Zoology. — *On the Larval Forms of Rhizocephala.* By H. BOSCHMA. (Communicated by Prof. C. PH. SLUITER.)

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From a taxonomic point of view the larvae of the Rhizocephala are of special interest, as their structure gives sufficient evidence for the relationship of this group of parasitic animals with the Cirripedia. Like the nauplii of *Lepas* and *Balanus* the corresponding larval stages of *Sacculina* and *Peltogaster* possess well developed frontal horns, a peculiarity which is not found in other groups of Crustacea.

In all Rhizocephala the eggs after being hatched remain for a considerable time in the mantle cavity and here the first stages of development take place. The structure and the development of the larval stages of *Sacculina carcini* are well known (DELAGE, 1884). In this species the larvae leave the mantle cavity at the first nauplius stage. Between this stage and the cypris there are three more nauplius stages, each of which has a more or less different shape. Especially between the first and the second nauplius stages there is a considerable difference in structure (cf. DELAGE, 1884, Pl. XXII, figs. 1 and 2).

In general the specific characteristics of the adult Rhizocephala are not easily defined. Often the internal structure, especially the form and situation of the testes and the colleteric glands may give sufficient data for the description, but in other cases, as in the Sacculinidae, there are a great number of species which correspond completely in their internal structure. Now in this family many species are sufficiently characterized by the appendages of the external cuticle, which have a constant specific form, or are at least subject to very little variation in different specimens belonging to the same species. One would expect now that the larvae of different species of Sacculinidae would possess distinct specific characteristics also and even more conspicuously than the adult parasites.

Among the material of Rhizocephala from the collections of a number of zoological museums, which I have at present at my disposal, I have found the larvae of seven species of *Sacculina* in the mantle cavity of these parasites. They are therefore at the first nauplius stage, as also results from their structure. All these larvae, some of which still are in an excellent state of preservation, in general have the same form. The nauplii of three species are represented in fig. 1. One of these (fig. 1*b*) is the larva of *Sacculina carcini* (from a specimen attached to *Pachygrapsus marmoratus* from the Mediterranean Sea). The other, smaller specimen (fig. 1*a*) is from a small still underscribed species of *Sacculina* from Japan, the third (fig. 1*c*) is the nauplius of *Sacculina exarcuata* Kossm. from

Hong Kong. The general form of these three nauplii is very similar : they all have well developed frontal horns and small triangular ventral

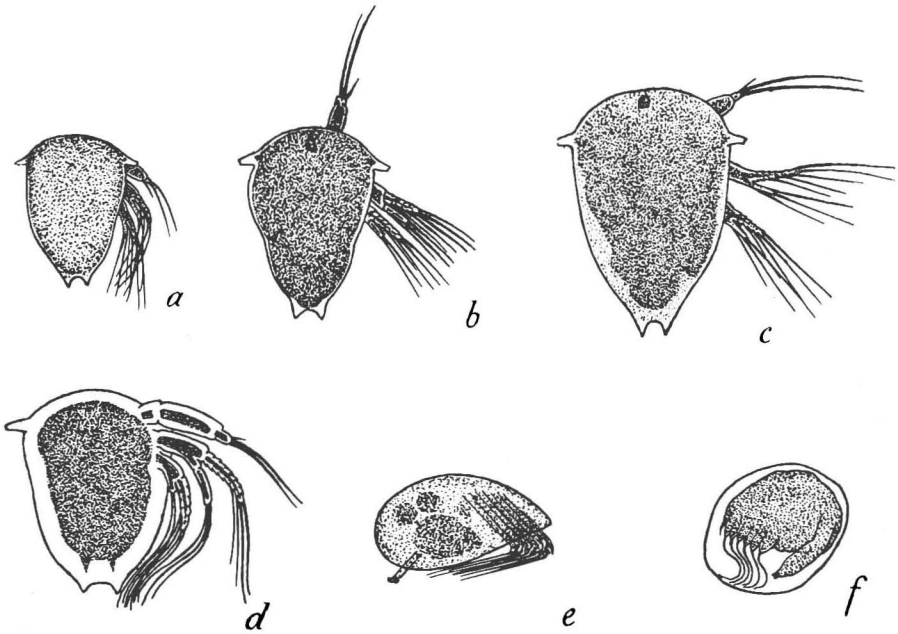

Fig. 1. Larvae of different Rhizocephala.
a—c, different species of *Sacculina*; *d*, *Peltogaster*; *e*, *Clistosaccus*; *f*, *Sylon*. × 130.
In *a—d* the appendages of one half are omitted. For further particulars see text.

appendages at the extremity of the abdomen. In two of them (*b*, *c*) a distinct eye spot is to be seen ; in the third species (*a*) this organ is completely wanting, which probably is a characteristic of the species. Another peculiarity, which, however, is subject to rather extensive individual variation, is the difference in size between the larvae of a certain species and those of another. The larvae of the japanese species (fig. 1*a*) are much smaller than those of *Sacculina carcini* (fig. 1*b*), whilst the latter again are rather small in comparison with those of *Sacculina exarcuata* (fig. 1*e*). I did not find specific differences in the structure of the three paired appendages of these and other nauplii of *Sacculina*. But also in other respects the first nauplius stage in this genus gives very few data for a distinction of different species by characteristics found in the larvae. They may possess some peculiarities which certainly are of specific value, e.g., the presence or absence of an eye spot, but in general their differences are too inconspicuous to be of use for taxonomic questions. As to the differences in size found between corresponding larval stages of different species we cannot maintain that these are of any specific value. The eggs of large specimens of a certain species of *Sacculina* may be somewhat larger than those of small specimens belonging to the same species, and the resulting larvae in both cases may be of somewhat different size.

Probably the second and later nauplius stages of different species of *Sacculina* will show more striking differences. It is quite possible that their structure may give valuable data for the taxonomy. Unfortunately, however, the later nauplius stages of two species only are known, viz., those of *S. carcini* and of *S. neglecta*. The free swimming nauplius of the latter has been described by SMITH, and from this author's figure (SMITH, 1906, Pl. 4, fig. 17) results that really this larva differs from the corresponding stage of *S. carcini*. Especially the shape of the ventral abdominal appendages is different in both forms : in *S. neglecta* they are rather broad and are provided with dentations at the internal surface only, whilst in *S. carcini* they have a more slender shape and have lateral hairs at the external as well as at the internal surface.

In the Peltogastridae the larval stages may prove to be of very great interest for taxonomic purposes, e.g., in the case of *Peltogaster curvatus* Kossm. and *Peltogaster paguri* Rathke. The structure and anatomy of the adult forms of both of these species are very similar, though usually the external shape is somewhat different. The only characteristic of specific value in the adult animals is the presence of small papillae at the extremities of the mantle in *P. curvatus* (DUBOSCQ, 1912), which as a rule do not occur in *P. paguri*. There are, however, some remarks in the literature on *P. paguri* which point to the fact that also in the latter species sometimes these papillae may develop (cf. LILLJEBORG, 1859, GUÉRIN—GANIVET, 1911). But in the two species under consideration the larvae furnish a characteristic which in my opinion decides at once that we have to regard the above mentioned forms as different species. SMITH (1906) gives a short description and a figure of the free swimming nauplius of *Peltogaster curvatus*, which is characterized by much elongated frontal horns. These horns are directed forward (cf. SMITH, 1906, Pl. 4, fig. 18). SMITH used this peculiarity even as a characteristic in the diagnosis of the genus *Peltogaster*. Here, however, this author was not right, for in other species of this genus the frontal horns are much smaller and they are directed laterally or backward. The best known larvae are those of *P. paguri* and *P. sulcatus*, especially by the investigations of NILSSON—CANTELL (1921). On account of the different size and shape of the frontal horns these larvae may be at once distinguished from those of *P. curvatus* and this fact gives sufficient evidence for the view that *P. paguri* and *P. curvatus* are distinct species.

The first nauplius stage of different species of *Peltogaster* again often has a very similar form. Fig. 1*d* represents such a larva of *Peltogaster gracilis* Kr. from Chili, which in very subordinate peculiarities only differs from that of *P. sulcatus* (cf. NILSSON—CANTELL, 1921, fig. 14*b*). In the larva of *P. gracilis* also the frontal horns are small and have a lateral direction. The swimming hairs are somewhat longer than those of *P. sulcatus*.

As in *Sacculina* and in *Peltogaster* in most of the other Rhizocephala

the larva develops in the mantle cavity till the first nauplius stage. This is known from *Peltogasterella* (KRÜGER, 1914), *Lernaeodiscus* (MÜLLER, 1862), and *Parthenopea* (KOSSMANN, 1873). On the other hand in the genus *Thompsonia,* which in many other respects also differs from the other genera of Rhizocephala, the nauplius stage is omitted and the larva develops directly into the cypris stage (HÄFELE, 1912; POTTS, 1915). Besides this genus there is still another in which the eggs develop directly into cypris larvae, viz. *Sesarmaxenos* (ANNANDALE, 1911), a rather imperfectly known parasite from a fresh water crab found at the Adaman Islands.

Till now the larval stages of the species belonging to the genera *Sylon* and *Clistosaccus* (the name *Apeltes* is a synonym of the latter genus) were completely unknown. SMITH (1906) as well as HOEK (1909), the authors of the two most extensive publications on the Rhizocephala as a whole, express the opinion that there are in the literature no data concerning the larvae of these genera. In the material of the Copenhagen Zoological Museum, which I am studying for systematic purpose, I have found the larvae of both of the above mentioned genera. In *Clistosaccus* as well as in *Sylon* the development of the eggs results in the formation of the cypris larvae, here also a nauplius stage is omitted. The larva of *Clistosaccus paguri* (fig. 1*e*) is very similar to that of *Sesarmaxenos;* it has six pairs of pleopods with strong swimming hairs and a pair of well developed antennae. Though the larvae in my material are already fully developed many of them still are contained in the egg membrane, which proves that they have not developed from nauplii. Concerning the larvae of *Sylon hippolytes* (fig. 1*f*, the figured larva was taken from the mantle cavity of a parasite on *Spirontocaris lilljeborgi)* I want to state that the specimens of my material in all probability are not yet fully developed cypris larvae. Already a distinct pair of antennae and the six pleopods of each side are to be seen, but probably the larva of *Sylon* has to undergo some more changes before leaving the egg membrane. The swimming hairs of the pleopods are here also well developed.

Knowing now the chief points of the structure of the larvae of *Clistosaccus* and *Sylon* one can understand a few remarks published by KRÖYER (1855). This author has seen the larvae of three different species of Rhizocephala, which he could compare with the figure of the larva of *Sacculina* published by CAVOLINI (1787). KRÖYER examined the larvae of *Peltogaster gracilis,* of *Sylon hippolytes,* and of a species which he called "another species of *Peltogaster*". Now in former times the species *Clistosaccus paguri* has often been confounded with *Peltogaster paguri,* with which it often bears a strong external likeness. From another paper by KRÖYER (1842) we may deduce that he certainly has possessed specimens of the arctic form *Clistosaccus.* According to KRÖYER (1855) the larva of *Peltogaster gracilis* is very similar to that of *Sacculina.* This undoubtedly is true and is proved by a comparison of the figs. 1*b* and *d* in the present

paper. The larvae of Sylon and of "the other species of *Peltogaster*" were characterized by KRÖYER as forms which probably represented a later stage in the development. The larva of *Sylon* was very similar to that of "the other species of *Peltogaster*", but both differed strongly from those of *P. gracilis* and *Sacculina*. We may therefore safely conclude that KRÖYER as early as 1855 already knew the larvae of *Sylon* and *Clistosaccus* ("the other species of *Peltogaster*"), but owing to his short and incomplete remarks on these larvae they remained unknown in literature.

It is an interesting fact that protection of the brood, which occurs in so many arctic forms of animals, manifests itself also in the Rhizocephala. *Clistosaccus paguri* and *Sylon hippolytes* are true arctic species, whilst the Sacculinidae and the species of the genus *Peltogaster* do not occur in the far north. *Sesarmaxenos* is a tropical species, but it lives in fresh water and in this medium the development of the larvae also in other groups of animals is shorter than that in marine animals of the same group. The species of the genus *Thompsonia* are strongly specialized forms and differ structurally in many details from the other Rhizocephala. It is difficult to explain why also in this genus the eggs develop directly into a cypris stage.

LITERATURE.

N. ANNANDALE, 1911. Note on a Rhizocephalous Crustacean from Fresh Water and on some specimens of the Order from Indian Seas. Rec. Ind. Mus., Vol. **6**.

F. CAVOLINI, 1787. Sulla Generazione dei Pesci e dei Granchi. Napoli. (This work was not accessible to me).

Y. DELAGE, 1884. Évolution de la Sacculine (*Sacculina carcini* Thomps.). Arch. Zool. Exp. Gén. (2), T. **2**.

O. DUBOSCQ, 1912. Sur les Peltogastrides des Côtes de France. Arch. Zool. Exp. Gén. (5), T. **9**, Notes et Revue.

J. GUÉRIN—GANIVET, 1911. Contribution à l'Étude systématique et biologique des Rhizocéphales. Trav. Sc. du Lab. de Zool. et de Phys. Marit. de Concarneau, T. **3**.

F. HÄFELE, 1912. Anatomie und Entwicklung eines neuen Rhizocephalen *Thompsonia japonica*. Abh. II. Kl. K. Ak. Wiss. München, Suppl. Bd. **2**.

P. P. C. HOEK, 1909. Die Cirripedien des nordischen Planktons. Nordisches Plankton, **8**.

R. KOSSMANN, 1873. Suctoria und Lepadidae. Habilitationsschrift, Würzburg. (also in: Arb. zool.-zoot. Inst. Würzburg, Bd. **1**, 1874).

H. KRÖYER, 1842. Monografisk Fremstilling af Slaegten *Hippolyte's* nordiske Arter. K. Dansk. Vidensk. Selsk. Naturvid. og math. Afh., Dl. **9**.

H. KRÖYER, 1855. Nogle Bemaerkninger om en höjst ufulstaendigt bekjaendt Kraebsdyr-gruppe. Overs. K. Dansk. Vidensk. Selsk. Forh. i. Aaret 1855.

P. KRÜGER, 1914. Ueber ostasiatische Rhizocephalen. Abh. II. Kl. K. Ak. Wiss. München, Suppl. Bd. **2**.

W. LILLJEBORG, 1859. Les Genres *Liriope* et *Peltogaster*, H. Rathke. Nova Acta Reg. Soc. Scient. Upsal. (3), Vol. **3**.

F. MÜLLER, 1862. Die Rhizocephalen, eine neue Gruppe schmarotzender Kruster. Arch. Naturg., 28. Jahrg., Bd. **1**.

C. A. NILSSON—CANTELL, 1921. Cirripedenstudien. Zur Kenntnis der Biologie, Anatomie und Systematik dieser Gruppe. Zool. Bidr. f. Uppsala, Bd. **7**.

F. A. POTTS, 1915. On the Rhizocephalan Genus *Thompsonia* and its Relation to the Evolution of the Group. Papers Dep. Mar. Biol. Carnegie Inst. Washington, Vol. **8**.

G. SMITH, 1906. Rhizocephala. Fauna und Flora des Golfes von Neapel, 29. Monographie.