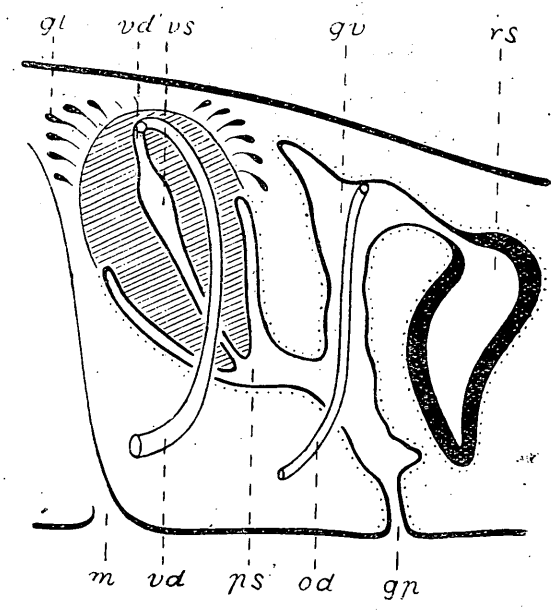
Female Organs

The female reproductive organs are composed of the ovaries, the oviducts, the vitelline glands, the receptaculum seminis and the vagina.

Ovary.—The paired ovary is of a rounded or ovoidal shape, and is placed in *Pr. lactea* between the first and the second anterior lateral branch, in *St. trigonocephala* between the fourth and the fifth diverticula and in *Et. limuli* usually immediately in front of the first branches. In both the first and the last named

species they are closely opposed to the brain, while in *St. trigonocephala* they are situated a little farther behind the brain. Besides, no special organ known as paraovarium is present.

The ovary is a solid mass of germ cells in several stages of development and is enclosed by a delicate membranous capsule of connective tissue, the tunica propria, which exhibits no sign of cellular structure or of distinct epithelium; the unripe ova are found in the anterior part and the more developed ones in the postero-lateral part, whence the oviduct takes its rise. Between the ova there exists a mass of protoplasm in which small nuclei are embedded. As was mentioned by IJIMA (29), CHICHKOFF (11), v. GRAFF (24), BÖHMIG and others, these protoplasmic masses probably represent undeveloped germ-cells. It may be that these act as nutritive cells, the products of which pass into the ova. Judging from the relative size, the ova become gradually larger and larger in all the dimensions. The nuclei become remarkably large and vesicular, the chromation granules become more and more undefined, and a distinct nucleolus makes its appearance in each nucleus. In the mature state the protoplasm is very finely granular and very conspicuous around the nucleus.



Text fig. 6. Copulatory organs of *Ectoplana limuli* in sagittal section. Diagrammatic.
Index letters as in text figs. 1, 3, 4 and 5.

Vitelline Gland.—The vitelline glands are represented by cel-

lular cords with the cells arranged in one or more rows; they are very extensively distributed posteriorly from the region of the ovaries and in the interstices between the gut diverticulae medially to the testes, so that there seems little room left for parenchyma. The cell cords stand in connexion with the oviduct at numerous points throughout the whole length.

In structural respects the vitelline gland is in all the species quite similar and is very simple. Unlike the ovary the organs are not surrounded by a definite membrane, the tunica propria. The vitelline cells are arranged close together, and in sections the cell-boundaries can be clearly made out with ease. The cell in the fully grown state is very large, and contains an ovoid or spherical nucleus, the latter being small in proportion to the size of the cell. There exist numerous highly refractive granules in the protoplasm, increasing in number as the growth of the cells proceeds, till eventually, when the cells have attained their full size; they form a relatively large proportion of the cell mass.

As to the function of the gland I am not in a position to make any assertion, but as is well known, they furnish in all probability not only the necessary nutriment for the embryo but also the substance of the cocoon.

Oviduct.—In *Procerodes* the oviduct generally starts on either side from the postero-lateral surface of the ovary. They proceed straight backwards along and just outside the longitudinal nerve cords, turning towards the median line in the region of the vagina and, finally, in *Pr. lactea* (Text figs. 1, 4), opening directly into a small outbulging of the vagina at the postero-inferior aspect and, in *St. trigonocephala* (Text figs. 2, 5), opening immediately into the vaginal canal at the postero-inferior portion. But in *Ect. limuli* the course of the oviduct and its relation to the ovary are very different, (Text figs. 3, 6; Pl. I., fig. 7). After leaving the ovaries at the outer-lateral part, they proceed backwards at a considerable distance outside the longitudinal nerve trunks, and then, in the region of the genital vestibulum, are directed towards the median line mounting dorsally at the same time and open into the vestibulum at the supero-lateral portion.

As at first described by STOPPENBRINK (57), three portions can generally be distinguished in the oviduct, viz., a foremost swollen portion designated by the name of the tuba, a middle portion receiving the vitelline glands at numerous points and a hindmost portion.

As is well known, the oviduct of each side starts from the postero-lateral aspect of the ovary as an ampullaceous passage filled with spermatozoa. There exists no direct communication on the boundary between the oviduct and the tuba, where "Schlussplatte" in the sense of BÖHMIG is formed. It always presents a well defined lumen and is, as in most species, lined with an epithelium of cylindrical cells, each of which shows at the base an ovoid nucleus. Internally the epithelium is seen to be uniformly covered with cilia. A large number of spermatozoa completely fill up its lumen. So far as my observations go, however, no trace of spermatozoa could anywhere be detected in the ovary.

The occurrence of sperm-masses in the tuba has convinced me that the spermatozoa introduced by the act of copulation from one individual into the receptaculum of another may perhaps be enticed by a certain chemotactic stimulus into the tuba, after leaving the receptaculum. As mentioned by STOPPENBRINK, MICOLETZKY, BURR and others, the tuba appears to function as a kind of the receptaculum. It is beyond doubt within the lumen of the tuba that fertilization takes place.

The tuba soon assumes the character of a narrow tube, which stands in connexion with the vitelline glands at many points through the whole length. The mode of their connexion presents no difference from that observed by BÖHMIG, and the vitelline glands are connected by means of a short funnel-like stalk with the oviduct.

In *Pr. lactea* the oviducts open behind the vagina into a common root, like in *Pr. lobata*, which presents the appearance of a small outbulging of the vagina, being directly marked by numerous eosinophil glands. In *St. trigonocephala*, although in some cases a tendency to such outbulging is observable, they generally open separately into the vagina, and are lined by an in-

sunken epithelium for a short distance before the opening (Pl. I, fig. 5). Numerous glands make their passage to the lumen of the vagina just inferior to the point where the latter receives the oviducts. In *Ect. limuli* the hindmost part of the latter receives the openings of the glands before opening into the vestibulum.

The lining epithelium of the oviduct is generally composed of normal ciliated cells with the exception of the proximal part of the same in *St. trigonocephala*, as described just above. Immediately outwards to the epithelium there exists a feeble muscular layer of circular and longitudinal fibres.

Receptaculum Seminis (*Uterus*). In one receptaculum-bearing marine Triclads, except *Uteriporus*, the receptaculum always lies behind the male organ. In *Pr. lactea* it is a spherical sac-like organ lying dorsally in the parenchyma, and it is lined with an epithelium of large cuboidal cells, which usually possess an avoid nucleus closs to the base. The appearance of the cells varies much with the state of their secretory activity; at the basal portion the protoplasm is usually homogeneous and deeply stainable, while at the distal portion it is vacuolated in consequence of the discharge of the secretory product. The cells rest upon a delicate basement membrane, beneath which are fine circular and longitudinal muscles. In *St. trigonocephala* the receptaculum is a large sac-like organ which is lined with a relatively thin epithelium, showing either uniformly homogeneous or very finely granular appearance. The nuclei are present near the base. In immediate contact with the epithelium is a fine basement membrane outwards to which comes a muscular layer, quite similar to that of the preceding. In *Ect. limuli* this organ is moderately large, of a somewhat conical shape, and the fairly thick wall presents an aspect closely similar in structure to that of the preceding species.

Upon the nature of the so-called uterus different views have been held by different authors. The latest view is that the organ is a seminal receptacle. In a few cases in *Pr. lactea* this organ contains spermatozoa in considerable quantity, which are enclosed by coarse granules. In the case of the other species it was

found to be filled with a granular substance, evidently the secretory product of the uterine wall. Besides, I have nowhere been able to find out ova and yolk cells. In my opinion, this organ has perhaps no functions in connexion with the union of the sexual elements and also with the formation of the cocoon, but it seems doubtless to act as a seminal receptacle. As already stated, it seems beyond doubt probable that fertilization takes place in the lumen of the tuba of the oviduct. I think, therefore, I am justified in showing the organ in question as the primary seminal receptacle against the tuba. As to the function of secretion of the uterine wall, it is difficult to account for the presence of a secretion in the uterus unless it serves as a nutrient medium for prolonging the activity of the male elements.

Vagina.—In *Pr. lactea* the vagina arising from the anterior part of the receptaculum runs anteriorly and obliquely downwards to join the vestibular part of the genital atrium from behind, and undergoes a small outbulging at the postero-inferior part. Its wall is of cuboidal cells resting upon a fine basement membrane, just outside which there exist internal circular and external longitudinal muscular layers. As I have already stated, the wall of the outbulging is perforated by the efferent ducts of the eosinophil glands, which are scattered in sparse numbers in the parenchyma around the same.

In *St. trigonocephala* the receptaculum give rise at its antero-superior part to the vaginal canal which runs down to open into the genital atrium from behind. As is shown in fig. 5 (Pl. I), the vagina has special epithelial cells in the wall, each being wholly destitute of nucleus. In sections the cell-boundaries can be clearly made out, being cuboidal. The epithelium rests upon a delicate basement membrane, exterior to which are distinctly seen the strong circular and weak longitudinal muscles. Moreover, outside the muscular layers there exists a cellular coating which probably partly represents the insunken parts of the lining epithelium. Processes from the cells are occasionally seen to extend to, and to join the epithelium. The vaginal part just inferior to the point where it receives the openings of the oviducts is

always distinctly marked by numerous eosinophil glands which open into its lumen.

So far as I have observed, the vagina is not very conspicuous in *Ect. limuli*, and the uterus opens almost directly into the postero-superior part of the vestibulum by a very short, narrow stalk, which may perhaps represent the vagina.

Genital Atrium.—Before proceeding further, I shall in the first place proceed to state as to the genital aperture. As already noted down, it in *Pr. lactea* is situated at a distance behind the mouth equal to about one-fifth that between the latter and the posterior body-end, in *St. trigonocephala* a little in front of the middle between them and in *Ect. limuli* in front of the middle of the posterior third of the body. The opening is lined by a ciliated epithelium continuous with that of the body. In *St. trigonocephala* and *Ect. limuli* some eosinophil glands open out on the ventral body-surface around the genital opening.

The aperture leads into an atrial cavity, which may be distinguished into two portions, viz., a penis-sheath and a vestibulum, the general structure of which it will be necessary to describe here, beginning with the penis-sheath.

Penis Sheath.—The lining epithelium of this is continuous with that of the penis ; in *Ect. limuli* it shows no nuclei, which are apparently displaced just beneath the muscular layer. Usually the epithelium rests upon a delicate basement membrane, outwards to which come two muscular layers of internal circular and external longitudinal fibres. In *St. trigonocephala* the cavity soon opens to the exterior by way of the minute aperture; while in *Pr. lactea* and *Ect. limuli* it communicates with the vestibulum.

Vestibulum.—In *Pr. lactea* this is a moderately distended cavity situated just inferior to the penis-sheath, and apparently separated from it by a constriction. The wall presents quite or almost the same appearance with that of the penis-sheath. *St. trigonocephala* shows an aspect quite like *Pr. ohlini*, and no special vestibular part is present in it.

The vestibulum presents in *Ect. limuli* the most peculiar aspects. It is a deep and wide cavity, which ascends vertically up

to immediately below the dorsal body-wall and undergoes laterally very irregular and complicated outbulgings, but always showing a bilateral symmetry, as is shown in figs. 7, 8 (Pl. I). I regret I am not able to demonstrate its form with adequate thoroughness.

The wall presents nothing peculiar. The inner wall is, except near the genital aperture, formed of a single layer, with wide variations in thickness in different parts, and exhibiting no nuclei at all. In certain portions the lining may be sufficiently distended to cause a virtual disappearance of the epithelium so that the underlying basement membrane or muscles abut directly on the cavity. A similar condition has been demonstrated by LANG (37) in the penis of *Yungia aurantiaca* and by LUTHER (41) in the atrium copulatorium of *Castrada segne*, in the bursa copulatrix of the Mesostomidae, etc. Immediately external to the epithelium there is a strongly developed muscular layer which also varies in thickness in different parts, and seems to be much thicker on the hind wall than elsewhere. It is, although I am not able strictly to say the kinds of the muscular fibres, for the most part composed of three sets of fibres, viz., internal circular, middle longitudinal and outermost circular, of which the middle circular layer is developed to a considerable degree. Externally the muscular coat is surrounded by numerous pyriform cells which perhaps represent partly the insunken parts of the lining epithelium and partly unicellular glands. Moreover, around the vestibulum muscles are developed to a considerable extent, which leave the wall in various directions, passing through the body-parenchyma (Pl. I, fig. 8). Now, from the morphological point of view I have come at length to the conclusion that the vestibulum of *Ect. limuli* is quite homologous with the vagina of *St. trigonocephala*.

In the Turbellaria we thus find an epithelial transformation leading to the condition in the Trematodes and Cestodes, in which the epithelium has been replaced by a thin refractive membrane or a cuticula. This fact, I believe, points out beyond doubt the probable homology between the Turbellarian epithelium or epidermis and the Cestode cuticula.

Biology.

Habitat.—Among the species examined, *St. trigonocephala* always occurs beneath stones or other sunken materials in the estuary of rivulets, where the water is entirely fresh, during ebb tide. The resting position of the worms, with their ventral surface uppermost, would seem to indicate a negative response to gravity, since when moving they may be in any position, depending upon the particular surface over which they happen to be gliding. The worms are very sensitive even to a slight irritation. The specimens contained in a glass dish, when jarred even very slightly, instantly stop, contract and remain immovable. They usually wander to a dark place. It is due perhaps to this property that the parasitic planarians never willingly leave their host animal.

In the course of the past year six parasitic species were recorded, which may be divided into two categories according to their relations to the host, viz., permanent parasitism and commensalism (pseudoparasitism). The species brought under the category of true parasitism is *Micropharynx parasitica* JÄGERSKIÖLD (32), which lives attached to the dorsal surface of the body of *Raja clavata* and *batis*. Regarding the habits of this species, however, no further report has, up to the present, appeared. The species brought under the category of commensalism are the worms which attach themselves firmly to the cephalothoracic appendages or to the gill-books of *Limulus*, such are *Bd. candida*, *Bd. wheeleri*, *Bd. propinqua*, *Syncoelidium pellucidum* and *Ect. limuli*. In general, these worms have long been regarded as true parasities which bring about the fall of the cephalothoracic appendages as well as of the gill-leaves, injuring the skin of the articulation. WILHELMI (69), however, has considered the question from a purely experimental point of view, and has come to the conclusion that these worms are not true parasites of *Limulus*. They do not apparently feed on any part of the host's body. So far as I have examined, any trace of injury caused by the parasites could nowhere be found on the skin of the articulation of *Limulus*.

They seem undoubtedly to content with the crushed remnants of food which may be floating in the water, or remaining between the spines of the segments, after feeding of the host animal. On the whole they are, as mentioned by WILHELMI, best regarded as commensal form.

Over 50% of *Limulus longispina* are always infested with a large number of *Ect. limuli* which lives attached chiefly to the proximal segments of the cephalothoracic appendages and to the gill-books, much as does the other ectoparasitic Bdellourid-species. According to Professor KISHINOUYE's statement they occur in large numbers confined to the three hindermost pairs of the cephalothoracic appendages, without wandering to the gills. However, my own observation, which is based upon *Limulus* collected by myself at Yobimatsu, in the province Bizen, shows beyond doubt the occurrence of the worms on the gill-books and other parts. They are not confined to the legs only. When present, they are very abundant, numbering more than one hundred in two specimens of *Limulus* examined.

Bdelloura and *Syncoelidium* all deposit their cocoons on the gill-lamillae of their host, *Limulus*. *Bd. candida* seems to show no preference for a particular region of the gill-books, but scatters its cocoon over the whole ventral surface. *Bd. propinqua* selects the basal, or proximal region of the leaf, while *Syn. pellucidum* prefers a small area near the edge, 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. These Limulus-infesting worms also differ in their time of breeding. *Bd. candida* oviposits during May and early June, *Syncoelidium* in the later part of July; *Bd. propinqua* appears to breed at the same time as the latter. I have not been able to discover the breeding time of *Ect. limuli*, but egg-laying seems to take place on the gill-lamellae of the host during July, because I have found the half-grown young of the parasites in abundance on the gills in the early part of August.

As stated by WILHELMI (69, 70, 71), it seems probable that the passage of the parasites from one crab to another can occur

only during copulation. The limulus deposits its eggs chiefly in August. On calm nights during that month, males and females, the former on the abdominal shield of the latter, return with the rising tide from the deep water towards sandy shores to breed; egg-laying taking place between the tide marks. This meeting of the sexes doubtless affords the parasites a good opportunity to shift from one host to another.

I will now give some general remarks of the parasitism of these animals. *Micropharynx* is regarded as a true parasite and is wholly destitute of eyes. The body-shape is that of the blade of an ovate leaf, the posterior end being often obliquely truncated and exhibiting some small folds on the inferiorly turned edge, which is more or less distinctly marked off, but shows a great variation in appearance. The worms are very firmly attached to their host's body by means of the caudal disc. In the limulus-infesting Bdellourids the body is generally lanceolate, the posterior end being truncated. The posterior portion known as the caudal adhesive disc is generally distinctly marked off by a constriction of the body from the anterior. While *Ect. limuli* is of a slender body which is entirely devoid of any such distinct part or organ as the special caudal disc mentioned just above. The worms, however, are able to adhere with surprising firmness to the surface of the host's body by means of slime which is being constantly secreted on the ventral surface of the body, especially on a narrow zone completely surrounding the body just within the lower ventral edge. Quite a considerable effort is required to displace them. When removed by means of a spatula together with the mud which is usually present on the ventral surface of *Limulus*, they adhere to the spatula so firmly that they cannot be washed away with ease. Their movement is rather ponderous, due to the powerful nature of their slime, as compared with that of the other species. They never leave the host of their own accord.

Among the limulus-infesting species, *Bd. propinqua* contains but a few rhabdites in the epidermis, while in the case of *Bd. candida*, *Bd. wheeleri* and *Syn. pellucidum* the epidermis is wholly destitute of them. Hence Wilhelmi (70) has come to the conclu-

sion that such a reduction of the rhabdites is a special adaptation; I shall now quote his own words. He says, "Die Rückbildung der Rhabditen korrespondiert mit meiner Annahme, dass die Rhabditen Schutzorgane sind, die auf Druck aus dem Epithel heraustreten. Offenbar sind sie bei den Bdellouriden, die geschützt auf der konkaven Bauchfläche und zwischen den Kiemenblättern des Limulus leben, infolge Funktionslösigkeit zurückgebildet worden." However, the fact that the epidermis is in *Ectoplana* and *Microparynx* always full of minute rhabdites lends probability, in my opinion, to the view that his hypothesis cannot be regarded as a perfect truth. Of course, I believe that the rhabdites are of use to the animal for protection.

Locomotion.—Like the other planarians, the freely living or parasitic worm is very active in its movements, creeping with steady, rapid motion over smooth surfaces, crawling after the manner of geometer caterpillars, or swimming on the surface of the water.

Gliding is the most usual mode of progressive movement when the worm is not disturbed, and so far as I have been able to observe, it is a combined reaction, brought about partly by muscular rhythmic, wavy motion of the ventral body-wall and partly by the action of the cilia in the mucus layer between the ventral surface of the body and the surface of which they are moving, the thin layer of mucus being secreted constantly.

Crawling is induced only when the animal is stimulated in certain ways, and of course, takes place by a successive alternation of the active muscular contraction and stretching. The ventral surfaces of the anterior and posterior regions of the body act like suckers as the worm loops. While the anterior end holds, the posterior is freed and then drawn up. Such looping fashion was particularly well observed in *Ect. limuli.*

Although certain species of Rhabdocoele can freely move by the ciliary reaction through the water, such a swimming is never seen in the Triclads. However, our forms, with their ventral surface uppermost, are able to creep along the water surface. This sort of movement seems to be brought about by the action of the

cilia, turning to account a large amount of mucus and the surface tension of the water. The mechanism may perhaps be equal to that of gliding, and the surface tension of the water serves for the purpose of a substratum. The movements of the parasitic worm seem to be slower in comparison than those of the freely living forms. This is, I think, due to a great amount of powerful mucus.

Note on the Classification of the Maricola.

Böhmig (5) was the first who founded a more rational classification of the marine Triclads in general. According to the features of the genital organs, he has at length distinguished seven well-established genera into two families and five subfamilies as follows: —

1. Fam. Procerodidæ.
   - i. Subfam. Euprocerodinæ, *Procerodes*.
   - ii. Subfam. Cercyrinæ, *Subussowia*, *Cercyra*.
   - iii. Subfam. Micropharynginæ, *Micropharynx*.
2. Fam. Bdellouridae.
   - i. Subfam. Uteriporinæ, *Uteriporus*.
   - ii. Subfam. Eubdellourinæ, *Bdelloura*, *Syncoelidium*.

Later, he (6) brought under the Procerodidae a new subfamily Stummerinæ for receiving a new genus *Stummeria*.

Then, Wilhelmi (71, 73) published an important paper on the marine Triclads, in which he classifies them according to a new system as in the following: —

1. Fam. Procerodidæ. *Procerodes*, *Stummeria*.
2. Fam. Uteriporidæ, *Uteriporus*.
3. Fam. Cercyridæ, *Cercyra*, *Cerbussowia*, *Sabussowia*.
4. Fam. Bdellouridæ, *Bdelloura*, *Syncoelidium*.
5. Fam. Micropharyngidæ. *Micropharynx*.

As is seen above, the Procerodid-subfamilies instituted by Böhmig were raised by Wilhelmi to the rank of distinct families, making use of some distinctive characters which do not appear to me to be of more than subfamily value. Now, casting a glance at the features of the genital apparatus, it is brought out clearly that

they agree with one another in some respects. The procedure of BÖHMIG, in my opinion, seems to me far more rational than that of WILHELMI, so that I do not hesitate to abide by the scheme which divides the Procerodidæ of BÖHMIG further into three subfamilies—Euprocerodinæ, Cercyrinæ and Micropharynginæ—for convenience' sake.

Now then, as already recorded, an attempt was made by BÖHMIG to divide the Bdellouridæ into two subfamilies, making use of distinctive characters which, to my mind, appear to be of sufficient magnitude to isolate those subfamilies as distinct families —Uteriporidæ and Bdellouridæ—co-ordinate with the Procerodidæ. In this respect the procedure of WILHELMI seems to me very reasonable. As an arrangement of all the previously recorded genera, subject, of course, to modification in the future, I would propose for the present to classify them according to a new system as follows:—

1. Fam. Procerodidæ.
   - i. Subfam. Euprocerodinæ BÖHMIG.
     - *Procerodes* GIRARD.
     - *Stummeria* BÖHMIG.
     - *Ectoplana* KABURAKI.[1]
   - ii. Subfam. Cercyrinæ BÖHMIG.
     - *Cercyra* O. SCHMIDT.
     - *Cerbussowia* WILHELMI.
     - *Sabussowia* BÖHMIG.
   - iii. Subfam. Micropharynginæ BÖHMIG.
     - *Micropharynx* JÄGERSKIÖLD.
2. Fam. Uteriporidæ.
   - *Uteriporus* BERGENDAL.
3. Fam. Bdellouridæ.
   - *Bdelloura* LEIDY.
   - *Syncoelidium* WILHELMI.
   - *Synsiphonium* HALLEZ.

Some principal characters of distinction between all the above

1) As to the systematic position of the genus *Ectoplana* I have already stated in detail in my former paper (33).

groups may be mentioned as in the accompanying diagnostic table:—

I. Receptaculum seminis single.

A. A single genital aperture. Receptaculum seminis situated posterior to the penis . . . . . Fam. Procerodidæ.

a^1. Penis unarmed.

a^2. Vasa deferentia not fusing together to form a common duct before entering the base of the penis. Intestine showing no sign of anastomosis . . . . . Subfam. Euprocerodinæ.

a^3. Freely living.

a^4. Oviducts opening into the vagina by a distinct duct . . . . . Genus *Procerodes.*

b^4. Oviducts opening separately into the vagina . . Genus *Stummeria.*

b^3. Ectoparasitic on *Limulus.*

Oviducts opening separately into the extremely wide, dorsally prolonged vestibulum . . . . . Genus *Ectoplana.*

b^2. Vasa deferentia united together into a single ductus deferens before entering the base of the penis. Intestinal branches anastomose . . . . . Subfam. Micropharynginæ.

Ectoparasitic on *Raja* . . . . . Genus *Micropharynx.*

b^1. Penis pointed or provided with stylet.

Vasa deferentia united together into a common duct before entering the penis, or not united. Oviducts opening separately into the vagina. . . . . Subfam. Cercyrinae.

c^2. Vasa deferentia fusing together to form a single ductus deferens in front of the penis.

c^3. Penis with long stylet. Ovaries placed closely in front of the pharynx-insertion . . . . . Genus *Cercyra.*

d^3. Penis pointed, without stylet. Ovaries situated behind the brain. Adhesive cells lying dorsally at the anterior end . . Genus *Sabussowia.*

d^2. Vasa deferentia or ejaculatory ducts opening separately very near the tip of the penis.

Paired testis placed in front of the insertion of the pharynx. Penis with long stylet. Ovaries nearly midway between the eyes and the pharynx-insertion. Adhesive cells lying dorsally at the anterior end. . . . . Genus *Cerbussowia.*

B. Two genital apertures. Receptaculum seminis situated between the pharynx and the penis . . . . . Fam. Uteriporidæ.

Receptaculum seminis connected by two canals with the oviducts which unite into an unpaired oviduct, before opening into the penis-sheath . . . . . Genus *Uteriporus.*

II. Receptaculum seminis double.

Three genital apertures. Receptaculum seminis opening by distinct ostia lateral

to the longitudinal nerves in front of the penis . . . . . Fam, Bdellouridæ.

A. Ectoparasitic on *Limulus*. Body with a distinct adhesive disc at the head end.

a. Receptaculum seminis saccular; duct arising from its anterior edge. Intestinal branches numbering 24–32. . . . . Genus *Bdelloura*.

b. Receptaculum seminis closely similar in appearance to the preceding; duct arising from its posterior inner surface. Posterior gut trunks uniting soon after hatching and forming an unpaired stem. . . . . Genus *Syncoelidium*.

B. Freely living. Body without any sign of adhesive disc. Receptaculum seminis tubular. . . . . Genus *Synsiphonium*.

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Abbreviations used in the Explanation of Plate.

br. . . . . . brain.
e. . . . . . eye.
g. . . . . . gut.
gl. . . . . . gland.
gp. . . . . . genital pore.
gv. . . . . . genital vestibulum.
l. . . . . . lens.
m. . . . . . mouth.
n. . . . . . nucleus.
N^{I}—N^{V} . . . . . Sensory nerves arising from the brain.
na. . . . . . anterior longitudinal nerve trunk.
nc. . . . . . transverse nerve commissure.
nl. . . . . . lateral nerve.
nm. . . . . . marginal nerve.
no. . . . . . optic nerve.
nt. . . . . . longitudinal nerve trunk.
nx. . . . . . brain commissure.
o. . . . . . ovary.
od. . . . . . oviduct.
rc. . . . . . retina cell.
rs. . . . . . receptaculum seminis (uterus).
si. . . . . . 'Substanzinsel.'
tu. . . . . . tuba.
v. . . . . . vagina.
vd. . . . . . vas deferens.

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PLATE I.

Plate I.

Fig. 1. *Procerodes lactea.* Outline of body in the living state (after the late Professor IJIMA's sketch), about 17×.

Fig. 2. *Stummeria trigonocephala* in the living condition, 10×.

Fig. 3. *Ectoplana limuli* in the living state, 6×.

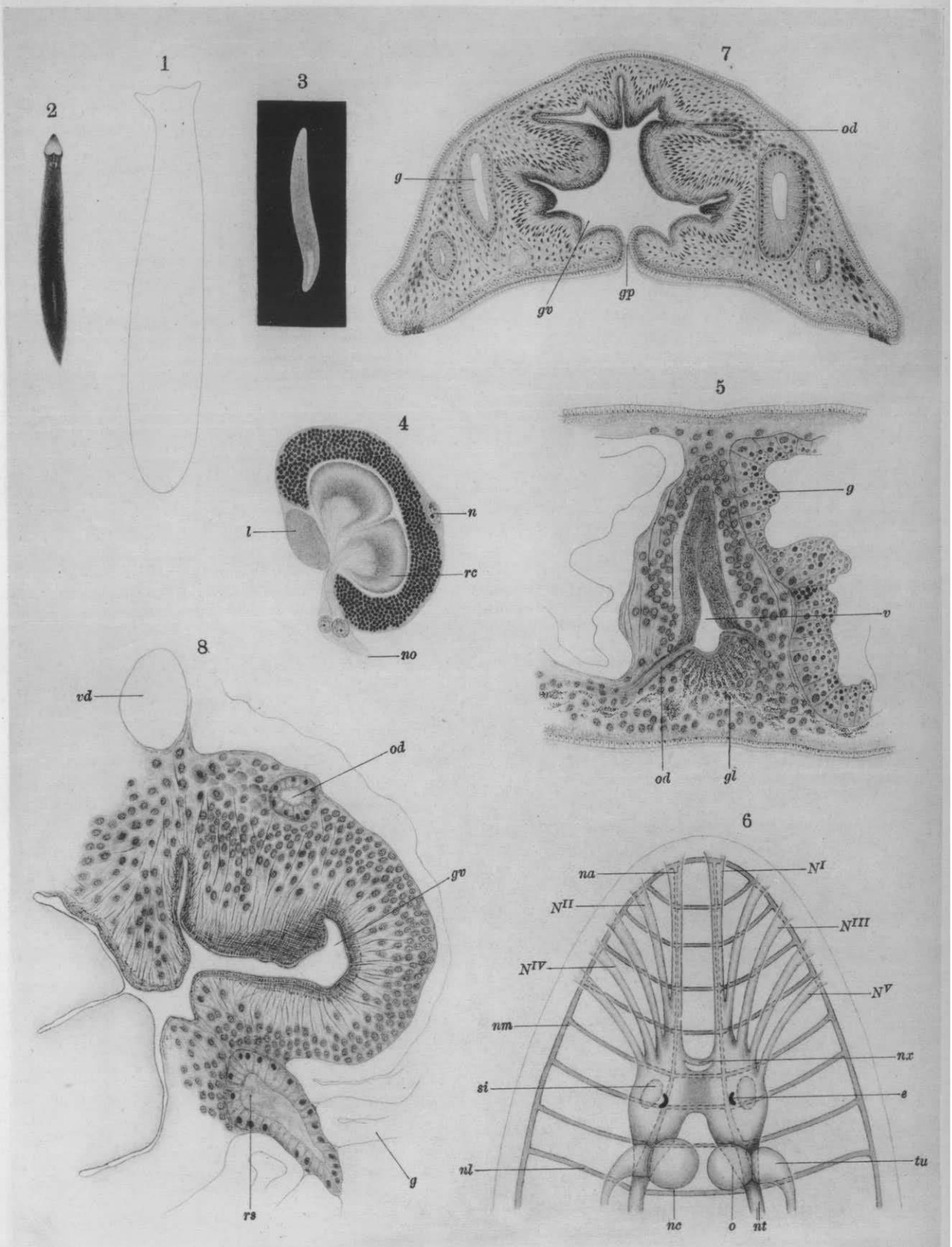
Fig. 4. *Stummeria trigonocephala.* Cross section of the eye, about 900×.

Fig. 5. Ditto. Cross section of body through the opening point of the oviducts into the vagina, 250×.

Fig. 6. *Ectoplana limuli.* Diagrammatic representation of the brain, as seen from the dorsal side, 150×.

Fig. 7. Ditto. Cross section of body through the vestibelum, 150×.

Fig. 8. Ditto. Horizontal section through the sexual organs, 300×.



KABURAKI, del.

T. KABURAKI: Japanese Tricladida Maricola.