日本動物學彙報

第九卷第五册

大正九年一月三十日發兌

ANNOTATIONES ZOOLOGICÆ JAPONENSES.

Vol. IX., Part V.

PUBLISHED

BY

The Tokyo Zoological Society.

TOKYO,

January, 1920.

CONTENTS.

(Published January 30th, 1920).

Notes on *Coeloplana bocki* n. sp. and its development.

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With 5 textfigures.

During the summer of 1918, I have had opportunities of collecting and studying in the Misaki Marine Laboratory a species of *Coeloplana* which lives commensally on stocks of an alcyonacean and which I regard to be new to science. According to verbal communication of Professor Ijima, Dr. S. Bock of Upsala should have discovered, some years ago, specimens of *Coeloplana* on *Nephthya* stocks which were collected and preserved in Misaki and taken over by him to his country. It is then more than probable that the first discovery of the *Coeloplana* in question is to be credited to him. However, so far as I am aware of, the species has never yet been described. Therefore, I take the liberty of calling it by the name of *Coeloplana bocki* in honour of the above Swedish zoologist.

The alcyonacean, on which the *Coeloplana* habitually occurs, represents, in my opinion, a species of the genus *Dendronephthya*. It thrives in fair abundance in the littoral of the neighbourhood of Misaki. Stocks of it harbouring the *Coeloplana* are not at all uncommon. It is not seldom that as many as fifty or sixty individuals of that worm-like coelenterate are taken from one and the same stock of a moderate size. The coelenterate may be found adhering to any part of the stock surface.

Aside from what concerns its habitat, *Coeloplana bocki* may be distinguished from the two *Coeloplana* species (*C. willeyi* and *C. mitsukurii*) previously described by Abbott* from the same locality by the body being on an average much smaller and by peculiarities in colouration as well as in the structure of polar plates. In all other respects, but notably in internal organization, the new species may be said to agree completely with both the species just referred to.

C. bocki commonly measures only about 1.5 cm. in diametre in the fully extended state, although in rare and exceptional cases the body may reach about 3 cm. in diametre. In both the species of Abbott the diametre measures generally 2 or 3 cm. and sometimes even as much as 5 or 6 cm. in the fully distended state Similarly as in *C. willeyi* the colouration of body varies within a wide range, but is characterized by the presence, on the dorsal side, of markings which are generally rather conspicuous. The markings consist of a number of deeply coloured branching and anastomosing stripes which on the whole run side by side in the tentacular direction and may be deep vermilion, dark red, brick-red, pinkish, orange or even greyish in different individuals. The stripes number a dozen or more in large specimens; in the smaller ones they may be discontinuous and irregularly streaky. At all times they grow indistinct towards the margin of body. The ground colour of body is usually similar to that of the stripes though very much lighter in tone. Rarely it is of a colour which more or less contrasts with that of the stripes; as for instance, I have found some cases of individuals, in which it was of an orange hue while the stripes were vermilion. The stripe marking constitutes a feature peculiar to the species; it is found in neither of the previously known species, both which are uniformly coloured, though *C. willeyi* may show small whitish patches confined to base of "dorsal tentacles" and to the margin of body.

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* Abbott, J. F. (1902). Preliminary notes on *Coeloplana*. Annot. Zool. Jap., Vol. IV, p. 103.
Same (1907). The morphology of *Coeloplana*. Zool. Jahrb. Anat., Bd. 24, p. 41.

Another striking distinctive feature of *C. bocki* consists in the peculiar structure of the polar plates. These are provided at their peripheral margin with 2–5 lobe-like processes, which somewhat remind one of those occurring in the same organ of *Ctenoplana*.* In large specimens of *C. bocki*, the occurrence of the processes is nearly constant, though in the smaller ones they may be merely indicated or even altogether absent. In both *C. willeyi* and *C. mitsukurii*, the lobation of polar plates is unknown to me even in largest individuals.

What is of greatest interest is the fact that a number of *C. bocki*, as they adhered on the host, were found to overlie a cluster of eggs which lay in direct contact with the ventral body-surface. The eggs contained embryos in various developmental stages. It was possible to rear up the embryos to an advanced stage in the aquarium. So that, the development of this interesting animal could be followed to a fairly satisfactory measure.

Genital Organs.—The *Coeloplana* is hermaphroditic. The gonads develop in the dorsal epithelial wall of certain canals, eight in number and which represent the meridional gastrovascular canals of pelagic ctenophores. The female gonad arises along the entire length of each of these canals as a linear tract of egg cells, exactly as in the ordinary ctenophore. The male gonad, on the other hand, occurs as separate compact masses of sperm-cells along the same canals, there being 4 or 5 such masses to each subtentacular, and about 2 of same to each subpharyngeal, canal. Each sperm-cell mass or testis is provided with a duct which opens on the dorsal surface of body and without doubt serves for leading out the spermatozoa. A corresponding duct is entirely wanting to the ovaries, the eggs apparently falling into the lumen of the gastrovascular canals to be subsequently ejected through the mouth. Along and close above each ovarial tract, the dorsal body surface forms a series of deep invaginations which are narrowly tubular in the

* Korotneff, A. (1886). Ueber *Ctenoplana kowalevski*. Z. w. Z. Bd. 43, p. 242.
Willey, A. (1896). On *Ctenoplana*. Q. J. M. S. Vol. 39, p. 323.

outer parts but expand terminally into an ampulla-like or somewhat irregular-shaped swelling. The number of the invaginations fluctuates between 7 and 13 to each subtentacular, and between 4 and 8 to each subpharyngeal, canal. Quite frequently, the invaginations, but especially their blind terminal swellings, are seen to contain a large quantity of spermatozoa; so that it is evident that they serve as sperm-receptacles. Where and how the spermatozoa meet the eggs in fertilization is not clear, but possibly they may make their way through the intervening tissues and reach the eggs in the ovaries.

Eggs.—As already indicated the laid eggs are found under the mother animal, agglutinated together by a gelatinous substance, instead of being set free as pelagic objects as in ordinary ctenophores. There they undergo development and reach the stage in which the embryo is completely formed. The number of eggs carried by an individual in the said position is generally from 10 to 50, but may sometimes be as large as 200. All those under one and the same mother individual are nearly in the same stage of development.

Newly laid eggs (Fig. 1) show essentially the same structure as those of pelagic forms. A distinct membrane envelops each egg. Directly within it is a rather narrow space which appears to be filled with a thin gelatinous substance. The size of eggs varies but little. The entire egg as surrounded by the membrane measures in average diametre about 0.3 mm., and the egg-body proper without the membrane 0.25 mm.

As in ordinary ctenophores, the egg-body consists of the ectoplasm (*ec*) presenting a finely granular appearance and of the endoplasm (*en*) showing an alveolar structure. The former occupies the entire periphery in a layer, while the latter in the central parts constitutes by far the greater portion of the entire egg-body. Two polar bodies (*p*) are frequently seen, lying on the surface of the egg-body; they are either spherical or more or less flattened. More rarely, there occur three polar bodies lying side by side, apparently as the result of division of the first polar body.

Fig. 1

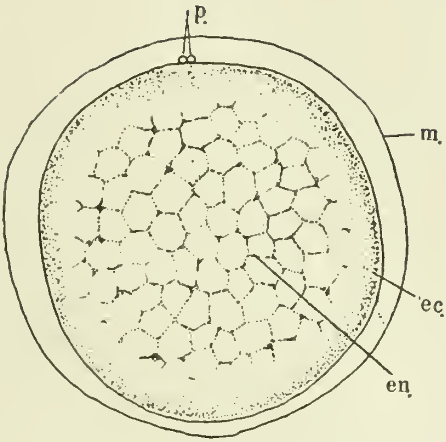

Fig. 2

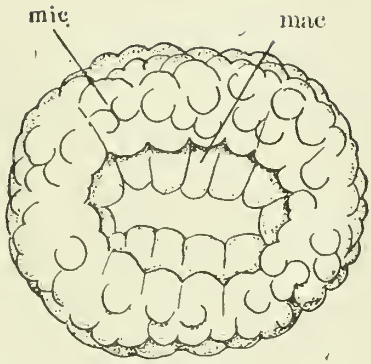

Fig. 1. Newly laid egg. × 170.
ec. Ectoplasm.
en. Endoplasm.
m. Egg membrane.
p. Polar bodies.

Fig. 2. A stage during gastrulation, seen from the micromere pole. × 170.
mac. Macromeres.
mic. Micromeres.

Development.—The segmentation of egg goes on in practically the same way as known from ordinary ctenophores. As in these, the third cleavage furrows are oblique and the resulting eight cells are arranged in the "disymmetrical" manner. The succeeding divisions, which lead to the formation of micromeres, are accomplished in nearly the same manner as was described by Ziegler[1] for *Beroë* and by Yatsu[2] for *Beroë* and *Callianira*.

The gastrulation occurs in precisely the same way as in ordinary ctenophores. At the close of segmentation there is a stage in which sixteen macromeres are arranged in a bowl-like group covered on the concave side (micromere pole) by an assemblage of numerous micromeres. Then, some "mesodermal" cells are budded off from the macromeres on the convex side of the group (macromere pole), while

1) Ziegler, H. E., 1898. Experimentelle Studien über die Zelltheilung. III. Die Furchungszellen von *Beroë ovata*. Arch. Entwicklungsmech. Bd. 7, p. 34.

2) Yatsu, N., 1911. Observations and experiments on the ctenophore egg: II. Notes on early cleavage stages and experiments on cleavage. Annot. Zool. Jap., Vol. 7, p. 333.

the micromeres are multiplying rapidly and gradually spreading over the macromeres (epiboly). Fig. 2 represents a stage in the above process, seen from the micromere pole of egg, where a moderately large elliptical gap exists between micromeres showing macromeres within. On the macromere pole too, there is in this stage another but somewhat smaller opening, which, however, is soon closed by the multiplying micromeres. The gap on the micromere pole persists for some time after the closure of the opening at the macromere pole, but sooner or later it too comes to be closed. Directly after the closure of the gastrula at both its poles, there appear first traces of the aboral sense-organ, tentacles and ribs, as well as of the stomodaeal invagination, all nearly at the same time. The aboral sense-organ develops on the micromere pole and the stomodaeal invagination on the macromere pole, while the tentacles and ribs do so on the lateral region of the gastrula nearer the micromere than the macromere pole. Thus, the gastrula develops into a typical cydippid embryo.

Cydippid Larva.—Fig. 3 shows an unhatched cydippid larva of a very early stage. The subspherical body exhibits at its one pole the mouth-opening (*o*) and at the opposite pole the sense-organ (*s*), besides a pair of tentacular rudiments (*t*) and the eight comb-plate rows (*c*). The sense-organ, when viewed from above, is of a rhomboid outline with the longer diametre in the sagittal plane of the larva; the otoliths form a small aggregation at both ends of the shorter diametre. The polar plates can not yet be observed. The comb-plate rows as well as the tentacle rudiments are located in the aboral half of the body. The former are arranged in four close pairs, each row containing

Fig. 3

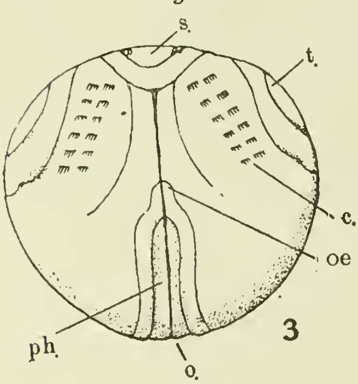

Fig. 3. A young cydippid larva, seen on the tentacular plane, × 170.
c. Comb-plate rows.
o. Mouth aperture.
oe. Oesophagus.
ph. Pharynx.
s. Aboral sense-organ.
t. Tentacular rudiments.

six or seven combs with cilia which are still very short. The tentacle rudiments appear each as a slight elevation of an elongate oval outline, which may be distinguished into a central and a peripheral part, both gently swollen and separated from each other by a slight groove-like depression. The tentacle appears to arise by prolongation of the central prominence, though the tentacular epithelium is derived by extension of that of the peripheral swelling.

The mouth (*o*) is nearly round. The pharynx (*ph*) it leads into exhibits also a roundish outline in optical cross-section. The inner end of pharynx lies nearly midway between the oral and aboral poles of the body. A short process at the inner end of pharynx indicates the oesophagus (*oe*).

In slightly more advanced larvae, the body presents a distinct lateral compression, it growing longer in the transverse axis than in the sagittal.

Meanwhile, the tentacle-stem makes its appearance in the area indicated above, at first as a tubercle-like prominence; the cilia of comb-plates lengthen; the mouth widens, elongating in the transverse direction, while the inner half of pharynx becomes compressed in the sagittal direction.

As the development still advances (Fig. 4), the lateral compression of body grows to the extent that the length of the sagittal axis measures about 2/3 that of the transverse axis. At the same time, the oral region is somewhat produced, so that the body now appears roughly heart-shaped with subtruncate oral end when viewed on the transverse plane (Fig. 4), but nearly egg-shaped when seen on the sagittal plane. The number of comb-plates in each row increases up to about ten, their cilia growing at the same time very considerably in length. A highly vaulted covering has now formed over the sensory cavity; and the otolith, forming a single mass of seven or eight granules, has assumed a central position in the cavity. The tentacles (*t*) have greatly elongated and have assumed a club-like shape; they are now thickly beset with colloblasts on the surface. The mouth (*o*) has widened remarkably in the transverse direction, while the inner half of pharynx (*ph'*) has done so in the sagittal direction. Yellowish and brownish pigment spots (*pg*) have appeared in the neighbourhood of the mouth, the sensory capsule and the tentacular apparatus. Besides, a quantity of dark spots now exists in the deeper tissues of the entire body, which fact makes difficult the inspection of the inner organization.

Fig 4

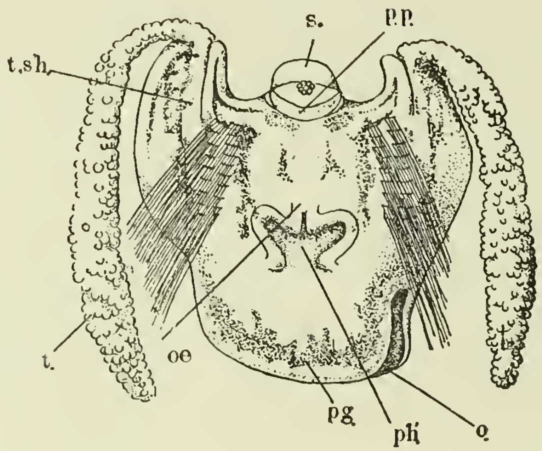

Fig. 4. The cydippid larva ready to hatch out, seen on the transverse plane, ×170.

o.	Mouth aperture.	*pg.*	Pigment spots.
pp.	Polar plates.	*s.*	Aboral sense-organ.
t.	Tentacle-stem.	*t.sh.*	Tentacle-sheath.
œ.	Oesophagus.	*ph'.*	Inner part of pharynx.

Fig. 4 represents the fully developed cydippid larva ready to hatch out. Such a larva is frequently observed to do stretching movements in the egg membrane and to press the mouth region against the latter as if in attempts to free itself. Eventually, the membrane ruptures and the larva escapes. For a short while after hatching in a vessel, the larva swims about very actively by means of the combs, sinking now and then to the bottom and adhering there by the inner surface of the inferior part of pharynx, which surface is turned outwards by excessively widely opening the mouth. Four or five hours* after hatching, the larva

* The time required for the development varies considerably with temperature.

takes to swimming much less frequently than before, but remains most of the time on the bottom, where it begins to creep about, using the above indicated pharyngeal surface as the sole. In still four or five hours, most of the cilia of comb-plates become either bent or broken off in the middle, and finally fall away altogether. The larva is then entirely incapable of swimming, and the creeping by means of the sole becomes the only way of locomotion. The pigments increase in the parenchyme; the tentacle-stem develops some ten branches; the sole flatly spreads out all around, while the inner end of the pharynx develops a few folds on the wall ("pharyngeal folds").

Fig 5

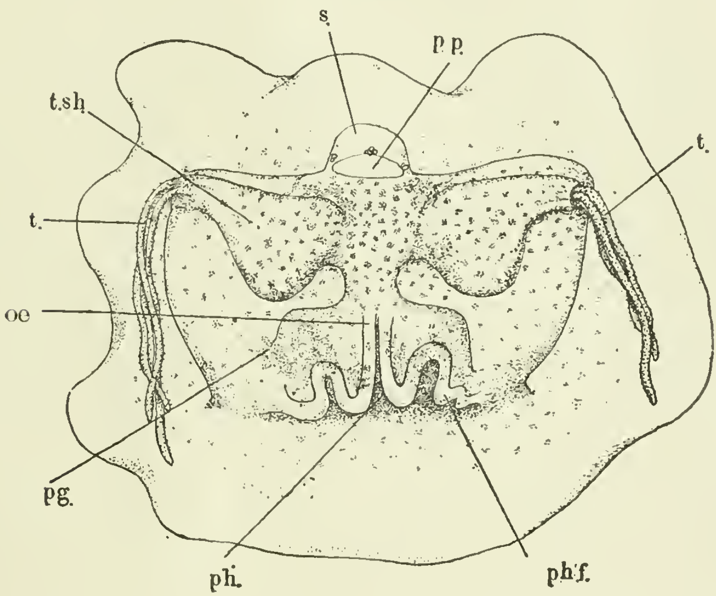

Fig. 5. A larva during metamorphosis, adhering to the substratum by the thinly spread-out sole. The main body laid back and seen on the transverse plane. × 170.
ph.f. Pharyngeal folds. Other letterings as in Fig. 4.

After two or three hours more, the adherent larva is at an advanced stage of metamorphosis. By that time the combs have completely fallen off, and the sole has extensively enlarged in all directions, flattening out in an almost film-like manner (Fig. 5). Thus, the larval body may now be said to represent a somewhat hump-like elevation in the central parts of a broad and thin basal expansion. It is easy to imagine that by gradual depression of the elevation, the entire body would assume the habitus of the adult. But stages representing this change have not come under actual observation.

Of individuals which have completely changed into the adult shape and which were taken from the alcyonacean host, the smallest and youngest observed was one only about 1 mm. in diametre. The most notable points in this little specimen were the facts that the gastrovascular system consisted of eight broad and subequal pouches arranged radially around a central cavity representing the infundibulum, and that there exists the peripheral canal-system consisting as yet of a sparse number of anastomosing canals. Of the eight radial pouches, the four in relation with the base of tentacles evidently represent the tentacular canals, and the remaining four the meridional canals, of the adult.

Conclusion.—In the light of the developmental facts noted above in brief, it goes beyond the reach of doubt that *Coeloplana* represents a highly specialized form of the Ctenophora. In fact, it will be conceded to by all that the genus appears to have been derived from a cydippid ancestral form by a loss of certain old characters and by concomitant acquirement of a series of new ones in adaptation to the change in habit of life from the pelagic to the creeping. Most remarkable is the undeniable indication that the entire creeping surface (ventral body surface) of *Coeloplana* was derived by the turning out of a large part of the inner pharyngeal surface of ordinary cydippids. It then seems that the flatness of body in this aberrant form of ctenophores may be regarded to be in a large measure due to that fact, and is not to be explained by assuming merely the reduction of vertical body-axis, as was done by Lang* and several other authors.

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* Lang, A. (1884). Die Polycladen des Golfes von Neapel. Fauna u. Flora d. Golf. Neapel. Monogr. XI.