BASTERIA, 56: 99-103, 1992

A note on pteropod ink

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Ink ejection by the pteropod mollusc *Cephalobrachia macrochaeta* is reported and compared to the same phenomenon earlier described by others for *Hydromyles globulosa*. Histological details of the intestinal system are given.

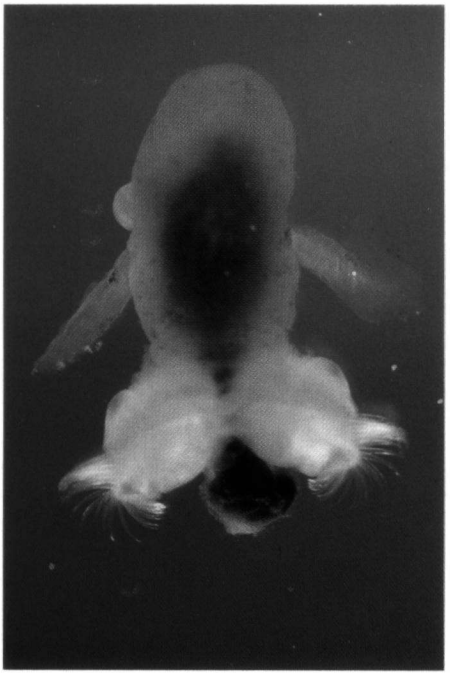
Key-words: Gastropoda, Pteropoda, *Cephalobrachia macrochaeta*, behaviour, ink ejection.

Ink ejection in molluscs is well known in the Cephalopoda, but ink production also characterizes pteropods. In their excellent book on the biology of pelagic molluscs Lalli & Gilmer (1989) described the observation made by Dr. G.R. Harbison that *Hydromyles globulosa* (Rang, 1825) [proposed as nomen conservandum by Tesch (1950) and Pruvot-Fol (1942)] when disturbed, ejects a brownish fluid through the anal opening. That this behaviour is not completely unique among pteropods is shown by *Cephalobrachia macrochaeta* Bonnevie, 1913, a species that also ejects a fluid when disturbed.

Cephalobrachia macrochaeta was collected at 45°15.0'N 29° 50.0'W, Sta. 14, haul 5, Amsterdam Mid North Atlantic Plankton Expedition, between 430 and 1000 m depth, mean temperature 9°C, 18 April 1980. In the aquarium, in which a specimen was held for some hours, production of an ink cloud at the moment it was photographed with flash light was observed (figs. 1-2). The brownish to black ink was delivered through the mouth. Since Gymnosomata in general are specialized predators on Thecosomata, and as the most abundant representative of the latter at station 14 was *Limacina retroversa* (Fleminger, 1823), it might be possible that the colour of the stomach content is due to the dark purple *L. retroversa* specimens eaten. However, in the stomach no fragments of *L. retroversa* could be identified.

To study the origin of the ink, a specimen was sectioned histologically, 5 µm thick, and stained with Mallory-Heidenhain. The intestinal system in *C. macrochaeta* shows two typical structures, viz. a blind sac near the connection stomach-hind-gut and a glandular sac in the middle of the hind-gut (fig. 3).

The blind sac close to the beginning of the hind-gut is also described for *Hydromyles globulosa* by Meisenheimer (1905); an epithelium almost similar to that of the liver-stomach complex was observed by Meisenheimer. Lalli & Gilmer (1989) mentioned this blind sac as the possible source of ink. In the specimen of *C. macrochaeta* the blind sac entrance is covered with ciliated epithelium that is continuous with the hind-gut epithelium. The inner epithelium (fig. 4) is similar to that of the liver-stomach cavity. The only remarkable structure of this blind sac is that it has a circular closing muscle around the opening to the stomach. It is difficult to believe that the epithelia of this blind sac produce an 'ink-like substance' as they are so similar to liver cells. This blind sac was hitherto considered unique in *H. globulosa*, which is no longer correct.



Figs. 1-2. Photographs of *Cephalobrachia macrochaeta* from dorsal during active 'ink' ejection in an aquarium after disturbance.

The middle of the hind-gut is slightly swollen in many Gymnosomata (Meisenheimer, 1905; Tesch 1913), but in the literature no special epithelia are described from this part of the hind-gut. In *C. macrochaeta* there is a large sac in the middle of the hind-gut, covered with a characteristic glandular epithelium (fig. 5). It consists entirely of flat glandular epithelial cells with large secretion granules in the active cells. In Mallory-Heidenhain these spherules stain orange. It is also remarkable that the opening of the hind-gut to the stomach and the anus are both provided with circular closing muscles.

The delivery of the contents of the blind sac and of the glandular sac, together with the hind-gut, is effected by contraction of the transversal body muscles that are very numerous in this area. Regulation of the ejection through the anus as well as through the mouth is possible as there are closing muscles at the openings (fig. 6).

That *H. globulosa* takes a separate place among the Gymnosomata as proposed by Lalli & Gilmer, is still a valid statement, but it is doubtful whether the ink ejection in *H. globulosa* supports this. Both *H. globulosa* and *C. macrochaeta* show ink ejection, but the delivery of the ink mass in the two species is probably different; *H. globulosa* brings the ink through the anal opening into the water, while *C. macrochaeta* ejects through

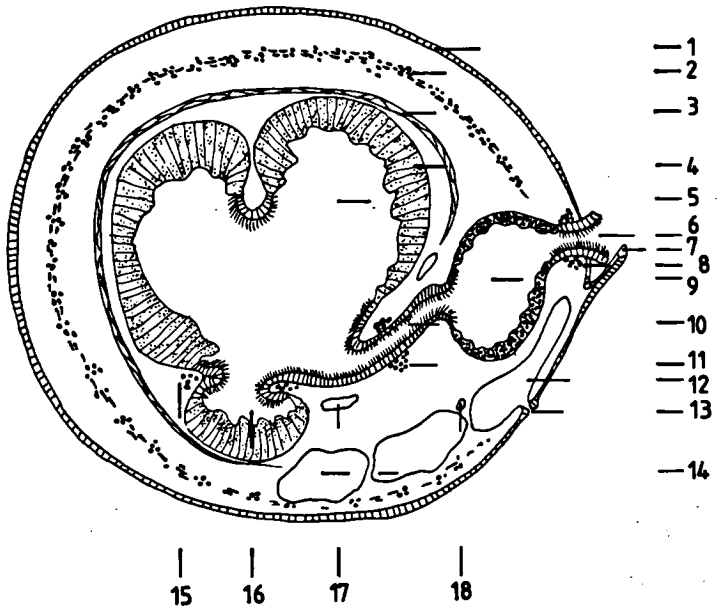


Fig. 3. *Cephalobrachia macrochaeta*, cross section at the level of the anus to show the main intestinal structures. 1 = epidermis of body wall, 2 = longitudinal and transversal muscles of body, 3 = epithelium of visceral cavity, 4 = epithelium of liver, 5 = liver-stomach cavity, 6 = anus, 7 = osphradium, 8 = circular muscle of anus, 9 = glandular sac, 10 = hind-gut, 11 = circular muscles at hind-gut entrance, 12 = kidney, 13 = kidney aperture, 14 = pericardial cavity, 15 = circular muscle of blind sac, 16 = blind sac, 17 = blood vessel, 18 = reno-pericardial duct, 19 = oesophagus, 20 = ciliated epithelium of hind-gut, 21 = outer layer of hind-gut, 22 = active secretory cells of glandular sac, 23 = young mucus cell of glandular sac.

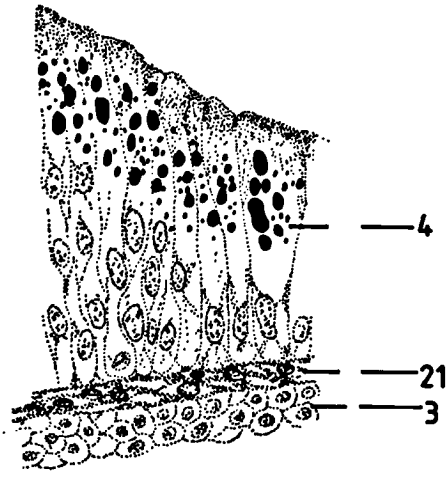


Fig. 4. *Cephalobrachia macrochaeta*, epithelium of blind sac (for explanation see fig. 3).

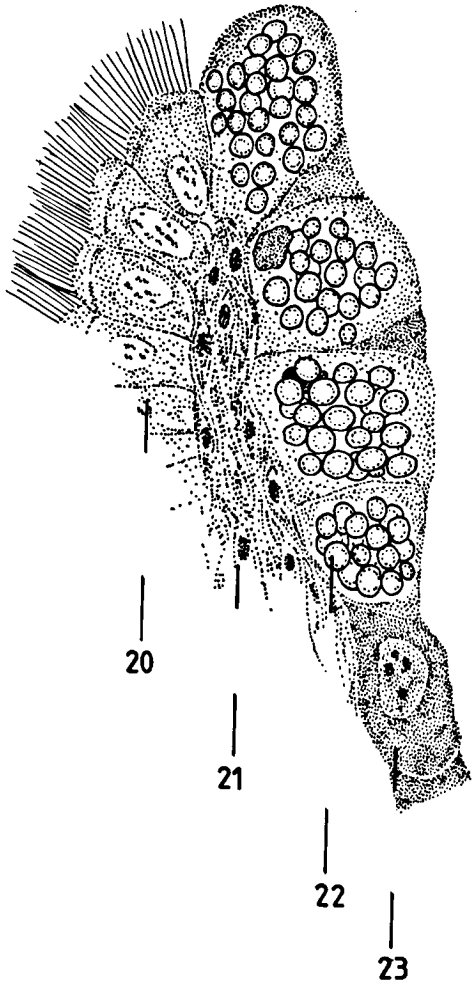


Fig. 5. *Cephalobrachia macrochaeta*, epithelium of glandular sac near the connection with hind-gut (for explanation see fig. 3).

the mouth, which does not seem to be a sufficiently large difference to support phylogenetic conclusions. The effect of dark ink ejection as a protective mechanism in deep-sea animals is not clear. The presently discussed species lives at depths of between 400 m and more than 1000 m, where constant darkness is found and dark ink will be invisible. We do not know what the ink looks like in total darkness; it may be phosphorescent.

For preparing the histological slides Mr. A.F. de Fluiter is kindly acknowledged.

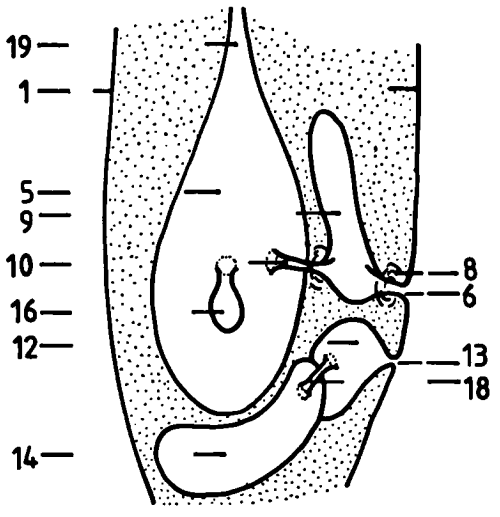


Fig. 6. *Cephalobrachia macrochaeta*, diagram of stomach, hind-gut, blind sac and glandular sac with the renal and pericardial cavity (for explanation see fig. 3).

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