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A New Remarkable Coral-boring Acrothoracican Cirriped

By

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Some years ago, while examining reef corals occurring in Tanabe Bay, I noticed an acrothoracican cirriped boring into two kinds of corals which were common in the littoral region. Mere casual examination of the specimens enabled me to ascertain that they represented a new and remarkable acrothoracican, apparently resembling *Lithoglyptes indicus*. Subsequent studies have elucidated the greater part of its structure. A preliminary report of my findings was presented at the Twelfth General Meeting of the Zoological Society of Japan held on October 24th, 1936 (Hiro, 1937). The following is a summary of the morphology of this new form. More detailed descriptions on its structure and development, in comparison with related forms, are now in preparation and will be published in near future.

Female

This curious acrothoracican is found in large quantities in the shallow waters around Tanabe Bay, invariably boring into living colonies of the two corals, *Leptastrea purpurea* (Dana) and *Psammocora profundacella* Gardiner. As shown in Fig. 1, the animal reminds us highly of *Lithoglyptes indicus*, the well-known acrothoracican recorded by Aurivillius (1894) from Java Sea, as boring into corals (probably belonging to *Porites* and *Goniastrea*) and molluscan shells.

The animal is unisexual; the dwarf male is always found attached to the wall of the pit inhabited by the female. The sac-like appearance of the female is due to the mantle covering its whole body. The mantle is tightly attached to the wall of the dwelling pit by an attachment-disc formed by the dorsal portion of the mantle. While alive, the animal is beautifully coloured; the upper surface of the operculum (Fig. 2 C), which is only visible from the outside, is marked with two

symmetrically disposed patterns of deep violet-blue colour on a blue-dotted ground. The upper part of the mantle beneath the operculum is also tinged with dull violet-blue, while all the remaining part is pinkish yellow. The larger specimen is 3—5 mm long, 2—4 mm wide and 0.8—1.5 mm thick. The operculum is about 1—3 mm in length and 0.3—1.2 mm in width, its dimension corresponding to that of the opening of the dwelling pit.

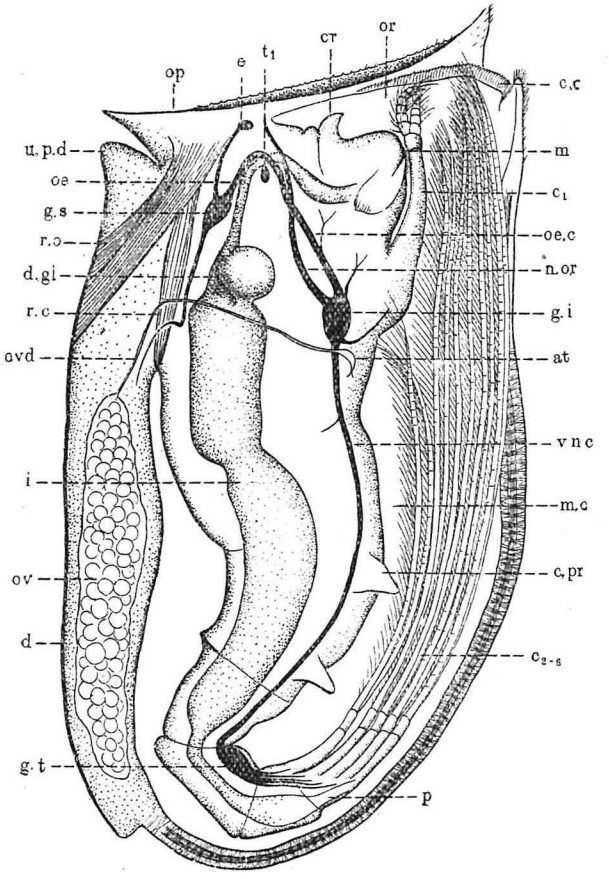

Fig. 1. Semidiagrammatic figure showing the structure of female of *Berndtia purpurea*, n. g., n. sp. ca.×30. *at* atrium c_{1-6} cirri I—VI, *c. c* comb-collar, *c. pr.* conical process, *cr* crest-like projection of labrum, *d* attachment-disc, *d. gl* digestive gland, *e* eye, *g. i* infra-oesophageal ganglion, *g.* s supra-oesophageal ganglion, *g. t* terminal ganglion, *i* intestine, *m* mouth, *m. c* mantle cavity, *n. or.* orificial nerve, *oe* oesophagus, *oe. c* oesophageal commissure, *op* operculum, *or* orifice, *ov* ovary, *ovd* oviduct, *p* proctodaeum, *r. c* retractor corporis, *r. o* retractor orificii, *t*, bodily transverse muscle I, *u. p. d* upper projection of disc (attachment-process), *v. n. c* ventral nerve cord.

The mantle-sac is flattened from the sides and the margins of its upper opening are thickened and hardened to form the opercular valves, which correspond to those of pedunculate cirripeds, though having no shelly plates whatever. The operculum (*op*), when seen from the above, is oblong, with a straight median slit, and when seen from the sides it is shaped like a cross-section of a canoe. Its upper surface is

somewhat hollowed out, smooth, and encircled by a sharply ridged chitinous edge, of which the outer ridge is provided with many close-set chitinous spines. The dorsal or rostral side of the mantle-sac forming the attachment-disc (*d*) is separated from the operculum by a deep notch and its upper end (*u. p. d*) is strongly protruded. The attachment-disc is flask-shaped or spatulate in outline.

In larval stages, the animal adheres by means of the lower part of the sac only. As excavation goes on and moulting is repeated, the animal gradually extends its attachment-area upwards and constructs the disc. On each side of the mantle and a little below the operculum near the disc, there is a peculiar chitinous thickening of the outer membrane, corresponding to the 'lateral bar' in other members of acrothoracicans; its situation coincides with the line along which the body within the mantle cavity is connected with the mantle-sac. This bar apparently serves as a fulcrum by pressing against the side wall of the dwelling pit at each excavation or contraction of the mantle, contrary to previous authors' view. A little way down within the orifice (*or*), the mantle opening is fringed on either side with a comb-like row of flattened setae. This comb-collar (*c. c*), which is a characteristic feature of the Acrothoracica, possibly acts as a barrier to prevent the entrance of any foreign object into the sac. The collar is not found at the ventral or carinal end of the orifice, which is protruded a little and flexible; when the operculum is closed, the carinal end of the margin is folded outwards.

The body enclosed within the mantle-sac is, as usual, considerably elongated, tapering posteriorly, and curved ventrally near the posterior end like a hook. It consists of an elongated prosoma and a distinctly segmented thorax. The prosoma bears a pair of mouth-cirri (c_1) just below the mouth opening. The succeeding elongated portion, which forms the main part of the body, does not show any distinct segmentation, though folded here and there. I am inclined to consider this portion as the posterior prolongation of the prosoma, and not the true thorax. Two pairs of the conical processes (*c. pr*), much like those in *Lithoglyptes indicus*, occur on the ventrolateral side of this portion. The crooked terminal portion of the body is distinctly segmented, and bears on its ventral side five pairs of long terminal cirri (c_{2-6}). This terminal segment represents four thoracic segments fused together, and each segment bears a pair of multiarticulated cirri. Accordingly, this new acrothoracican has seven true thoracic segments and six pairs of thoracic cirri. The caudal appendage is entirely lacking.

The internal structure is rather peculiar for an acrothoracican. The mantle-sac is lined within by two layers of muscles, an inner transverse and a medial longitudinal, and also by an outer layer of obliquely running elastic fibres. Besides, some short muscles run from the upper process of the attachment-disc to the lateral bar. A pair of powerful retractor orificii (*r. o*) are attached to the dorsal end of the orifice, and run obliquely down to the attachment-disc; these muscles apparently serve to raise the operculum from the pit in which the animal is lodged.

The alimentary canal is composed of a narrow oesophagus, globular digestive glands, a broadly elongated intestine and a proctodaeum. The oesophagus (*oe*) runs backwards from the mouth, and turns perpendicularly downwards at a small transverse muscle (t_1). The digestive tract then enters into an expanded intestine to which a pair of globular digestive glands (*d. gl*), not seen in other acrothoracicans, are attached one on each side. The intestine (*i*) is abruptly narrowed in the crooked posterior portion of the body, and enters into the rectum and the terminal proctodaeum (*p*) to open externally with the anus.

The nervous system consists of two main nerve masses, the cerebral or supra-oesophageal ganglion (*g. s*) and the ventral or infra-oesophageal ganglion (*g. i*). Both the ganglia issue offshoots to supply nerves to adjacent organs. The ganglia are connected together by a pair of commissures passing around the oesophagus. From the cerebral ganglion a pair of nerve cords go to the operculum and another fused pair run downwards to the attachment-disc. The former is the optic nerve and terminates at a well-developed eye (*e*). The presence of an eye or an optic ganglion has never been reported in acrothoracicans so far described. The latter nerve cord, which may be named the dorsal nerve cord, obviously represents the antennular or peduncular nerve of ordinary cirripeds. The infra-oesophageal ganglion sends out the orificial nerves (*n. or*) which run upwards nearly parallel to the oesophageal commissure (*oe. c*). This nerve undoubtedly corresponds with the adductor nerve of ordinary cirripeds. From the terminal ganglion (*g. t*), which is the large thoracic ganglia fused together and situated on the ventral side of the crooked portion of the body, arise five pairs of pedal nerves each going to one of the terminal cirri.

Of the excretory organs, the maxillary gland, like that found in other acrothoracicans and ordinary cirripeds, is present on either side a little below the second maxilla. Besides, there are many large cell masses containing brownish-yellow granules scattered all over the lacunae

around the oesophagus in the head portion. They are probably of the same nature as the so-called cephalic nephrocytes, which has been described by Bruntz (1904) in *Balanus tintinnabulum*, a well-known balanid.

The ovaries (*ov*) form a large mass filling up the lacunar cavity within the thickened part of the mantle underneath the attachment-disc. The oviduct runs through the lateral side of the head portion, and opens near the base of the mouth-cirri, passing through the atrium (*at*). The cement glands commonly found in ordinary cirripeds seem to be entirely lacking.

Male and its Development

As stated above, the dwarf male is invariably found attached to the wall of the dwelling pit alongside the upper part of the attachment-disc of the female, instead of being attached directly to the female's body like in other acrothoracicans. From 1 to 6 males occur in a pit where a female is lodged.

As shown in Fig. 2A, the shape of the male is rather unique for an acrothoracican, being considerably elongated and somewhat tadpole-

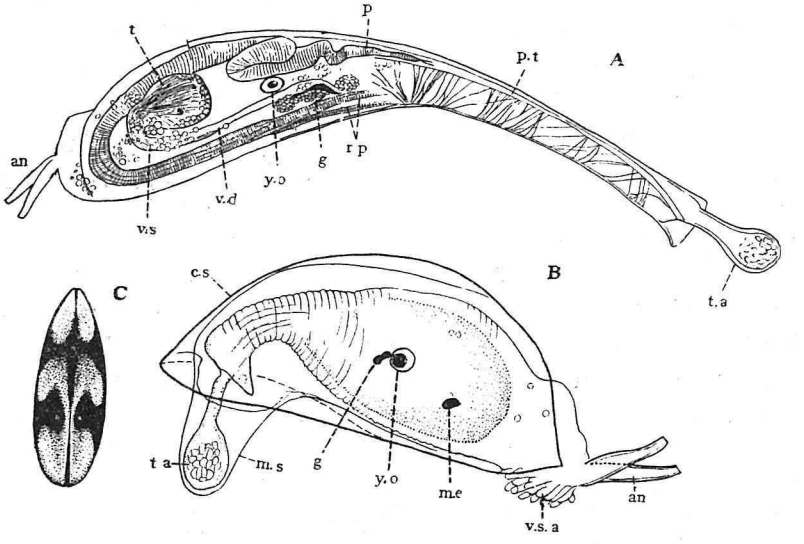

Fig. 2. A, Adult male of *Berndtia purpurea*, n. g., n. sp. ca. × 70. B, Pupal-staged male. ca. × 110. C, Upper view of operculum of the female. The white spot in the lower pattern indicates the position of the eye, which is dicernible from the outsides as a golden refulgent body. ca. × 10. *an* antennule, *c. s* cypris-sac, *g* nerve ganglion, *m. e* vestige of median eye, *m. s* mantle-sac, *p* penis, *p. t* penis tube, *r. p* retractor penis, *t* testis, *t. a* terminal ampulla, *v. d* vas deferens, *v. s* vesicula seminalis, *v. s. a* vestiges of naupliar swimming appendages, *y. o* 'yellow organ'.

shaped. The whole length is about 1.2—1.5 mm and the greatest width about 0.2 mm. The anterior main portion is surrounded by a layer of longitudinal muscles running beneath the outer chitinous integument, while the posterior tail-like portion lacks the muscles. A remnant of the cypris-sac with a pair of antennules (*an*) is attached to the anterior extremity. The posterior portion is shaped like a proboscis and its terminal end bears an ampulla-like sac (*t, a*) of unknown nature. Such a peculiar appendage has never been described in other males of acrothoracicans and ordinary cirripeds, so far as I know.

The genital organ is ordinary in structure, and consists of a single winding tract, which can be divided into four sections, the testis (*t*), vesicula seminalis (*v. s*), vas deferens (*v. d*) and the penis (*p*). The entire tract is considerably longer than the body, and has a winding course peculiar to this form. The penis, which is entirely concealed in the penis tube (*p. t*), arises from the ventral side of the middle portion of the body, and runs forwards, and then turns backwards along the dorsal side of the body, revolving around the testis. The penis tube opens at the prosbosciformed posterior end bearing the terminal ampulla. Near the beginning of the penis, there are a dark-coloured, elongate ganglion (*g*) and a large, rounded peculiar yellow body (*y. o*), similar to those found in other acrothoracican males.

The most noticeable feature of this acrothoracican is that the male nauplius develops directly to a cypris larva, without passing through the metanauplius stage. The pupa (Fig. 2B) shows nearly complete characters of an adult male. The body, however, is not so much elongated as in the adult, and is entirely enclosed within a thin, translucent mantle-sac (*m. s*) inside the cypris-sac (*c. s*), which is ready to be cast off. The vestiges of naupliar swimming appendages (*v. s. a.*), as well as the antennules, still remain at the anteroventral end of the body. The median naupliar eye (*m. e*) is also found in this stage, although it disappears in the adult male. The thoracic appendage such as those appearing in metanauplius and cypris stages in ordinary cirripeds are not formed altogether.

According to Kühnert (1934), *Trypetesa* (=*Alcippe*) passes from the egg to the adult three stages, the nauplius-, the metanauplius- and the cypris-stages. In *Cryptophialus*, however, according to Darwin (1854) the egg develops directly to the pupa, without any naupliar or thoracic appendages being formed in its developmental course. In this respect, this acrothoracican is just intermediate between *Trypetesa* and *Cryptophialus*.

Systematic Position

From the foregoing observations it is quite certain that the present form represents a new type of the acrothoracican, closely allied to *Lithoglyptes indicus* in its general organization. It is, however, distinguished from the latter mainly in the number of cirri and in the absence of the caudal appendage of the female, and also in the structure of the male.

On the other hand, this new cirriped comes between *Trypetesa* and *Cryptophialus* in its abbreviated development, but it is much different from both in minor points. Therefore, I propose to name it *Berndtia** *purpurea* n. g., n. sp.

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Explanation of Plate

Fig. 1. Pits infested by *Berndtia purpurea*, formed on the colony of *Psammocora profundacella*. ×1.

Fig. 2. Section of a block of *Leptastrea purpurea* showing the dense infection of *Berndtia purpurea*. ×1.

Fig. 3. Pits occupied by *Berndtia purpurea*, formed on the colony of *Leptastrea purpurea*. ×1.

* Chosen in honor of Dr. Wilhelm Berndt, who has made much contribution to the study of the Acrothoracica.

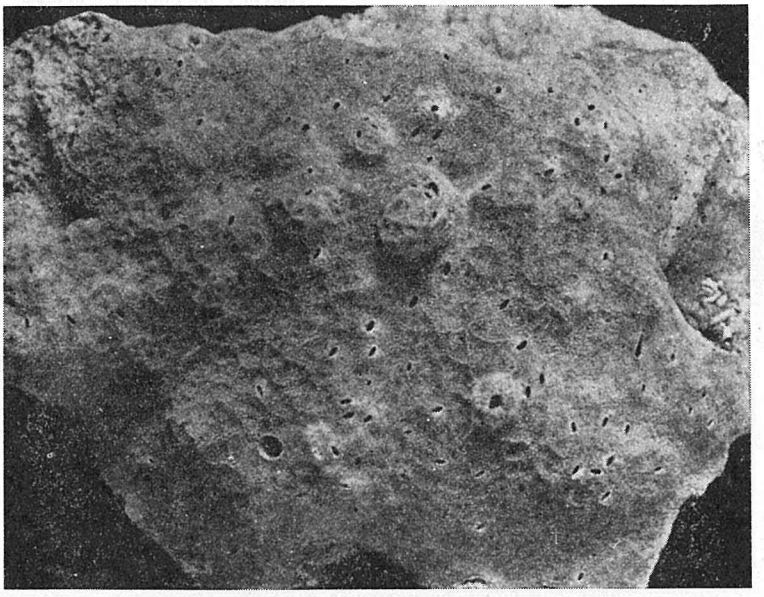

Fig. 1.

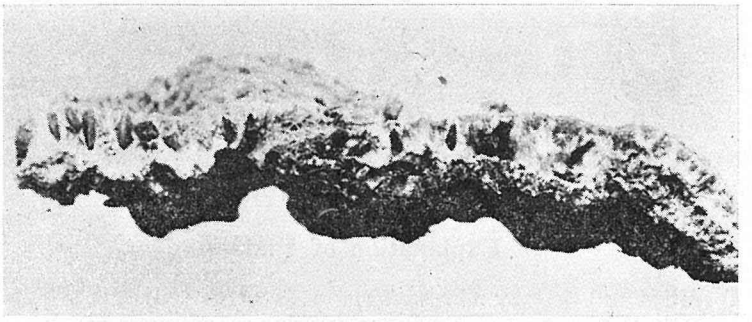

Fig. 2.

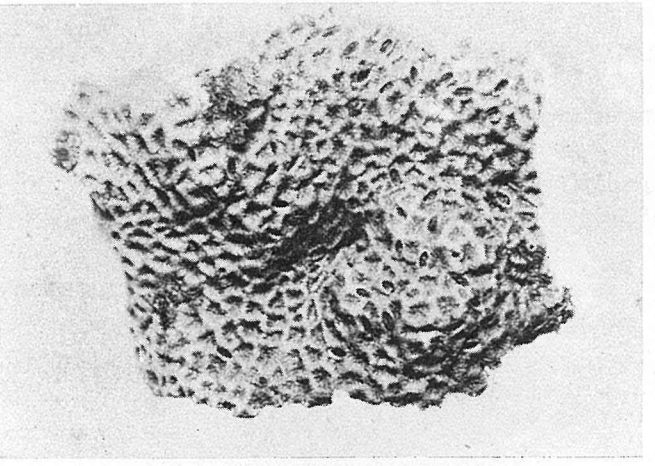

Fig. 3.