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DANA-REPORT No. 67.

LARVAE OF DECAPOD CRUSTACEA

THE OCEANIC PENAEIDS

SOLENOCERA - CERATASPIS - CERATASPIDES

BY

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WITH 345 FIGURES IN THE TEXT

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PREFACE

The present paper deals with larval forms of the oceanic Penaeid genera *Solenocera*, *Cerataspis* and *Cerataspides*.

The material for this investigation arrives from three different sources: (1) The Carlsberg Foundation sponsoring different "Dana" and other expeditions, supplemented with material of larvae of *Solenocera membranacea* from expeditions of the Danish fishery research vessel "Dana" in the Atlantic south of Ireland and towards Bretagne, (2) material from the Zoological Museum of the University of Copenhagen and (3) the material placed in the British Museum, London.

Detailed information on the collection of the material from expeditions sponsored by the Carlsberg Foundation, Denmark, is given in the following three papers:

1. Introduction to the Oceanographic Reports. The Danish "Dana"-Expeditions 1920–22. By Johs. Schmidt. Oceanogr. Rep. edited by the "Dana" Committee No. 1, Copenhagen 1929.
2. Introduction to the Reports from the Carlsberg Foundation's Oceanographical Expedition Round the World 1928–30. Dana-Report No. 1, Copenhagen 1934.
3. List of Supplementary Pelagic Stations in the Pacific Ocean and the Atlantic with an Introduction by Å. Vedel Tåning. Dana-Report No. 26, Copenhagen 1934.

These three papers describe the basis for the "Dana"-Expeditions, state their purposes and extension and explain the sampling methods and the gear used. They further include complete lists of stations and hauls with all information on position, temperature, depth, gear, etc.

An additional part of the material is from the collections of the Zoological Museum of the University of Copenhagen. The material from this source includes the major part of the specimens of *Cerataspis* and *Cerataspides* and was collected in the second half of the 19th century by captains of the Danish Navy and Commercial Fleet. In the lists of available material heading the description of each larval stage the material from the Zoological Museum of the University of Copenhagen is marked Z.M.

The last part of the material is from the collections of the British Museum Natural History, London, from where I have received all available material on the three genera included in this paper. The material is collected by the different "Discovery" Expeditions, the British Antarctic ("Terra Nova") Expedition 1910, and the "Great Barrier Reef" Expedition. Included are also a few samples from other sources. All the material belonging to the British Museum is in the lists of localities marked B.M.

For further information on locality, bottom, temperature, depth, gear, etc. are referred to the following papers:

1. "Discovery" Investigations. Station list, 1925–1927. "Discovery" Report, vol. I, Cambridge, 1929.
2. "Discovery" Investigations. Station list, 1929–1931. Ibid. vol. 4. Cambridge, 1932.
3. G. E. R. Deacon: A General Account of the Hydrology of the South Atlantic Ocean. Ibid. vol. 7. Cambridge, 1933.

4. C. M. YOUNGE: Origin, Organization and Scope of the Expedition. "Great Barrier Reef" Exped. 1928–29, Vol. 1. No. 1, 1930.

5. F. S. RUSSEL — J. S. COLMAN: The Zooplankton I. Gear, Methods and Station Lists. — Ibid. Vol. 2, No. 2, 1931.

6. S. T. HARMER — D. S. LILLIE: British Antarctic ("Terra Nova") Expedition 1910, List of Collecting Stations. — Nat. Hist. Rep. Zool. Vol. II, No. 1, 1914.

I take this opportunity to offer my best thanks to the above mentioned institutions for their having trusted me with these collections of Penaeids; collections which although limited in number, can well be described as unique as they cover the tropical and subtropical regions of all the oceans and include animals which up to the present time are only little known. Especially the larval forms are practically unknown except for *Solenocera membranacea* described by Mme HELDT and in few papers from the previous century.

It is my pleasant duty to render a special thank to my friend and colleague Dr. ERIK M. POULSEN for many valuable discussions and support in different ways with this paper.

In presenting this work it is my privilege to thank all those persons and institutions who by different means have rendered me valuable help in connection with this paper:

Dr. ERIK BERTELSEN, "Dana" Collections and Danmarks Fiskeri- og Havundersøgelser, Charlottenlund.
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Dr. ERIK M. POULSEN, Danmarks Fiskeri- og Havundersøgelser, Charlottenlund.
Dr. A. RACEK, University of Sydney, Australia.
The Dr. JOHS. SCHMIDT's Foundation for Oceanographers.
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Zoological Museum, University of Copenhagen.

The area investigated and from which the samples for this paper are collected ranges from 50° North to 40° South, the most northern point being south of Ireland to which position larvae of *Solenocera membranacea* have been carried with the Gulf-Stream. The most southern point is the Cape waters of South Africa. But as the Penaeidae is a mainly tropical family most of the catches are from the true tropical areas within the two tropic circles of the Cancer and the Capricorn.

For the pelagic fishery wire-length paid out is given in the list, as far as it has been recorded, stated as m.W. The capital letter before the m.W. indicates gear used; for detailed information see the above-cited papers. The following are the abbreviations for types of gear most commonly used:

E. 300 — open ringtrawl, 300 m in diameter, meshes 24–18–12 mm, mouth to end.
S. 200 — open stramin-net, 200 cm in diameter, about 400–500 strands per one m.
P. 100 — open combined stramin and silk net, 100 cm in diameter, stramin 450 strands per one m, silk 23 strands in 10 mm.

The nets are fished horizontally; the actual fishing depth for wire lengths less than 1000 m is approximately one third of the wire-length paid out, for larger lengths of wire ca. one half of the wire-length.

The material has been preserved in alcohol, most of it for a period of 20–100 years; therefore, no information as to colour of the specimens is given. However, the black and brown pigments—or in cases red pigment turned black during the period of conservation—seem to be well preserved, and notes of such pigment are given. The only species here described, which the author has seen alive is the larvae of *Solenocera membranacea*. These are hyaline, but with very strong, red pigment and a little yellow on the thorax, and especially the tissue of the whole intestine is heavily imbedded with red chromatophores with the result that the intestine shows as a distinct, dark-red string through the whole abdomen.

The figures accompanying the descriptions of the species are all drawn by means of a camera lucida with a scale for measurements drawn together with the figure and placed beneath it, or close to a group of figures all drawn at the same time and with the same magnification.

For the larvae here described for the first time a special nomenclature has been used with "species larva" in between the generic and the specific names, like: *Solenocera* sp. larva *sumatransis*. This is done for not claiming priority with the larval name, when later the adult is known, and is described for the first time, or the larva will be referred to an already known species. The other possibility, only to give the different larvae a number or a letter, is not advisable and can easily cause confusion when the number of newly described larvae are as high as in this paper.

Further the second larva described in this paper has been named *Solenocera membranacea* subspecies *capensis*, because judging from the larva alone, it is a separate species in close relation to *S. membranacea*, but as it only is a larva, and some of the characters to distinguish it are distinctly larval characters, which will change in the adult, I feel with the present knowledge more justified only to make it a subspecies.

GENERAL PART

RATE OF GROWTH

In most groups of invertebrates and in fish growth in weight and in size is continuous throughout life. For the adult it is generally accepted that the rate of growth is decreasing with age and that in very old specimens the growth has nearly ceased, or is extremely slow. In Arthropods of course the growth is discontinuous. It occurs chiefly, but not entirely at intervals corresponding to sheddings of the external chitinous cuticle which in Crustacea occur at intervals till the end of life. But growth does also take place in a smaller scale between the moults in larval forms with a thin cuticle where often at the end of an instar or after one or more very good meals the skin between the segments becomes expanded, adding a small percentage to the total length of the animal.

The especially large growth from instar to instar during the larval life was used by BROOKS (1886) in his "Challenger" Report on the Stomatopods to find out whether his material provided an unbroken series of larval stages or whether some of the intermediate stages were missing. He writes ". . . the measurements usually enabled me to decide with confidence whether a given larva does or does not belong to a certain series. In a few cases these comparative measurements gave proofs of specific identity which could hardly be made more conclusive by rearing the larvae". In series which he attributed to *Coronis* he found the rate of growth to be constant with an increase from stage to stage of five fourths, or a growth factor of 1.25. From this he further could conclude that "the series (in the material at hand) is consecutive, with the exception of one missing stage before the last".

This numerical relation was termed "BROOKS' law" by FOWLER (1909, p. 224) in his work on the Biscayan Ostracods. He further modified it to read: "During early growth each stage increases at each moult by a fixed percentage of its length which is approximately constant for the species and sex". FOWLER called this percentage the "growth factor". SEYMOUR-SEWELL (1912) with a reference to FOWLER's paper gave growth-factors for several marine Copepodes, and so did SKOGSBERG (1920) and POULSEN (1962) for some species of Ostracods.

RAMMER (1928) studying Cladocera and GURNEY (1929, 1931, 1942) studying mainly fresh-water Copepoda, were impressed by the fluctuations in the intensity of the growth-factor, the differences shown by different individuals, the occurrence in older specimens, especially Cladocera, of moults without change in form and without growth. RAMMER arrived at the conclusion that BROOKS' law of growth has no value for the Cladocera he had examined; the law could therefore not be upheld, and GURNEY concluded, that fresh-water Copepoda showed such great irregularity in the growth-factor that very little reliance could be placed upon it, but in marine Copepoda as well as Decapoda there is a marked tendency for the growth-factor to be about 1.25, but there is much irregularity and the factor tends to decrease with age.

If we after this consider the present material with a series of stages or several different stages, the following will be seen (for *Cerataspis* only the length of the carapace has been given because of the diminutive size of the abdomen placed in a bent position underneath the thorax; all measurements are taken from the basis of rostrum to the cleft in telson):

Solenocera membranacea.

	carapace	growth-factor	total length	growth-factor
III Protozoea	1.3 mm		4 mm	
I Mysis	2.1 —	1.62	5 —	1.25
II —	3.2 —	1.50	5.8 —	1.16

Solenocera sp. larva _danae._

	carapace	growth-factor	total length	growth-factor
III Protozoea	2 mm		6 mm	
I Mysis	3 —	1.50	12.5 —	2.08
II —	6 —	2.00	22 —	1.76
III —	10 —	1.67	30 —	1.36

Solenocera sp. larva _sumatransis._

	carapace	growth-factor	total length	growth-factor
I Mysis	2 mm		7 mm	
II —	3 —	1.50	10 —	1.43
III —	5 —	1.67	16.5 —	1.65
IV —	5.5 —	1.10	18.5 —	1.12

Cerataspis longiremis.

	carapace	growth-factor
I Mysis	1.6 mm	
II —	3.2 —	2.00
III —	7.0 —	2.19
IV —	10.0 —	1.43

Cerataspis petiti.

	carapace	growth-factor
I Mysis	4 mm	
II —	4.5 —	1.12
III —	7 —	1.9 (damaged)
IV —	10.5 —	1.50
V —	12.0 —	1.14

Cerataspis monstrosa.

	carapace	growth-factor
II Mysis	5 mm	
V —	11.5 —	1.32 as average growth-factor pr. stage.

This shows for *Solenocera*, when the carapace is measured, first an increase in the growth-factor and then a decrease. The early increase is explained by the fact that the carapace in the younger stages does not nearly cover the thorax and therefore in the following stages grows proportionally much more than the rest of the body. But coming to the second or the third mysis the carapace covers the whole thorax and therefore, from now on, the growth rate measured on the carapace decreases. Measuring the total length there is a decrease through the stages in *S. membranacea* and in *S.* sp. larva *danae,* but *S.* sp. larva *sumatransis* shows first an increase and then a decrease. It must here be remembered that the material at hand is very small in numbers and therefore not absolutely reliable.

When considering the three *Cerataspis* where only the carapace has been measured we observe first an increase and then a decrease as is also the case for the carapace of *Solenocera.*

A larger material including more stages was dealt with in an earlier investigation of *Meganyctiphanes norvegicus* (HEEGAARD, 1948) with results as follows:

Meganyctiphanes norvegicus (after HEEGAARD, 1948).

	total length	growth-factor	remarks
I Nauplius	0.45		no mouth opening
II —	0.40	−0.125	
I Metanauplius	0.42	1.025	
I Calytopis	0.85	2.025	strong elongation of abdomen
II —	1.57	1.85	
III —	2.13	1.36	
I Furcilia	2.69	1.26	
II —	3.26	1.21	
III —	4.16	1.28	
IV —	5.42	1.30	
	including 98 larvae + nauplii		

Further investigations made by BIRGER RASMUSSEN (1953) on *Pandalus borealis* along the Norwegian coast show that the growth-factor fluctuates from year to year, as an example is referred to his investigations from the "Torungen Ground" in the years 1942–1946 (pp. 54–55). The growth-factor is larger in 1945 than in 1946, and as a general result of the investigations he concludes in his summary (p. 153): "The growth and maturing change, not only from one locality to another, but also from brood to brood born in different years in one and the same locality". In this connection can be mentioned that the change of sex from male to female in this shrimp takes place at an age of 5 years at Spitzbergen but already in the second year in Skagerrak.

In the paper from which the above growth diagram of *Meganyctiphanes* has been taken (HEEGAARD, 1948) it is also shown that for the same species taken at the same locality and at the same time there is variation within the stages. We are not able to give a definite description of a certain instar. In Fig. 7 of that paper is shown that if the course of the development of the pereiopods is defined to include nine consecutive groups, we find that Furcilia I is placed in groups 1–3, Furcilia II in groups 2–6, Furcilia III in groups 5–8 and Furcilia IV in groups 7–9. This shows not only a wide spreading in the course of development, but also a considerable overlapping between an instar and the stages preceding as well as following it. This explains the different opinions in the literature of the numbers of instars in certain species and shows, what so often has been overlooked in investigations that an instar of a species can not be described without stating reasonable limits for variation in numbers of setae or even sometimes of joints. Therefore it needs more experience and knowledge in larval development to decide to which instar a certain larva belongs than to determine an adult to a certain species. It also points to the fact that an ecdysis does not only take place when a larva has reached a certain definite stage of development. Time and temperature are also important factors in causing a greater or lesser success for the larva in catching food, thus influencing the degree of development it will reach before moulting.

A further consideration of the growth-factor for *Meganyctiphanes* in the diagram above shows that the factor is negative between the first and second Nauplius, simply due to the fact that the stomodeum and the proctodeum have not broken through in the first Nauplius. Therefore the larva can in this stage only use its own yolk for metabolism as well as for producing new organs. This shrinking is also observed for insects during pupal life, and it is in both cases natural that it must be so. From Metanauplius to Calytopis we found the largest growth-factor, viz. 2,025. This is easy to explain by the fact that the abdomen is more elongate, in fact only a thin string, in the first Calytopis, whereas it is short and more massive in the Metanauplius. The same factor of body change has POULSEN (1962, p. 128) also pointed to when he writes: "BROOKS' law is only valid when growth alone is concerned, and not when growth is combined with a change in form". Finally in the later Furcilia stage the growth-factor again has increased a little because the larva now has acquired fully developed mouth appendages and therefore can start to attack bigger prey. A similar increase can be observed when a larva changes from feeding on detritus to being carnivorous, or has grown to a size where it can successfully attack animals which are abundant on the locality, but which up to then have been too big or too fast-swimming for the larva to attack or catch.

A note published by PROVENZANO (1962) from his investigations at Miami, further elucidates this matter. By studying the larval life of several species of anomuran crabs and caridean shrimps reared in isolation in the laboratory he found that the moulting to the post larval stage occurred after a variable number of instars. He further found that the occurrence of intermediate forms at the end of the larval series may be connected with the general variability of number of larval instars in these groups. This is to my opinion caused by the fact, that an ecdysis does not take place just because a larva has reached a certain state of development, but because a cuticle can only last a certain time, partly dependent on its thickness, which increases with each instar. Temperature, food, and possibly also certain chemical factors influencing the food available in the surrounding waters may also affect the number of instars. If the larva between two instars has succeeded in being well fed, the new instar will be further advanced in (the larval) development than if the individual larva has just managed to survive or even has been starved.

We therefore see that BROOKS' law has to be used with great care, as he also did himself; it was first FOWLER (1909) who raised it to a law with BROOK's name attached to it. Certain factors have to be constant, what they not always are, like changes in form, in feeding, in living habits, in environment and finally also in internal organs. As an example PRZIBRAM and MEGUSAR (1912) found in *Sphodromantis* that the weight doubled from moult to moult, and that the increase in length of the prothorax is, on an average $\times$ 1.26. In 1929 PRZIBRAM concluded that the doubling of the weight was caused by the doubling of the cells, whose linear dimensions would consequently increase as the cube root of 2. But we have already seen a multiplying of cells together with a shrinking of the body as in the first Nauplius of *Meganyctiphanes* and in the pupal stage of many insects, and we know that in Rotifera, after reaching the adult stage, the number of cells seems to be constant for male or female of one and the same species. But still the animal may grow considerably in size, length and weight, but it is here the single cell which becomes larger.

Finally we can conclude that the larva with all the factors which constantly influence its growth seems to have, as in other invertebrates and fish, a growth-factor which already in the larval life has a tendency of slowly decreasing for finally to reach zero or even be negative about the time of the natural death of the animal.

Data of growth for larvae dealt with in this paper are given on p. 144.

We can therefore see that, as BROOKS writes, the growth-factor can be of some help to clear whether an instar of a larval life is missing or not in a certain material, but it has to be used with caution and is best to be relied on for animals living in great abundancy or evenly and commonly distributed through their biotop.

SOLENOCERA

History

Only little is known of the larvae of the *Solenocera*, mostly because the genus is an oceanic Penaeid, of which even the adult is still one of the least known natant genera. This is possibly also caused by the habit of the adult to burrow into the bottom. It is therefore very likely that this shrimp genus is much more common than generally supposed.

The earliest record of the larva in the literature is from 1863 when FRITZ MÜLLER describes some larvae from Desterro on the Atlantic coast of Southern Brazil. MÜLLER refers the larvae to the Penaeids or *Cryptopus*. They are all Penaeids, and *Cryptopus*, his Figs. 18–21, is a *Solenocera*. MÜLLER's Figs. 18, 19 is by him referred to "einer dritten Art kurz vor der Verwandlung in die Mysisform". The carapace shows characters of both third Protozoea and first Mysis, the limbs and the body segmentation is as in the third Protozoea. His last two Figures, 20, 21 are clearly details of a larva in the Mysis stage. (See further pp. 45–47).

In 1893 ORTMANN describes a larva of the Penaeids with the name of *Opisthocaris muelleri*, new genus, new species. This is also a *Solenocera* larva and in the second Mysis stage. As it also was taken at the coast of Brazil, ORTMANN suggests the possibility that his larva is an older stage of the above mentioned larva of MÜLLER. For this reason the species was given the name *muelleri*.

Between these two publications came BATES' "Challenger" Report on the Macrura in 1888, where he on page 363 under the name of *Platysacus crenatus* novum genus, nova species, describes a larva from the Atlantic Ocean off Sierra Leone on the African coast. This larva is also a *Solenocera* and in the third Protozoea stage. Further can be mentioned that it belongs to the same group of *Solenocera* as *Solenocera membranacea* of which the larva first was known much later, but the two are distinctly different species.

In 1904 Lo Bianco gave beautiful, coloured pictures of *Solenocera membranacea* (*S. siphonocera*, Pl. X, Figs. 39–40), and describes them as Zoea and Mysis stages. They represent second Protozoea and first Mysis stage. The morphology of the figures is not correct in detail for *Solenocera membranacea*. The spines on the carapace of the second Protozoea are entirely missing, and the ones placed on the carapace of the first Mysis are not in the correct number or position for that species. Fig. 40 shows a pair of post-cardiac spines which are only found in *Solenocera* larva, but the rest of the spines are not placed in the right position. The two lateral spines on the telson-furca are missing in Lo Bianco's figure. Besides showing the beautiful colour of the living larva Lo Bianco gives the information, that the larvae are found throughout the year at depths down to 300 m. Already in 1902 and in 1903 the same author records the larva from the Napoli plankton and in 1900 he points out together with Monticelli that the *Platysacus crenatus* Bate and the *Oposthocaris muelleri* Ortmann must be *Solenocera* larvae. Lo Bianco's figures were reproduced by Williamson 1915 in "Nordisches Plankton", and Stephensen 1923 recorded the larvae in the Mediterranean and Atlantic Ocean (outside Gibraltar) and in the English Channel.

In 1924 Gurney described some *Solenocera* larval stages from the "Terra Nova" Expedition. Two from the Atlantic Ocean station 43, and a third Protozoea which with few exceptions has the same characters as the third Protozoea of *Solenocera* sp. larva *elongata* described in this paper also from "Terra Nova" St. 43, and which probably is the same specimen. Further from the same station Gurney described a first Mysis larva of *Solenocera* which is the first Mysis stage of the same species. Both are here referred to my *S.* sp. larva *elongata*. From the Pacific Ocean Gurney figures a second and third Protozoea named *Solenocera novaezelandiae* (?) Borr.

In 1938 J. Heldt described the *Solenocera membranacea* larvae at the Oceanografic Station Salammbo on the Mediterranean coast of Tunis, and in 1955 she gave full descriptions of all the larval stages of that species except nauplii from the same locality. Later Kurian has described the same larva from Split in the Adriatic, 1956.

Description

Carapace

In the *Solenocera* larvae the carapace is provided with a varying number of spines and sometimes the whole carapace is covered with longer and shorter hairs. The spines are either smooth or have short hairs or secondary spines covering their surface. The most dominant of the spines is the rostrum. It starts as a thick, hollow rod, which mainly through compressions becomes massive in the first and second mysis, only in the true tropical and oceanic forms much later. Finally ridges and grooves may be found on the carapace. It has therefore been practical to give names to all these characters on the carapace in order to facilitate a distinct description of the species, to provide definite distinctions between the different species making comparisons possible, and finally to arrange the different larvae into groups with certain larval characters being the same for all members inside a group.

Fig. 1 shows a carapace with all the different characters which are found in the larvae. It is of course only a diagram, as no single larva examined possesses all the characters figured.

The carapace (Fig. 1) is often divided into two parts, the carapace proper and a rostral plate (1) (the following numbers in brackets refer to the number given in Fig. 1). The rostral plate is just a curved laminar plate along the anterior margin of the body carrying the rostrum. The rostrum (7) is usually well developed and in the younger stages bent in a semicircular arch pointing ventrally. The rostrum may be smooth on its surface or barbed with short hairs or scales. It is never toothed on its ventral side, but may develop one or two dorsal teeth (8) in the Mysis stages, never in the Protozoea stages. Sometimes the rostrum extends backwards as a dorsal keel on the carapace proper behind the rostral plate. This ridge may also be provided with a single tooth in the Mysis stages, and to distinguish this tooth from the previously mentioned teeth, as not being placed on the rostrum proper on the rostral plate but behind it, I have named this tooth epigastric-rostral tooth (9). From the rostral plate, if present, extends further a pair of strongly developed spines pointing

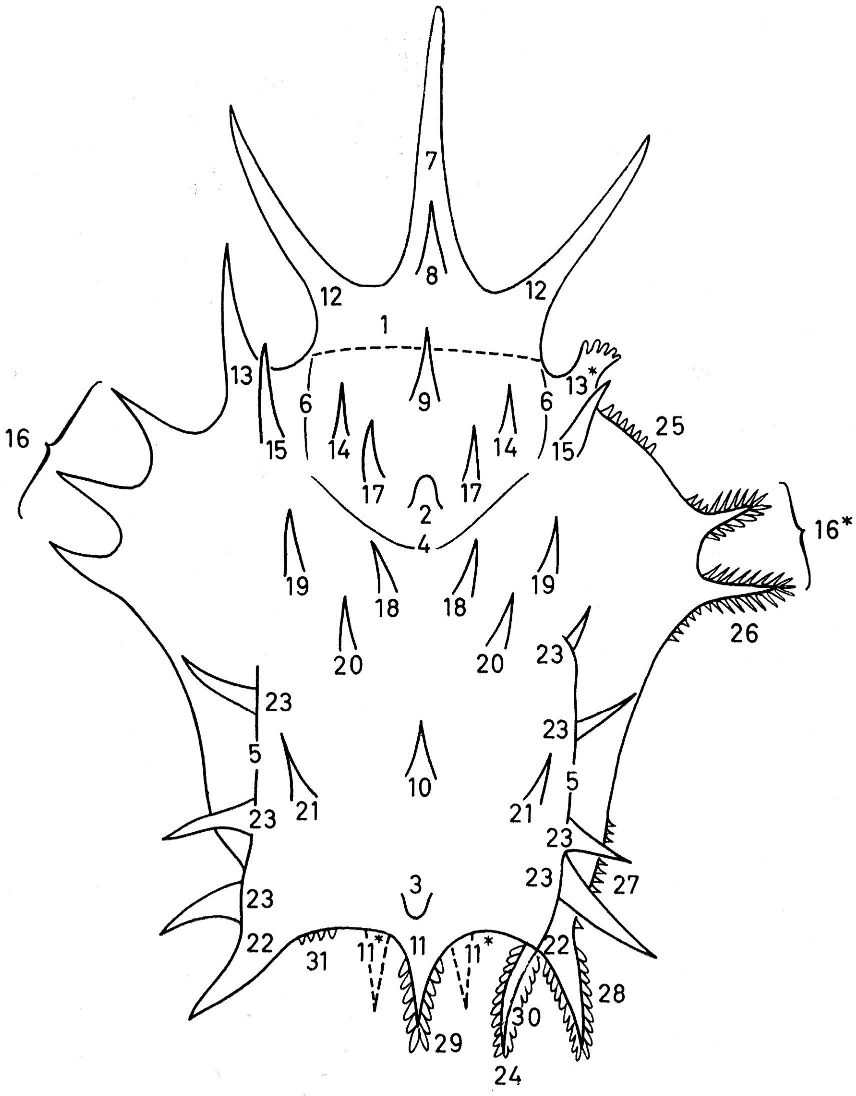


Fig. 1. Diagram of the carapace of *Solenocera*.

1. Rostral plate
2. Anterior dorsal organ
3. Posterior dorsal organ
4. Cervical groove
5. Branchio-cardiac groove
6. Cervico-branchial groove
7. Rostrum
8. Rostral tooth
9. Epigastric rostral tooth
10. Epi-cardiac or *dorsal* spine
11. Medio-posterior marginal spine

11* Medio-posterior marginal spines

12. Supra-orbital spine
13. Antennal spine

13* Antennal process

14. Post-orbital spine
15. Post-antennal spine
16. Branchiostegal spines

16* Branchiostegal process

17. Medio-gastric spine
18. Pre-hepatic spine
19. Latero-hepatic spine
20. Supra-hepatic spine
21. Post-cardiac spine
22. Latero-posterior marginal spine
23. Branchio-cardiac or *lateral* spines
24. Posterio-branchial groove spine
25. Supra-antennal teeth
26. Branchiostegal teeth
27. Branchio-lateral teeth
28. Posterio-marginal teeth
29. Medio-posterior teeth
30. Posterio-branchial teeth

31 Medio-posterior marginal teeth

forwards above the eyes, the supra-orbital spines (12). These are always present on *Solenocera* larvae whether or not a rostral plate is present; they arise from the rostral plate when this is present. Laterally to these and more ventrally is placed a pair of antennal spines (13), named thus because they point forward from the carapace dorso-laterally of the second antenna. This pair of spines is found in the Mysis stages, but not in the Protozoea stages and is always much smaller than the supra-orbital spine. In older Mysis or postlarval stages it may be reduced to a tooth-like process on the antero-lateral corner of the carapace. Characteristic for all *Solenocera* larvae is the presence of two dorsal organs. The anterior dorsal organ (2) is the largest and placed medially on the carapace in front of the cervical groove (4) but behind the rostral ridge and the epigastric-rostral tooth when present. The second dorsal organ (3) is placed posteriorly on the carapace just in front of a medio-posterior marginal spine (11) or when two such spines are present between them. The medio-posterior marginal spine (11) (or spines) is dentated on its surface or at the tip in the Protozoea, but usually smooth in the Mysis. Between the two dorsal organs in the medial line is, with few exceptions, placed a strong, unpaired spine, the epicardial or dorsal spine (10), it is the only unpaired spine found on the carapace except for the posterior marginal spine (11). Finally the latero-posterior corner of the carapace is in many forms projected backwards into a spine, the latero-posterior marginal spine (22). This spine may variate in the different species and stages from being the strongest spine on the whole carapace to only a tiny tooth as in *Solenocera muelleri* or *S.* sp. larva *aequatorialis,* and is even missing in *S.* sp. larva *danae* and *S.* sp. larva *sumatransis.* When the spine is present it is usually in the Protozoea and often even in the Mysis, lined on both sides with the postero-marginal teeth (28). When the spine is absent, the teeth, if present, are placed directly on the margin of the carapace as in *S.* sp. larva *sumatransis.* Between the medio-posterior marginal spine and the latero-posterior marginal spine, the postero-branchial groove spine (24) is placed. This spine is found in all *Solenocera* larvae so far known, but not in any other Penaeid larvae. It could therefore also be called the *Solenocera* spine as characteristic for the *Solenocera* family. In most *Solenocera* larvae, and always in the Protozoea stages, it is covered with a dentated rim (30), which often degenerates with age and may disappear in the oldest larval stages. *Solenocera membranacea* is the only *Solenocera* species of which the first post-larval stage is known, and in this stage the spine is lost. Possibly it disappears in all the *Solenocera* species with the first post-larval stage, because in no adult *Solenocera* any spine is found, which can be traced back to be homologous with it.

These are the spines and organs on the carapace present practically in all *Solenocera* larvae, with only very few exceptions, where one or two of them are missing at the same time, as already mentioned above. However, several other spines, dentations and ridges may be found, all figured together on the diagram, Fig. 1. They are briefly the following: On the carapace behind the supra-orbital spines (12) and in line with them is a pair of small spines, the post-orbital spines (14); similarly placed are the antennal spines (13); behind these and in line with them is a pair of accessory spines, the post-antennal spines (15); finally laterally to the anterior dorsal organ (2) and a little in front of it is very often a pair of small spines, the medio-gastric spines (17). All these spines are found anteriorly of the cervical groove (4) which sometimes is prolonged into a second groove, the cervico-branchial groove (6), running forward on both sides of the carapace reaching its frontal border between the supra-orbital spines (12) and the antennal spines (13); when a rostral plate (1) is present it meets the cervico-branchial groove at its postero-lateral corner.

Behind the cervical groove the following spines may be found. The pre-hepatic spines (18), a little behind and in line with the post-orbital spines. In about the same transverse line on the carapace are the latero-hepatic spines (19), in line with the post-antennal spines (15). A little further back in the area between the last two spines (18–19) a pair of supra-hepatic spines (20) may be found. Finally behind the unpaired dorsal spine (10) may be placed a pair of spines, the post-cardiac spines (21). The dorsal spine as well as the lateral spines (in cases only one lateral spine is present), may be homologous with the spines having the same names in the Brachyuran Zoea. Laterally along the posterior half of the carapace may be found a ridge or groove, the branchio-cardiac groove (5). Along this groove are often placed a number of spines, usually three to four, the branchio-cardiac or lateral spines (23). The branchio-cardiac groove forms posteriorly a long lobe or spine; the spine may have lateral spines as in *Solenocera* sp. larva *elongata,* and the lobe can be developed into an enormous posterior horn as in *S.* sp. larva *danae.* Because of a connection of the spine with the branchio-cardiac groove, the spine is named postero-branchial groove spine (24). Finally on each side of the margin of the carapace a little behind the antennal spine (13) can be found one to three spines, the branchiostegal spines (16). These spines are most strongly developed in the Mysis, but may already be present in the Protozoea, but then they are much smaller and more delicate.

Characteristic for the *Solenocera* is the toothed margin of the carapace. The teeth are more numerous in the Protozoea than in the Mysis, but are often found in limited numbers even on the older Mysis stages. After their placement I have divided them into different groups, which may overlap or be distinctly separated with smooth stretches between them. Further, in most Protozoea the carapace margin is lined by a thin cuticle with marginal teeth. This cuticle may be drawn out into longer or shorter flat or spine-like lobes which then bear the teeth on their whole surfaces or only on their distal margins. These lobes or rims are only found in the Protozoea and disappear with first Mysis. The groups of teeth on the carapace are as follows: anteriorly on the side of the carapace behind the antennal spine are the supra-antennal teeth (25), which reach backwards to the first branchiostegal spine (16) if this is present or to that region; they are in most Protozoea substituted by a short, semicircular lobe with a toothed margin. Posteriorly to these follow the branchiostegal teeth (26) which may be placed on one or two lobes at each side of the carapace. Most latero-posteriorly are the branchio-lateral teeth (27) which may be followed by the postero-marginal teeth (28) placed either along the margin of the carapace proper or lining the two edges of the latero-posterior marginal spine if this is present. Finally the medio-posterior marginal spine or spines (11), if present, are usually tipped or lined with a row of teeth, the medio-posterior marginal teeth (29).

These different groups of marginal teeth on the carapace are very characteristic for the *Solenocera,* and form a clear distinction mark for the larvae in the plankton. Similar teeth, although in a much lower number, are also found in some larvae of Euphausiacea, but here the carapace is always smooth without the many spines present in the *Solenocera.* Spines of this kind are also found on the carapace in the larvae of the near related Sergestidae, where the spines in some of the known Protozoea are even twice as long as in the *Solenocera,* but in the Mysis of Sergestidae the spines are much shorter and fewer in number than in *Solenocera.* The larvae of the two families are, however, easily distinguished because no posterior dorsal organ and no toothed margin of the carapace are known in the larvae of Sergestidae where the spines on the carapace often are branched.

Abdomen and Telson

The abdomen is already divided into six segments plus telson in the second Protozoea, and spines are present on its surface from the third Protozoea. These spines may be placed in five different positions as shown in Fig. 2: An unpaired dorsal spine (1); an unpaired ventral, usually shorter spine (5); further three paired spines with one on each side: a lateral spine (2), a dorso-lateral (3) in front of the dorsal spine and a ventro-lateral (4) pointing backwards from the posterior margin of the segment. The pleura of the abdominal segments are never found in the Protozoea. They usually appear in the second Mysis or later.

In the first Mysis stage a lateral process develops on each side of the first abdominal segment much like the one found in most Zoea of Brachyura, where it, however, is placed on the second abdominal segment. The process is not homologous with the one in the Brachyura which disappears with the Zoea stage. It has been suggested for the Brachyura that this process supports the carapace and keeps it in position. In the *Solenocera* this process develops in the second Mysis into an elongated ridge running in antero-dorsal to ventro-posterior direction (Figs. 4–5). In the adult of which I have only had opportunity to examine *Solenocera membranacea* it seems (Figs. 3–8) to be the same for most members of that genus and for some other Penaeids. On the first abdominal segment the pleuron is by a dorso-ventral line divided into two halves with a flexible suture between. Further on the dorsal side of the segment the cuticle has formed an anterior carina which is placed below a narrow posterior ridge on the same segment. This formation of a lower anterior carina part starts already to develop in the second Mysis with the ridge between the anterior and posterior part running just in front of the dorsal spine. On the second abdominal segment is a similar division of carina into a lower anterior and a higher posterior section (Figs. 7–8), but the pleura are undivided in the second segment

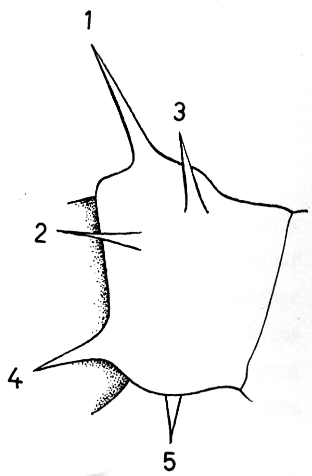


Fig. 2. Diagram of an abdominal segment of *Solenocera* with the following spines:

1. dorsal spine
2. lateral spine
3. dorso-lateral spine
4. ventro-lateral spine
5. ventral spine

as also in the following ones. A comb of stiff hairs is found along the margin of the anterior part of the pleuron on the first segment, beginning close to the dorsal line of the segment. This division of carina on the first and second segments enables the shrimp to bend the abdomen in a dorsal direction until the abdomen forms an angle of 90° with the carapace. With this bending the frontal section of the carina of the first segment disappears under the carapace and the dorsal part of the second segment is placed close to the posterior line of the first segment as shown on Fig. 8. By this procedure which the shrimp undertakes for digging itself into the mud, the posterior part of the carapace reaches backwards underneath the pleuron of the first segment, and the stiff hairs on the margin of the pleuron prevent mud and smaller sand grains from penetrating

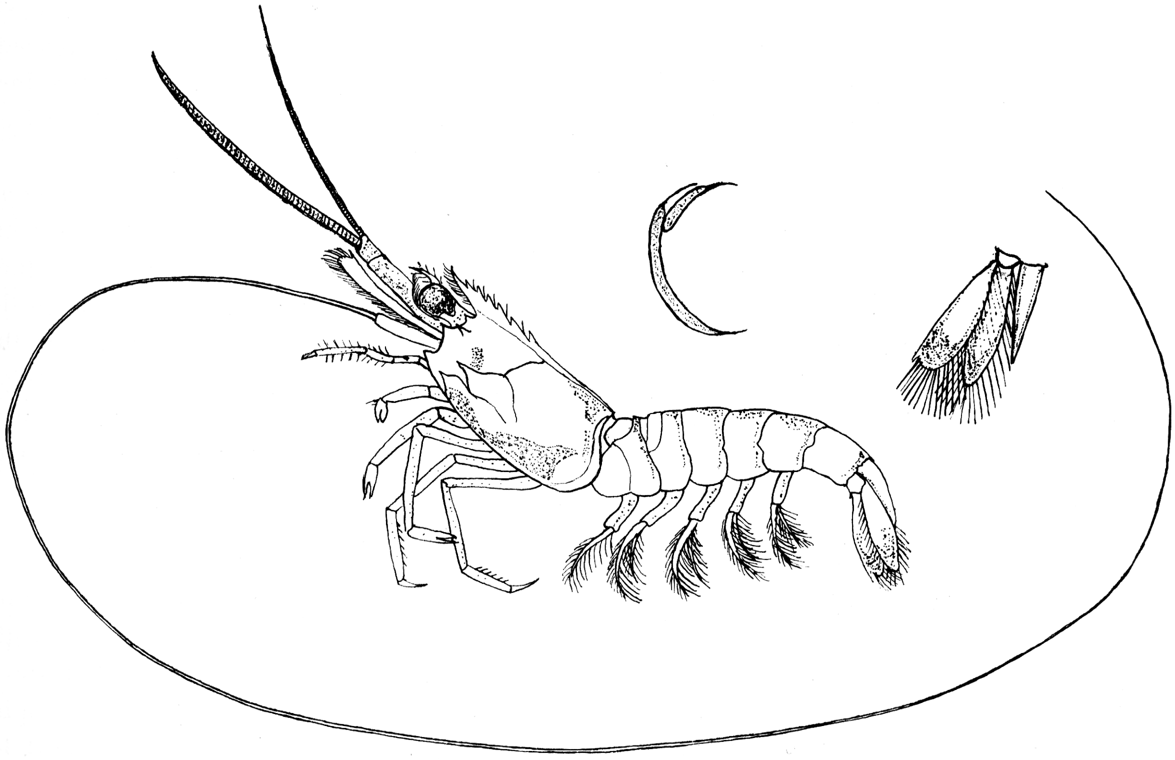
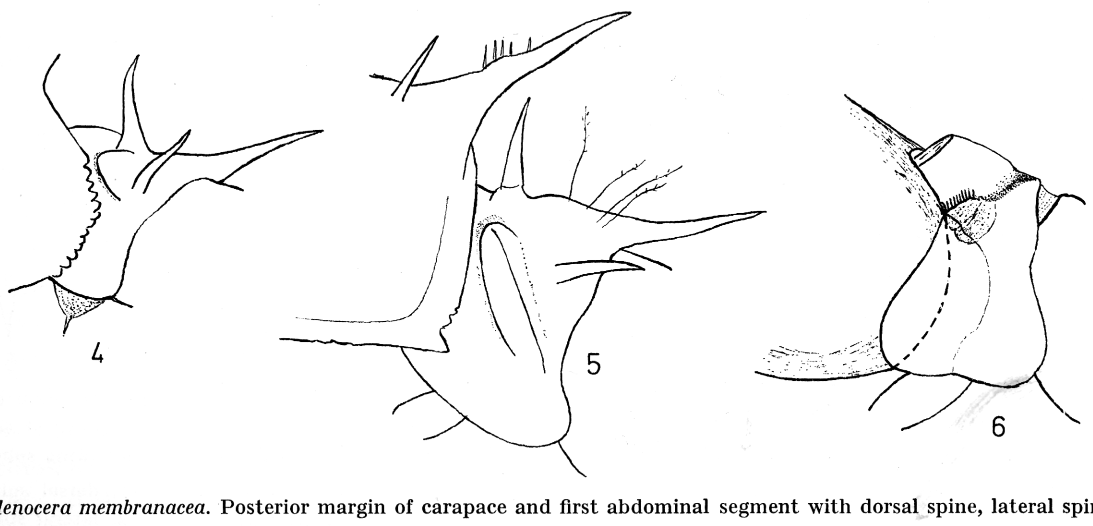


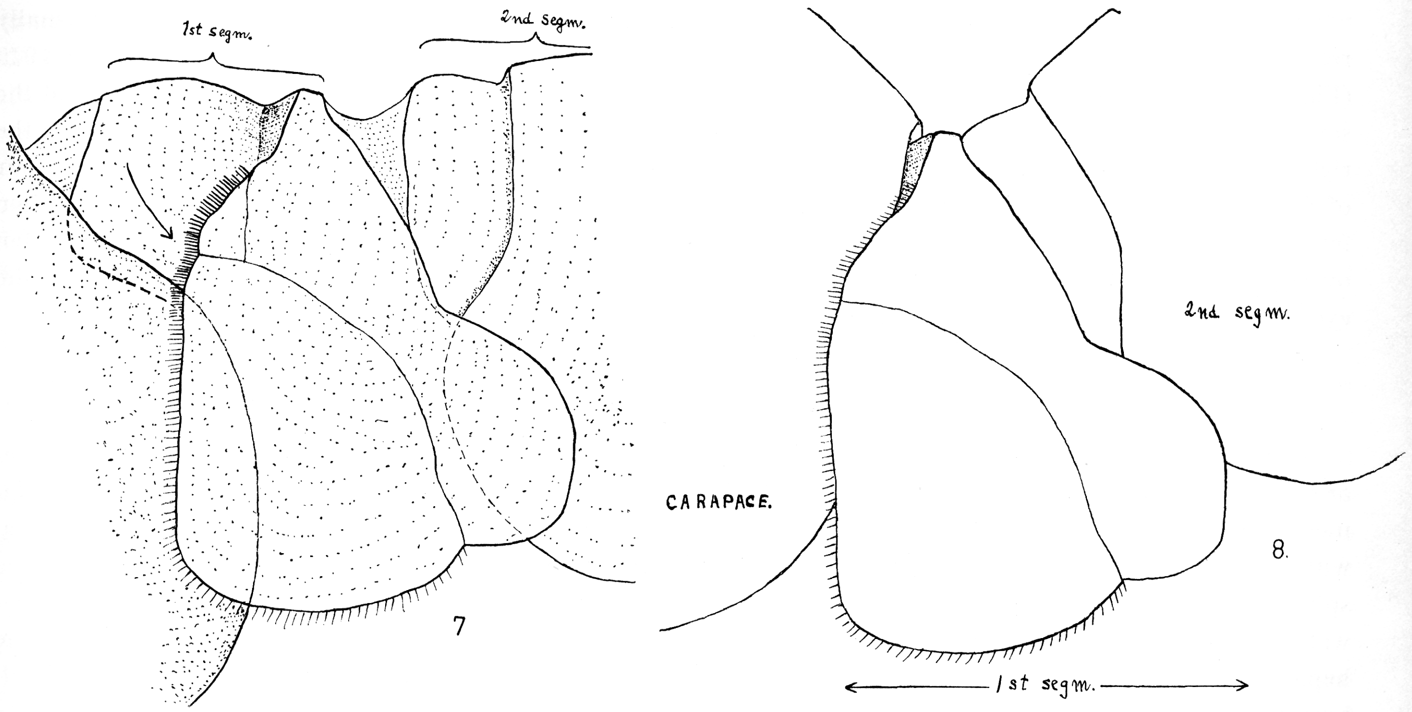
Fig. 3. *Solenocera membranacea* H. MILN.-EDW. Adult female. Separate Figures: above-transverse section of the two flagella of the left first antenna showing one half of the siphon in cross-section, right-telson and the left uropod.



Figs. 4–6. *Solenocera membranacea*. Posterior margin of carapace and first abdominal segment with dorsal spine, lateral spine and dorso-lateral spine in first Mysis Fig. 4 and second Mysis Fig. 5. Development of lateral process, Figs. 4, 5, and 6. Division of the lateral pleuron of first segment in the adult, Fig. 6. For further explanation see text.

inside the carapace damaging the gills, and an opening is kept for the incoming water for respiration, as shown with the arrow on Fig. 7. In the more dorsal part pointing towards the anterior part of the carina the hairs are placed more thickly than on the rest of the margin. The outgoing respiratory water leaves the shrimp through the antennal siphon.

The telson is in the larval forms always bifurcate. In the Protozoea the branches are running almost transversally to the longitudinal line so that the telson is more or less T-shaped. In the Mysis the two branches are moved more towards each other making the telson more Y-shaped. Each branch is normally furnished with four inner setae and one terminal spine. On the lateral margin of the telson are placed three curved



Figs. 7–8. *Solenocera membranacea* adult. Posterior margin of carapace and first and second abdominal segments in two different positions. For further explanation see text.

spines, which are first present in the Mysis, but often found as plumose setae already in the Protozoea. As in most Penaeid larvae of these stages their mutual placement may vary from species to species.

Special Sense Organs

The dorsal organs are always found in a number of two in the *Solenocera* larvae, and they are generally very large. The anterior one is placed in front of the cervical groove and is the largest of the two, the posterior and smaller is placed near the hind margin of the carapace either in front of the unpaired medio-posterior marginal spine or if this is paired between the pair. In the Sergestidae, both in the Protozoea and the Mysis (*Mastigopus*), only the anterior organ is present. A dorsal organ can be traced either in the embryo, larva or adult of most groups of Crustacea, but the variation in structure and position and number (1–3) makes it doubtful whether all dorsal organs are homologous.

In *Trilobites* (RAYMOND 1920, p. 86) there is commonly in the region of the eye a median tubercle which has been related to the dorsal organ of *Apus*. In some primitive forms this tubercle was developed into a long spine, and RAYMOND suggests that the tubercle is a vestigial organ, and that it "very strongly suggests the zoeal spine of modern Brachyuran Crustacea". RAYMOND, however, later states that there may be even a series of tubercles in *Trilobites* placed in the median line, and exactly like the anterior dorsal organ. Some facts in the *Solenocera* speak against this assumption. In the *Solenocera* the dorsal organ is tubercular, and although its function is not yet clear, it can hardly be considered as an only vestigial organ in the larva. Further the dorsal organ may in the decapod larvae be found in a number of up to three unpaired organs placed in the median line, and in most *Solenocera* a dorsal or zoeal spine is found in addition to the dorsal organ; also in the Brachyura a few genera are without the zoeal spine. It appears more likely that the dorsal or zoeal spine and the dorsal organ are two distinctly different developments, but it is probable that a form of a dorsal organ is replaced by a spine, when lost, like an eye may be replaced by a limb-like lobe, but never by a new eye.

An "ocular papilla" is also found in each eye-stalk in the *Solenocera* larva. In the first Protozoea this organ is placed in the region of the developing eye underneath the carapace, but in the second Protozoea, where the eyes are stalked, the papilla is placed on the anterior lower side of each eye-stalk and is usually retained throughout larval life. This papilla is often called the frontal organ, but Gurney, Lebour 1940 (Fig. 16) show that in the larva of *Sergestes crassus* both frontal organ and ocular papilla are present at the same time, which indicates that they are separate organs, and therefore only the ocular papillae will be the right name to use. Also in the first Protozoea of *Parapenaeus longirostris*, Heldt 1938 (Fig. 64,1) is a pair of frontal organs ventrally in front of the carapace which likely are the ocular papilla. This organ is often found in the eyestalk of decapod Crustacea, but as it is placed on the lower side of the eyestalk it is often overlooked. It may be the beginning of the later x-organ which is a hormonal gland in connection with the eye producing a hormon regulating the colour-changing in the chromatophores.

Chromatophores and Coloration

The chromatophores are not described in the literature except for the two figures of *Solenocera membranacea* (*S. siphonocera*) of Lo Bianco, 1904 (Pl. 10, Figs. 39, 40). They show that the larvae are pigmented with red and orange. After the figures the red is more developed in the Mysis than in the Protozoea, with two pairs of dark red spots on the carapace near the base of the supra-hepatic and the medio-gastric spines. A red line runs through the first five abdominal segments, this is the strongly pigmented intestinal wall, and occasionally a single red spot is found at the basis of telson. The orange is especially found on the hepato-branchial region of the carapace and on the limbs. The material to be dealt with in this paper is all long preserved material with no traces of chromatophores left.

Appendages

First Antenna.

This appendage seems to be jointed throughout the Protozoea stages. After Heldt's figures (1955) of the first Protozoea of *S. membranacea* the antenna consists of several (5) ringed joints proximally of the two distal joints; in the second Protozoea the number of the rings are still five; in the third Protozoea they are coalesced into two joints proximally of the two distal ones. In the youngest larva from the present material, the third Protozoea, the first antenna is always four-jointed. In the first Mysis the basal joint enlarges and develops the statocyst bulge on its lateral side together with a ventral incavation, which is the beginning statocyst incavation. Further the first and second joints coalesce so that the peduncle of the first antenna in the first Mysis is reduced to three joints. The sutures between the coalesced joints can not be seen, but from the setae placed on the third and fourth joints in the third Protozoea it can safely be concluded that the coalescence occurs between the first and second joints. Further, from the most distal joint, the former fourth joint now the third joint, the two flagella of the first antenna begin to develop and grow rapidly during the following stages after each ecdysis. In the first Mysis the flagella are unjointed, in the second they may in some forms remain unjointed, but have developed groups of olfactory hairs on the surface of the lateral flagella. In other forms they have more than doubled their length and each consists of five to ten joints, but in this case the olfactory hairs remain still undeveloped. The development of the first antenna proceeds in this way through the following stages. The statocyst seems to be fully developed in the fourth Mysis stage in oceanic forms with a slower development, and in the first post-larval stage in the more coastal forms with only two Mysis stages.

Second Antenna.

This limb is the ambulatory organ of the Protozoea through its three stages and therefore well developed right from the beginning. In the first and possibly the second Protozoea the peduncle seems after Heldt's (1955) figures to be two-jointed, in the third Protozoea it is only one-jointed. The exopod is the swimmeret and therefore strongly flexible, often ringed into many joints and in all Protozoea stages provided with a series of swimming setae on its tip and median edge. The endopod is usually three-jointed, and even if the lines between the joints are missing the appearance and arrangements of the setae point clearly to a three-jointed endopod. In the Mysis this changes. As in all other Penaeidae the locomotory function is transferred from the second antenna to the pereiopods, and therefore the exopod looses its swimming setae and begins to transform into the unjointed antennal plate. The protopod remains unjointed as in the last protozoea and the endopod is in the first Mysis reduced to an unjointed branch which through the following stages becomes the long, flexible flagellum.

Labrum.

The labrum or upper lip is a large semi-globular cup which anteriorly on the median side may continue as a shorter or longer spine. This spine can, as in *S.* sp. larva *elongata*, be very long and curved into an S-shaped hook (see Fig. 170).

Mandible.

The mandible is a strong biting-crushing organ with a well developed pars incisor and pars molaris on the corpus mandibulae. In the three Protozoea stages the mandible is without a palp. In the first Mysis stage is a short unjointed palp, and from the second Mysis stage the palp is two-jointed, as in the adult, only not yet furnished with so many setae as in the adult. Also the connection between corpus mandibulae and its palp is not yet so flexible or movable as later, when the cuticle on the corpus mandibulae itself becomes thicker.

Labium.

The labium or the lower lip is in most of the forms well developed and can be divided into three components: the basal plate or peduncle and two longer or shorter lateral arms, each ending in a disc-shaped plate. The two arms vary very much in length in the different species. In some, e. g. *S.* sp. larva *danae, S.* sp. larva *braziliensis* or *S.* sp. larva *sumatransis* they are very short nearly not existing as separate parts. In *S.* sp. larva *elongata* and in *S.* sp. larva *aequatorialis* they are well developed, in the latter even to the effect that each labium plate is placed on a long stalk so the plates can be stretched forward, even in front of the mouth. This indicates a direct use of them by the animal when feeding on detritus or small plankton organisms which by the two labium plates with their rows of stiff marginal setae can be filtered and drawn backwards between the mandibles to be masticated before passing into the mouth. In *S.* sp. larva *nodulosa* the same result is partly, but also only partly, reached through a stalk-like basal plate on the labium moving the rest of the labium forward like a deep, hollow spoon, but without an eventual independence between the right and the left side as is possible in *S.* sp. larva *aequatorialis.*

First Maxilla.

The first maxilla is of the usual type with two mastigatory endites. The endopod is two- or three-jointed in the Protozoea and three-jointed in the Mysis. The exopod has the usual bulbous shape with four strong plumose setae. The exopod is lost with the first Mysis stage and does not reappear in the later stages.

Second Maxilla.

This limb has also a lobate exopod with four plumose setae in the two first Protozoea stages, and usually five setae in the third Protozoea. With the first Mysis the exopod achieves the shape of the adult as a fan-shaped, thin, leaf-shaped organ with a row of plumose marginal setae; the setae are not so thickly plumose as in the Protozoea. The protopod is furnished with the usual four endites, two coxa-endites and two basiendites, which are found already in the Protozoea, but first fully developed in the Mysis. The endopod is well developed with up to five joints, but in the younger stages there is often no clear separation between some or all of the joints.

First and second Maxillipedes.

In the Protozoea the endopod branch is much better developed than the exopod. This as well as the many setae on the medial margin of the protopod show that it is an organ more for catching and holding the prey than for swimming. The limbs retain partly the same form in the Mysis, but the exopodial branch is here better developed than in the Protozoea.

Third Maxilliped.

It is only a rudimentory organ throughout the Protozoea and first in the third and last Protozoea it becomes distinctly bifurcated, but it is still too undeveloped to have any real function. In the first Mysis it suddenly starts its proper development and is from now on the longest of the three maxillipedes and can with its endopodial branch reach forward often in front of the eye. It is still more densely provided with setae than the 1st and 2nd maxillipedes.

Thoracopods.

All the thoracopods start to develop as small limb buds in the Protozoea stages, and in the third Protozoea they can be seen clearly as two rows of five bifurcated limb-rudiments behind the maxillipedes hanging down from the posterior part of the carapace; they are without any segmentation or any function. Also in these limbs a sharp change takes place with the first Mysis stage where they appear as well developed bifurcated appendages which have taken over the locomotory function. At the same time a chela starts to develop on the three first pairs, but the joints of the chela have still long setae, also in the following Mysis stage or stages. They can first function as chelae in the first Postlarval stage. The fourth and fifth periopod are ordinary, bifurcated appendages without chelae. Their function is only locomotory and therefore they have well developed exopods in the Mysis stages; on the fifth pereiopod the exopod is a little better developed in the second than in the first Mysis stage. On the Postlarva the exopod has decreased in size on all these limbs as the swimming function has been taken over by the pleopods.

Pleopods.

The five pairs of pleopods start as limb-buds in the Mysis, but although bifurcated they have no function throughout the Mysis life. First in the first postlarval stage they become fully developed and takes over the function of swimming except for the special function and morphological development of the first and second pair as part of the sexual apparatus.

Uropods.

The uropods or the sixth pair of pleopods develop in the third Protozoea as a small bifurcated appendage which already in the Mysis takes part in the tailfan, but first in the Postlarva they reach their final shape.

Gills

The gills develop from coxa and can possibly be considered as epipodites of this joint. The development starts with the most distal one on coxa and proceeds from there proximally towards the body. Based on their shape and placement the gills are arranged into four groups, of which here no distinction are made for the last two, which I shall return to later. Three of the groups are placed in three parallel lines.

Most distal on each coxa is a mastigobranchia. The mastigobranchia is always lamellar of shape, usually like a thin, membranous leaf, and starts on the first maxillipede as a leaf-shaped lobe much like the exopod of the second maxilla with both an anterior and a posterior lobe. On the second maxilla the mastigobranchia usually consists of two parts, a proximal leaf-shaped membrane and a distal lobose process. These two parts are united at the base and attached to coxa by one short peduncle. The mastigobranchiae are further found on the limbs from the third maxillipede to the fourth pereiopod both included, but here only their proximal lobes are present, and they are much smaller than on the two previous limbs. In most forms the mastigobranchiae have a smooth margin, but in some forms like *S.* sp. larva *nodulosa* and *S.* sp. larva *sumatransis* a few long, flexible hairs appear on the distal margin of the mastigobranchiae of the five last pairs of thoracopodes but never on the mastigobranchiae of the first and second maxillipede. The fifth pereiopod is without gills or gill-buds in all the examined larvae. This is not the case with the adult, and therefore the gill number may increase in the postlarval stages when the carapace is finally covering the whole thorax. As the gills extend backwards the gills of the fifth thoracapod would not be protected under the short larval carapace and possibly therefore they only develop later.

The next line of gills are the podobranchiae. They are like all the following gills built after two types. In one type they consist of a long stem from which the gill-filaments form small sidebranches dichotomously

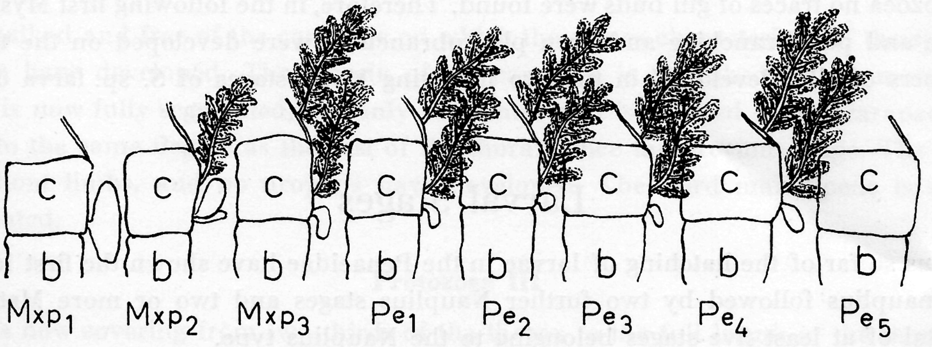


Fig. 9. *Solenocera*. The limbs with basis and coxa provided with full number of gills as developed in the larvae, showing from below the three lines of gills: nearest to basis the mastigobranchiae, in the middle the podobranchiae, and above the pleurobranchiae. For further explanation see text.

to both sides, Fig. 9. This is the case in most of the examined species. The other type is built with a short, wide peduncle with all the gill-filaments extending as long fingers on a hand from the distal end of the peduncle. Finally the gills may be built after a diagram intermediary between these two types. It starts with the finger-shaped type, but the fingers are arranged obliquely slanting in a proximal direction. The peduncle continues as the most proximal finger from which further finger-shaped gill-filaments are branched.

The podobranchiae constitute the first line of the branched gills. They extend from the coxa just proximally of the mastigobranchiae, and the larva has only one on each coxa. They start first on the second maxillipede, and may be found with one gill from the coxa of all the following limbs until the fourth pereiopod where the most posterior one is placed.

Proximally of the podobranchiae are the arthrobranchiae and the pleurobranchiae. They differ as to their placement; the arthrobranchiae extend from the articular membrane between the coxapodite and the body wall, and the pleurobranchiae from the lateral wall of the somite dorsally to the articulation of the appendage. When examining the larvae one gets the impression that both arthrobranchiae and pleurobranchiae start to bud from the most proximal corner of coxa and from there move dorsally over the articular membrane to the limb and further to the lateral wall of the somite. It is possible that all the gills in the *Solenocera* larvae are either podobranchiae or arthrobranchiae and that no proper pleurobranchiae yet have developed, but it seems as if in older stages the gills placed outside on coxa slowly move dorsally. As the material is too small for a more detailed study and especially because not one single postlarva is present in the material or could be obtained for examination, no distinction is made in this paper between arthrobranchiae and pleurobranchiae.

This most proximal of the three gill-lines starts on the third maxillipede and is found usually also in a single number derived from each limb until the fourth pereioped.

Summing up, the maxima of gills present in the *Solenocera* larvae are as following: One mastigobranchia on each limb from first maxillipede to the fourth pereiopod, one podobranchia from the second maxillipede to the fourth pereiopod and one pleurobranchia from the third maxillipede to the fourth pereiopod. The fifth pereiopod is thus the only thoracopod limb without any gills, when we consider the first and second maxilla as placed on the cephalon. However, the exopod of the second maxilla functions as a gill although it is no gill proper and has no gill-filaments.

Finally, the larval stages in which the gills first occur are the following: In the first Mysis the mastigobranchiae and the podobranchiae start as small buds on the limbs. This, however, with exception of the fourth pereipod, which in the first Mysis only has developed a single gill-bud on coxa for the future mastigobranchia, while all the preceding ones have two gill-buds. In the second Mysis the gills are fully developed, also the podobranchia on the fourth pereiopod plus the pleurobranchia, when present, and the latter not only as a bud, but as a fully developed gill. Only in *S.* sp. larva *danae* small gill buds were found on the first and second maxillipede already in the third Protozoea, but in the four other species in this material with a third Protozoea no traces of gill buds were found. Therefore, in the following first Mysis fully developed mastigobranchiae and podobranchiae and even pleurobranchiae were developed on the third maxillipede. No further numbers of gills developed in the two following Mysis stages of *S.* sp. larva *danae.*

Larval Stages

All observations so far of the hatching of larvae in the Penaeidae have shown the first larva to be a Nauplius or a Protonauplius followed by two further Nauplius stages and two or more Metanauplius stages, which gives a total of at least five stages belonging to the Nauplius type.

In the *Solenocera* the youngest known stage is the first Protozoea, and this stage is so far only known from a single species *Solenocera membranacea* which has been caught and described by HELDT (1938, 1955) from the southern Mediterranean. This first Protozoea is followed by a second and third Protozoea. Dr. HELDT states, that the first Protozoea is very rarely found in the plankton, and first the third Protozoea is frequent in the Mediterranean throughout the year (1955). This seems also in accordance with LO BIANCO (1904) who does not make clear distinctions between the different stages. He figures the second Protozoea and the first Mysis stage and writes that the larvae are common throughout the year in the Mediterranean at Capri from 300 m to the surface.

The fact that the first and the second Protozoea are so rarely seen, the latter, however, more frequently than the first, shows that the first and partly the second Protozoea must hide in places where they have not yet been regularly found. Further, the fact that no Nauplius has yet been referred to the genus *Solenocera,* although they must have Nauplius stages like the rest of the Penacidac, is likely to be explained by the *Solenocera* spawning their eggs on the bottom in deeper water, where plankton hauls seldom are made. This may explain why the Nauplius has not been caught and still is unknown. Possibly only during the three Protozoea stages the larvae move towards the upper water layers. This gives a reasonable explanation why only the third Protozoea and the following Mysis stages are caught in quantities corresponding to the frequent occurrence of this shrimp in the Mediterranean, where much research has been carried out especially on this group both from Napoli and in later years from Tunis and other places in the Mediterranean Sea.

After the third Protozoea follow the Mysis stages, which by some investigators of decapod larvae also are called Zoea stages. This is not done in this paper because true zoea in the old sense of the word is only referred to Brachyuran and allied larvae. I think there are good reasons for using the term only for the in several points reduced larvae of the Brachyura. Further there is a sharp distinction to be kept between the Protozoea larva in the Penaeids and the following larva, here called the Mysis. Among other things the locomotory function is transferred from the second antenna and partly the mouth appendages in the Protozoea to the pereiopods in the Mysis.

The number of Mysis stages seems to be at least two, and in some forms, especially true oceanic forms, several more Mysis stages are added to the first two before the first postlarval stage is reached.

Protozoea I

This stage has like other first Protozoea in Penaeidae and Euphausiacea, as far as they are known, sessile eyes, covered by the carapace, and no rostrum is developed. The segmentation of the thorax is beginning, but the abdomen is still unsegmented. The limbs are found back to the third maxillipede, but the latter is not more than a limb bud with a few setae. The first antenna is furnished with several (5) annulated joints proximally of the two distal joints as in the following stage. The first and second maxillae have in this and the following stage a lumpish exopod with four strong, plumose setae. The endopod of both the first and the second maxilla in both first and second Protozoea is well developed, but only the basal joint of it is separated from the rest. The first two maxillipedes are both swimmerets as well as mastigatory in their function. No trace of uropods can be seen.

Protozoea II

The eyes are stalked and free of the carapace on which the spines characteristic of the species and a long untoothed rostrum have developed. The margin of the carapace is furnished with a more or less toothed edge. The thorax is now fully segmented, but only its frontal part is covered by the carapace which has not increased in size to the same degree as the rest of the thorax since the previous stage. The abdomen is still unsegmented, without limbs, and no uropods have developed. The third maxillipede is still a limb-bud, but clearly bifurcated.

Protozoea III

The carapace is now covering from two thirds of the thorax to the full length of the thorax as it is found in *Solenocera* sp. larva *danae*. The rostrum is still without teeth, but the spines on the abdomen have increased in this stage. The abdomen is fully segmented, only the telson may not in all species yet be completely delimited from the sixth abdominal segment. The first antenna is now reduced to four joints in total, which means that the four basal joints have coalesced into one, and the three distal joints remain; the second joint from the base has even enlarged a bit in size from a ring to a proper joint. The second antenna is still the main locomotory organ. The mandible is still without a palp. The first maxilla is unchanged, only the endopod has in most species become three-jointed. In the second maxilla the endites are more developed than in the two preceding stages, and especially many more stiff setae have appeared on their surface so they are now well fitted for serving the feeding of the larva. Also the endopod may have added some joints although its relative length in relation to the rest of the limb is unchanged; the endopod of the two first maxillipedes is now divided into several joints, and the third maxillipede is somewhat enlarged but still unfunctional.

The thoracopods following the maxillipedes are now present, but only as short, bifurcated and unjointed rudiments, without any function or setae except a few embryonic setae on the tip. No abdominal appendages are present apart from the uropods which are developed in their bifurcated shape on the sixth abdominal segment, but they are in this stage so rudimentary that they can only become functionary in the following stage.

Mysis I

In the first Mysis which follows after the third Protozoea great changes take place which justify the change of name of the larval type. The carapace is much enlarged and has become more squarish, it is now covering the whole thorax. The rostrum has developed one or two dorsal teeth on its upper surface, but none on the ventral, in conformity with the lacking of ventral teeth in the larva as well as in the adult. The shape of the telson has changed from a T-shape to a Y-shape through a changed angle between the two branches and the medial plate of the telson. The branches are placed in a more longitudinal axis to the medial plate. The three lateral spines on each side of the telson which are characteristic for the adult Penaeid are present.

The antennae and mouth-appendages are no longer swimmerets; this function has now been taken over by the well-developed bifurcated five pairs of thoracopods. The pleopods have started to bud on the abdomen, and the uropods are fully developed and able to be an active part of the tailfan. A small process has developed on the lateral side of the first abdominal segment. In some species this process is in connection with the lateral spine on that segment, but often the process is free, placed ventro-anteriorly of the spines of the segment.

The first antenna has undergone a further reduction to three joints, with the two basal joints coalesced into one joint. The hook on the medial margin of the basal joint for the coming statocyst hollow has started to develop. Finally the two flagella have appeared as two yet unjointed processes from the distal joint of the antenna. The second antenna has also changed, its exopod is no longer a locomotory organ, but is transformed into the unjointed antennal scale which, however, not yet has reached the full size and number of setae. The endopod has coalesced into a single joint, which in the following stages will become the longer flagellum of the second antenna. The protopod is unjointed.

The mandible has in this stage formed a short, unjointed palp always without setae, and the pars-incisiva and the pars-molaris are more clearly differentiated. In the first maxilla the exopod has in some species totally disappeared, in others it is under reduction. The two endites have now reached their full development like in the adult with the distal endite or basi-endite furnished with tooth-like setae for tearing and cutting, while the setae on the coxa-endite are stiff and hair-like as in a broom. The endopod is now in most cases three-jointed.

The second maxilla has no longer a fleshy exopod with setae of the thick type, but a thin leaf-shaped one, with many plumose setae along its margin and with the most posterior setae longer and stronger than the rest. As both an anteriorly pointing and a posteriorly reaching part of the exopod is developed the endopod has grown in size. The numbers of joints have increased and the four medial endites of the protopod are larger and with more setae than in the preceding stages. The maxillipedes are now three in number, all fully developed. The first maxillipede has shortened and is now clearly a feeding organ. The third maxillipede which up to this stage has been rudimentary and without function is from now on the largest of the three. The maxillipedes have well developed exopods functioning as swimmerets together with the exopods of the thoracopods. The two jointed protopod and the endopod have on their medial margins a brim of long setae for filtering water, for catching and holding the prey, and for carrying it to the mouth. It appears that the endopod of the third maxillipede has an additional function as cleaning organ for the mouth appendages.

The first three thoracopods or pereiopods have started to develop a chela and are, together with the two non-chelate, following pairs, the principal locomotory organs, but as the tail-fan now also is functioning the shrimp is able, possible already from the Mysis stage, to jump backwards by clapping the tail-fan and the abdomen against the underside of the body like the adult shrimp. The protopods of the thoracopods are two-jointed and the abdominal appendages or the pleopods are, except for the uropods, only small unfunctional limb-buds.

Mysis II

The toothed edge of the carapace is further reduced although its teeth seldom have completely disappeared. An extra dorsal tooth on the rostrum may have been added. The carapace which already from the first Mysis fully covered the thorax reaches now beyond this and its connection with the free abdomen is supported through the lateral processes on the first abdominal segment. These processes were already present in the first Mysis, but they have enlarged in the second Mysis and are now in most cases shaped as a ridge on both sides of the first abdominal segment running in a dorso-anterior to ventro-posterior direction. The process usually fits in ventrally to the posterior branchio-cardiac spine if this is present, dorsally to the latero-posterior marginal spine if this is present, or between them if both are present as in *Solenocera* sp. larva *elongata* or *S.* sp. larva *aequatorialis*. The pleura have in this stage started to develop from the abdominal segments. The telson is more elongate and slim because the uropods have developed further both in number of setae and in length. The telson and the uropods now form a perfect, functioning tailfan.

In the basal joint of the first antenna a cavity has begun to develop, and the static nerve has grown into sense-cells in the epithelium of the cavity, thus starting the development of the statocyst. The two flagella have increased further in length, as with each preceding moult, and in most species they have from the second Mysis stage started to become annulated. In some species the olfactory hairs have started to develop in groups medially on the two flagella. The three-jointed stem has developed more setae than in the first Mysis stage.

The second antenna has developed further, especially its endopodial flagellum which now reaches to near the tip of the rostrum, in some species even in front of the rostrum.

The mandible has developed more cutting and crushing teeth on its masticatory parts, and the palp is now two-jointed as in the adult, but not yet provided with quite so many setae as later. The first maxilla is similar to that of the preceding stage, only with a little stronger endite parts; the exopod, if not already lost in the first Mysis, has now definitely disappeared. On the second maxilla the exopod and the four masticatory endites have grown, but the endopod is either only of the same size as in the first maxilla, i. e. relatively reduced, or it has started an actual reduction and reaches now in no case so far forward as the exopod, but only to the middle of it.

No distinct changes have taken place in the first maxillipede from the previous stage, in both stages the endopod is divided into four joints. On the second maxillipede the endopod has reached the full number of five joints, whereas the first Mysis only had two to four joints in its endopod. The third maxillipede has five endopodial joints already from the first Mysis and is thus, as mentioned, already from that stage the largest of the maxillipedes and the only one with the full number of five endopodial joints. In the second Mysis the third maxillipede has further enlarged, being now much longer than the first and second ones.

The chelae on the 3 first pairs of pereiopods have developed further, but they are not yet functioning and have still setae on their tips. The second, distal joint has widened to give space for the muscles of the movable fingers of the chelae. The two last non-chelate pereiopods are well developed. The pleopods have each developed an unjointed protopod, and an unjointed exopod and endopod, each tipped with a few embryonic setae, but yet unfunctioning. The uropods and their brim of setae have enlarged.

Mysis III

The description of this and the following stage can only be based on *S.* sp. larva *sumatransis* and *S.* sp. larva *danae* as the only hitherto known *Solenocera* species with more than two Mysis stages.

The toothed edge of the carapace has now entirely disappeared or only a tiny part of it is left in the branchiostegal area and on the posterior marginal teeth. The ridge on the rostrum has become more compressed and keel-shaped and may have added an extra tooth. Except for the rostrum, the spines on the carapace and the abdomen have become relatively smaller, and the carapace itself is more stream-like than before. The lateral process on the first abdominal segment has elongated and reaches nearly the ventral margin of the pleuron. The telson is more squarish.

The flagellum of the second antenna has grown reaching beyond or much beyond the tip of the rostrum. The molar part of the mandible and the coxa-endite of the first maxilla have developed further. The three maxillipedes are now much more powerful organs, and the same is the case with the exopodial swimmerets of the pereiopods. Also the pleopods have developed further.

This description is—as mentioned above—only based on two species both with more than two Mysis stages. In such species the development of the limbs seems to be much slower than in species with only two Mysis stages before the postlarval stage. Thus larvae with several Mysis stages have, for instance, in the second Mysis stage appendages of a much less finished shape than in species where the second Mysis is the last Mysis stage.

Mysis IV

Within *Solenocera* a fourth Mysis stage has only been found in *S.* sp. larva *sumatransis.* Here the fourth Mysis is still more like an adult *Solenocera* than the previous stage. It has smaller spines, longer and more compressed rostrum with a higher rostral keel on the carapace, a more stream-lined carapace, and a stronger abdomen, telson and tail-fan. In this species a pair of small spines has developed dorsally on the telson near its base. The pleopods are larger, but the pereiopods have not changed much, perhaps they have elongated a little. The maxillipedes are a little better developed.

No further number of Mysis stages is at present known for this species or for any species of the genus *Solenocera*, but it must be expected that a fifth Mysis stage exists in some *Solenocera*.

First Postlarva.

In more coastal forms of the *Solenocera* like *Solenocera membranacea* and probably several others (*S. muelleri* and *S.* sp. larva *aequatorialis*) the second Mysis is followed by the first postlarval stage in which considerable changes take place. These changes are so important that it is justified to speak of a complete metamorphosis. At least the changes are so considerable that it is impossible from the last Mysis to conclude what adult it will develop into, even if we should know the corresponding adult, which may not be the case for several of the here described larvae.

In the change from the last Mysis to first Postlarva all the spines of the carapace except for a few anterior spines are lost in the only species, *Solenocera membranacea* of which the Postlarva is known. As the adult *Solenocera*, so far known, not have all the fantastic spines and teeth of the *Solenocera* larva, we are justified in assuming that they are lost also in all other species of *Solenocera* with the ecdycis from the last Mysis to the first Postlarva. This makes the establishment of connections between Mysis stages and adult forms all too risky without direct observation of the moulting, or when not considering an area where a single species is so strongly dominant in numbers that the relation between an abundant larva and an equally abundant adult is fairly reasonable.

The above is valid for the typical coastal forms, but in the more oceanic species and possibly also in the species from certain tropical regions where growth is slower, the Mysis stages are not limited to two, but a third, a fourth or even more Mysis stages may follow as described in this paper for *Solenocera* sp. larva *danae* and *S.* sp. larva *sumatransis*. Therefore in these cases the length of the larval life will be much extended, and only after a series of several Mysis stages the Postlarva will appear and develop through several moultings into the adult and sexually ripe shrimp.

SPECIAL PART

DIAGNOSIS FOR THE LARVAE OF *SOLENOCERA*

Smaller Penaeid larvae in either Protozoea or Mysis stages, with three Protozoea and two to five Mysis stages.

The carapace in the Protozoea has along the whole margin or on parts of it and on the marginal spines toothed filaments, which partly remain through the younger Mysis stages. The carapace is spiny, more so in the older stages. At least the older Protozoea and all Mysis stages have the carapace more or less covered with spines. Long, bushy hairs extend often from the surface of the carapace and abdomen. The rostrum has never spines ventrally, a large rostral plate is often found at its base. Both anterior and posterior dorsal organs are present on the carapace. Older Protozoea and all Mysis have a spiny abdomen.

The mouth-appendages indicate carnivorous habits, the incisor part of the mandible is strongly developed, usually with several pointed teeth. The molar part is much smaller. The mandibular palp is at the most two-jointed. The basi-endite of the first maxilla has strong teeth. The pereiopods are well-developed in the later stages. Mastigobranchiae are in all Mysis larvae found on all maxillipedes and pereiopods except number five.

Solenocera membranacea, H. Milne-Edw.

Figs. 3–14, 22, 23.

Penaeus membranaceus, H. Milne-Edw. 1837, p. 417.
Penaeus siphonoceros, Philippi, 1840, p. 190, pl. 4, Fig. 3.
Solenocera philippii, H. Lucas 1850, p. 223, pl. 7, II, Fig. 1.

Larva:

Solenocera siphonocera, Lo Bianco 1904, p. 31, pl. 10, Figs. 39, 40.
Solenocera membranacea, J. Heldt 1938, p. 123–126, 190–196, with Figs.
Solenocera membranacea, J. Heldt 1955, p. 29–50, pl. 1–12.

Localities.

Many specimens of Protozoea I, II, III, Mysis I, II, Postlarva I from near Naples (6 miles north of the island Ischia in line with Cuma on the Mainland), 100 m depth, taken in all depths from bottom to near surface, but most abundant in the lower water layers. June 1964.

Protozoea III:

Locality unknown, British Museum.

Mysis I:

Dana St.	10598–III,	51°00′ N–12°31′ W,	800, 600, 400 mW.	18-8-1957:	4 spec.
—	10598–IV,	51°00′ N–12°31′ W,	1400, 1200, 1000 mW.	18-8-1957:	2 spec.
—	10987–II ,	50°54′ N–14°08′ W,	200, 150, 125 mW.	25-8-1958,	1 spec.
—	11311–II ,	52°26′ N–16°30′ W,	200, 150, 125 mW.	19-8-1959,	2 spec.

Mysis II:

Dana St. 4008–III,	21°40′ N–18°00′ W,	300 mW,		16-3-1930, 1 spec.
— 9308 ,	51°00′ N–20°36′ W,	1500 mW,		27-8-1954, 1 spec.
— 9804 ,	51°00′ N–18°00′ W,	200, 150, 125 mW.		20-8-1955, 1 spec.
— 9804 ,	51°00′ N–18°00′ W,	600, 400 mW.		21-8-1955, 1 spec.
— 9806 ,	50°55′ N–14°00′ W,	100, 50, 25 mW.		21-8-1955, 3 spec.
— 9806 ,	50°55′ N–14°00′ W,	1000, 800 mW.		21-8-1955, 1 spec.
— 10598–III,	51°00′ N–12°30′ W,	800, 600, 400 mW.		18-8-1957, 2 spec.
— 10598–IV,	51°00′ N–12°30′ W,	1400, 1200, 1000 mW.		18-8-1957, 1 spec.

Description.

Protozoea III.

Fig. 10.

This stage has already been described by Heldt in 1938, 1955, but there are certain points which can be added to her description.

Carapace:

Formula after the figure: 1. 2. 3. 5. 7. 10. 11. 12. 13. 15. 16. 17. 18. 19. 20. 23. 24. 25. 26. 27. 29. 30.

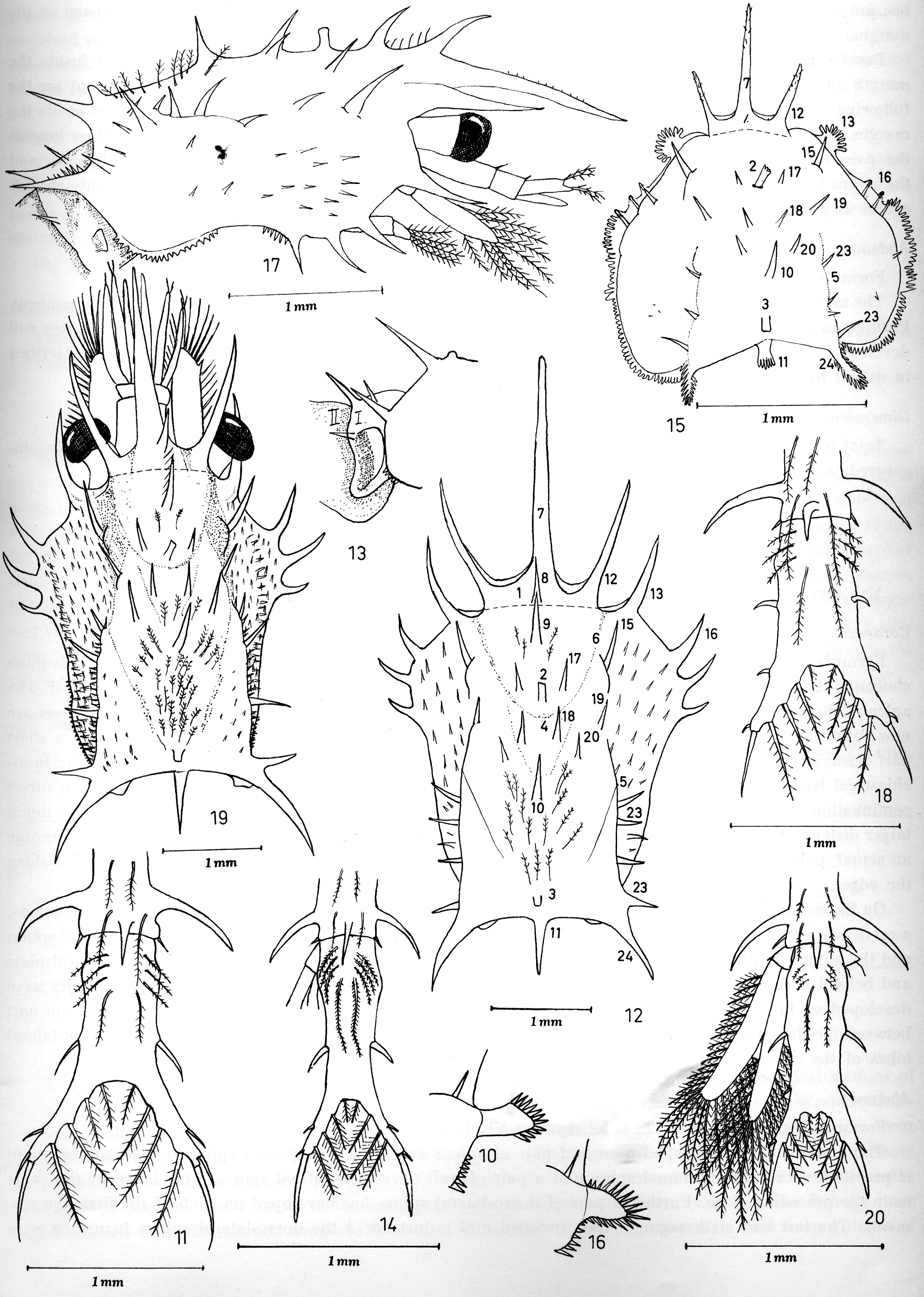
Madame Heldt (1938, 1955) when describing this and the following stage has arranged the spines in two semicircles on each side of the carapace, but their placement is more definite and fits into the general plan of *Solenocera,* shown in this paper Fig. 1. The formula for the Protozoea is given above.

In front of the carapace proper is the rostral plate (1) just extending as a curved plate from the carapace. This plate varies very much in the different species. It can be even longer than wide or only short as in this species, or it can in some species be entirely missing. This plate, when present, carries the rostrum and the supra-orbital spines, which both are well developed in this species and have fine hairs at their surfaces. Both the anterior and posterior dorsal organs are of medium size. The frontal organ has small sensory papillae at its tip. Of the grooves on the carapace only the branchio-cardiac groove on each side is weakly suggested. The unpaired epi-cardiac spine is present and as always, when present, the largest of the spines placed outside the margin of the carapace. Behind this spine and pointing in the opposite direction, going from the posterior margin of the carapace, is the medio-posterior marginal spine which in the Protozoea carries serrate marginal brims. In some of the specimens the spine can be seen clearly through the brims, and it will appear as a naked spine in the following stage.

The antennal spines are not yet developed, but on their place is a brim edged by the supra-antennal teeth. Also this will in the following stage be replaced by proper antennal spines. Remaining along the margin of the carapace behind the supra-antennal brim is a large branchiostegal, toothed brim and penetrating into its anterior part are three branchiostegal spines still in the embryonic form and not yet reaching outside the brim. This brim passes directly into the branchio-lateral brim which is continuing the marginal brim with its toothed edge until it reaches the postero-branchial spine (No. 24). This spine points posteriorly as a continuation of the branchiocardiac groove, and is found in all *Solenocera* larvae as one of their characteristica. The spine is here, as shown in the figure, flattened and rhomboid, only at its distal part it is covered with the toothed larval brim which seems one of the characteristica for this species. There is a distinct open space between the teeth on the postero-branchial spine and the posterior part of the branchio-lateral teeth, the

Fig. 10–14. *Solenocera membranacea.* Fig. 10, postero-branchial groove spine of third Protozoea. — Fig. 11, telson of first Mysis. — Fig. 12, carapace of second Mysis. — Fig. 13, posterior part of carapace and first and second abdominal segments of second Mysis, especially showing the lateral process on the first abdominal segment. — Fig. 14, telson of second Mysis.

Fig. 15–20, *Solenocera membranacea* subsp. *capensis.* Fig. 15, carapace of first Protozoea. — Fig. 16, postero-branchial groove spine of third Protozoea. — Fig. 17, carapace with some appendages and first abdominal segment of first Mysis. — Fig. 18, telson of first Mysis. — Fig. 19, carapace with first and second antennae of second Mysis. — Fig. 20, telson and left uropod of second Mysis. — Numbers attached to Fig. 12 and 15 refer to the numbers in Fig. 1.


17
1 mm
15
1 mm
13
19
1 mm
12
1 mm
18
1 mm
11
1 mm
14
1 mm
10
16
20
1 mm

last not reaching right to the basis of the postero-branchial spine, but leaving a distinct open space on the margin.

Besides the already mentioned unpaired epicardiac spine several paired spines are found inside the margin on the surface of the carapace. They are all well developed and of about average size, and are the following: the post antennal spines behind the antennal brim are the largest of the paired spines inside the margin. Between them and the anterior dorsal organ is the medio-gastric spine only about half as long as the paired spines. Behind this spine is a triangular arrangement, the pre-hepatic, the latero-hepatic, and the supra-hepatic spines. Farther backwards on the carapace along the only suggested branchio-cardiac groove is placed a series of three to five branchio-cardiac or lateral spines.

Abdomen.

Formula, segments I–VI: 1. 2.

The abdomen is six-segmented with a large dorsal spine and a pair of large lateral spines on each segment. Further on each segment is a pair of tiny bulbs where in the following stage the dorso-lateral spines will develop. The rest of the animal, the abdomen, the telson and the appendages, has already been described in details by Heldt (1938, 1955). For any further details is referred to these descriptions.

Dimensions.

Total length 4.5 mm, length of carapace without rostrum 1.5 mm, width 1.8 mm, rostrum 0.7 mm, uncovered thoracal segments plus abdomen 1.8 mm, abdomen 1.3 mm.

Mysis I.

Fig. 11.

Also here is referred to the description by Heldt (1938, 1955).

Carapace.

Formula: 1. 2. 3. (4). 5. (6). 7. 8. 9. 10. 11. 12. 13. 15. 16. 17. 18. 19. 20. 23. 24. 26. 27. 30. It is more elongated than in the stage before this, and the toothed brims along its margins are somewhat reduced. The antennal brim has been replaced by a pair of strong antennal spines. The three branchiostegal spines are now fully developed, and from the carapace the branchiostegal brim with its teeth is reduced to a short part posteriorly of the branchiostegal spines. Further there is now an open, bare space between the branchiostegal teeth and the following branchio-lateral teeth, in the Protozoea these two groups were in direct continuation of one another. Finally the brims have also been reduced in their posterior part leaving a much larger distance between the branchio-lateral teeth and the branchial spine. The last spine has further become an actual, pointed spine, not flat and lamellar as in the Protozoea, but it has still a partly toothed brim along the edges.

On the dorsal side of the carapace a cervical groove has started to develop together with its prolongations, a cervico-branchial groove on each side reaching forwards into the concavity between the supra-orbital spines and the antennal spines. The rostrum is elongate and provided with a dorsal tooth both on the rostral plate and behind it, so we have both a rostral tooth and an epigastric-rostral tooth. Further, plumose hairs have developed on the carapace mostly on its medial part in front of the anterior dorsal organ and on the part between the dorsal spine and the posterior dorsal organ. Finally a few spines have appeared on the lateral lobes of the carapace below the branchio-cardiac groove.

Abdomen.

Formula, segments I–V: 1. 2. 3. 5., segment VI: 1. 2. 4. 5.

The abdomen has developed a second pair of spines and a third unpaired spine so that each segment is provided with a strong dorsal spine and a pair of well developed lateral spines. This is so far the same as in the preceding stage. Further a pair of dorso-lateral spines has developed on each of the first five segments. The last and sixth segment has stretched and is instead of the dorso-lateral spines furnished with a pair of smaller ventro-lateral spines. Finally on each of the first five segments, but not on the sixth, an unpaired ventral spine is present. The segments have on their dorsal surfaces a few fine, plumose hairs which increase in number and size towards the posterior segments of the abdomen. The first abdominal segment has on each side developed a small, leaf-shaped lateral process.

Telson.

The telson (Fig. 8) is Y-shaped with a massive stem with two rows each with four long, plumose hairs. The branches of the furca terminate with a long, curved spine, and on both lateral margins of the telson are three shorter spines, two, one behind the other, near the tip of each branch and the third a little above the bottom of the cleft.

For the appendages see Heldt 1938 and 1955.

Dimensions:

Total length 7 mm, length of carapace without rostrum 2.3 mm, width of same about 1.8 mm, rostrum 1.5 mm, abdomen 2.5 mm.

Mysis II.

Figs. 12–14, 22.

The whole larva has grown considerably and the spines of the carapace are larger, the numbers of plumose hairs on the carapace and the abdomen have strongly increased in number and size, and each of the lateral wings of the carapace, nearly naked in the first Mysis, is in the second Mysis covered with many short, but soft, spiny hairs. The grooves of the carapace are deeper and more distinct, and the most posterior of the lateral spines has moved out on the base of the postero-branchial spine. The teeth of the carapace are further reduced, only few of the posterior branchio-lateral teeth are present. On the abdomen the lateral pleuron has started to develop. The telson plate and the proximal pair of lateral marginal spines have become larger and the latter are pointing dorsally in a right angle to the surface of the plate. The plate itself is more slim than in the first Mysis. On the first abdominal segment the lateral process has enlarged (Fig. 13). The formula for the carapace is: 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13.

Dimensions:

Total length 12 mm, length of carapace without rostrum 3.5 mm, width of same 2.5 mm, rostrum 2.3 mm, abdomen 5.5 mm.

Approximate dimensions of stages in mm.

	Protozoea III	Mysis I	Mysis II
Total length......	4.5	7	12
Carapace.........	1.5 × 1.8	2.3 × 1.8	3.5 × 2.5
Rostrum.........	0.7	1.5	2.3
Abdomen........	1.3	2.5	5.5

Distribution and Remarks.

Fig. 23.

This species is known from the Mediterranean where it has been taken near the biological stations of Napoli and Tunis and along the Adriatic coast of Italy and Jugoslavia, all localities from the Western Mediterranean. Although the species nowhere has been recorded from the eastern Mediterranean it may occur there. Further it is found in the Northern part of the subtropical region of the Atlantic down to the Azore Islands and in the Gulf of Biscaya. The larvae are carried with the Gulf Stream as far north as to the south-west coast of Ireland where many of the specimens here recorded were fished. Finally three females have been recorded from the Atlantic coast of Venezuela at the Gulf of Paria by Smith in 1886 from a depth of

31 fathoms. On these specimens, together with two specimens from Louisiana (see further under *Solenocera muelleri*) BURKENROAD (1934) has established a new species *Solenocera vioscai.* The adult of *Solenocera membranacea* has been taken at 50–800 metres near the bottom on sand or mud, into which it digs. The larvae are recorded farther out in deeper water where they have been transported by the currents.

According to the investigation by HELDT (1955) only two Mysis stages exist in this species. The second Mysis is followed by the first Postlarva, which also has been found by me.

Solenocera membranacea, subspecies *capensis*

Figs. 15–21, 23.

Localities:

Protozoea III:

Discovery St. 100 B. {33°20′ S–33°46′ S. / 15°08′ E–15°18′ E.} 5–0 m, 30.9.1926. B. M. 4 spec.

Mysis I:

Discovery St. 102. 35°29′20″ S–18°33′40″ E, 50–0 m, 28.10.1926, B.M. 1 spec.
— — 260. 33°06′30″ S–17°45′15″ E, 100–0 m, 19.7.1927, B.M. 1 spec.
— — 277. 1°44′00″ S–8°38′00″ E, 63 m, 7.8.1927, B.M. 2 spec.

Mysis II:

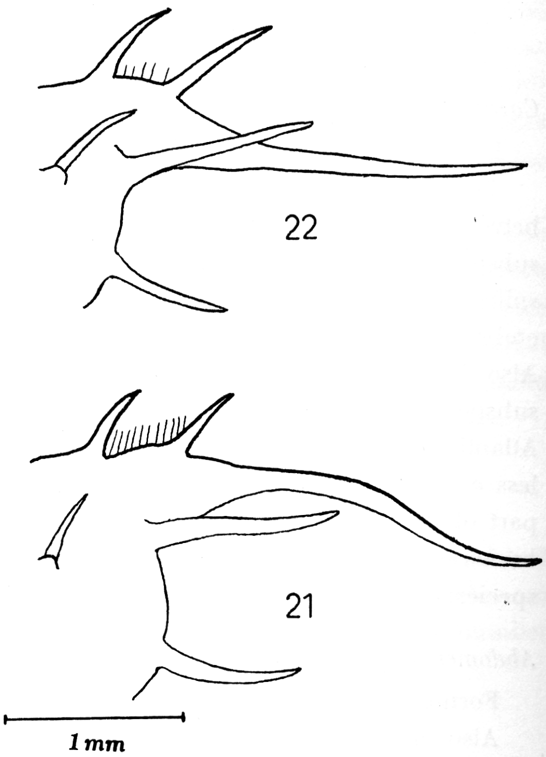
Discovery St. 89. 34°05′15″ S–16°00′45″ E, 50–0 m, 28.6.1926, B. M. 1 spec.
— — 99 A. 33°20′00″ S–17°17′00″ E, 5–0 m, 27.9.1926, B.M. 1 spec.
— — 99 E. 33°11′00″ S–17°26′00″ E, 5–0 m, 27.–28.9.1926. B.M. 22 spec.
— — 100 B. {33°20′00″ S–33°46′00″ S, / 15°08′00″ E–15°18′00″ E} 5–0 m, 30.9.1926, B.M. 16 spec.
— — 102. 35°29′20″ S–18°33′40″ E, 50–0 m, 28.10.1926, B.M. 3 spec.
— — 276. 5°54′00″ S–11°19′00″ E, 150 m, 5.8.1927, B. M. 17 spec.

Description.

This subspecies from the southern Atlantic around Cape the Good Hope is very closely related to the North Atlantic species from the Mediterranean and eastern North Atlantic, and in the adult described from South Africa by BARNARD in 1950 no distinction from the North Atlantic form is noted, but when examining the larvae from "Discovery" taken in this South African region and as far north as Cape Lopez in the republic of Gabon, W. Africa, I observed that they in certain characters differ from the North Atlantic larvae. This justifies the establishment of a new subspecies for the African form from the South Atlantic on the larva alone, because the adult to these larvae must also have similar characters differing from the North Atlantic *S. membranacea.* This can easily be overlooked when only examining one type and for the other type relying on the literature. In general it can be said that the subspecies *capensis* is a bit larger and stouter, and that its spines, except the rostrum, are shorter than in the Mediterranean species. The spines extending from the margin of the carapace are more robust and curved in the subspecies *capensis.* This can best be seen on Figs. 21, 22, which show the nearly straight rostrum and supra-orbital spine and the slender and only slightly curved antennal spine in *Solenocera membranacea* (Fig. 22). Fig. 21 presents subspecies *capensis* showing the strongly downwards bent and double curved rostrum, the robust, double curved supra-orbital spine and the upward curved, robust antennal spine. The postero-branchial groove spine is of a different shape in the Protozoea, and the placement of its toothed brims also differs. Also the shape of the telson and the placement of its marginal spines differ. But the differences between the two forms are not larger than that the formula for the carapace remains the same for both through all the known larval stages.

Returning to the adult there is the species *S. africanum* which STEBBING has described in 1917 as very close to *S. membranacea*. BALSS, 1925, has expressed doubt as to the validity of STEBBING's species. BALSS's view has been confirmed by BURKENROAD, 1934, who suggests that *S. africanum* is a "varietal form of *S. membranacea*". BARNARD, 1950, maintains the two species *S. membranacea* and *S. africanum*, of the latter later a total of 28 specimens have been found in the South African Museum, the relatively small number of the former in the same collection is not given.

When returning to the Discovery material of larvae from the Cape district, it can be stated that all the larvae belong to this species, but that they all differ in the same, only minor characters from the Mediterranean and North Atlantic larvae of *S. membranacea*. These South African larvae include not less than 48 specimens taken at 8 different localities, but although they are from two different years they have all been taken in June–October. One would have expected that if two closely related species *S. membranacea* and *S. africanum* occur in the Cape Water, both species would be present in a larval collection of that size. As this is not the case, I am unable on the present material to throw more light on the problem of one or two species, but as the larvae show smaller, but distinct differences from the North Atlantic larvae of *S. membranacea* I have chosen to call them *S. membranacea* subsp. *capensis*. Later investigations must decide whether they are the larvae of *S. africanum* or whether the whole stock in South Africa, both *S. membranacea* and *S. africanum* is one species, as suggested by BALSS and BURKENROAD.



Figs. 21–22. Frontal part of carapace of second Mysis, from lateral. Fig. 21, *Solenocera membranacea* subsp. *capensis*. — Fig. 22, *S. membranacea*. The figures show the bent rostrum in the subspecies *capensis* and the more straight rostrum in *S. membranacea* as well as the longer and more delicate spines in the latter.

Protozoea III.

Figs. 15–16.

Carapace.

Formula: 1. 2. 3. 5. 9. 10. 11. 12. 13. 15. 16. 17. 18. 19. 20. 23. 24. 25. 26–27. 29. 30. The formula for the carapace is the same as in the North Atlantic form, but the carapace is a little stouter and perhaps a little wider in the South African form, and the postero-branchial groove spine (Fig. 16) is a little different in shape from the same spine in the other form. In the North Atlantic form the free part of this spine is rhomboid and the brim of teeth is only found on the two distal sides of the rhombe (Fig. 10). The branchio-lateral filament and its teeth do not reach back to the postero-branchial groove spine, but leave an open space in between along the carapace margin. In the subspecies *capensis* these brims coalesce and the teeth cover the whole free part of the postero-branchial groove spine. Further the spine itself is not rhomboid as in the Mediterranean form, but pointed and a little downwards turned whereas the Mediterranean turns upwards. The rostral plate seems a little deeper or longer in subspecies *capensis* than in the North Atlantic *membranacea*, and the sides or lateral wings of the carapace are already in the Protozoea III covered with a dense layer of fine, soft, embryonic hairs giving the surface of the carapacė a shaggy surface, whereas the sides form a thin, hyalin membrane in the North Atlantic form.

Dimensions:

Total length 4.5 mm, length of carapace without rostrum 1.8 mm, width of same 2.0 mm, rostrum 0.6 mm, abdomen 1.3 mm.

Mysis I.

Figs. 17–18.

Carapace.

Formula: 1. 2. 3. (4)*. 5. (6). 7. 8. 9. 10. 11. 12. 13. 15. 16. 17. 18. 19. 20. 23. 24. 26. 29. 30.

The carapace is a little more robust and hairy than in the North Atlantic form, for instance the hairs placed between the rostral tooth and the epigastric rostral tooth are in the North Atlantic form only few, whereas subspecies *capensis* has a whole series of hairs on the rostral carina between the two dorsal teeth on the rostral spine. Also on the lateral wings of the carapace, where the carapace in the Protozoea III was woolly with embryonic hairs, are now soft, spine-shaped hairs in a much larger number than in the North Atlantic form. Also the plumose hairs on the posterior part of the carapace in the median section are more numerous in subspecies *capensis* than in the North Atlantic form. The postero-branchial groove spine has in the North Atlantic form still left a little of the rhomboid shape at the basal part of the spine, but in *capensis* the spine is less narrow proximally which is the protozoeal form of the spine. It gives a natural basis for the new distal part of the spine which is conical, missing the rhomboid wing characteristic for the Northatlantic *S. membranacea*. The dentated filament is in the first Mysis only covering the proximal part of the spine in both species.

Abdomen and Telson.

Formula, segments I–V: 1. 2. 3. 5., segment VI: 1. 2. 4. 5.

Also these are a little more robust in *capensis*, but the most characteristic difference is the placement of the lateral spines on the telson plate. In the North Atlantic form the two most distal spines are placed on the distal half of the branch of the furca, but in *capensis* (Fig. 18) only one spine is found here. The next spine is first seen near the bottom of the furcal cleft but still on the branched part of the furca. The third spine is placed nearly half way up on the uncleaved part of the telson plate. Further the bottom of the cleft is clearly concave in the North Atlantic form, but convex in the subspecies *capensis* due to a small process which has started to grow out from the telson plate at the bottom of its furcal cleft. This difference in the telson plate can very clearly be seen, and is perhaps the best way of distinguishing between the two forms when only one form is available and no direct comparison possible. But also the geographical distribution gives a clear neutral zone between their areas of occurrence. The North Atlantic form reaches down to the Azores and the larvae may perhaps be taken down to the tropic of Cancer. The subspecies *capensis* is found in the Cape water of South Africa and the larva have been taken till towards Equator (Discovery St. 276, 277), possibly the adults may occur northwards to Cape Lopez, West Africa.

Dimensions:

Total length 7.5 mm, length of carapace without rostrum 2.5 mm, width of same 2 mm, rostrum 1.6 mm, abdomen 2.7 mm.

Mysis II.

Figs. 19–21.

Carapace.

Formula: 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 15. 16. 17. 18. 19. 20. 23. 24. 27.

The size is the same in the two forms, but the cuticle is thicker in *capensis* which gives the preserved material a darker colour. This was also the case in the two preceding stages. Further, the spines emerging from the margin of the carapace are more curved in *capensis* than in the North Atlantic form, where the spines are more straight, delicate and longer except for the rostrum, as can be seen by comparing Figs. 21 and 22. The difference in shape of rostrum is clearly seen in the figures. In *S. membranacea* from the North Atlantic the ventral line of the rostrum is straight and parallel to the longitudinal axis of the animal, and the dorsal line is first bending down from the rostral ridge of the carapace towards the thinner part of the free rostral spine. In subspecies *capensis* there are no straight lines in the rostrum. The ventral line curves

* A bracket around the number here and in the following indicates that the present spine is rudimentary or vestigial in this stage.

first upwards, then it turns downwards in a long arch and ends by running horizontally. The dorsal line starts running horizontally, then it turns downwards and ends in another, lower horizontal line. The supra-orbital spine is curved as an open S, and the rather robust antennal spine forms a semilunear curve with its concavity dorsally. The post-antennal spine is pointing in a more anterior direction in *S. membranacea* than in subspecies *capensis* where it is shorter and points more dorsally. The postero-branchial groove spine is longer and more curved in *capensis* than in the North Atlantic species.

The wings of the carapace are covered with a thick layer of soft, spine-shaped hairs. This coating is also found in the North Atlantic species, but with much fewer hairs and therefore with more open space between the hairs. The subspecies *capensis* has usually a group of plumose hairs in the middle area on the carapace between the dorsal spine and the posterior dorsal organ. These hairs may start even in front of the dorsal spine behind the prehepatic spines, but a certain individual variation in number and placement of the hairs seems to occur. Of the branchio-lateral teeth a little is left posteriorly as in the North Atlantic species.

Abdomen.

Formula, segments I–V: 1. 2. 3. 5., segment VI: 1. 2. 4. 5.

The abdomen has made no greater change from the preceding stage. The first five segments are furnished with a dorsal spine, a ventral spine and pairs of lateral and dorso-lateral spines. The last segment has no ventral spine but a pair of ventro-lateral spines. The plumose hairs of the abdomen are the same in number as on the first Mysis, but the single hairs have grown very long and flexible.

Telson.

The telson has narrowed, being more slim, as was the case also in the North Atlantic species. Further the lateral spines on the telson plate have moved further towards the root of the telson so that now only the distal spine is placed on the branch of the furca, while the second spine in the middle of the row now is placed clearly above the bottom of the cleft and the third spine midway on the uncleaved part of the telson as in the preceding stage, but still a little closer to the basis of the telson plate than in the first Mysis. The telson spines are now clearly parallel to the dorsal spines on the abdominal segments sticking up from the telson plate, whereas they are more in a lateral plane with the telson or forming an angle, always less than 90°, with the telson plate in the North Atlantic species of *S. membranacea.*

Dimensions:

Total length 12 mm, length of carapace without rostrum 3.4 mm, width of same 2.5 mm, rostrum 2.2 mm, abdomen 5.6 mm.

Approximate dimensions of stages in mm.

	Protozoea III	Mysis I	Mysis II
Total length......	4.5	7.5	12
Carapace.........	1.8 × 2.0	2.5 × 2.0	3.4 × 2.5
Rostrum.........	0.6	1.6	2.2
Abdomen........	1.3	2.7	5.6

Distribution and Remarks.

The subspecies *capensis* has received its name because it was taken by the "Discovery" in the waters round the Cape of Good Hope, South Africa. Most of the catches of the larvae are from the surface, a few from depths down to 150 m (Fig. 23). Two more catches of this subspecies were made further north along the west African coast, one of them off Loanda where a plankton haul 150 m below the surface gave 17 specimens all of Mysis II, another haul a little further north off Cape Lopez, yielded two specimens in the first Mysis stage. This leaves an open space from Cape Lopez until the most southern locality of *S. membranacea* around the Azore Islands. Further it can be noted that the larvae have been taken relatively close to the coast, which seems to support the author's opinion, that *Solenocera* spawns at the bottom in waters of 100–800 m depth. All records of larvae are from close to the shelf of a continent or an oceanic island and never farther away from this than the current may have brought the larvae through their short span of larval life.

The literature and the larval material and its distribution seem to indicate as the most likely, that the type of *Solenocera membranacea* in time has been divided into three or maybe four groups if counting *S. af-*

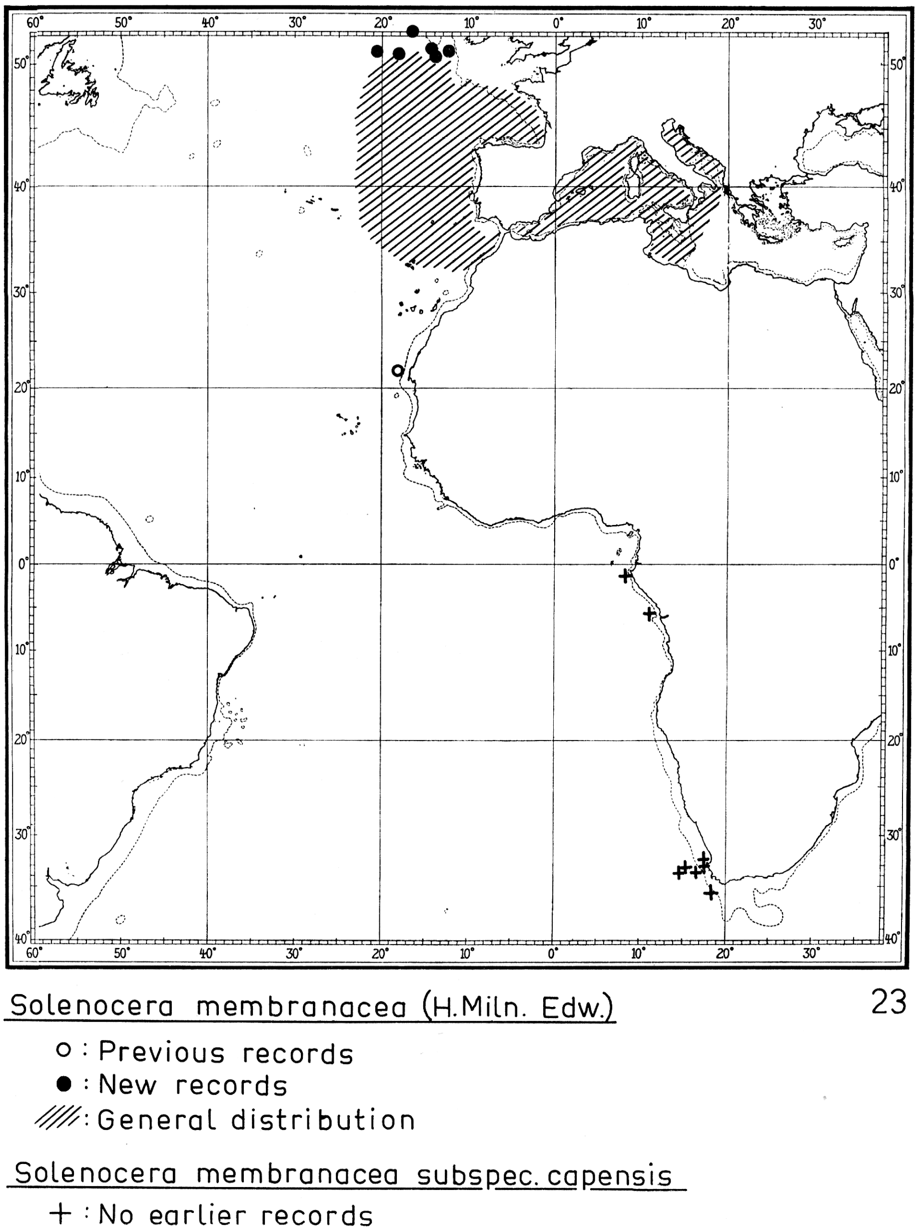


Fig. 23. Map of distribution.

ricanum as a separate one. The groups are the Mediterranean and North Atlantic *Solenocera membranacea*, the South-East Atlantic *S. capensis* from around South Africa reaching north along the west side of Africa to Cape Lopez, and may be *S. africanum* along the Eastern coast of South Africa in the Indian Ocean, and finally *S. muelleri* as the name must be, if it is the larva to the adult described by BURKENROAD as *S. vioscai* which may be the adult to MÜLLER's and ORTMANN's larva *Opisthocaris muelleri* which will be discussed later in this paper. The *S. vioscai* is known from the coast of Venezuela and described by SMITH in 1885 as *S. membranacea*, but BURKENROAD (1934) has established it as a separate species *S. vioscai* on the above mentioned three females taken by SMITH at Venezuela and two more taken near Pass à la Loutre in Louisiana. If as suggested in this paper *S. muelleri* is the larva of this form, its known distribution will be much enlarged, as the larva has been taken in the Florida current by the HUMBOLT Expedition and further along the whole coast of Brazil down to Desterro where MÜLLER's larvae are from.

Whether these four types are to be regarded as independent species or three of them are to be considered as subspecies of *S. membranacea* must more or less be a question of personal opinion. It can at least only be settled by examining the adults, which have not been at disposal for the present author, and furthermore the question is partly outside the scope of this paper. However, it is clear that we have at least three distinct separate stocks, perhaps four, because the border lines in the distribution between *S. capensis* and *S. africanum* are not clear. Each of these three or four stocks has its own special morphological characters, although all of them are closely related to one another. Judging only from the larvae it can be said that *capensis* is so close to *membranacea* that it is reasonable to place *capensis* as a subspecies under *membranacea*. The larva of *S. africanum* is not known, or at any rate only one larval species is known from the South African area. The larva of *S. muelleri* is so far removed morphologically from the ones on the Eastern hemisphere that it is reasonable to establish it in its own species *Solenocera muelleri* to which BURKENROAD's *S. vioscai* then probably is a synonym.

Solenocera muelleri (ORTM.)

Figs. 24–50.

"Eine dritte Art." FRITZ MÜLLER, 1863, p. 22, Figs. 18–22.
Opisthocaris muelleri ORTMANN, 1893, pp. 77–78, pl. 4, Fig. 5.

Localities.

Protozoea III:

FRITZ MÜLLER's larva from Desterro, Brazil, 1863. several spec.

Mysis I:

Discovery St. 709, 14°01,4′ S–36°30,7′ W, 216–0 m, 24.10.31. B.M. 2 spec.
Unknown locality B.M.

Mysis II:

Coast of Brazil (*Opisthocaris muelleri*) ORTMANN, 1893, several species.
Discovery St. 708, 10°20,6′ S–34°54,7′ W, 208–0 m, 23.10.31 B.M. 1 spec.
— — 709, 14°01,4′ S–36°30,7′ W, 216–0 m, 24.10.31. B.M. 4 spec.
Unknown locality, B.M.

Description.

Mysis I.

Figs. 24–38.

Carapace.

Formula: 1. 2. 3. 4. 5. 7. 8. 9. 10. 11. 12. 13. 14. 16. 18. (19). 22. 23. 24. 27. 28. 29. 30.

This small larva is very characteristic in many points and is therefore easy to recognize. In the first Mysis the surface of the carapace is very uneven with many longitudinal ridges and furrows. From MÜLLER's figure of the third Protozoea (1863, Pl. II, Fig. 18) the most characteristic is a larva with branchiostegal spines as well as branchio-lateral spines, the presence of these types of spines is hitherto only known in the larval *Solenocera* sp. larva. *barbata*. MÜLLER has further shown in his figure a most unusual swelling on the side of the carapace furnished with two spines on its dorsal part, it looks mostly as a deformity and is not observed in any other *Solenocera* larva. It was therefore highly interesting that the material for examination included one sample, with two specimens of Mysis I also from the coast of Brazil and in which these characters of MÜLLER's larva still could be recognized although in a one stage older larva than MÜLLER figured. The swelling is the beginning of a convoluted surface where the branchiostegal lobe is about to develop, because this lobe is not found in third Protozoea, but begins to develop in the first Mysis. MÜLLER's bulb inside the carapace margin is longer than the one I found in the following stage, which was the youngest stage I had at hand. Here the bulb was partly transformed into a beginning lobe. MÜLLER further found two spines attached to this bulb, whereas I in the first Mysis found several spines of which two were larger than the rest. The paired prehepatic spines are by MÜLLER drawn as a single spine in the medial line, a mistake which very easily can be made, especially when not having made a diagram over the possible spines as the one presented in this paper, Fig. 1.

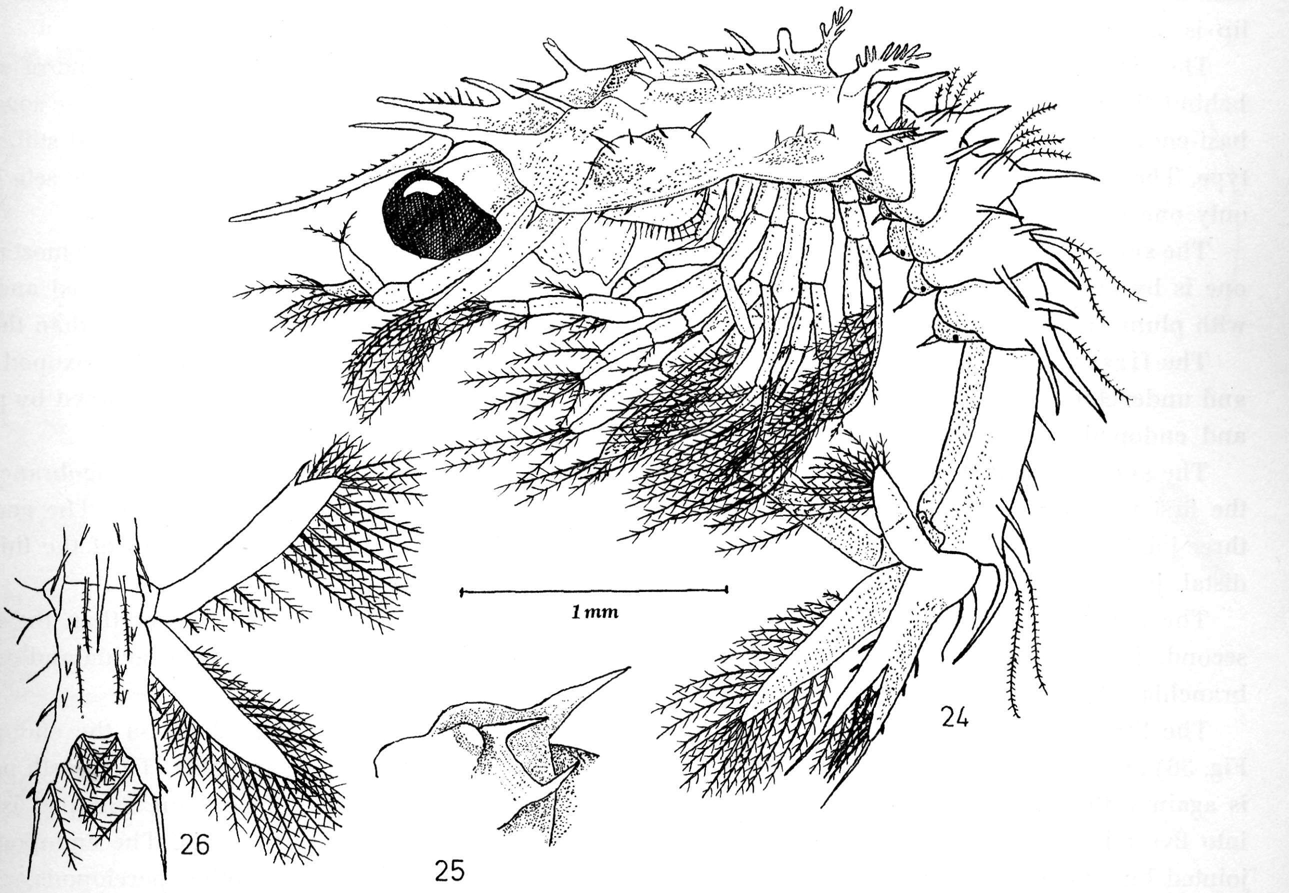
The carapace of the first Mysis has a large and well-developed rostral plate. The rostrum itself is long and a little curved, and covered with fine, anteriorly pointing, spines mostly on its dorsal side. There are both a rostral and an epigastric rostral tooth, of which the rostral tooth is the largest and has many stiff surface hairs. Still in the middle line behind the rostrum is the anterior dorsal organ which is rather long and at its tip divided into two small bulbs. The posterior dorsal organ is much smaller, though above average size. The cervical groove is very distinct and extends forwards into the concavity between rostrum and the ridge on which the supra-orbital and postorbital spines are placed. The supra-orbital spines are as usual the largest spines except for the rostrum, but also the post-orbital spines are large. Here it may be mentioned that in all the other larval species there has never been observed a post-orbital spine, but instead of this a post-antennal spine. This seems to be the same spine which normally is placed posteriorly to the supra-orbital and the antennal spine in a longitudinal line between these two first spines, but closest to the antennal spine, and therefore I have called it the post-antennal spine. Further when the carapace has a cervico-branchial groove debouching between the supra-orbital spine and the antennal spine, the spine called the post-antennal spine has always been found laterally of this groove, but in *S. muelleri* the spine is placed on top of the ridge running backwards from the supra-orbital spine, and can therefore most naturally be mentioned the post-orbital spine. Of longitudinal grooves or ridges we have further the branchio-cardiac groove which in this species is very long running anteriorly in line with the pre-hepatic spines which also are present. In the following stage, the second Mysis stage, this spine extends farther forward so as to connect with the ridge from the supra-orbital spine. Thus here a longitudinal ridge connects the supra-orbital spine with the postero-branchial groove spine, whereas the first Mysis still has an open stretch between these two spines. Following the carapace margin from the rostrum backwards we find first the already mentioned supra-orbital spines, after them follow a short, conical, antennal spine, and then, most extraordinarily, four branchiostegal spines. In all the other species known the maximum is three, and in *Solenocera muelleri* it is only in the first Mysis that we find four such spines. In the following stage the most posterior of them has disappeared, reducing the number to the normal maximum of three. Further back on the margin are placed also four branchio-lateral spines plus one on the posterior corner itself, this latter is not the often found latero-posterior marginal spine, because this is also present, only it has moved a tiny stretch away from the corner. This last spine is large and covered with filamental teeth. Also the number of the branchio-lateral spines is reduced in the following stage to three + one, but here the number is not unusual, the third Protozoea of *Solenocera* sp. larva *barbata* has 7–8 of them. From the posterior margin extends posteriorly the latero-posterior marginal spines, above them is the postero-branchial groove spines and above them again, close to the middle line, a pair of medio-posterior marginal spines, all three pairs are covered with filamental teeth.

Inside the margin the following spines are placed: the unpaired dorsal or epi-cardiac spine in the median line between the two dorsal organs but closest to the posterior dorsal organ; in front of this the pre-hepatic spines; farther anteriorly and more laterally the post-orbital spine, which both have been mentioned; and along the branchio-cardiac groove four spines. The most anterior one of these four spines is in line with the prehepatic spine, which therefore also can be looked upon as the latero-hepatic spine up to which the branchio-cardiac groove or ridge has reached. At the side of the spines a few soft hairs have started to develop on the carapace. In the following stage these hairs increase considerably in both size and numbers.

Abdomen.

Formula, segments I–V: 1. 2. 3. 5., segment VI: 1. 3.

On the abdomen all six segments have both a dorsal and a dorso-lateral spine. The first five segments are further furnished with a pair of lateral spines and a ventral spine. These three spines are missing on the sixth segment, but on the dorsal ridge of this segment is a double row of short spines. Further several long, flexible and partly plumose hairs are found on all the segments beginning from the dorsal ridge where they are longest and continuing along the pleura towards the ventral side of the segment. These are more developed and better seen in the following larval stage and are best developed on the three first abdominal



Figs. 24–26. *Solenocera muelleri.* First Mysis. Fig. 24, total view of larva, from lateral. — Fig. 25, part of first abdominal segment showing the lateral process and the three spines on the dorsal half of the segment. — Fig. 26, telson and right uropod.

segments. On the first abdominal segment we further have the lateral process which is first a membrane between the lateral spine and the dorso-lateral one, then a cutinous bulb, later a muscular bulb, anteriorly of the membrane, but fitting closely into it as shown in Fig. 25. The two spines here, one at each end of the membrane, are soft and vestigial in this stage and in the following second Mysis stage, where the lateral spine is free of the membrane while the dorso-lateral one is lost.

Telson.

The telson has nearly parallel sides. The cleft of the furca is shaped as an anglé of about 50°. The two lateral spines are only small and placed near the tip of the furca, the third spine is somewhat larger and placed about midway on the lateral margin of the telson. The double row of spines on the dorsal ridge of the sixth abdominal segment is extending on the telson with three pairs of small spines, three in each row. Also the two long hairs from the sixth segment hanging down above the telson have a counterpart of two long hairs, but these are a little shorter than those on the sixth segment. On each side of the furcal cleft are the usual four plumose setae.

Appendages.

The first antenna has the usual three-jointed peduncle of which the first joint is extremely long, about twice the length of the two following joints together and shows a beginning development of the statocyst hollow. The two following joints have many stiff setae on their medial margins, and the two flagella are short and unjointed.

The second antenna has not yet developed the spine on the distolateral corner, but only stiff plumose setae.

The mandible has a clear distinction between molar- and incisor part, the latter is furnished with a characteristic series of thin, spine-like teeth. The palp is short, unjointed and fleshy. The labium or lower lip is small and split nearly to its base.

The first maxilla has developed a stout basi-endite with strong, cutting teeth and a line of stiff setae behind the teeth on the lateral side of the lobe. The coxa-endite is smaller, with shorter setae towards the basi-endite, longer setae on the proximal half of the end of the lobe; all setae are of the usual stiff, plumose type. The endopod is three-jointed and the exopod has remained as a small bulb with a single seta left; that only one seta is present may be caused by the poor state of preservation of the material.

The second maxilla is of the usual kind with four protopodial lobes or endites of which the most proximal one is by far the largest. The endopod is five-jointed and the exopod is narrow, moon-shaped and fringed with plumose setae of which the most proximal one is very large, three to four times longer than the others.

The first maxillipede has a wide protopod with a mastigobranchia on the coxa. The exopod is small and undeveloped, the endopod is four-jointed and the whole medial margin of the limb, shaped by protopod and endopod, is lined with many stiff and plumose setae.

The second maxillipede has a shorter, also two-jointed, protopod and a smaller mastigobranchia than the first maxillipede. The exopod is better developed with some swimming setae distally. The endopod is three-jointed with a very large basal joint and with a brush of four stiff setae at the tip of the third, most distal, joint; other setae are placed along the medial margin of the limb.

The third maxillipede is developed as an ambulatory limb, and is much longer than the first and second. The protopod is two-jointed with two small gill-buds on coxa for one mastigobranchia and one podobranchia. The endopod is five-jointed; the exopod has distally long swimming setae.

The three first pairs of thoracopods show a beginning development of a chela on the endopod (see Fig. 36) and have on coxa two gill-buds for one mastigobranchia and one podobranchia. The fourth pereiopod is again without beginning chela, the coxa has only a single bud for one gill, and the endopod is divided into five joints. The fifth pereiopod is shorter than the others and without gill-buds. The endopod is five-jointed but short, only the exopod is of full length equal to the exopods of the other pereiopods.

The pleopods are hardly visible, small limb-buds on the first five abdominal segments. The uropods have an unjointed protopod and long lancet-shaped exopods and endopods. They are about as long as the telson, but they have not yet got their full armament of setae.

Dimensions:

Total length 5 mm. Length of carapace 1.5 mm, width of same 1 mm, length of free rostrum 1 mm, length of abdomen 2 mm. This is the smallest of the known larvae. The third Protozoea described by MÜLLER was after his measurement only 1.2 mm. He does not mention how the measurements were taken, but it must be without including the rostrum.

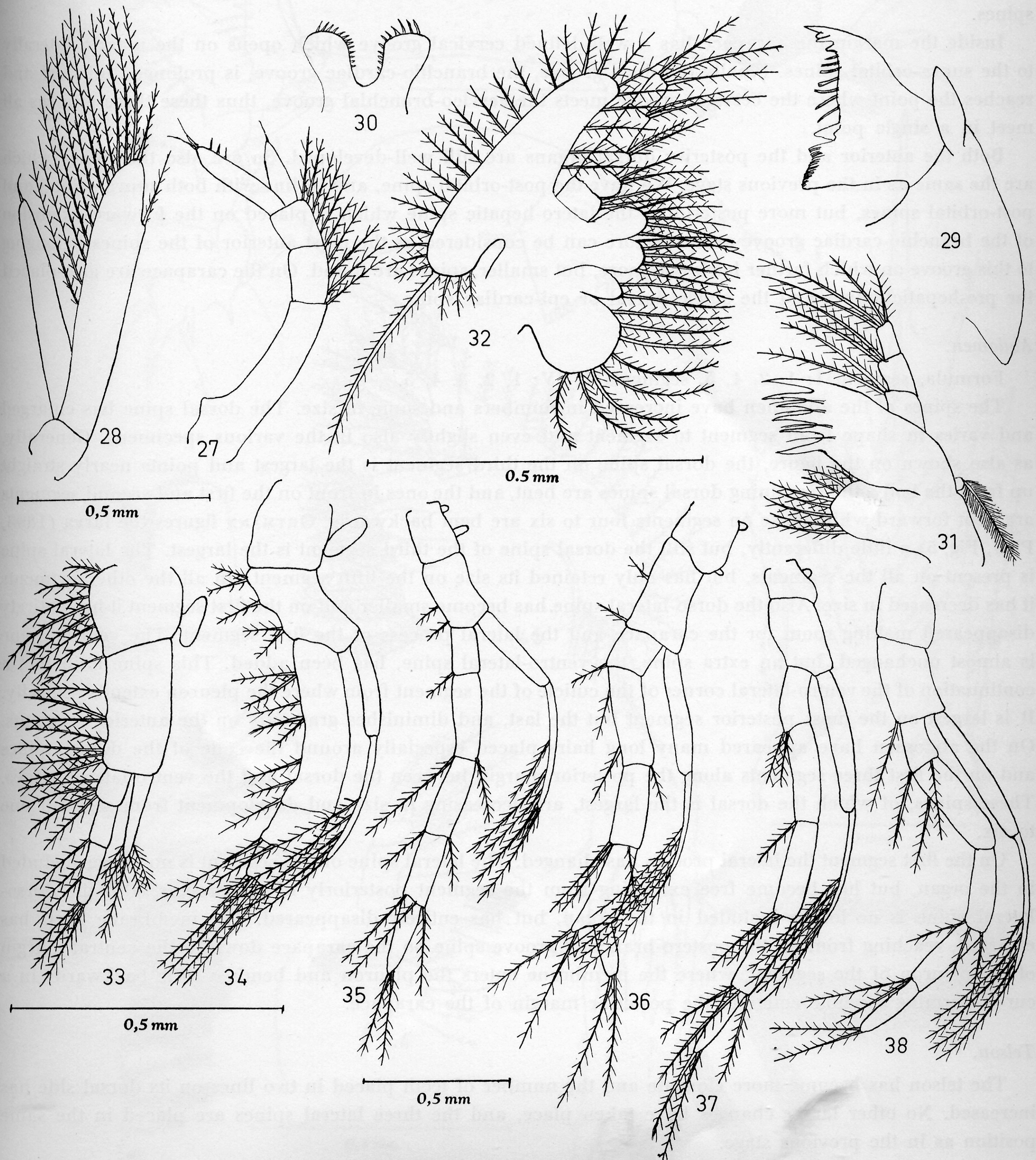
Mysis II.

Figs. 39–49.

Carapace.

Formula: 1. 2. 3. 4. 5. 7. 8. 9. 10. 11. 12. 13. 14. 16. 18. (19). (22). 23. 24. 27. (29). (30).

The whole carapace is in this stage covered with longer and shorter hairs besides the actual spines. The longest of these hairs are even plumose with some short side-hairs on the shaft. The rostrum has enlarged a little from the previous stage, but it has lost most of the hairs which covered it in the first Mysis. Also the rostral tooth and the epigastric rostral tooth have enlarged, and the rostral plate has developed to a whole platform in front of the body, the largest in all the known larvae, it carries a pair of large, curved supra-orbital spines. The antennal spine is almost unchanged from the last stage, but the number of branchiostegal



Figs. 27–38. *Solenocera muelleri*. First Mysis. Fig. 27, first antenna. — Fig. 28, second antenna. — Fig. 29, mandible. — Fig. 30, labium. — Fig. 31, first maxilla. — Fig. 32, second maxilla. — Figs. 33–35, first, second and third maxillipedes. — Fig. 36, first pereiopod. — Fig. 37 and 38, fourth and fifth pereiopods.

spines have been reduced to three, the most posterior one has disappeared, and the remaining three are decreasing in size in posterior direction. Also the branchio-lateral spines have been reduced to three and the latero-posterior marginal spine has disappeared only leaving the little spiny bud directly on the corner where it also was in the first Mysis. The postero-branchial groove spine has become more spine-like and lost its serrate brim except for very tiny bits. The same is the case with the pair of medio-posterior marginal spines.

Inside the margin the carapace has a well-defined cervical groove which opens on the margin laterally to the supra-orbital spines. Finally the third groove, the branchio-cardiac groove, is prolonged forward and reaches the point where the cervical groove meets the cervico-branchial groove, thus these three grooves all meet in a single point.

Both the anterior and the posterior dorsal organs are still well-developed. So are also the spines which are the same as in the previous stage. We have the post-orbital spine, and in line with both supra-orbital and post-orbital spines, but more posteriorly, the latero-hepatic spine which is placed on the forward extension of the branchio-cardiac groove and therefore can be considered as the most anterior of the spines belonging to this groove on which farther back two more, but smaller, spines are found. On the carapace are also placed the pre-hepatic spines and the single dorsal or epi-cardiac spine.

Abdomen.

Formula, segment I: 1. 2. 4. 5, segments II–IV: 1. 2. 3. 4. 5.

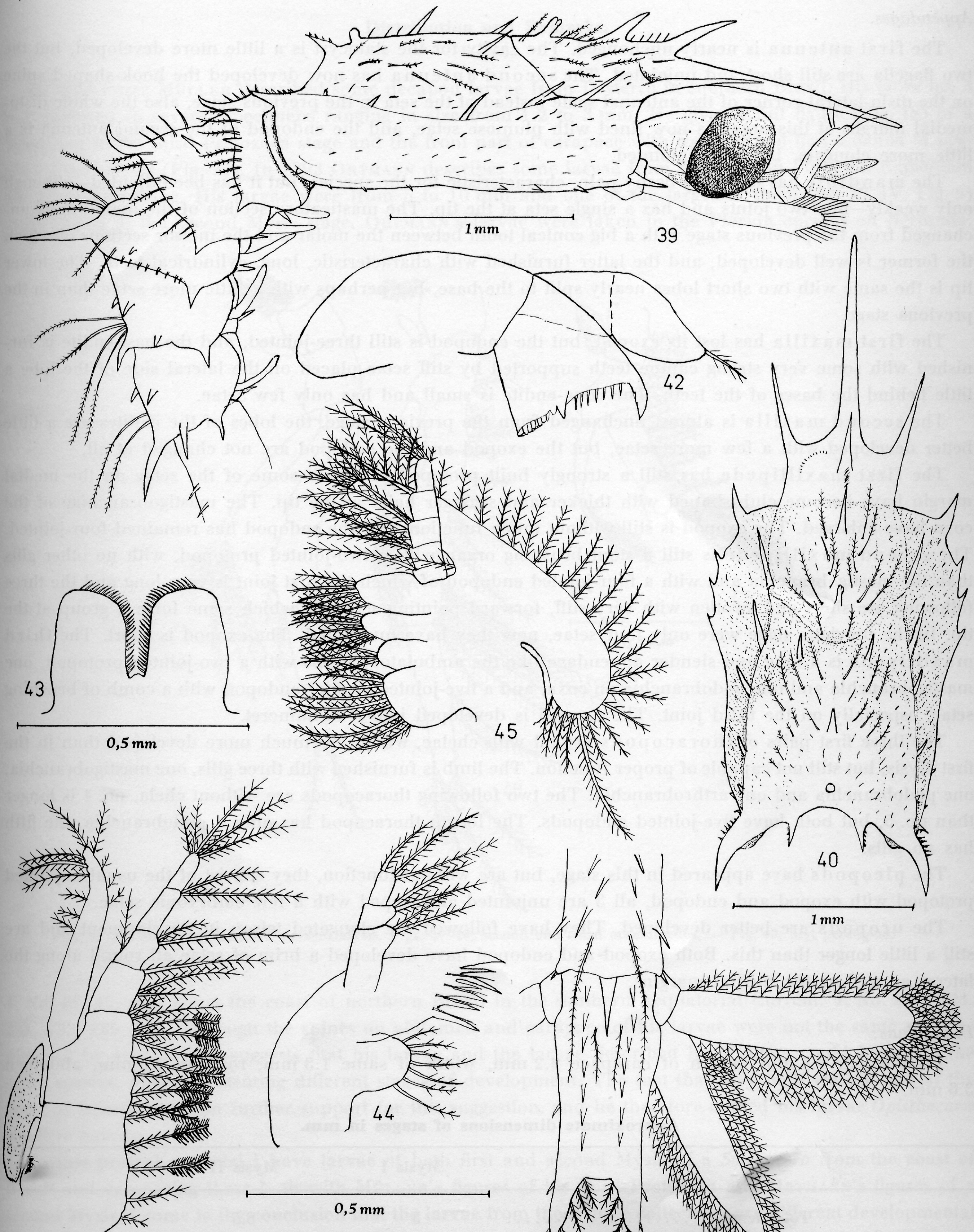
The spines of the abdomen have increased in numbers and some in size. The dorsal spine has enlarged and varies in shape from segment to segment and even slightly also in the various specimens. Generally, as also shown on the figure, the dorsal spine on the third segment is the largest and points nearly straight up from the body, the remaining dorsal spines are bent, and the ones in front on the first and second segments are bent forward while those on segments four to six are bent backwards. ORTMANN figures the larva (1893, Pl. 4, Fig. 5) a little differently, but still the dorsal spine of the third segment is the largest. The lateral spine is present on all the segments, but has only retained its size on the fifth segment, on all the other segments it has decreased in size. Also the dorso-lateral spine has become smaller and on the first segment it has entirely disappeared making room for the carapace and the lateral process of the first segment. The ventral spine is almost unchanged, but an extra spine, the ventro-lateral spine, has been added. This spine is in fact a continuation of the ventro-lateral corner of the cuticle of the segment from where the pleuron extends ventrally. It is largest on the most posterior segment but the last, and diminishes gradually on the anterior segments. On the abdomen have appeared many long hairs placed especially around the cone of the dorsal spines and on the first three segments along the posterior margin between the dorsal and the ventro-lateral spines. These spines, of which the dorsal is the largest, are decreasing in size and development from segment one to six.

On the first segment the lateral process has changed. The lateral spine of this segment is no longer included in the organ, but has become free extending from the segment posteriorly of the process, also the dorso-lateral spine is no longer included in the organ, but has entirely disappeared. The membrane itself has enlarged, reaching from off the postero-branchial groove spine on the carapace down to the ventral margin of the pleuron of the segment, where the membrane enters the pleuron and bends a little backwards in a curve, forming a whole collar to the posterior margin of the carapace.

Telson.

The telson has become more elongate and the number of teeth placed in two lines on its dorsal side has increased. No other larger changes have taken place, and the three lateral spines are placed in the same position as in the previous stage.

Figs. 39–46. *Solenocera muelleri*. Second Mysis. Fig. 39, carapace and part of abdominal segments, from lateral. — Fig. 40, carapace, from dorsal. — Fig. 41, telson with right uropod. — Fig. 42, mandible. — Fig. 43, labium. — Fig. 44, first maxilla. — Fig. 45, second maxilla. — Fig. 46, first maxillipede.


39
1 mm
42
40
1 mm
43
0,5 mm
45
46
44
0,5 mm
41

Appendages.

The first antenna is nearly unchanged. The cavity for the statocyst is a little more developed, but the two flagella are still short and unjointed. The second antenna has now developed the hook-shaped spine on the disto-lateral corner of the antennal scale instead of the seta in the previous stage, also the whole disto-medial margin of this organ is now lined with plumose setae, and the endopod of the second antenna is a little more elongate, but still unjointed.

The mandible has the same fleshy palp, characteristic for the species, but it has been divided—although only weakly—into two joints and has a single seta at the tip. The masticatory section of the mandible is unchanged from the previous stage with a big conical tooth between the molar and the incisor sections of which the former is well developed, and the latter furnished with characteristic, long, cylindrical teeth. The lower lip is the same with two short lobes nearly split to the base, but perhaps with a little more setae than in the previous stage.

The first maxilla has lost its exopod, but the endopod is still three-jointed, and the basi-endite is furnished with some very strong canine teeth supported by stiff setae placed on the lateral side of the lobe a little behind the bases of the teeth. The coxa-endite is small and has only few setae.

The second maxilla is almost unchanged from the previous stage, the lobes of the endites are a little better developed with a few more setae, but the exopod and the endopod are not changed at all.

The first maxillipede has still a strongly built protopod of which some of the setae on the medial margin have become club-shaped with thicker and stronger hairs at the tip. The mastigobranchiae of the coxa have enlarged. The exopod is still without much function, and the endopod has remained four-jointed. The second maxillipede is still a stout brushing organ with a two-jointed protopod, with no other gills than the mastigobranchia and with a four-jointed endopod of which the first joint is very long and the three following are short and swollen with very stiff, forward pointing setae, of which some form a group at the tip. In the previous stage were only four setae, now they have multiplied. The exopod is short. The third maxillipede is a long and slender appendage like the ambulatory limbs with a two-jointed protopod, one mastigobranchia and one podobranchia on coxa, and a five-jointed slender endopod with a comb of brushing setae, especially on the third joint. The exopod is developed into a swimmeret.

The three first pairs of thoracopods are all with chelae, which are much more developed than in the first Mysis, but still not capable of proper function. The limb is furnished with three gills, one mastigobranchia, one podobranchia and one arthrobranchia. The two following thoracopods are without chela, no. 4 is longer than no. 5, but both have five-jointed endopods. The fourth thoracopod has only a podobranchia, the fifth has no gills.

The pleopods have appeared in this stage, but are without function, they consist of the usual unjointed protopod with exopod and endopod, all 3 are unjointed and tipped with a few embryonic setae.

The uropods are better developed. They have followed the elongated telson in development and are still a little longer than this. Both exopod and endopod have developed a brim of setae all round along the lateral as well as the medial margins.

Dimensions:

Total length 8.5 mm, length of carapace 2.2 mm, width of same 1.3 mm, rostrum 1.5 mm, abdomen 3.6 mm.

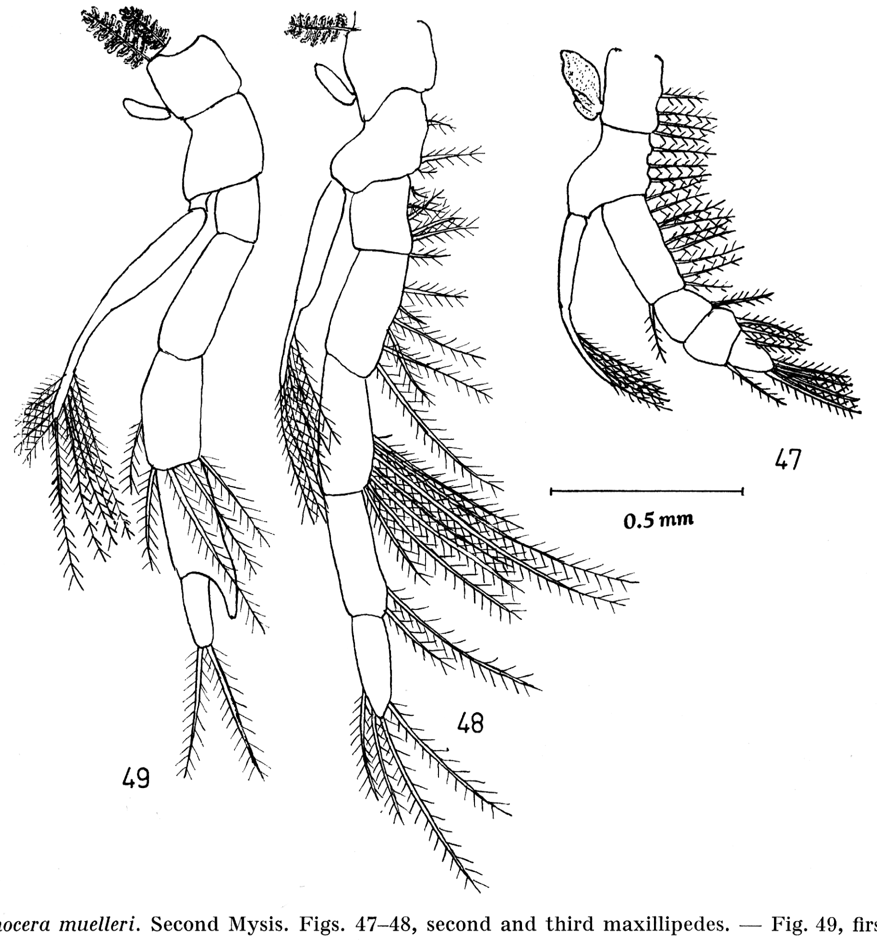
Approximate dimensions of stages in mm.

	Mysis I	Mysis II
Total length	5	8.5
Carapace	1.5 × 1	2.2 × 1.3
Rostrum	1	1.5
Abdomen	2	3.6

Distribution and Remarks.

Fig. 50.

In 1863 Fritz Müller described some decapod larvae from Desterro in southern Brazil. His larva no. 3 was captured in several specimens ranging in size from 1.2 to 3 mm. He gives a full figure (Fig. 18) of a *Solenocera* in the third Protozoea stage and the front part of carapace with rostrum and first antenna of possibly a first Mysis (Fig. 22). In 1893 Ortmann describes some larvae from the German Plankton Expedition der Humboltstiftung. His larvae were from 5 to 10 mm and one of the larger of them (his Pl. IV, Fig. 5) must belong to the second Mysis stage. Ortmann's larvae were taken in the Florida current off Bermuda,

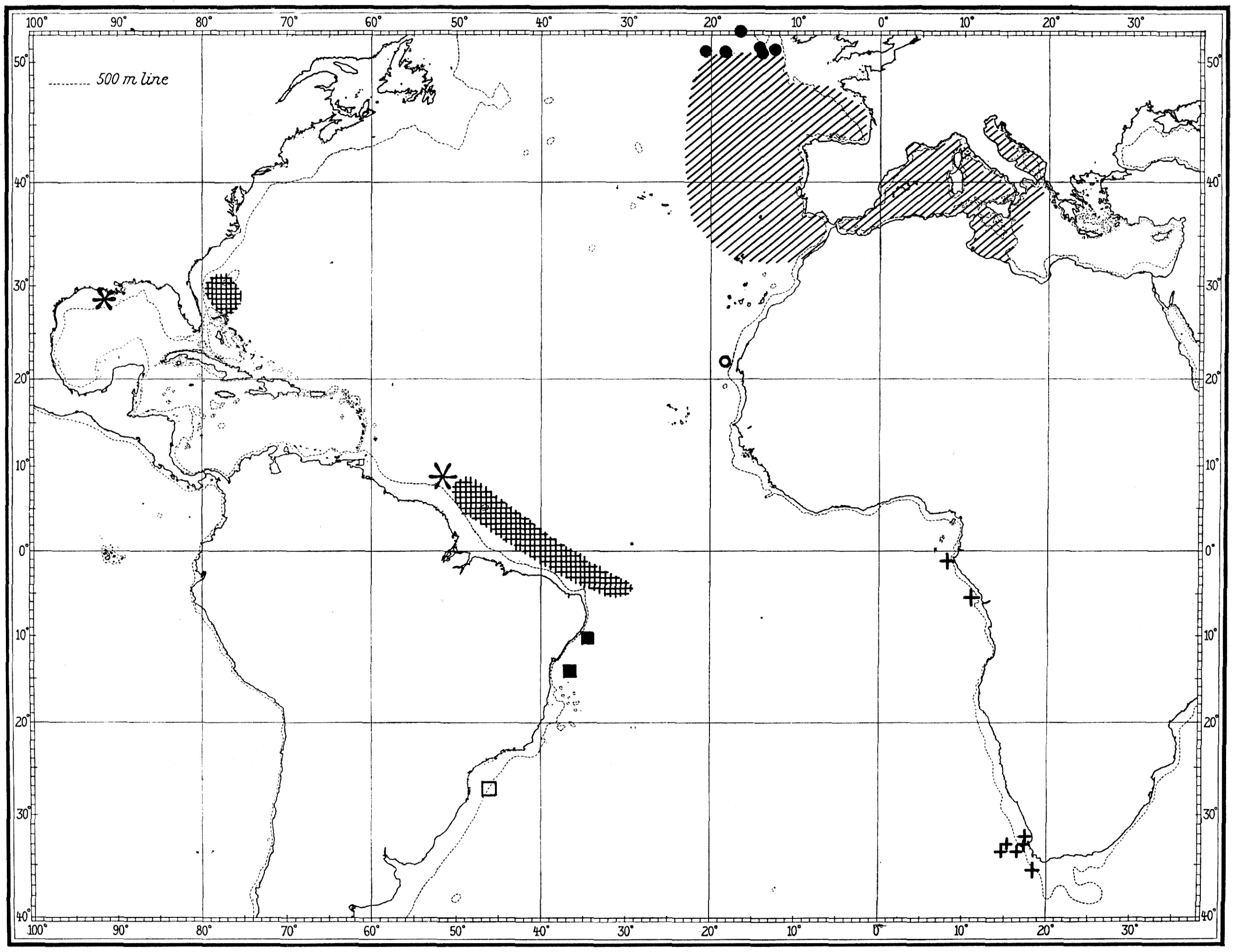


Figs. 47–49. *Solenocera muelleri*. Second Mysis. Figs. 47–48, second and third maxillipedes. — Fig. 49, first pereiopod.

J. No. 45, 47, and along the coast of northern Brazil in the southern Aequatorial Current, J. No. 218, 228, 231, 232, 235, 246. Although the spines on abdomen and carapace of his larvae were not the same as those pictured by Müller, he suggests that his larvae and the larvae described by Müller could belong to the same species, only representing different stages of development. The fact that they both were found at the coast of Brazil gave him further support for this suggestion, and he therefore named his larvae *Opisthocaris muelleri* nov. sp.

In this present material I have larvae of both first and second Mysis of a *Solenocera* from the coast of Brazil and comparing these both with Müller's figures of his third Protozoea and Ortmann's figures of a second Mysis, I come to the conclusion that the larvae from these three collections are different developmental stages of the same species, which I therefore have named *Solenocera muelleri*.

If we first compare my first Mysis with Müller's third Protozoea we see that both have branchiostegal and branchio-lateral spines, further Müller's larva has a lateral swelling with two spines on the carapace



50

Solenocera mülleri (Ortm.)

□ # } Previous records

■ : New records

✳ : Solenocera vioscai, adult

Solenocera membranacea (H. Miln. Edw.)

o : Previous records

● : New records

//// : General distribution

Solenocera membranacea subspec. capensis

+ : No earlier records

Fig. 50. Map of distribution.

above the branchiostegal spines, which also is present in my first Mysis only with three additional small spines. This swelling is the developing branchiostegal lobe which appears in the second Mysis where the swelling has disappeared. On the abdomen Müller only pictures a dorsal and a lateral spine; it is very likely that the dorso-lateral spines of the Mysis stages not have developed in the Protozoea. Further Müller has by mistake moved the pair of pre-hepatic spines up in the middle line and pictured them as a single spine, which easily can happen, as they are very small and can be overlooked in a poorer microscope than we have to-day. This must be the case as no *Solenocera* larva has more than one dorsal spine placed directly in the medial line between the dorsal organs. This explanation also holds good for a few of the other missing spines, or probably these have not yet been developed in the Protozoea. Müller further pictured the latero-posterior marginal spine as one of the branchio-lateral spines not noticing the difference in shape and size. Comparing Ortmann's figures with mine of the second Mysis, it is seen, that they generally agree, Ortmann only missing smaller details, because of his less detailed drawing. He mentions neither branchiostegal spines, or branchio-lateral spines, nor the vestigial bud of the latero-posterior marginal spine. He also only pictures one dorsal spine on the abdomen. But his showing of both a post-antennal spine and a latero-hepatic spine is very characteristic, as such spines not are found in any other known species. Further the long hairs of the abdomen and the woolly carapace are also characteristics of importance. I think therefore that it is justifiable to regard them all as larvae of the same *Solenocera* species. If we do so we have a species which is found east of Florida and along the Brazilian coast down to Desterro in southern Brazil on about 28th southern latitude.

When trying to discover which adult *Solenocera* this larva belongs to we are on much less solid ground. Only it must be one of the most common *Solenocera* species from this area, because the larvae are so relatively numerous and frequent. Further as the larva has in general features some resemblance to the larva of *Solenocera membranacea*, it can be suggested as a possibility, but not more, that this larva is the larva of *Solenocera vioscai*, Burkenroad, which is the *Solenocera membranacea* of the western hemisphere and is known from the Venuzuelan coast and from the coast of Louisiana.

If we compare the Mysis larva of *Solenocera membranacea* with the same stage of *Solenocera muelleri* we find a strong resemblance. They have both an elongate carapace with a large rostral plate, which is smallest in *S. membranacea*, a little larger in *S. membranacea* subsp. *capensis* and nearly twice as large in *S. muelleri.* They all have branchiostegal lobes with three spines, and here the lobes are largest in *S. membranacea* and smallest in *S. muelleri*. The postantennal spine in *S. membranacea* has been replaced by a post-orbital spine, but, as already mentioned, it is in *S. membranacea* placed between the antennal and the orbital spine, so that these two can be identical. Further we have in all species many lateral spines, and on the anterior part of the carapace *S. muelleri* has lost the following two spines, which are present in *S. membranacea*: the medio-gastric spine and the supra-hepatic spine, instead *S. muelleri* has three small branchio-lateral spines which are not found in *S. membranacea*, but these spines are largest in the first Mysis and nearly gone already in the second Mysis, and the same goes for the latero-posterior marginal spine which is well developed in the first Mysis but lost in the second Mysis. The strongest disagreement between them is that the medio-posterior marginal spine is paired in *S. muelleri*, but single in *S. membranacea* and *S. membranacea* subsp. *capensis.* Finally all these species are strongly hairy on carapace and abdomen with some very characteristic long hairs; these hairs are least numerous and shortest in *S. membranacea* and largest in size and number in *S. muelleri, S. membranacea* subsp. *capensis* is placed in between. The hairs are in all three species placed in very much the same groups. On the abdomen the spine formulae are the same for all three species. On the telson *S. muelleri* has two lines of dorsal teeth not found in *S. membranacea* and *S. membranacea* subsp. *capensis*.

The appendages are very much the same in all three and have a fleshy mandibular palp and strongly carnivorous mouth appendages; the thoracopods and uropods in the second Mysis are much alike. Therefore, although we have no proof, it is most likely that *Solenocera muelleri* is the larva of Smith's *S. membranacea* from Venuzuela and Burkenroad's *S.* sp. larva *vioscai* from Louisiana. If this later is proven to be true they all have to bear the name *Solenocera muelleri*.

Solenocera sp. larva *aequatorialis*

Figs. 51–65.

Localities.

Mysis II:

"Discovery" St. 276. 5°54′00″ S–11°19′00″ E 110–0 m. 5.8.1927. B.M. 1 spec.

Description.

Mysis II.

The sample contained only a single specimen which had been partly dissected earlier. The figures have therefore been drawn after the three separate pieces found in the sample, and appearing as parts of the same specimen.

Carapace.

Formula: 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 15. 17. 18. 19. 20. 21. 22. 24. 26. 27. 28. (29). 30.

The rostrum is well developed and a little curved with a strong carina on the carapace including 3 teeth. At the posterior base of the rostral carina a small anterior dorsal organ is placed; the posterior dorsal organ, in front of the medio-posterior marginal spine, is also diminutive.

Along the margins to each side of the rostrum is a large, ventrally curved, supra-orbital spine reaching over and beyond the eye. Behind it and still a little more laterally of the margin arises a smaller spine underneath the second antenna and the eye, the antennal spine. Behind this and for about one third of the length of the carapace is developed a pair of dominant wings, the alae branchiostegalis, which are very characteristic for this species. Their free margins are edged with brims of filamental teeth, the branchiostegal teeth. Along the medial part of the carapace the margin is without such brims, which only start again in the posterior third of the carapace, the branchio-lateral brim-teeth. On the latero-posterior corner of the carapace is a short spine, the latero-posterior marginal spine, covered with a toothed filament; above it is the poster-branchial groove spine, a lamella-shaped spine with filamental teeth on its dorsal margin. Finally, posteriorly in the medial line, the medio-posterior marginal spine forms a short backwards pointing spine, which in its most distal part is split into two pointed tips.

On the carapace, but inside the margin is the dorsal or epicardiac spine, which is unpaired and placed in the medial line far back on the carapace. To each side of it is a post-cardiac spine. This is the only species known with such a spine, except *S.* sp. larva *sumatransis*, where a branchio-cardiac groove spine has moved into this position in the third and fourth Mysis stages. Behind the antennal spine is the long curved post-antennal spine; it is placed a little nearer to the longitudinal medial line of the carapace than the antennal spine, and this makes it open to discussion whether it is a post-antennal or a post-orbital spine. On the diagram Fig. 1 both are shown, but except for *S. muelleri* I have considered them as post-antennal spines. In *S.* sp. larva *aequatorialis* alone the spine is placed behind the antennal spine, arising from a hump on the carapace placed in line with the supra-orbital spine. Further the post-orbital spine is placed inside the cervico-branchial groove which reaches the carapace margin anteriorly between the supra-orbital spine and the antennal spine. But in *S.* sp. larva *aequatorialis* this groove is displaced due to the hump at the base of the "post-antennal" spine, and reaches the margin between the rostrum and the supra-orbital spine. For these reasons I have chosen to use the same name as in the previously described larvae and call this spine the post-antennal spine. Farther back between this and the post-cardiac spine is another spine, the latero-hepatic spine, which is much smaller than the two in front of it and of about the same size as the following paired spines. To each side of the anterior dorsal organ are the medio-gastric spines placed in front of the not very distinct cervical groove. Behind the medio-gastric spines and the cervical groove are the pre-hepatic spines, and behind them again the supra-hepatic spines, the latter are not only a little behind the pre-hepatic spines, but also in front of the dorsal spine and placed a little more laterally on the carapace than the pre-hepatic ones. Finally the branchio-cardiac groove is present, but without any spines.

Abdomen.

Formula, segments I–V. 1. 2. 3., segment VI. 1. 3. 4.

The first five abdominal segments have each a well developed pleuron as a free curve ventrally from the tergum. The terga have laterally on their posterior margins, a little above the middle, an incision which is stronger on the fifth segment than on the preceding ones. All the segments have a strong backwards-pointing spine which is straight on the first abdominal segment but backwards curving on the following segments. At the base of this spine on the dorsal ridge of the segment are several small accessory spines. On the sixth segment a double row of thin, accessory spines is found along the whole dorsal ridge. The first five segments have a lateral and a dorso-lateral spine both well developed and of about equal sizes,

Figs. 51–58. *Solenocera* sp. larva *aequatorialis*. Second Mysis. Fig. 51, carapace, from dorsal. — Fig. 52, same, from lateral. — Fig. 53, abdomen. — Fig. 54, last part of sixth segment, telson and uropods. — Fig. 55, mandible. — Fig. 56, labium. — Fig. 57, first maxilla. — Fig. 58, second maxilla.

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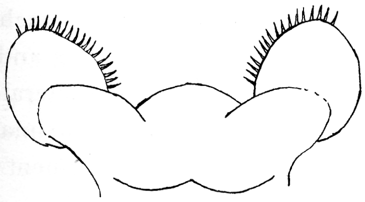

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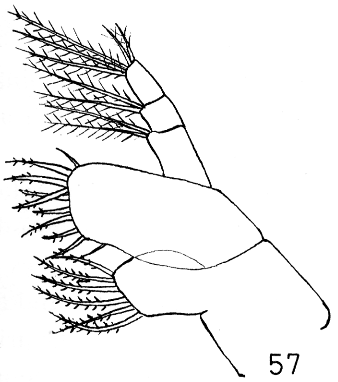

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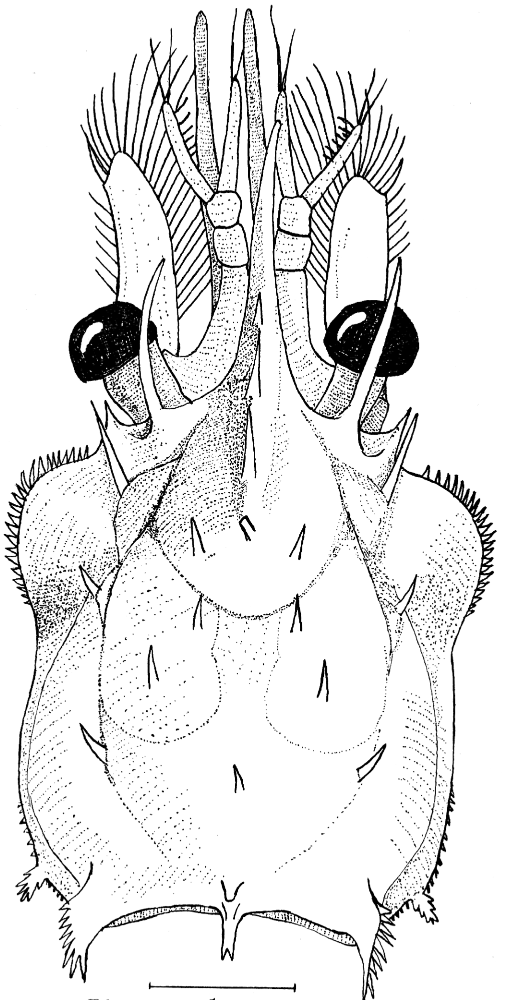

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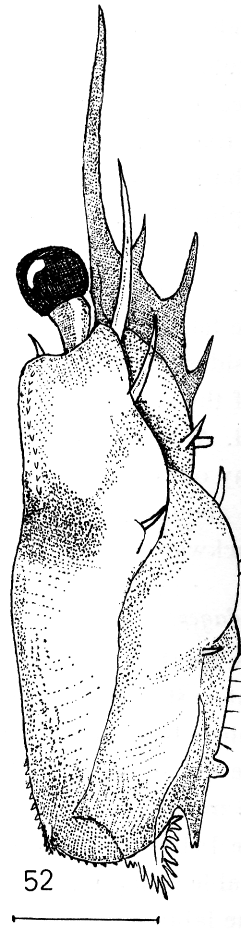

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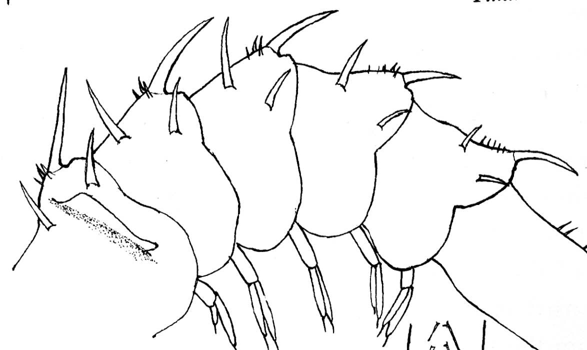

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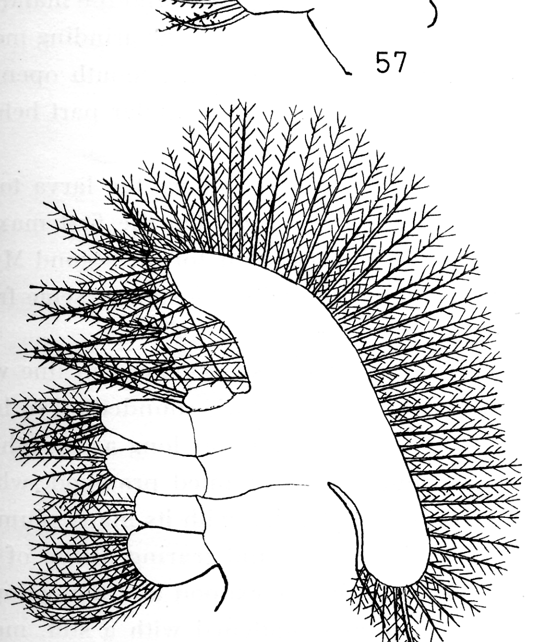

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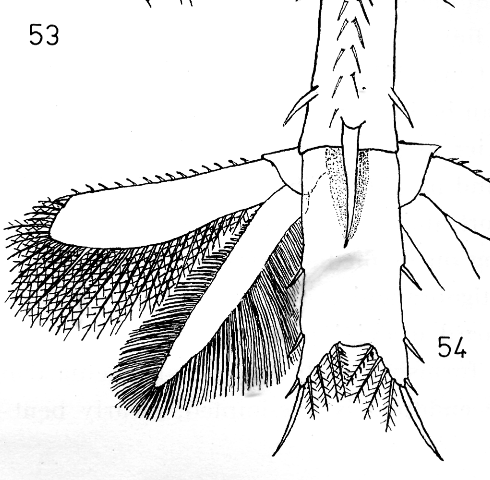

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half the length of the dorsal spine. The sixth segment has a dorsal spine, and below this is a second spine on each side situated on the place of the dorso-lateral spine, but its direction is that of a lateral spine. I have here called this spine the dorso-lateral spine, indicating that the lateral spine is missing on this segment, but substituted by a pair of small ventro-lateral spines, supporting the uropods from below. The first abdominal segment has its lateral process, which in this species is a long, lamellar membrane standing a little below the dorsal spine, running between the dorso-lateral and the lateral spines and reaching ventrally to near the beginning of the free pleuron. Shortly after its beginning it reaches its greatest height, it terminates as a spiny tip (Fig. 53).

Telson.

The telson is about $2^1/_2$ times as long as wide with nearly parallel sides. The furca is open, with its two inner sides forming an angle of nearly 60°, but with a flattened lobe at the bottom of the cleft. On each medial side of the cleft are four plumose setae. The terminal spine on each furcal branch is very long and a little curved. At its lateral base is the first of the three lateral spines, the last one is placed on the lateral margin halfway out on the telson plate and the second one midway between nos. 1 and 3. The two proximal spines are of about equal sizes, the most distal one a little smaller. The dorsal spine of the sixth segment reaches far backwards over the telson.

Appendages.

The first antenna has the usual three joints, but with a very deep arch on the proximal joint from which the statocyst is developing on the ventral side of the joint. The two flagella of the first antenna are short and unjointed, the lateral one has olfactory hairs.

The antennal scale of the second antenna is setose on nearly its whole margin. The setae are longer on the medial than on the lateral side. A well developed curved spine is placed on the latero-distal corner.

The labrum is short, and the labium is cleft nearly to the bottom with the lateral lobes divided into a movable arm and a setose, rounded plate at the end. They seem well fitted for reaching round the mandible and the labium outside the mouth opening, and thus for keeping the food within reach of the grinding molar part—the best developed part of the mandible—and for pushing the ground food into the mouth opening.

The mandible has small, pointed teeth in the incisor part and a strongly developed molar part behind it. The palp is two-jointed.

Both the first and the second maxillae are not strongly developed; this also shows the larva to be not so strongly carnivorous as those of *S.* sp. larva *sumatransis* or *S.* sp. larva *danae*. On the first maxilla the two endites are of medium size, and the endopod, consisting of the usual three joints for the second Mysis stage, is not very strong, but it is furnished with very long setae reaching in line with the shorter setae from the endites of the protopod.

The second maxilla has the four endites tipped with a line of stiff, plumose setae placed in line with the ones from the five-jointed, normally shaped endopod. The exopod or scaphognath is rounded off in both ends with a line of plumose marginal setae of which the most distal one is three times as long as the others.

The first maxillipede has as usual for *Solenocera* a very wide, but thin two-jointed protopod, which like a bar can be held transversely to the longitudinal line of the animal thus shaping with its many plumose setae a barrier to prevent food-particles to escape backwards during the cutting and tearing action of the mandibles and maxillae. The protopod is the main functional part of the limb; the exopod and the endopod are only short and of less functional importance. The first endopodial joint is flattened with a stiff, membranous wing on its medial margin. The endopod is four-jointed. On the lateral side of coxa is a large, two-winged mastigobranchia.

The second maxillipede is a little longer than the first one, but its protopod is not nearly as stout. The coxa is furnished with a mastigobranchia composed of an anterior lobose and a posterior leaf-shaped section. The endopod is five-jointed, clearly bent in a medial direction between the second and the third joints.

The t h i r d m a x i l l i p e d e is much longer and more like an ambulatory limb. The exopod is well developed as a swimmeret, the endopod is five-jointed with long stiff setae at the tip. In this species it is characteristic for this limb as well as for the thoracopods, that most endopodial joints, except the first one, have a short

Figs. 59–64. *Solenocera* sp. larva *aequatorialis*. Second Mysis. Figs. 59–61, first, second and third maxillipedes. — Fig. 62, first pereiopod. — Fig. 63, fourth pereiopod. — Fig. 64, fifth pereiopod.

plumose seta on the distal corner towards the exopod. On the protopod is a smaller mastigobranchia and behind it a podobranchia and an arthrobranchia.

The t h o r a c o p o d s are of the usual type with chelae on the three first pairs. The first four pairs have a two-jointed protopod with a small mastigobranchia, a podobranchia, and an arthrobranchia. The arthrobranchia is only small on the fourth pereiopod. The fifth pereiopod has no gills at all. All thoracopods have well-developed exopodial swimmerets and a 5-jointed endopod.

The pleopods are only small and vestigial as usual in the second Mysis with short, unjointed protopods, and small exopods and endopods, the latter only with a small embryonic seta at the tip.

The uropods are well developed. They are of about the same length as the telson, or a little longer. Both the exopod and the endopod have setae along the whole margin. This rich provision with setae must be considered as a primitive character, and the setae on the lateral margins will be lost in the following stage. The setae are short and spiny on the lateral margin of the exopod and of the uropod up to the claw-like spine, at the disto-lateral corner.

Fig. 65. Map of distribution.

Dimensions:

Total length 12 mm, length of carapace 3.5 mm, width of same 3 mm, length of free rostrum 2.2 mm, length of abdomen 5.5 mm, telson 1.5 mm.

Distribution and Remarks.

Fig. 65.

This larva has been described here for the first time, and based on a single specimen from the African west coast northeast of the Ascension, a little to the North of the Congo river. From this tropical eastern part of the South Atlantic, but closer to the African continent, are records of *Solenocera membranacea* subsp. *capensis* and near Sierra Leone BATES' *Platysacus crenatus* from the Challenger Report (vol. 24, pp. 363–367, pl. 63), the latter is, as mentioned on p. 19, a third Protozoea of a *Solenocera* belonging to the same group as *S. membranacea, S.* sp. larva *barbata, S.* sp. larva *elongata* and also related to *S. muelleri,* the new larval name for ORTMANN's *Opisthocaris muelleri*. The latter species is not closely related to the here described *S.* sp. larva *aequatorialis* which is more of the type of *S.* sp. larva *sumatransis*. These groupings refer of course only to the larval forms as we do not know the adult forms, or at least not to which adult form the larvae belong. The most characteristic features of the larva seem to be the large branchiostegal alae, the presence of both a latero-posterior marginal spine and a post-cardiac spine on the carapace, as well as the less carnivorous mouthparts.

Solenocera sp. larva *danae*

Figs. 66–108.

Localities.

Protozoea III.

Dana St. 3922-II 3°45′ S–56°33′ E, 600 m.W., depth 3520–3570 m; 12.12.1929, 1 spec.

Mysis I.

Dana St. 3903-IV 5°30′ N–93°38′ E, 100 m.W., depth 1390–1470 m; 17.11.1929, 5 spec.

Mysis II.

Dana St. 3860-XX 2°57′ S–99°36′ E, 600 m.W., depth 2690–5310 m; 20.10.1929, 2 spec.
— — 3860-XXI 2°57′ S–99°36′ E, 300 m.W., depth 2690–5310 m; 20.10.1929, 1 spec.

Mysis III.

Dana St. 3903-II 5°50′ N–93°28′ E, 600 m.W., 17.11.1929, 1 spec.
— — 3903-III 5°50′ N–93°28′ E, 300 m.W., 17.11.1929, 1 spec.

Description.

Protozoea III.

Figs. 66–76.

Carapace.

The carapace is squarish and covers the whole thorax as viewed from above. After diagram 1 the following organs, spines and teeth are present on the carapace: 2. 3. 4. 7. 11. 12. 15. 18. 19. 24. 25. 26. 27. 30.

The rostrum is a long, smooth rod bent under the animal. On the carapace the cervical groove and the cervico-branchial groove are present, but they are not very distinct. Both anterior and posterior dorsal organs are present. The anterior organ is not high compared with most species, but very broad and rounded. The posterior dorsal organ is diminutive and placed just in front of the paired medio-posterior marginal spines, these are relatively short and edged by a brim with six to seven teeth.

The supra-orbital spine on each side of the rostrum is well-developed and reminds in shape of the tusk of an elephant. This stage has no antennal spine, but behind the place for it, almost in line with the anterior dorsal organ, is a pair of post-antennal spines. Behind the post-antennal spines is a pair of latero-hepatic spines, and farther medially is a pair of pre-hepatic spines. Finally posteriorly on the carapace a pair of conical, large posterior branchial spines points backwards from the carapace. These last spines have brims of teeth on their ventro-lateral margin and medio-dorsal side. Further, marginal teeth are found on the carapace in three groups: supra-antennal, branchiostegal and branchio-lateral teeth.

Abdomen.

Formula, segments I–VI: 1. 2.

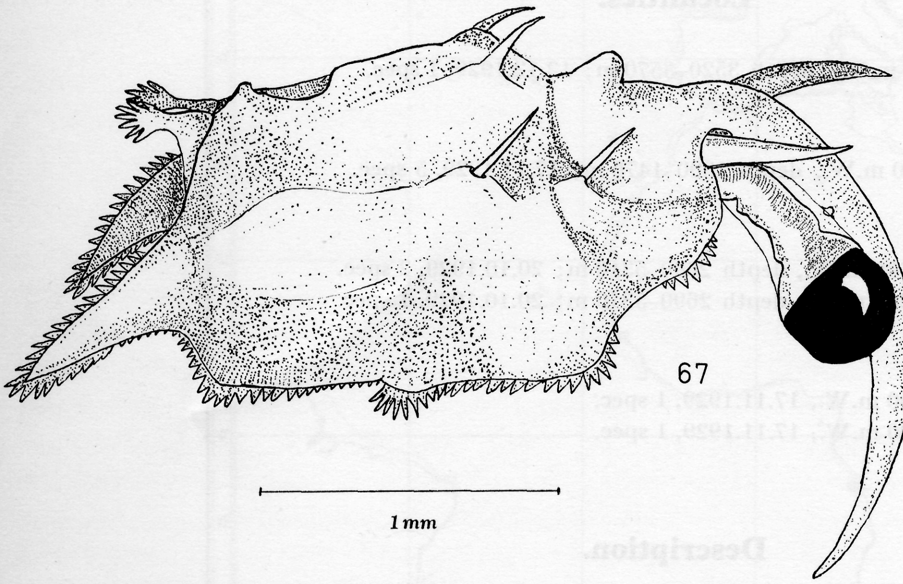
The abdomen has developed its full number of six segments, each provided with a dorsal spine and a pair of lateral spines, all long, slender and posteriorly curved.

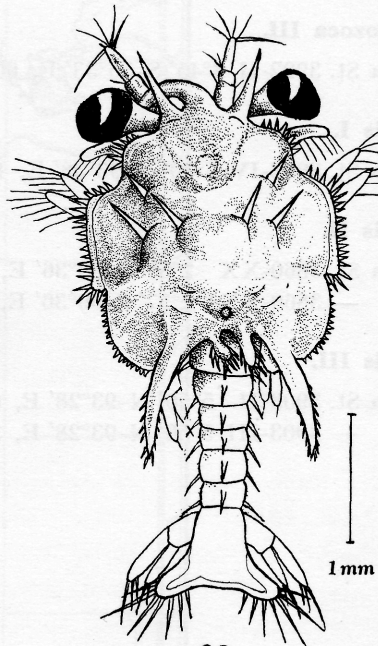
Telson.

The telson has a squarish central plate which posteriorly continues as two lateral wings or branches forming nearly right angles with the central plate of the telson. No teeth or spines are found on the telson, but each telson branch is furnished with seven setae each with a few hairs like embryonic plumose setae.

Appendages.

The first antenna is four-jointed with the joints decreasing in width distally. The first joint is naked, the second joint is furnished with a single long and stiff seta at the distol-medial corner. Similar stiff setae are also placed along the medial line of the two following joints, and the last joint is tipped with several longer and shorter setae. At the disto-lateral corner of the third joint a group of setae are about appearing. The





Figs. 66–67. *Solenocera* sp. larva *danae*. Third Protozoea. Fig. 66, larva from dorsal. — Fig. 67, carapace, from lateral.

eye-stalk is fairly long and allows relatively large movements of the eye-ball. Dorsally on the distal part of the eye-stalk the ocular papillae (Fig. 67) can be seen.

The second antenna, the main locomotory organ in this stage, has an unjointed protopod without setae, a four-jointed endopod, and a one-jointed exopod, the two latter are true swimmerets. Each of the three proximal joints of the endopod has two setae at the medio-distal corner. The fourth and most distal joint is tipped with five long setae. The exopod consists of about ten rather narrow rings of which the more distal ones have a strong seta, one on each ring at its medio-distal border.

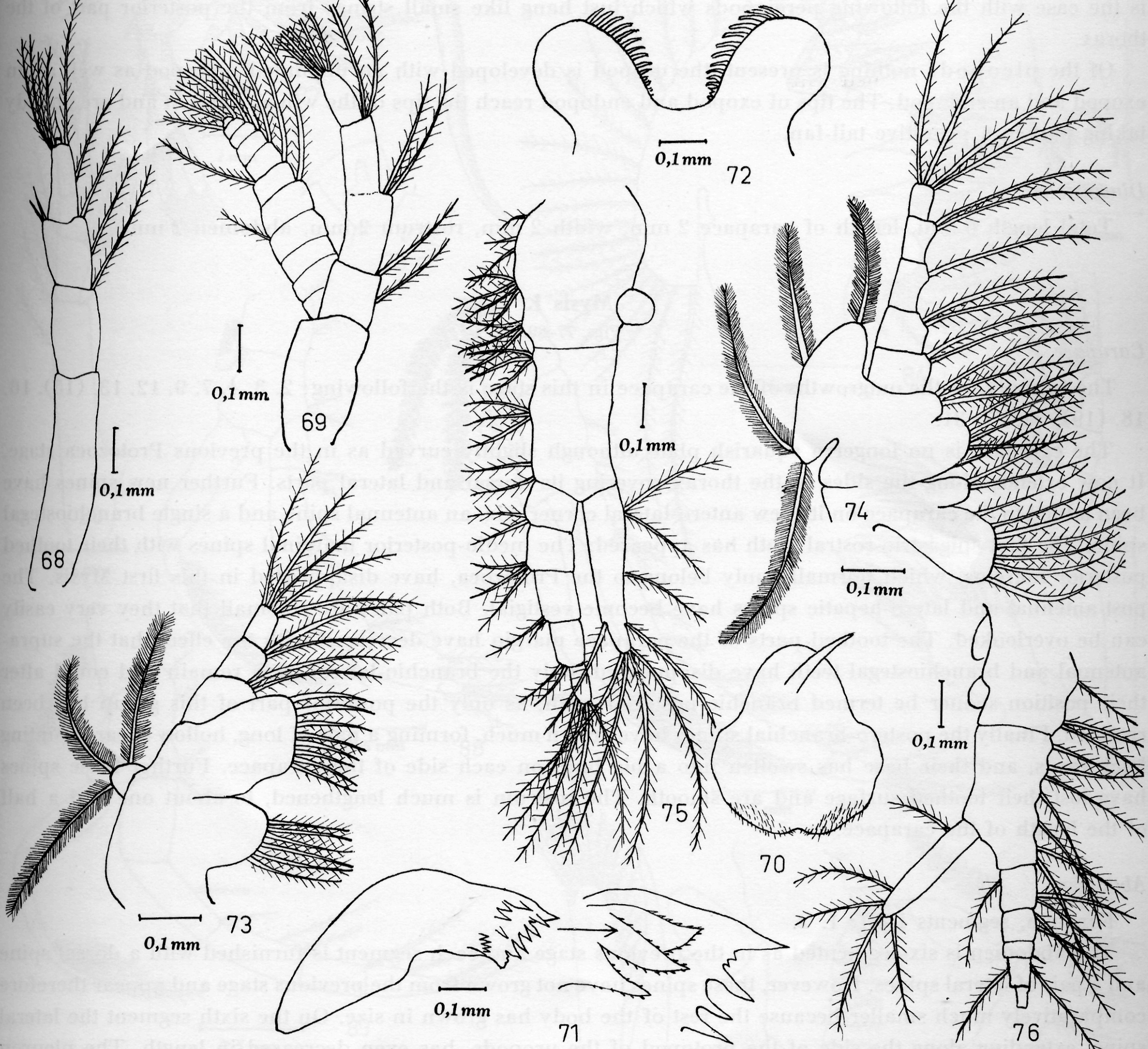
The labrum or upper lip is heart-shaped with the apex pointing forward; the part of it closest to the mouth is spoon-shaped and furnished with stiff hairs on its posterior free border. Near its apex is a ventral horn.

The mandible is slender without a palp and with, in the main only the teeth of the incisor part developed. These teeth are placed in two to three rows across the mandible, and each tooth is furnished with smaller spines or teeth to the effect that it can function as a small saw (Fig. 71).

The labium or lower lip is deeply cleft, with a short or hardly any stalk and with strong combing setae on the inner, medially turned margins of the two lobes.

The first maxilla consists of the usual two endites with barb-like, plumose setae. The endopod is three-jointed, each of the two first joints has two setae, and the third joint is tipped with five setae. The endopod is in this stage a small vestigial bulb with only three strong, plumose setae. The usual number of setae on such an exopod is four.

The s e c o n d m a x i l l a is furnished with four endites: two coxa-endites and two basi-endites; further with a long, slender five-jointed endopod with the following numbers of setae: 2–2–1–2–4. Possibly the only



Figs. 68–76. *Solenocera* sp. larva *danae*. Third Protozoea. Fig. 68, first antenna. — Fig. 69, second antenna. — Fig. 70, labrum. — Fig. 71, mandible. — Fig. 72, labium. — Fig. 73, first maxilla. — Fig. 74, second maxilla. — Figs. 75–76, first and second maxillipedes.

single seta on the third joint is caused by an accidental loss of the other. The exopod is still bulbous and provided with the normal four stout, plumose setae, but it has become more elongate both in the proximal and the distal direction.

The f i r s t m a x i l l i p e d e is the largest in this stage. The protopod *is two-jointed consisting of coxa and* basis. On coxa a beginning gill-exite or mastigobranchia shows as a bud. The exopod is un-jointed, rather weak and has a few swimming setae at the lateral margin and on the tip. The endopod consists of five joints and is the largest. Along the medial margins of the protopod and the endopod is a row of trapping setae.

The second maxillipede is shorter than the first. The protopod is two-jointed and more distinctly jointed than the first maxillipede, on coxa are placed two exite buds for beginning gills (mastigobranchia and podobranchia). The endopod is five-jointed, but short and much compressed which shows that it was not properly developed and jointed in the previous stage. The exopod is short, unjointed and has a few setae.

The third maxillipede is only in a rudimentary, bifurcate stage without any function, and the same is the case with the following pereiopods which just hang like small strings from the posterior part of the thorax.

Of the pleopods nothing is present, the uropod is developed with an unjointed protopod as well as an exopod and an endopod. The tips of exopod and endopod reach the tips of the wings of telson and are already taking part in a primitive tail-fan.

Dimensions:

Total length 6 mm, length of carapace 2 mm, width 2 mm, rostrum 2 mm, abdomen 2 mm.

Mysis I.

Figs. 77–89.

Carapace.

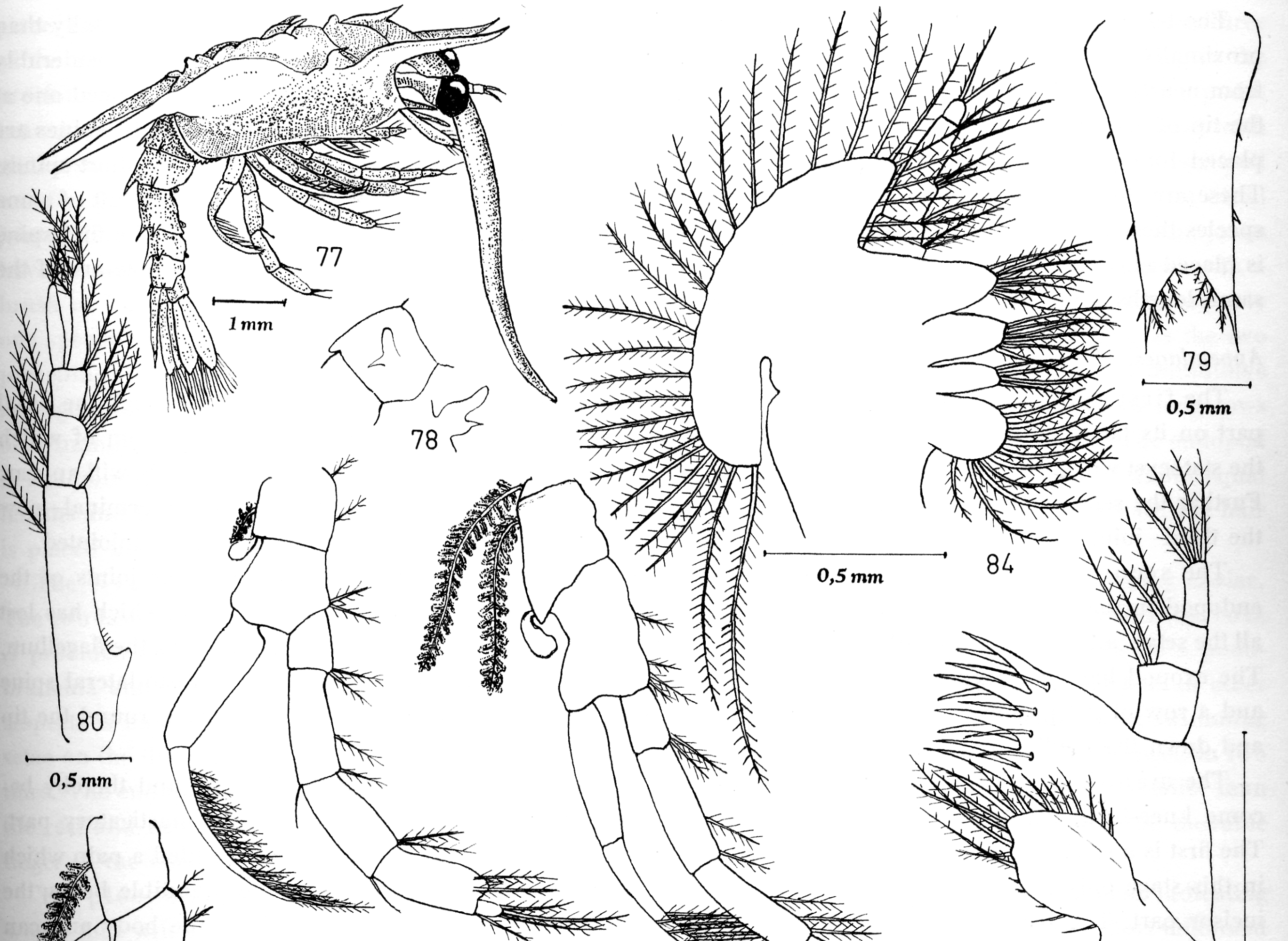
The formula for the outgrowths of the carapace in this stage is the following: 2. 3. 4. 7. 9. 12. 13. (15). 16. 18. (19). 24. 27. 31.

The carapace is no longer a squarish plate although slightly curved as in the previous Protozoea stage. It now extends along the sides of the thorax covering its dorsal and lateral parts. Further new spines have been added to the carapace on its new antero-lateral corner, viz. an antennal spine and a single branchiostegal spine. The first epigastrio-rostral tooth has appeared. The medio-posterior marginal spines with their toothed posterior margins, which normally only belong to the Protozoea, have disappeared in this first Mysis. The post-antennal and latero-hepatic spines have become vestigial. Both pairs are so small that they very easily can be overlooked. The toothed parts of the carapace margin have decreased with the effect that the supra-antennal and branchiostegal teeth have disappeared, only the branchio-lateral teeth remain and could after their position sooner be termed branchio-posterior teeth, as only the posterior part of this group has been retained. Finally the postero-branchial spines have grown much, forming a pair of long, hollow spears pointing backwards, and their base has swollen into a big bulb on each side of the carapace. Further these spines have lost their toothed surface and are smooth. The rostrum is much lengthened, to about one and a half of the length of the carapace.

Abdomen.

Formula, segments I–VI: 1. 2.

The abdomen is six-segmented as in the previous stage and each segment is furnished with a dorsal spine and a pair of lateral spines. However, these spines have not grown from the previous stage and appear therefore comparatively much smaller because the rest of the body has grown in size. On the sixth segment the lateral spine, extending along the side of the protopod of the uropods, has even decreased in length. The pleuron on each side of each abdominal segment has started to develop as a free lobe. This was not visible on the Protozoea III, neither was the lateral process on the first abdominal segment present. The further development of this small process is already described in general on p. 15. However, it can be pointed out that in this species the process in its early stage is fused with the lateral spine of the same segment (Fig. 78) so that the process is placed dorso-anteriorly to the spine. In this early stage of the development the process seems to keep the carapace in place in a way similar to that of ladies' hatpins in the beginning of this century, in so far as the process fits in between two of the branchio-lateral teeth at the margin of the carapace and through this grip keeps the carapace from sliding backwards over the abdomen or to one of the sides which could have a disastrous result for the gills, which just have started to develop along the sides of the thorax and on the exterior side of the pereiopods where they only are protected by the covering sides of the carapace.



Figs. 77–89. *Solenocera* sp. larva *danae*. First Mysis. Fig. 77, in total, from lateral. — Fig. 78, first abdominal segment, above from lateral, below from ventral. — Fig. 79, telson. — Fig. 80, first antenna. — Fig. 81, second antenna. — Fig. 82, mandible. — Fig. 83, first maxilla. — Fig. 84, second maxilla. — Figs. 85–87, first, second and third maxillipedes. — Fig. 88, first pereiopod. — Fig. 89, fourth pereiopod.

Telson.

The telson has changed considerably towards its final shape. In the Protozoea it was wider distally than proximally due to the distal split being so open that it was forming a T. This split has now closed considerably from nearly 180° to only about 50°, thus widening the base of the telson. The setae which are placed one at the tip of each wing forming the telson cleft have changed into spines, and in the cleft inside the spines are placed four plumose setae on each side. On both lateral margins of the telson plate are three short spines. These are the characteristic spines for the Penaeid telson, which now have appeared. On the adult of some species these spines, however, move from the margin onto the dorsal side of the telson plate. The first spine is placed close to the larger distal spine on the telson. The two intervals between the three spines are of the same lengths, thus dividing the telson into three equally long sectors.

Appendages.

The first antenna. The first and the second joints have coalesced into a single joint of which the basal part on its lateral side has developed the—for most decapods characteristic— arch at the bottom of which the statocyst will be formed. Already a few short hairs indicate where the opening to the concavity will appear. Further the setae on the lateral sides of the antenna have increased in number and from the terminal—now the third—joint the two flagella have started to develop. In this stage they are only short and unjointed.

The second antenna has also changed. The protopod remains unjointed, but the four joints of the endopod in the Protozoea have in the first Mysis coalesced into a single baton-shaped joint which has lost all the setae, and which in the following stage develops into the basal joint and growing centre for the flagellum. The exopod has also been reduced to a single, flattened joint, the antennal scale, with a disto-lateral spine and a row of stif plumose setae reaching from this spine along the rest of the lateral margin, round the tip and down the medial margin.

The mandible has now developed a distinct molar part, not present in the last stage, and thereby become knee-bent, divided into two major parts: the corpus mandibulae proper and the masticatory part. The first is a sausage-shaped body to which all the muscles fasten and to which has been added a palp which in this stage only is a small bulbous one-jointed sausage placed latero-dorsally on the mandible below the incisor part. The second part of the mandible—the masticatory part—forms an angle to the body and can be divided into two sub-parts, the insisor part which also was present in the previous stage and the new developed molar part, which is relatively large in this species. These four parts of the mandible are shown in fig. 82.

The first maxilla has only changed a little. The exopod which had lost one of its setae in the third Protozoea, has now disappeared completely. The endopod remains unchanged with its three joints, only the number of distal setae on the third joint is reduced from five to four. The two endites of the protopod have become more massive both in shape and thickness of the chitin. What in the previous stage only were setae on the baso-endite have now grown into direct claws or teeth-like excrescences from the endite without any joint or link. Further another row of hair-like setae has developed inside of them on the lateral side of the endite. The coxa-endite has grown and acquired a rhomboid shape, but the setae are the same, only their numbers have increased. Finally a clear marginal line on the protopod is dividing it into a distinct coxa and basis.

The second maxilla has also approached the shape of the adult. The sizes of the endites and their numbers of setae have increased. The endopod has undergone a smaller reduction. It consists of two smaller joints at the base and a small terminal joint, but the joints in the middle have coalesced into one. The number of setae on the small terminal joint is reduced from four to two. The exopod has grown into a long semilunate leaf with a row of plumose setae along its convex margin.

The three maxillipedes have developed further. The first pair is now the smallest and the third, which in the previous stage only was rudimentary, has become about twice as long as the first and second pairs. The first maxillipede has a protopod consisting of two joints of about equal lengths, although the coxa is more stoutly built and provided with a mastigobranchia. The exopod has diminished its number of joints from five to four. Because of the loss of the intermediate setae it is not clear how the reduction has taken place, but it looks as if joints three and four in Protozoea III have coalesced into a single joint, number three of the endopod in Mysis I. The second maxillipede is only a little larger than the first, and like in the previous stage the protopod is divided into coxa and basis. Coxa bears both a mastigobranchia and a podobranchia, both were present as small buds in the Protozoea III. The exopod is two-jointed, but short with all the swimming setae placed on the second joint. The endopod is two-jointed. In Protozoea III the endopod was five-jointed, but with only indistinct sutures between some of the joints, especially the three most distal joints. Here in Mysis I these three joints have coalesced into one joint, and also the first and the second joints have coalesced resulting in a total of only two joints in the endopod. The distal joint is now tipped with a brush of five setae, whereas no setae were observed in the third Protozoea, this may be accidental, as only one specimen of this stage was available. The third maxillipede is slender and twice as long as the two preceding ones. The protopod is now divided into coxa and basis. The coxa is furnished with a very diminutive mastigobranchia and two podobranchia. The exopod is long, slender and two-jointed with two long rows of swimming setae on the distal joint. The exopod reaches to the tip of the third endopodial joint. The endopod is five-jointed, joints number one and five are the shortest, the intermediate three joints are of about equal lengths and twice as long as number one or five. The fifth joint is tipped with three setae and a hair, the hair is placed most laterally.

The five pereiopods are now fully functional limbs of which the three first are developing chelae. The two last pereiopods are never chelate. The pereiopods have all a two-jointed protopod of which the coxa is provided with both a mastigobranchia and a podobranchia; only the fifth pereiopod lacks both podobranchia and mastigobranchia, although its protopod is divided into both coxa and basis and also in other respects is built like that of number four. The exopod is in all pereiopods two-jointed with strong swimming setae on the distal half or for most of the length of the second exopodial joint. The setae are arranged in two lines. The endopod is in all pereiopods five-jointed, and in the three first pairs the distal joint is smaller than the rest and has a narrow base to the preceding joint, as preparation for its development into the movable finger of the chela.

The pleopods have started to develop, but only as very tiny buds on the abdominal segments indicating where they will appear. The uropods have developed into a proper part of the tail-fan, with a short unjointed protopod and an exopod with long plumose setae at its tip and along its medial margin towards the endopod. The endopod has also a brim of setae around the whole of its margin, but these setae are shorter than those on the exopod.

Dimensions:

Total length including rostrum and telson 12.5 mm. Length of carapace 3 mm. Width of same 3 mm. Length of postero-branchial spines 2–2.5 mm. Rostrum 6 mm. Abdomen 3 mm.

Mysis II.

Figs. 90–103.

Carapace.

The formula for the carapace in this stage is: 2. 3. 4. 7. 9. 12. 13. (15). 16. 18. (19). 24. (27). (31).

The carapace changed a little more from the first Mysis. Most characteristic are the enormous postero-branchial spines which posteriorly reach beyond the basis of the telson plate and at their basis form two elongate bulbs on the carapace, one on each side. The third large "spine", the rostrum has also enlarged, its free part is now a little more than one and a half the length of the carapace without rostrum. Both anterior and posterior dorsal organs are small, but distinct. The anterior organ is placed just behind the epigastric-rostral tooth. The antennal spine and the single branchiostegal spine have become larger. The pair of latero-hepatic spines which in the previous stages were vestigial remain very small and are difficult to distinguish and so are also the post-antennal spines. The prehepatic spines are the only remaining pairs of spines of reasonable size in the inner area of the carapace. Of the branchio-lateral teeth only a few small ones remain on the posterior margin of the carapace behind the postero-branchial spine.

Abdomen.

Formula, segments I–VI: 1. 2.

The abdomen is nearly unchanged except that it has grown in size in the same proportion as the rest of the animal. The lateral process on the first abdominal segment has enlarged a little and is now separated at the base from the lateral spine of the segment. The lateral spines of the last segment are very small.

Telson.

The telson has grown more narrow and elongate, and the three spines on the lateral margin have moved towards the tip of the plate. The most distal spine is placed near the tip as in the previous stage, but the following spine has moved up close behind it, and the third spine is now placed at a distance from the tip of the telson of about one fourth of the whole length of the telson. At the bottom of the cleft of the telson a flattened arch was found in the first Mysis. This arch has in this stage developed to a full median lobe inside the original cleft, so that the normal telson cleft is now divided into two equally sized clefts one on each side of the median lobe. The four setae placed on each of the inner sides of the single cleft in the first Mysis are placed on the inner lateral side of each of the clefts caused by the new development of the lobe in the middle.

Appendages.

The first antenna has as in the previous stage a three-jointed protopod, but several more setae have been added to its margins, on the medial and lateral margins is a continuous line of setae from the basis to the tip of the protopod. The setae are placed in three groups: a line of short hairs at the border of the statocyst groove, a semilunate line on the medio-distal corner of the same joint, and another semilunate line on the same corner of the second joint. Finally the two terminal flagella have become much longer and have already started to become annulated.

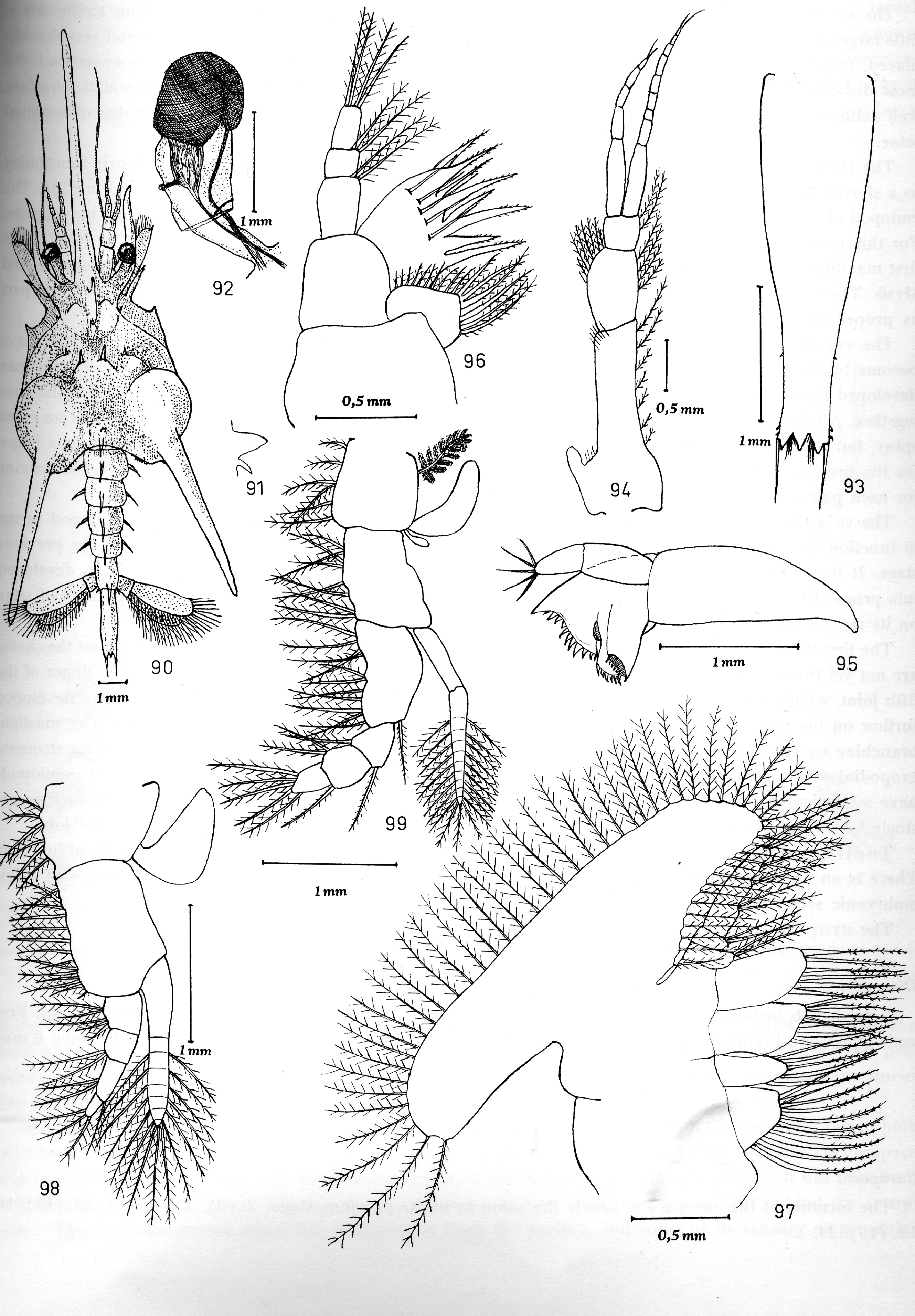
The eye (Fig. 92) has the ocelli placed in two groups, a larger dorso-medial part and a smaller ventro-lateral part, divided by a deep cleft, but fused at the bottom of the cleft. The eyestalk is also divided into two sections. Nearest to the ocelli it forms a tubular collar, which at its base is cut angularly to its length, more proximally is the narrower inner eyestalk. Inside the collar part is a group of nerve-cells with nerves coming from the eye, and posteriorly of this plexus are the neurites continuing to the brain. From this plexus nerve-threads lead to the brain, and from the plexus other nerve-threads spread to the "ocular papillae". Farther from the basis of the smaller group of ocelli a group of thin muscle fibres stretches through the eyestalk to a sclerit at the basis of the eyestalk, and shortly before this muscle passes the collar section of the eyestalk, it penetrates a sclerit hinge from the cuticle of the eyestalk. The function of this muscle seems to be to bend the eyestalk and thus to turn the group of ocelli towards a certain point.

In the second antenna no stronger changes have taken place, only the endopod consists of a basal joint, and the flagellum has started to develop and reaches in this stage four fifth of the length of the rostrum.

The mandible has grown still stronger, both its corpus mandibulae as well as its incisor and molar parts which now are more differentiated. Finally the palp is two-jointed and tipped with four to five short setae.

The first maxilla shows a stronger division between coxa and basis, and coxa has a much wider basis than in the previous stage. The coxa-endite has relatively decreased in length, although the rhomboid shape is retained. Its setae are stronger than in the previous stage, especially the posteriorly placed ones. Together with the basi-endite it forms a very strong tearing brush. The endopod is nearly unchanged.

Figs. 90–99. *Solenocera* sp. larva *danae*. Second Mysis. Fig. 90, in total from dorsal. — Fig. 91, lateral process on first abdominal segment and lateral spine. — Fig. 92, eye. — Fig. 93, telson. — Fig. 94, first antenna from dorsal. — Fig. 95, mandible. — Fig. 96, first maxilla. — Fig. 97, second maxilla. — Figs. 98–99, first and second maxillipedes.


92
1 mm
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1 mm
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98
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97
0,5 mm

The second maxilla. No important changes have taken place since last stage. The four endites are a little larger and are now clearly cut off from their protopodial base, and their setae are stout and very densely placed, they have lost the plumose hairs on their proximal half. The endopod is a little more reduced, the most distal joint is absorbed into the more proximal ones, only the first and second endopodial joints are well defined from one another. The exopod has enlarged and is more flat with a larger number of marginal setae.

The first maxillipede is interesting as especially the protopod has enlarged and is clearly functioning as a shovel carrying the food to the tearing by the first maxilla and the brushing by the second maxilla. The endopod of the second maxillipede functions as a movable lid or finger for the shovel of the first maxillipede. For this reason the number of setae have increased on the protopod and the first endopodial joint of the first maxillipede, and the setae have become more stiff. The rest of the endopod is unchanged from the first Mysis. The exopod has become stronger and has longer plumose setae, and it is now jointed in its distal part as proper swimmerets. The mastigobranchiae are only single-lobed.

The second maxillipede is a little larger than the first one. On the coxa the mastigobranchiae have become bilobed, but the second lobe is still very small. The endopod, in the previous stage two-jointed, has developed four strong and massive joints of which the first one is nearly as long as the three following ones together. All four joints have numerous strong setae on their medial margins, and each joint has an extra spiny, but still plumose, seta on its disto-lateral corner. As already mentioned, this endopod acts as a finger for the protopod of the first maxillipede. The exopod is two-jointed, the distal joint with movable sections for each pair of setae.

The third maxillipede is the longest of all the limbs, to judge from its structure the endopod seems to function as cleaning brush for the mouth appendages. The leg has not changed much from the previous stage. It is a little larger, the mastigobranchia is still single-lobed and the podobranchiae have developed into proper functioning gills. The exopod is stronger, and the endopod has acquired a larger number of setae on its medial margin.

The first three pairs of pereiopods have developed proper chelae at the tip of the endopod, but the chelae are not yet functioning, and the stiff finger on the fourth joint is nearly as long as the movable finger of the fifth joint, which still is tipped with three setae. Further the endopod is hairy, and the gills have developed further on the protopod like in the maxillipedes. The exopod is a long, slender swimmeret. The mastigobranchiae are all only single-lobed. The fourth pereiopod is the longest of the pereiopods and has the strongest exopodial swimmerets. The fifth pereiopod is a little smaller than the fourth. The first to fourth pereiopods have a mastigobranchia and a podobranchia. The fifth pereiopod has no gills. All the mastigobranchiae are single-lobed, only in the second maxilla the mastigobranchiae have started to develop a second lobe.

The five pairs of pleopods have developed into small, bifurcate rudimentary limbs still without function. There is an unjointed protopod and an unjointed exopod and endopod, the last two are tipped with a few embryonic setae.

The uropods are almost fully developed and are now reaching behind the telson plate.

Dimensions:

Total length including rostrum 22 mm. Carapace length 6 mm, width about 6 mm. Rostrum 9 mm. Free ends of postero-branchial spines 6 mm, including the bulbous basis on carapace 9.5 mm. Abdomen 6 mm.

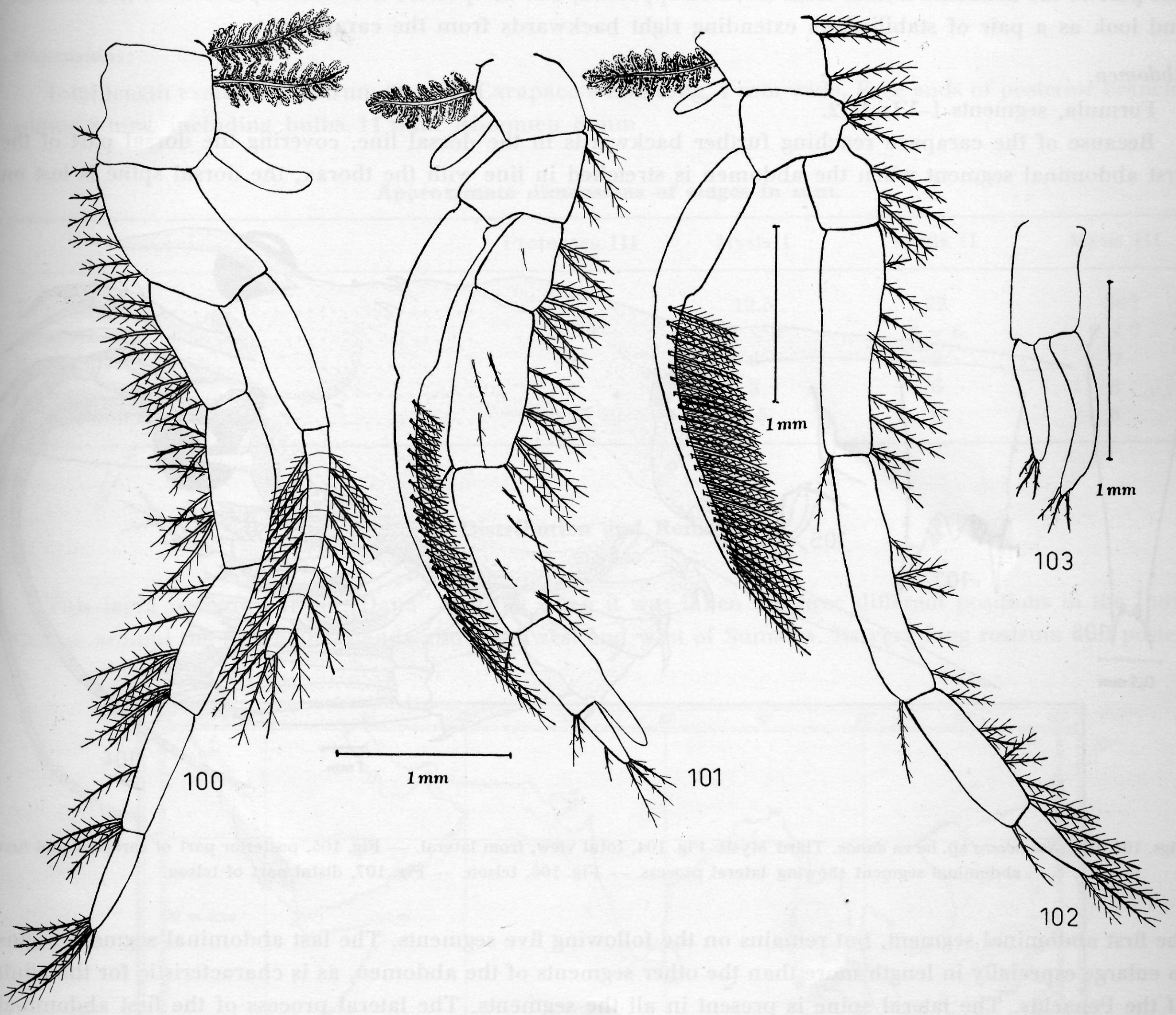
Mysis III.

Figs. 104–107.

Carapace.

The formula of the carapace is nearly the same as in the previous stage: 2. (3). 4. 7. 9. 12. 13. (15). 16. 18. (19). 24.

The whole appearance of the larva in this stage approaches that of the adult, but still too many larval characters are present to give sufficient background for judging whether or not this is the larva of any known *Solenocera* species. When disregarding all the larval characters not enough remain to provide the characters of the adult. This is partly caused by two principles in the adult taxonomy of Penaeids. First this is built on the shape of the carapace with spines, teeth and ridges, and this changes considerably from the last larva



Figs. 100–103. *Solenocera* sp. larva *danae*. Second Mysis. Fig. 100, third maxillipede. — Fig. 101, first pereiopod. — Fig. 102, fourth pereiopod. — Fig. 103, first pleopod.

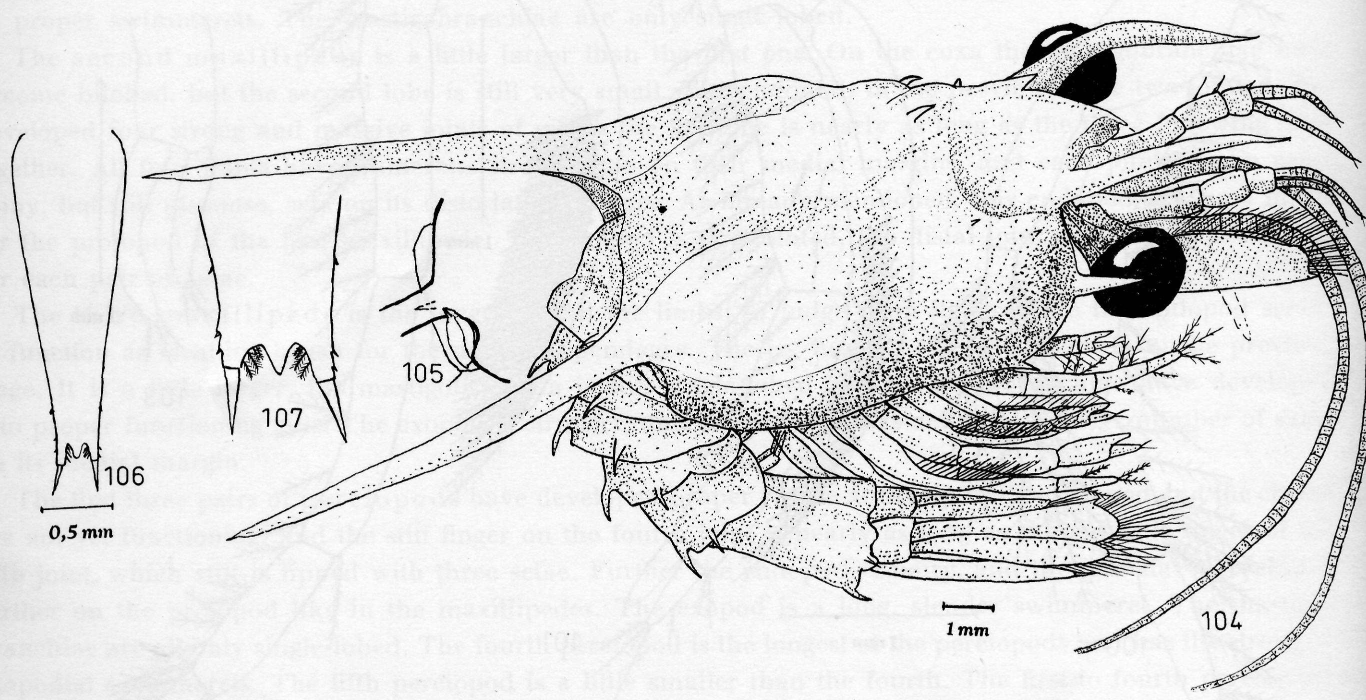
to the first post-larva, and secondly, especially in modern time, it has become a bad habit in Crustacean taxonomy to use the Petasma and Thelysium, or often only one of them as a primary character. This procedure often excludes more than half the specimens of a sample due to the number of immature specimens and of those of the opposite sex, in smaller samples all may be excluded.

The rostrum is probably very long, at least it has a very wide and solid base on the carapace, but in both specimens available to me it was broken off at its base on the carapace or close to it (Fig. 104). On the carapace is in this stage also found only one single dorsal tooth on the rostral ridge, after its position it has here been termed epigastric-rostral tooth. The anterior dorsal organ is very small and placed just behind the rostral ridges. The posterior dorsal organ has disappeared from the surface, but some of its sensory or glandular cells can be seen as a dark spot under the cuticle. The cervical groove is not very distinct. The supra-orbital spines are still large, strongly forward curved horns, and the antennal spines have enlarged a little from the previous stage. The branchiostegal spine remains a small marginal tooth on the carapace. Both the post-antennal spines and the latero-hepatic spines are still present, but very small and so vestigial that they are difficult to discern. Only the pro-hepatic spines are clear and distinct in this region of the carapace. The last part of the branchio-lateral teeth have disappeared, but the postero-branchial spines have grown larger and look as a pair of stabilisators extending right backwards from the carapace.

Abdomen.

Formula, segments I–VI: 1. 2.

Because of the carapace reaching further backwards in the dorsal line, covering the dorsal part of the first abdominal segment when the abdomen is stretched in line with the thorax, the dorsal spine is lost on



Figs. 104–107. *Solenocera* sp. larva *danae*. Third Mysis. Fig. 104, total view, from lateral. — Fig. 105, posterior part of carapace and first abdominal segment showing lateral process. — Fig. 106, telson. — Fig. 107, distal part of telson.

the first abdominal segment, but remains on the following five segments. The last abdominal segment begins to enlarge especially in length more than the other segments of the abdomen, as is characteristic for the adult of the Penaeids. The lateral spine is present in all the segments. The lateral process of the first abdominal segment, has moved a little forward and is placed in front of the lateral spine with a clear interval between them (Fig. 105). Further it is now a swollen, leaf-shaped organ fastened to the segment only at its ventro-anterior part, and it fits well into the curve between the free basis of the postero-branchial spine and the latero-posterior margin of the carapace, keeping the latter in a fixed position. No musculature of the segment has yet moved into the process.

Telson.

Telson has grown perhaps a little more conical posteriorly, and the median process inside the telson furca has enlarged to become nearly larger than the side wings of the furca, finally the two large spines on each wing are now in a terminal position to the wing.

Appendages.

The appendages have all developed further. The flagella of both the first and second antennae have lengthened, the endopodial flagellum of the second antenna is now longer than the carapace, still more setae have developed on the mouth appendages so that they now function as a trap basket for detritus, small organisms or torn-off parts of prey animals. The endopods of the thoracopods are excellent for grabbing the food, although the chelae on the three first pairs not yet are in full shape; they seem to be able to start functioning for more tiny objects, but their musculature is not yet much developed. The abdominal appendages are still rudimentary, unfunctioning organs a little larger than in the previous stage but with the same shape. The uropods are large and form the main part of the telson fan.

Dimensions:

Total length excluding rostrum 20 mm. Carapace 9 mm long, 7 mm wide. Free ends of posterior branchial spines 8 mm, including bulbs 11 mm. Abdomen 8 mm.

Approximate dimensions of stages in mm.

	Protozoea III	Mysis I	Mysis II	Mysis III
Total length	6	12.5	22	30?
Carapace	2 × 2	3 × 3	6 × 6	9 × 7
Rostrum	2	6	9	?
Abdomen	2	3	6	8
Postero-branchial spines	0,75	2,5	6	8

Distribution and Remarks.

Fig. 108.

This larva is known from "Dana" in 1929 when it was taken on three different positions in the Indian Ocean, around the Seychelle Islands and northwest and west of Sumatra. Its very long rostrum and postero-

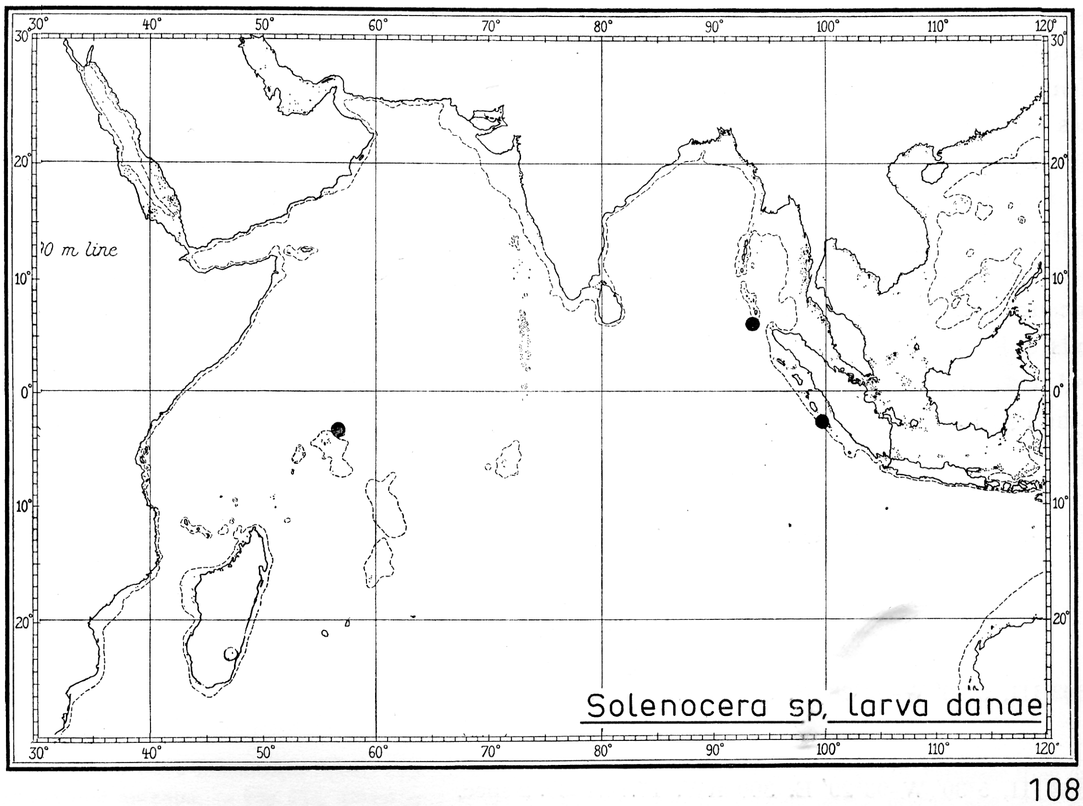


Fig. 108. Map of distribution.

branchial spines make it likely that the species is a strictly tropical species of *Solenocera*. It may be restricted to the Indian Ocean or it may be distributed from around the Indonesian Islands and New Guinea into the Pacific Ocean. It is not likely to round the Cape into the Atlantic. But at the present time no records are known except the three from the Indian Ocean. It has been taken at depths between 25 and 250 m, but very likely it may reach further down. It is worth to note that all the localities are not from the open ocean but relatively near an island-coast, which indicates that the adult *Solenocera* as expected spawn in shallower water, 500–600 m or less. Although the depth at the stations where the larvae were taken range from 1400–1500 m they are not far from an island shelf. Further the youngest larva, a Protozoea III, which means larval stage no. 6, was taken only rather few miles north of the shelf around the Seychelle Islands. Here the current during the middle and last half of the year runs in a northern direction (date of capture 12.12.1929). This can easily result in the transport from the shelf to the position of capture,—smaller local currents between the islands may play their part.

The species is a true tropical, oceanic *Solenocera* furnished with the big spines so often found in true oceanic forms, especially in the Tropics. The only known fully developed *Solenocera* is *Solenocera membranacea* studied by HELDT (1938, 1955) from first Protozoea to Postlarva, the Nauplius stages are not found. She concludes that only two Mysis stages exist. This is the case for this species, at least at the coast of Tunis. Here can briefly be reminded of the papers of PROVENZANO (1962) on variable numbers of instars in the same species of decapod larvae and of RASMUSSEN (1953) on the change of sex from male to female in *Pandalus borealis* at Spitzbergen at an age of five years, whereas in Skagerrak it changes already in the second year. This does not include that there is the same number of ecdyces in the two years period in Skagerrak and the five years period at Spitzbergen because time is also a factor although not the only one for the duration of a cuticle. Further we know that in the ocean two factors can retard growth: low temperature, and scarcity of food. As *Solenocera* is a tropical or subtropical genus only the scarcity of food can be involved, and in the tropical ocean food is far more scarce in the open ocean, than along the continental coasts and in subtropical waters where *Solenocera membranacea* is found. It is therefore understandable that in the two cases from the present material with a true oceanic tropical species of *Solenocera*, where enough material is available, viz.: *S.* sp. larva *danae* and *S.* sp. larva *sumatransis*, we find at least three or four Mysis stages. The same is the case for the other genera dealt with in this paper *Cerataspis* and *Cerataspides* of which all three species have at least five Mysis stages each.

For *Solenocera* sp. larva *danae* the following points may indicate the likeliness of more, still unknown, Mysis stages to follow the here described third Mysis stage before the first postlarval stage is reached: the rostrum although partly broken off is in the third Mysis still as in the young larva bent downwards and not stiff and more straight, forward pointing as in an adult *Solenocera*. The rostrum has only one dorsal tooth and no carina. The very long posteriorly directed postero-branchial groove spines are still present and without any indication of decrease in size. These spines can not be expected to remain in the first postlarva, but their loss may occur in a single moult. The pereiopods as well as the pleopods have a decidedly larval shape. The uropods only reach slightly beyond the telson plate and the shape of the tip of the telson plate is still furcate, and a strong spine is still present at the tip of each furcal branch. These characters are all larval indicating the likelihood of more Mysis stages to follow this third Mysis stage, before the first postlarval stage is reached.

Solenocera sp. larva *sumatransis*

Figs. 109–153.

Localities.

Mysis I:

Dana St. 3903 III, 5°30′ W–93°28′ E. 300 mW., 17.11.1929. 1 spec.

Mysis II:

Dana St. 3903 III, 5°30′ W–93°29′ E. 300 mW. 17.11.1929. 2 spec.

Mysis III:

Dana St. 3903 III, 5°30′ W–93°28′ E. 300 mW. 17.11.1929. 1 spec.
— — 3903 V, 5°30′ W–93°28′ E. 50 mW. 17.11.1929. 1 spec.

Mysis IV:

Dana St. 3903 III, 5°30′ W–93°28′ E. 300 mW. 17.11.1929. 1 spec.

Description.

Mysis I.

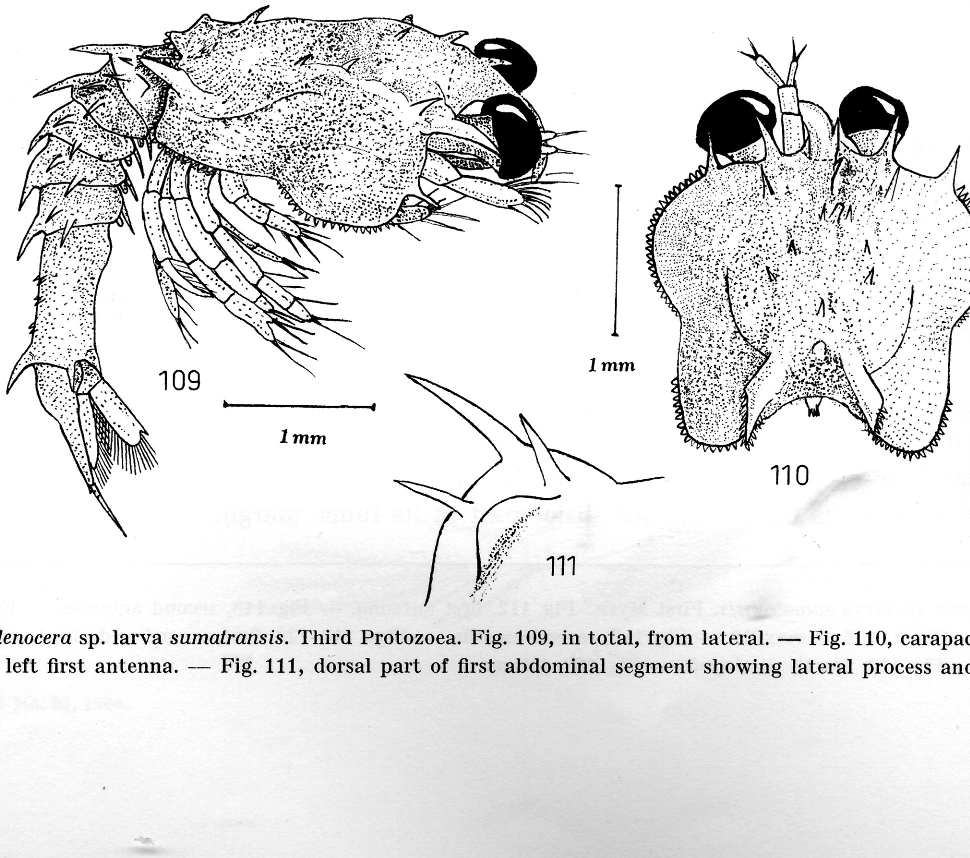
Figs. 109–123.

This is a small, clumsy larva with a short rostrum, a wide carapace with very many filamental teeth along its margin, and a short abdomen.

Carapace.

Formula: (1). 2. 3. (5). 7. 8. 9. 10. 11. 12. 13. 15. 17. 19. 20. 24. 25. 26. 27. 28. 29. 30.

The carapace is squarish, a little wider than long. The rostrum is of medium size and has at each side of its base a very small, triangular, rostral plate, shaped as a short, narrow lobe from the carapace (Fig. 109). The rostrum is provided with two dorsal teeth, the distal is placed on the rostral plate, the other on the ridge of the posterior prolongation of the rostrum on the carapace. This latter tooth is here named the epigastric-rostral tooth. Between these two teeth is a row of stiff hairs. A little further back in the median line of the carapace follows the small, conical anterior dorsal organ. Near the posterior end of the carapace is the still smaller posterior dorsal organ. Between these organs, in the median line, is the dorsal or epi-cardiac spine. The distance between this spine and the posterior dorsal organ is less than one third of the interval between the two dorsal organs. On the posterior dorsal organ is a single medio-posterior marginal spine which, however, is not an actual spine, but only a small, conical process with a brim of four teeth at its tip. The rest of the spines are paired and are the following: at the side of rostrum is the supra-orbital spine which, although the largest spine on the carapace, is smaller than in most other species. Farther laterally on the margin follows the antennal spine at the base of the second antenna. Posteriorly on the carapace, still reaching beyond the margin, is the posterior branchial groove spine, which in this species is shaped like a rectangular



Figs. 109–111. *Solenocera* sp. larva *sumatransis*. Third Protozoea. Fig. 109, in total, from lateral. — Fig. 110, carapace from dorsal including eyes and left first antenna. — Fig. 111, dorsal part of first abdominal segment showing lateral process and three spines.

wing. It starts on the carapace a little from the margin as a high ridge and reaches backwards past the margin, at its distal end it is lined with filamental teeth. The ridge of this spine extends anteriorly into the branchio-cardiac groove, which is present in this stage, but very weak, hardly visible. Inside the margin of the carapace are the following spines: Between the antennal spine and the supra-orbital spine, but behind them the post-antennal spine; on each side of the anterior dorsal organ the rather small medio-gastric spine; farther back a little more laterally the latero-hepatic spine; and finally latero-posteriorly of this the supra-hepatic spine.

The filamental teeth still form a whole brim along the lateral margins of the carapace, only broken for a short interval at its middle. Anteriorly come first the supra-antennal and the branchiostegal teeth in one continuous line, then after a short interval without teeth follows the second unbroken line of teeth consisting of the branchio-lateral and the postero-marginal teeth, and in continuation of the latter are the teeth on the postero-branchial spine.

Abdomen.

Formula for segments I–V: 1. 2. 3. 5 and for segment VI: 1. 2. 4.

Of the six segments the last one is very long, about four times as long as any of the preceding segments. This is characteristic for the larvae of *sumatransis*, which is one of the species of *Solenocera* with the longest sixth abdominal segment in the larvae. Each of the first five segments is provided with a relatively short, but stout dorsal spine and a more delicate ventral spine. Laterally, close to the dorsal spine, are a pair of lateral and a pair of dorso-lateral spines, both with spines much smaller than the dorsal spine. The sixth segment has neither these last pairs nor the ventral spine, but instead a pair of ventro-lateral spines ventrally of the base of the uropods. Dorsally of the base are the lateral spines. The lateral process (Fig. 111) is placed laterally on the first abdominal segment in very close connection with the dorso-lateral spine. The cuticle-pad starts a little anteriorly of the base of this spine, almost, but not quite, touching it, and curves down to midway on the lateral side, with the lateral spine almost in line with the apex of the curve. The process itself is only a thin, membranous lobe.

Telson.

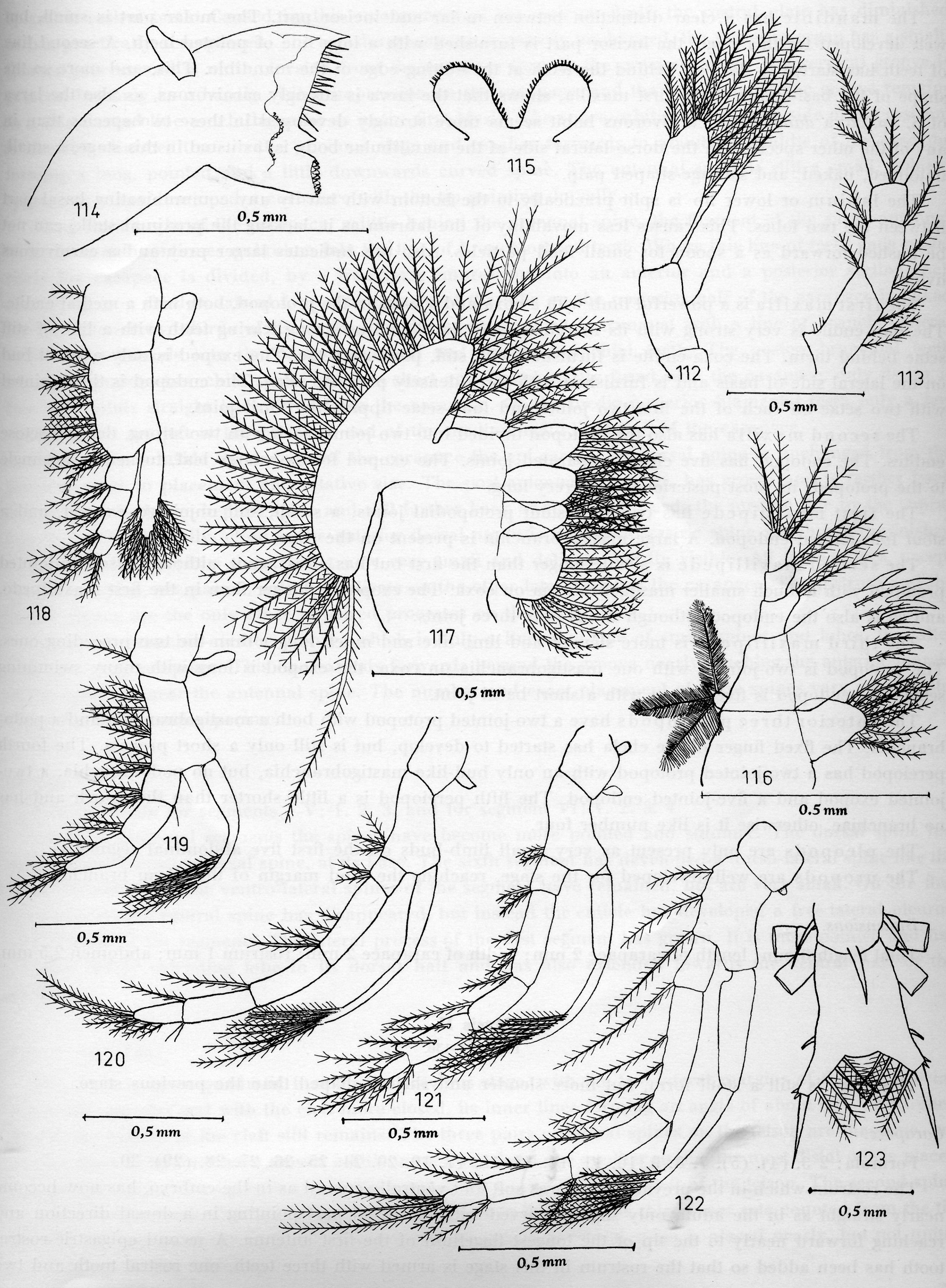
The telson-plate is short and wide, with a furca of only a little above 90° opening between its branches. The two sides of the cleft do not meet, but are seperated from one another by a short convex lobe. Along the medial margin of each furcal branch are the usual four plumose setae. Each branch is tipped with a long, straight spine, and has at its base, but on the lateral margin, two small, short spines placed close together, a little farther back on the lateral margin is the third, a little larger spine.

Appendages.

The first antenna has the, for the first Mysis stage usual, three joints in the peduncle. The two first joints are the longest; the third is tipped with the rudiments of its two flagella. The setae are already well developed, especially on the medial side. Both flagella are tipped with setae, and the lateral one has also a few short setae along its side. The basal joint of the first antenna is coalesced from the several joints in the Protozoea where the appendage was an ambulatory organ. The usual process and curve on this joint for the later statocyst, have started to develop, and a few stiff hairs are found along the margin of the later statocyst groove.

The second antenna shows also a retarded development. It has a two-jointed protopod and an un-jointed endopod, the latter has a single, plumose, terminal seta; in other species both branches are usually naked in this stage. The exopod has started to change into an antennal scale, it has flattened and bears a series of plumose setae at its tip and on the distal part of its inner margin.

Figs. 112–123. *Solenocera* sp. larva *sumatransis*. First Mysis. Fig. 112, first antenna. — Fig. 113, second antenna. — Fig. 114, mandible. — Fig. 115, labium. — Fig. 116, first maxilla. — Fig. 117, second maxilla. — Figs. 118–120, first, second and third maxillipedes. — Fig. 121, first pereiopod. — Fig. 122, fourth pereiopod. — Fig. 123, telson.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The mandible has a clear distinction between molar and incisor part. The molar part is small, but well developed for this stage, the incisor part is furnished with a long line of pointed teeth. A second line of teeth has started to develop behind the teeth at the cutting edge of the mandible. This, and more so the shape of the basi-endite of the first maxilla, shows that the larva is strongly carnivorous, as also the larva of *S.* sp. larva *danae*. The carnivorous habit seems more strongly developed in these two species than in any of the other species. On the dorso-lateral side of the mandibular body is, as usual in this stage, a small, unjointed, naked, and sausage-shaped palp.

The labium or lower lip is split practically to the bottom with hardly any communicating basal part between the two lobes. This causes less movability of the labrum as it, lacking the proximal stalk, can not be pushed forward as a spoon for small food particles. Also this indicates larger prey and a carnivorous living.

The first maxilla is a powerful limb with a coxa and a basis in the protopod, both with a medial endite. The basi-endite is very strong with its marginal setae developed as strong tearing teeth with a line of stiff setae behind them. The coxa-endite is furnished with stiff, plumose setae. The exopod is only a small bud on the lateral side of basis and is furnished with three densely plumose setae. The endopod is three-jointed with two setae on each of the first two joints and four setae tipping the third joint.

The second maxilla has also the protopod divided into two joints, each with two strong, densely setose endites. The endopod has five clearly separated joints. The exopod forms a large leaf, turned in an angle to the protopod; its most posterior seta is very long.

The first maxillipede has two very stout protopodial joints, a small, still unjointed exopod, and a stout four-jointed endopod. A large mastigobranchia is present on the coxa.

The second maxillipede is a little longer than the first but has a less stout, although also two-jointed protopod with a much smaller mastigobranchia on coxa. The exopod is longer than in the first maxillipede, and so is also the endopod although it has only three joints.

The third maxillipede is more slender and limb-like and much longer than the two preceding ones. The protopod is two-jointed with one mastigobranchia on coxa, the exopod is long with many swimming setae. The endopod is five-jointed with a short basal joint.

The anterior three pereiopods have a two-jointed protopod with both a mastigobranchia and a podobranchia. The fixed finger of the chela has started to develop, but is still only a short process. The fourth pereiopod has a two-jointed protopod with an only bud-like mastigobranchia, but no podobranchia, a two-jointed exopod and a five-jointed endopod. The fifth pereiopod is a little shorter than the fourth and has no branchiae, otherwise it is like number four.

The pleopods are only present as very small limb-buds on the first five abdominal segments.

The uropods are well-developed for the stage, reaching the hind margin of the telson branches.

Dimensions.

Total length 6 mm; length of carapace 2 mm; width of carapace 2 mm; rostrum 1 mm; abdomen 2.5 mm.

Mysis II.

Figs. 124–136.

This stage is still a stout form, but more slender and shrimp-shaped than the previous stage.

Carapace.

Formula: 2 3. (4). (5). 7. 8. 9. 10. 11. 12. 13. 15. 17. 19. 20. 24. 25. 26. 27. 28. (29). 30.

The rostrum which in the previous stage was soft and ventrally curved as in the embryo, has now become nearly straight as in the adult, only slightly curved with the distal part pointing in a dorsal direction and reaching forward nearly to the tip of the longest flagellum of the first antenna. A second epigastric-rostral tooth has been added so that the rostrum in this stage is armed with three teeth, one rostral tooth and two epigastric-rostral teeth. Caused by this enlargement of the rostrum itself, the rostral plate has diminished or has practically disappeared. The two dorsal organs are nearly unchanged, the posterior organ has a small, thinner process and is more elevated from the carapace than in the previous stage. The cervical groove is present, but only as a hardly visible impression on the carapace, and the branchio-cardiac groove remains as a thin curved line much the same as in the first Mysis. The supra-orbital spine at the side of the rostrum is like this slimmer than in the previous stage and reaches forwards to about the middle of the eyeglobe forming a long, pointed and a little downwards curved spine. The antennal spine is still a small, pointed spine, but it has developed a curvature with the tip pointing dorsally.

Along the margin of the carapace, a little behind the antennal spine, the filament of the supra-antennal teeth starts and continues unbroken into the line of branchiostegal teeth. Where this line of teeth ends posteriorly the carapace is divided, by a transverse impression, into an anterior and a posterior section each continuing as a shallow lateral lobe. The margin of the lobe on the posterior half of the carapace is naked for the anterior two-thirds of its length, but the posterior third is trimmed with a line of branchio-lateral teeth which extends into the postero-marginal and postero-branchial teeth. The postero-branchial teeth fringe the postero-branchial spine which is short and broad partly fused with the carapace, only its tip is free and points straight backwards from the carapace. Of the medio-posterior filamental teeth only a few vestigial ones are left at the posterior end of the medio-longitudinal line of the carapace.

Of the spines inside the margin of the carapace the epi-cardiac or dorsal spine is unchanged from the previous stage in placement and relative size. The post-antennal, however, has grown and is farther back followed by the latero-hepatic spine and still farther back and a little towards the median line by the supra-hepatic spine. Laterally, close to the anterior dorsal organ is the medio-gastric spine which has diminished much from the previous stage, being now very small and delicate, hardly visible. All these spines, except the dorsal spine, are paired, with a dublicate on the other lateral half of the carapace. The rostrum and the dorsal organs are the only other unpaired processes on the carapace.

Along the branchio-cardiac groove, which is only a line, is a line of small spines and lobes, the latter with two or three spines. This line extends forwards beyond the groove nearly reaching the anterior margin of the carapace near the antennal spine. The number and exact placement of these spines vary even on the two sides of the same specimen.

Abdomen.

Spine formula for segments I–V: 1. 2. 3. and for segment VI: 1. 2. 3. 4.

On the abdominal segments the spines have become more pointed and slimmer. The dorsal spine has now a small accessory basal spine, at its base. The sixth segment has developed a dorso-lateral spine like the other segments, and the ventro-lateral spines of the segment have remained, but are very small. On the first five segments the ventral spine has disappeared, but instead the cuticle has developed a free lateral pleuron on each side of the segments. The lateral process of the first segment has grown. It is more pointed and has a larger, freely extruding lobe in its dorsal half and has also extended towards the ventral part of the segment.

Telson. (Fig. 126).

The form is more quadratic than in the previous stage, with the two lateral margins of the telson being practically parallel and with the cleft more closed, its inner lines forming an angle of about 60°. The arched lobe at the bottom of the cleft still remains. The three pairs of lateral spines on the telson are the same, but the two most distal ones have moved a little more away from one another so that the most distal one is placed only a little behind the tip in line with the most distal seta in the inner cleft of the telson. The second spine is placed farther back near the bottom of the cleft and in line with the third inner seta counted from the tip towards the bottom of the cleft. The third and most proximal lateral spine is placed nearly, but not quite, half way up on the telson.

Appendages.

The first antenna has only changed little from the previous stage. The statocyst groove has become deeper, the lateral process at its base is enlarged and the numbers of setae along its three joints have increased. Also the two flagella have grown in length, but they have not yet become annulated. The missing annulation is characteristic for *Solenocera* larvae with more than two Mysis stages. In the species with only two Mysis stages these flagella are often divided into a few rings in the second Mysis.

The second antenna is much like in the first Mysis, only the antennal scale has developed further with setae on its lateral margin and a well developed hook-shaped spine at the disto-lateral corner. The endopod has lost its terminal seta and instead grown to twice its former length as an approach to the later flagellum-like form, but it is still unjointed.

The upper lip is a globular cup which together with the lobes of the lower lip forms a basket around the mouth-opening. The lips are, as in most larval forms, very large with movable parts, well fitted for carrying the food into the mouth-opening after it has been ground into pieces by the mandibles and the first maxillae.

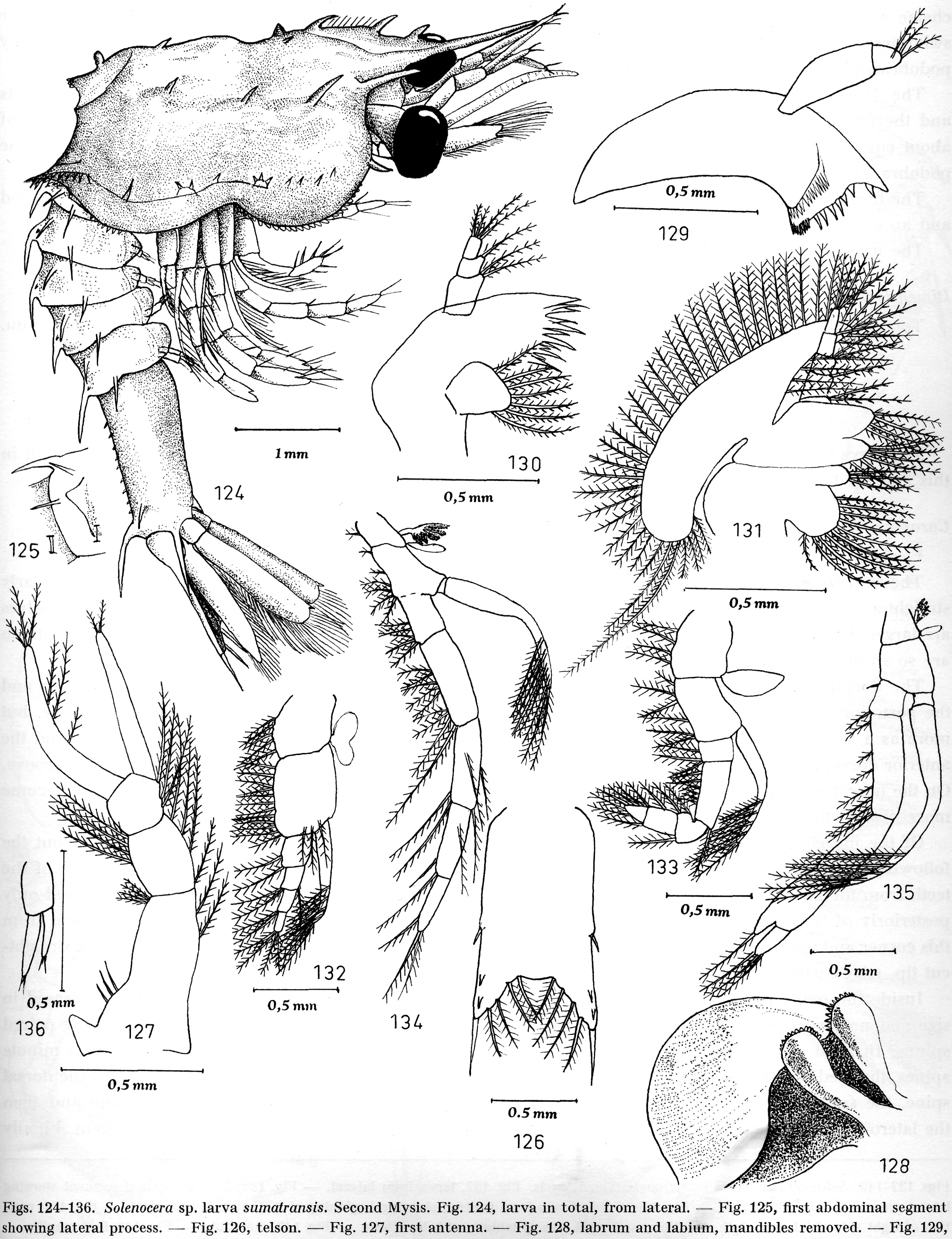
The mandible has developed a second distinct line of incisor teeth behind the marginal line showing the carnivorous habits of this larva. The mandibular palp is two-jointed as always in the second Mysis and has a few setae on the distal joint.

The first maxilla has not changed much from the previous stage. The basi-endite is extraordinarily strong and almost mandible-like; it definitely takes part in the tearing up of the prey. In order not to obstruct this function the coxa-endite is much smaller than in most other species, but furnished with a brush of stiff, plumose setae, which can function as a grate behind the basi-endite and the mandible, preventing the prey from escaping backwards. The palp of the maxilla has decreased a little in size, but is still three-jointed.

The second maxilla. The protopod has not changed much since the first Mysis stage, and the endopod is still five-jointed, but shorter than the frontal lobe of the exopod; in the first Mysis it was longer. This is mostly because the exopod itself has grown, with both the anterior and posterior lobes becoming very long. In the first Mysis the most posterior seta was very long about twice the length of the other seta on the exopod. In the second Mysis the posterior seta remains very long, and the first seta laterally of it has also grown in size being nearly as long. Further the long seta is no longer the last one, four more short setae have been added on the posterior lobe towards the coxa. The function of the one very long seta in the first Mysis and the two long setae in the second Mysis is unknown, but as they are more stiff than the rest they possibly serve as organs for cleaning the mouth-appendages, especially the many trapping setae on the median edge of the flat and very broad protopod of the first maxillipede. This protopod of the first maxillipede is the dominating part of the limb and seems to function as a shovel or a barrier preventing the food in escaping backwards. The exopod and the endopod are only short, the latter with four joints and the former with few swimming setae on the tip. On the lateral side of coxa is only one mastigobranchia.

The second maxillipede is also furnished with a two-jointed protopod with setae on the medial margin and one mastigobranchia on the coxa, no other gills, but it is not so flat and broad as the protopod of the first maxillipede. The exopod is still short with a few swimming setae at its distal end. The endopod is five-jointed with a geniculation between joints number two and three so that the three distal joints are bent like a hook towards the proximal part of the limb; this geniculation can be useful both for cleaning the limbs in front of it and for holding the prey and pushing it under the cutting and tearing organs of the mandibles and the first maxillae. Also the second maxillipede has only one mastigobranchia on the coxa, and no other gill filaments.

The third maxillipede is slender and long, a little longer than the following pereipods. It has a two-jointed protopod of which the coxa bears both a small mastigobranchia and a bushy podobranchia behind it. The endopod has five long and slender joints with a normal number of plumose setae. The exopod is also a well developed swimmeret. The three first pereipods have all chelae, which now are shaped as proper chelae, but still not functioning, partly because of their muscles not being fully developed, partly because the branches of the chelae are tipped with long, plumose setae, which certainly will be in their way if the



Figs. 124–136. *Solenocera* sp. larva *sumatransis*. Second Mysis. Fig. 124, larva in total, from lateral. — Fig. 125, first abdominal segment showing lateral process. — Fig. 126, telson. — Fig. 127, first antenna. — Fig. 128, labrum and labium, mandibles removed. — Fig. 129, mandible. — Fig. 130, first maxilla. — Fig. 131, second maxilla. — Figs. 132–134, first, second and third maxillipedes. — Fig. 135, first pereiopod. — Fig. 136, one of the pleopods.

chelae were to clasp any object. The endopod, of course, is five-jointed and the exopod is a long, slender swimmeret, the protopod is two-jointed, and its coxa is furnished with a small mastigobranchia and a bushy podobranchia.

The fourth and fifth pereiopods are ambulatory with the exopods forming strong swimmerets and the five-jointed endopods shaped as walking limbs and as organs for catching the prey. They are of about equal size with a two-jointed protopod. But the fourth has only a very small mastigobranchia, one podobranchia and one arthrobranchia, and the fifth limb has no branchiae.

The five pairs of pleopods have all an unjointed protopod, a short, unjointed and unfunctional exopod and an endopod (see figure 136).

The uropods are well-developed parts of the tail-fan.

Dimensions:

Total length 10 mm; length of carapace 3.5 mm; width of same 3 mm; rostrum 1.8 mm; abdomen 3.7 mm.

Mysis III.

Figs. 137–149.

The larva is in this stage more shrimp-like in shape, although it remains a definite Mysis larva both in this and the following stages.

Carapace.

Formula: 2. 3. (4). 5. 7. 8. 9. 10. (11). 12. 13. 15. 17. 18. 19. 20. 21. 24. 26. 28. (29). 30.

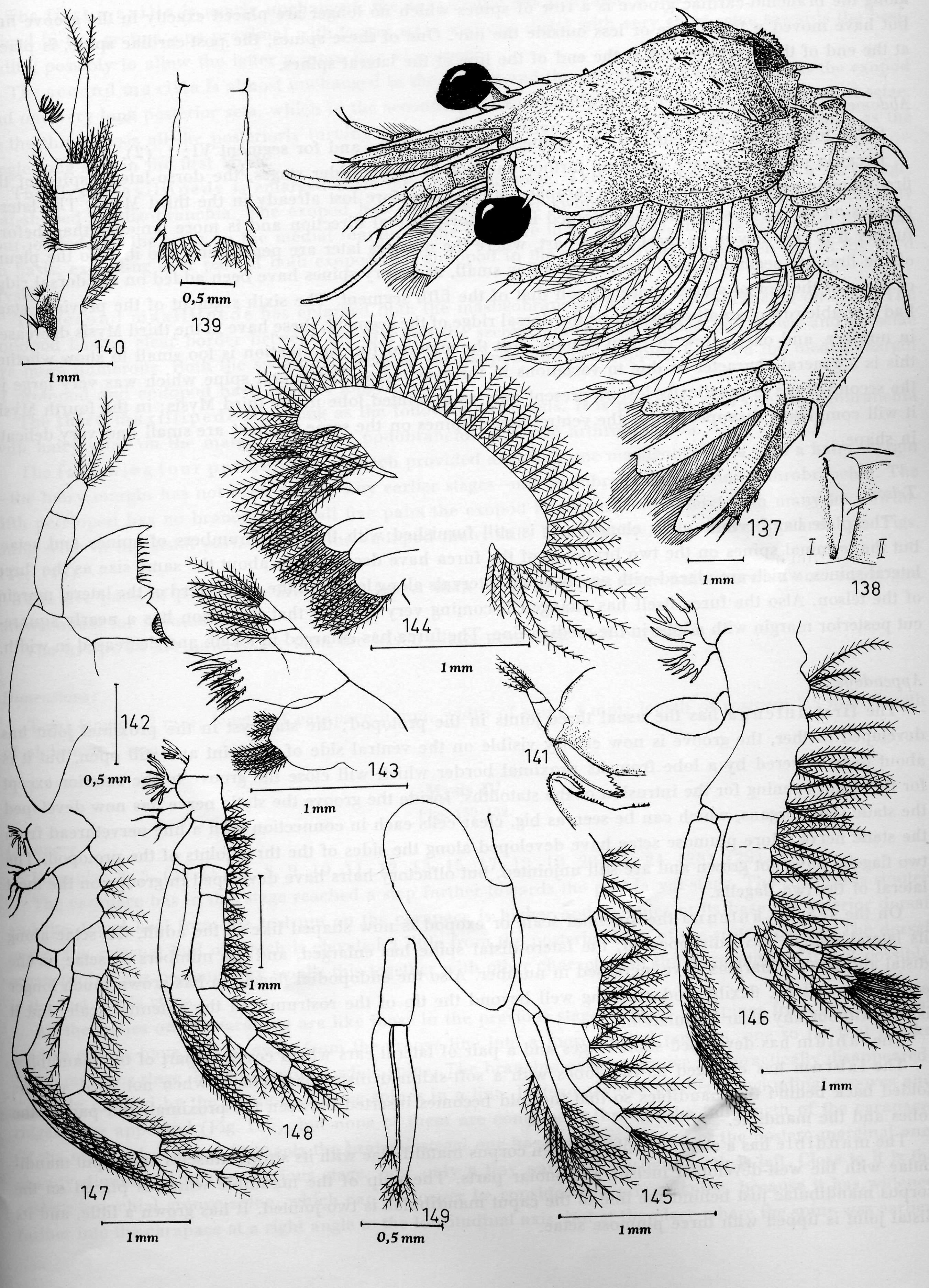
The rostrum has developed further with a strong rostral ridge on the carapace and with its free part nearly straight and provided with one rostral tooth and two epigastric-rostral teeth. Because these teeth in themselves are larger than in the previous stage they appear as being placed closer together, the intervals between them are so short as to appear only as incisions in the dorsal ridge of the rostrum.

The dorsal organs are both small, the anterior one is placed immediately behind the rostral ridge and the posterior one close to the posterior marginal spine, which still is present, not so much as a spine, but more as a very short, spiny lobe with three small filamental teeth. The cervical groove directly behind the anterior dorsal organ is present, but only as an indistinct impression on the carapace, not as a line or groove. On the lateral side of the carapace the line for the posterior part of the branchio-cardiac groove has become more distinct than in the previous stage.

Of the marginal spines of the carapace the supra-orbital spines are well-developed as usually, but the following antennal spines are smaller than in the previous stage. A little behind these spines a brim of the teeth from the branchiostegal filament is breaking the smooth carapace margin for a short distance and only posteriorly of the latero-posterior corner of the carapace the next series of filamental teeth is present from this corner and until the postero-branchial groove spine. This latter is short, wide and lamellar with a straight-cut tip, edged with filamental teeth.

Inside the margin of the carapace are the unpaired dorsal or epicardiac spine, which has decreased in size and no longer is the largest of the spines inside the margin of the carapace, and the following paired spines: In front of the cervical groove a little to the side of the anterior dorsal organ is a pair of very minute spines, the medio-gastric spines; behind these are first the prehepatic spines and then, anteriorly of the dorsal spine, the supra-hepatic spines; and behind the antennal spine are first the post-antennal spine and then the latero-hepatic spines, the latter are a little smaller than the post-antennal spine in front of them. Finally

Figs. 137–149. *Solenocera* sp. larva *sumatransis*. Third Mysis. Fig. 137, larva from lateral. — Fig. 138, first abdominal segment showing lateral process. — Fig. 139, telson. — Fig. 140, first antenna from ventral, showing beginning of statocyst development. — Fig. 141, position of right side of labrum, rigth mandible, and right side of labium with bent lobe. — Fig. 142, mandible. — Fig. 143, first maxilla. — Fig. 144, second maxilla. — Figs. 145–146, first and second maxillipedes. — Fig. 147, first pereiopod. — Fig. 148, fourth pereiopod. — Fig. 149, one of the pleopods.


137
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along the branchio-cardiac groove is a row of spines which no longer are placed exactly in the groove line, but have moved a little more or less outside the line. One of these spines, the post-cardiac spine, is placed at the end of the carapace and at the end of the line of the lateral spines.

Abdomen.

Spine formula for segment I: 1. 2., segments II–V: 1. 2. 3., and for segment VI: 1. (2). 3. 4.

Because of the carapace reaching farther backwards in the older stages, the dorso-lateral spine of the first segment gets in the way for the carapace, and is therefore lost already in the third Mysis. The lateral process on the same segment has enlarged in the dorso-lateral direction and is more lamellar than before, further it is very low in its most dorsal part, where the muscles later are penetrating into it. Also the pleura of the first five segments have grown and a few small, accessory spines have been added on the dorsal ridge of some of the dorsal spines especially on that of the fifth segment. The sixth segment of the previous stage had a double row of small spines along the dorsal ridge of the segment, these have in the third Mysis decreased in number, and only a few of them remain. But the material for examination is too small to show whether this is a general character or due to variations in the specimens. The lateral spine which was very large in the second Mysis is practically lost or present only as a pointed lobe in the third Mysis; in the fourth Mysis it will completely disappear. Also the ventro-lateral spines on the same segment are small and very delicate in shape.

Telson.

The plate has become more elongate. It is still furnished with the same numbers of spines and setae, but the terminal spines on the two branches of the furca have decreased to about the same size as the three lateral spines, which are placed with nearly equal intervals along less than the distal third of the lateral margin of the telson. Also the furca itself has changed becoming very open so that the telson has a nearly square-cut posterior margin with a lobe in the median line. The furca has enlarged in length and decreased in width.

Appendages.

The first antenna has the usual three joints in the protopod; the statocyst in the proximal joint has developed further, the groove is now clearly visible on the ventral side of the joint and still open, but it is about to be covered by a lobe from its proximal border which will close the groove to the exterior except for the distal opening for the intrusion of the statoliths. Inside the groove the static nerve has now developed the static sense-organs, which can be seen as big, clear cells each in connection with a fine nervethread from the static nerve. More plumose setae have developed along the sides of the three joints of the protopod. The two flagella have not grown and are still unjointed, but olfactory hairs have developed in groups on the most lateral of the two flagella.

On the second antenna the antennal scale or exopod is now shaped like in the adult, the setae along its lateral margin have disappeared, the latero-distal spine has enlarged, and the numbers of setae on the distal and medial margins have increased in number. Also the endopodial flagellum has grown much longer and is now a long, flexible rod reaching well beyond the tip of the rostrum and the antennal scale, but it is still without any clear annulation.

The labium has developed some ridges and a pair of lateral ears which covers a part of the mandibles.

The labrum has enlarged its two lobes with a soft-skinned distal part which, when not used, can be folded back behind the mandibles so that the fold becomes inserted between the proximal, stiff part of the lobes and the mandible.

The mandible has a clear division between corpus mandibulae with its strong muscles and caput mandibulae with the well-developed incisor and molar parts. The palp of the mandible which is placed on the corpus mandibulae just behind the line to the caput mandibulae is two-jointed. It has grown a little, and its distal joint is tipped with three plumose setae.

The first maxilla is nearly unchanged, the coxa-endite has increased a little in size, and its setae are placed in two groups, one proximal with longer setae and one distal with very short setae towards the basi-endite, possibly to allow the latter a more free movement.

The second maxilla is almost unchanged in the endites and the endopod. On the first Mysis the exopod had one very long posterior seta, which in the second Mysis was multiplied to two long and four short setae. In the third Mysis all the posteriorly turning setae are longer than the others, but not nearly as long as the single long seta in the first Mysis.

The first maxillipede is enlarged since the preceding stage. The coxa is provided with a very large, leaf-shaped mastigobranchia. The exopod has developed longer swimming setae, the endopod is still only four-jointed. All the setae on the medial margin of the limb are long, plumose, filtering setae. But the setae on basis, extending over part of both exopod and endopod in the second Mysis, have been lost in the third Mysis.

The second maxillipede has enlarged both the mastigobranchia and the podobranchia on coxa. The endopod has no clear border between the first and the second joints. The exopod has grown and its setae are more numerous. Both the swimming setae on the exopod and the trapping setae on the medial margin of protopod and endopod have become longer.

The third maxillipede is as long as the following pereipods. It is provided with one mastigobranchia with hairy setae on the margin, with one podobranchia and one arthrobranchia.

The following four pereiopods are each provided also with one mastigobranchia with a hairy margin —the hairy margin has not been seen in any earlier stages—one podobranchia and one arthrobranchia. The fifth pereiopod has no branchiae. In all five pairs the exopod is a strong swimmeret with many long swimming setae in the distal part. All over the endopod many stiff, but plumose, setae have appeared (see Figs. 147, 148).

The five pairs of pleopods are a little longer than in the previous stage but otherwise unchanged and unfunctional for swimming.

The uropods are now longer than the telson plate, projecting well beyond it.

Dimensions:

Total length 17 mm; length of carapace 5 mm, width of same 4 mm; length of rostrum 2.7 mm; length of abdomen 7 mm.

Mysis IV.

Figs. 150–152.

Carapace.

Formula: 2. 3. (4). (5). 7. 8. 9. 10. 11. 12. 13. 15. 17. 18. 19. 20. 21. 24. (28). (29). 30.

The carapace has in this stage reached a step further towards the post-larval stage. The rostrum is stouter and the dorsal keel from the rostrum on the carapace is higher and includes at its base the anterior dorsal organ, the external bud of which is elevated a little from the posterior base of the rostral carina. The dorsal organ proper has become very small; this together with other characters of the stage suggests that it possibly is the last Mysis stage.

All the spines on the carapace are like those in the previous stage. Two of the spines from the branchio-cardiac groove have moved away from the groove-line into a more medial position, one so far that it, like in the previous stage, is named post-cardiac spine. The branchio-cardiac groove has practically disappeared, it is only marked by the position of three spines in a line. Instead several smaller, longitudinal grooves and ridges have appeared (Fig. 150), but none of them are continuous through the full length of the carapace. Of the marginal dentated filaments the branchiostegal one has disappeared and of the postero-marginal one, already diminished in the previous stage, now only a tiny part with vestigial teeth is left. Close to it is the postero-branchial groove spine, which can no longer be considered a proper spine, because it has widened further into the carapace at a right angle to the longitudinal axis, but at the place where the spine was earlier.

The medio-posterior marginal spine is a small outstanding crest with three to four filamental teeth. Against this crest and just in front of it are the last remnants of the posterior dorsal organ.

All these parts: spines, dental filaments, filamental crests and wings are larval characters and will all be lost in the first post-larval stage. This renders it so difficult, even if the adult should be a known species, to refer a larva to its proper adult form, without being able either to observe the first post-larval cuticle below the last larval skin or, still better, to follow the ecdyces.

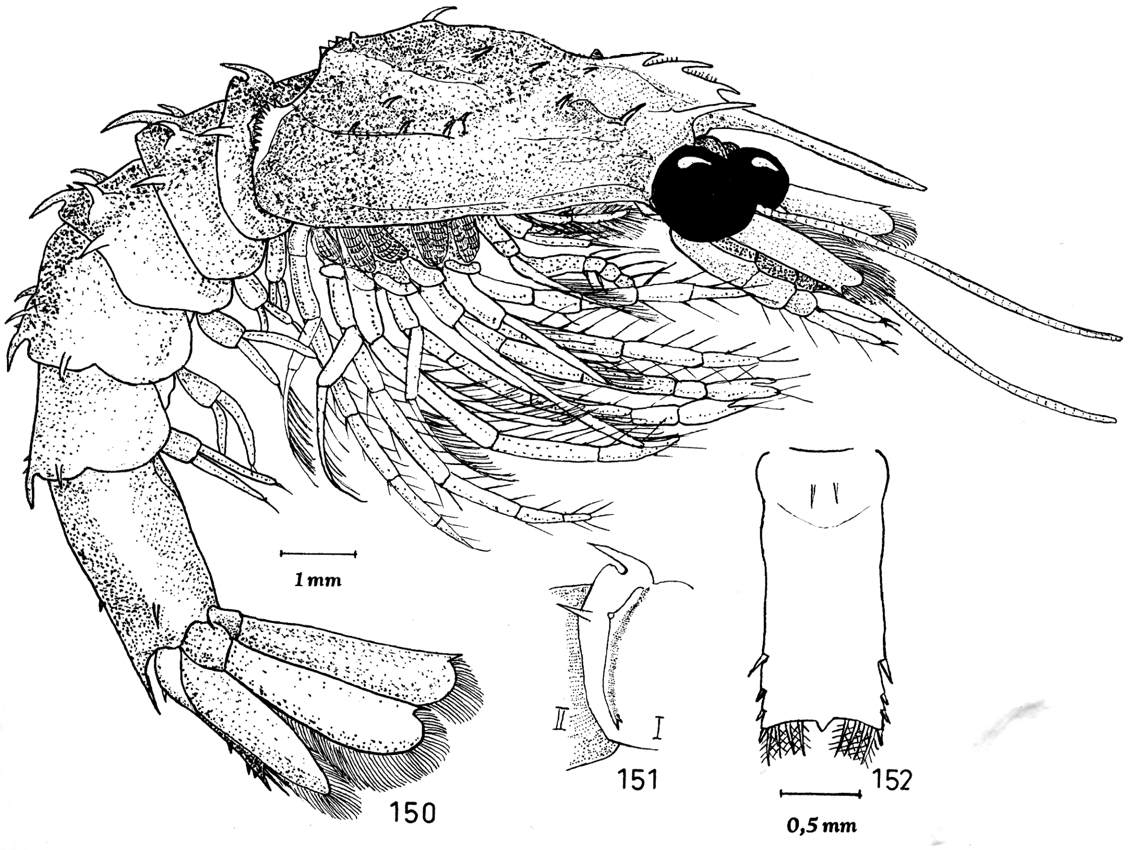
Abdomen.

Formula, segment I: 1. 2., segments II–V: 1. 2. 3., segment VI: 1. 3.

The pleural plates have developed further, some of the accessory spines on the dorsal spines have become larger, and as a dorsal keel has appeared along the dorso-medial line, some of these accessory spines have moved a little away from the dorsal spine, on which they started, now riding (more separately) on the adjoining keel. This is first and foremost the case for the posterior segments of the abdomen. Also the lateral process on the first abdominal segment has become more membranous and has developed a small extruding spinal bud, placed where the membrane is highest, about one third from its dorsal outspring. On the sixth segment the lateral spine is only a rounded arch of the posterior margin, and also the ventro-lateral spines are very vestigial.

Telson.

The telson has become more elongate so that the three lateral spines are placed on the distal one fourth of the lateral margin. A pair of tiny spines has now appeared on the dorsal side of the telson near its base on each side of the distal part of the dorsal spine from the sixth segment, from where they reach in over the base of the telson (Fig. 152). The lateral margins of the telson plate are still parallel, but the posterior free



Figs. 150–152. *Solenocera* sp. larva *sumatransis*. Fourth Mysis. Fig. 150, larva from lateral. — Fig. 151, first abdominal segment with lateral process. — Fig. 152, telson.

margin of the plate is now nearly square-cut with a very shallow furca and a triangular lobe at the bottom of the furca.

Appendages.

The change from the previous stage is only small. The statocyst in the basal joint of the first antenna is now closed except for the small distal opening which remains throughout life. No statoliths have yet been placed in the cavity, but along its inner wall seems to be a fine ramification of branches from the nervus staticus and the fine sense-organs, on which the statoliths are to rest. The two flagella of the first antenna are still unjointed and about as long as in the previous stage.

The endopodial flagellum of the second antenna has grown to about twice the length of the antennal scale and has started to become annulated, which makes it more flexible. The protopod of the same limb has developed a short, but pointed and conical, spine on its disto-lateral corner just in front of the antennal spine of the carapace.

The mandibular palp is still two-jointed but has become larger, reaching in front of the labium.

The two lobes of the labrum are no longer bent distally towards their proximal parts, but form instead a bulge over the caput mandibulae which reaches forward to meet the posterior margin of the labium.

The first maxilla has still a three-jointed endopod. The exopod of the second maxilla is placed as a large, semilunate leaf covering the mouth region laterally and reaching forward nearly as far as the mandibular palp, exteriorly or laterally of it.

The three pairs of maxillipedes are stout feeding organs and have nearly the same shape as in the previous stage. This also holds good for the five pairs of pereiopods. The three first pairs are chelate, but have still many trapping setae also on the chela. This makes this distal part of the limbs useless as proper chelae, but they can serve as a good trap for catching the prey. The fifth pair of pereiopods are still without gills of any form. It is of interest to note that the mastigobranchiae on the pereiopods in the third and fourth Mysis are setose.

The pleopods have grown in size, but not in development. They are hardly of any locomotory function for the larva.

The uropods are well developed, and their exopods are more than twice as long as the telson plate.

Dimensions:

Total length 22 mm; length of carapace 7 mm, width of same 5 mm; length of rostrum 3.5 mm; length of abdomen 11 mm; length of telson 3.5 mm.

Average size in mm of different Mysis stages.

Mysis stage	I	II	III	IV
Total length	6	10	17	22
Carapace	2 × 2	3 × 3	5 × 4	7 × 5
Rostrum	1	1.8	2.7	3.5
Abdomen	2.5	3.7	7	11
Telson	1	1.3	1.5	2

Distribution and Remarks.

Fig. 153.

All the specimens of this species are from the same locality Dana St. 3903, south of the Nicobar Islands a few miles west of the northern point of Sumatra. They were caught at different depths between 10 and

200 m with 50 to 300 meter wire. The only complete larval development of a *Solenocera* which is known at least for its last part is that of *S. membranacea* with two Mysis stages. But two of the larvae described in this paper have more than two Mysis stages, so this number can not be constant for the genus *Solenocera*. In *S.* sp. larva *danae* we found three Mysis stages. It has already been mentioned under remarks to *S.* sp. larva *danae* (pp. 102–104), that it is likely that still more Mysis stages are to follow the known three stages in this species. For *S.* sp. larva *sumatransis* four Mysis stages are described in this paper, and both the third and the fourth Mysis of this species seem closer to the adult form than the third Mysis in *S.* sp. dana *danae*. The fourth Mysis of *S.* sp. larva *sumatransis* may be the last or one of the latest Mysis stages, although nothing can be said definitely about it.

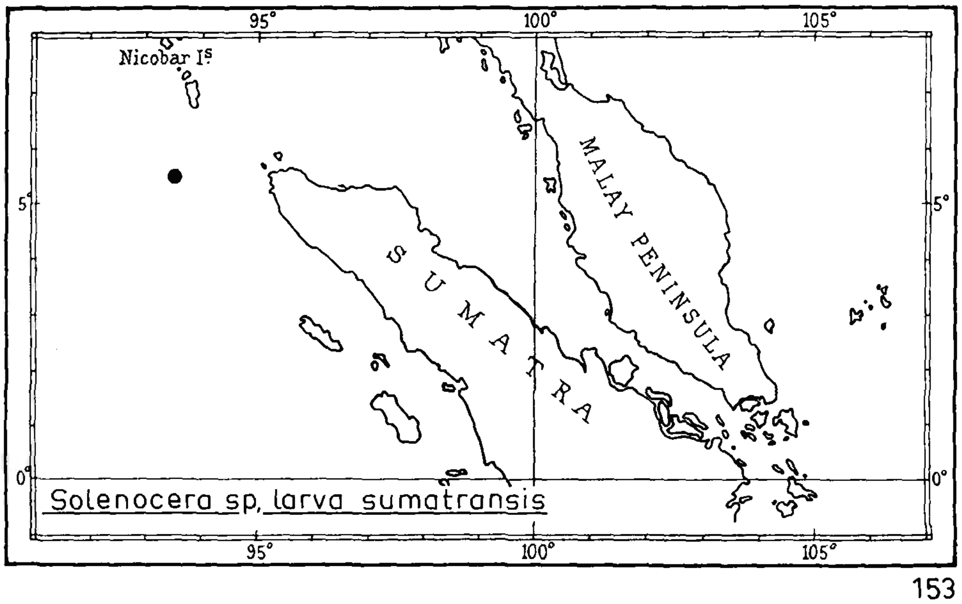


Fig. 153. Map of distribution.

The following points are in favour of the assumption that the fourth Mysis of *S.* sp. larva *sumatransis* is one of the last Mysis stages in this species: The rostrum has almost the adult form with a strong toothed carina on the carapace and a stiff, nearly straight, pointed, free part. The lateral margins of the carapace are straightened out and have no longer larval lobes. The statocyst is about ready to function, the telson has nearly lost its furca, and the uropods reach beyond the telson. The pleura are well developed. The lateral spine on the sixth abdominal segment has disappeared in the fourth Mysis stage, and the pleopods have developed elongated exopods and endopods. It is of interest to note that the mastigobranchiae in the first and third Mysis develop a setose margin not found in any first or second Mysis, nor in the third Mysis of *S.* sp. larva *danae* where the mastigobranchiae are smaller and more pointed at the tip than in *S.* sp. larva *sumatransis*.

Of the two species which come closest to having a true tropical oceanic occurrence, *S.* sp. larva *sumatransis* and *S.* sp. larva *danae*, the larvae have a more carnivorous life than the other *Solenocera* larvae. This is seen not only from their very large and well-developed mandibles, but also from the facts that the basiendite of the first maxilla is rather mandibular in shape and can function as a secondary mandible and from the many stiff, but plumose, trapping setae on the other mouth appendages as well as on the pereiopods. As the demand for food is growing with age of the larva we also observe an increasing development in size and number of these trapping setae especially in those on the pereiopods after each moult.

Solenocera sp. larva *nodulosa*

Figs. 154–169.

Localities.

Mysis II.

Dana St. 3921 III. 3°36′ S–58°19′ E., 300 mW. 11.12.1929. 1 spec.

Description.

Mysis II.

Only a single specimen, a second Mysis, exists of this interesting species which in many points links up to the *Solenocera* but in others is different. Of the here described *Solenocera* larvae, *S.* sp. larva *sumatransis* comes closest to it. Due to our scarce knowledge of the genus it is difficult to decide whether the larva belongs to *Solenocera* or a related genus, but it can not be doubted that it belongs to the Solenoceridae.

Carapace.

Formula: 2. 3. 4. 6. 7. 9. 11. 12. 13. 15. 16. 23. 24. 27.

The carapace is a large, swollen globe or sooner one larger globe above the thorax and one smaller over the cephalon. One of the most characteristic features of the species is that it is the only known *Solenocera*, or related form without a dorsal or epicardiac spine. The rostrum is short and bent in front of the animal as normally the case in early Protozoea-stages, but it extends backwards as a strong ridge on the carapace with a single diminutive epigastric-rostral tooth. Posteriorly of the base of the rostral ridge is the small anterior dorsal organ; the still smaller posterior dorsal organ, is situated at the base of the medio-posterior marginal spine or partly inserted into the base of the spine. The spine is smooth without larval filament. Along the margin of the carapace the supra-orbital spine extends laterally to the rostrum, covering the eye in its full length. Laterally to it is the antennal spine, which together with the rostrum is shaping a large, shallow orbit between the two spines. Posteriorly of the antennal spine, but still on the margin, is a single branchiostegal spine shaped as an anteriorly pointing apex on a large branchiostegal lobe. After this spine follows a smooth margin nearly to the posterior corner of the carapace, only for the last interval towards the postero-branchial groove spine the margin is dentated with nine large branchio-lateral filamental teeth. After this filament follows the already mentioned postero-branchial groove spine, which is without filament, but very large. Inside the margin of the carapace are the two dorsal cones, the cephalic and the thoracal. They have no spines on their surface, but laterally on the carapace are two other cones on each side, both tipped by a spine. The anterior cone is the smallest. The spine on its top seems to represent the post-antennal spine. The second larger cone placed more posteriorly has the single and the only existing branchio-cardiac or lateral spine as its apex.

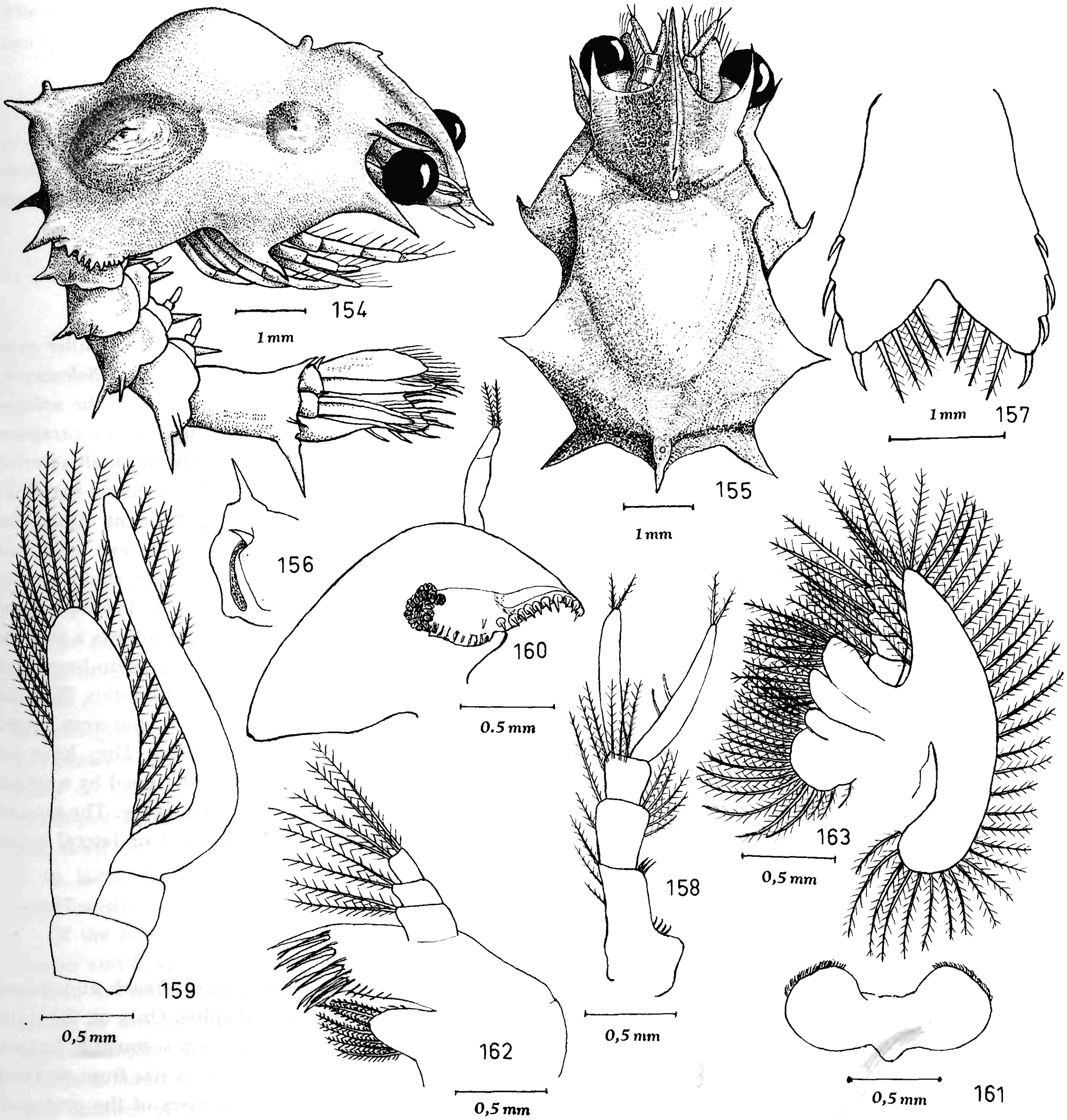
Abdomen.

Formula, segments I–V: 1. 2. 5., segment VI: 1. 2. 4.

The pleura have started to develop, but they do not yet cover the postero-ventral part of each abdominal segment, which is free below the pleura and furnished with a large, conical, ventral spine. Only on the sixth segment the ventral spine is missing and replaced by a pair of ventro-lateral spines. Each segment is further furnished with a large dorsal spine and a smaller lateral spine, the lateral spines increase in size from segment one to five, on segment six the lateral spine is again only small. The disto-lateral corners of the protopod of the uropods are prolonged into a spine, which is in line with the ventro-lateral spine of the sixth segment. On the first abdominal segment the lateral process is flattened; it starts at the lateral spine of the segment and continues as a membranous ridge into the pleuron.

Telson.

The telson is different from that of the other larvae here described, more flattened and much wider, with an open, not very deep, furcal incision, which makes the furcal branches short and leaf-shaped. Inside the furcal cleft are four plumose setae on each side, and one short spine is tipping each branch. Three equally long spines are placed with about equal intervals along the distal half of the lateral margin with the proximal one off the bottom of the furcal cleft.

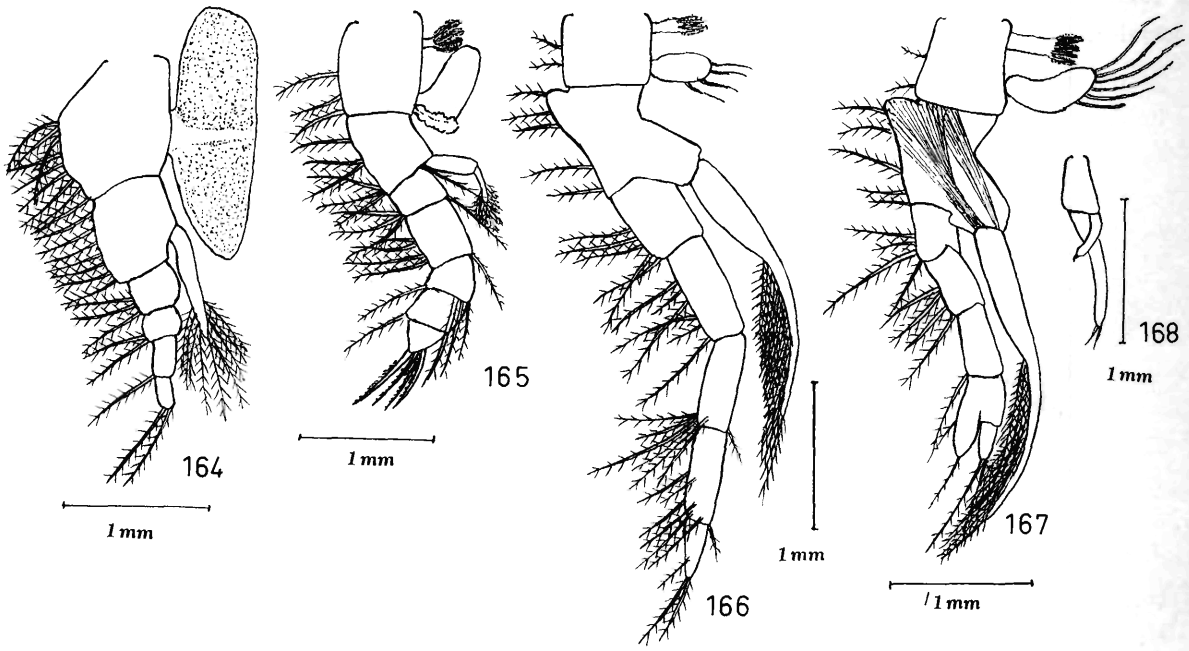


Figs. 154–163. *Solenocera* sp. larva *nodulosa*. Second Mysis. Fig. 154, larva from lateral. — Fig. 155, larva from dorsal. — Fig. 156, first abdominal segment with lateral process. — Fig. 157, telson. — Fig. 158, first antenna. — Fig. 159, second antenna. — Fig. 160, mandible. — Fig. 161, labium. — Fig. 162, first maxilla. — Fig. 163, second maxilla.

Appendages.

The first antenna has a three-jointed protopod with the basal joint about as long as the two following joints together. No statocyst is developed, but the process and the concavity for its future incavation are present with short hairs where the opening is going to be. Stiff setae are placed along both sides of the protopod. The last joint is tipped with two relatively short, still unjointed flagella, the lateral one has a few olfactory hairs along its inner margin. Both flagella are tipped with two short setae.

The second antenna has a short protopod and an antennal scale with setae on the whole medial and distal margins and half way down the lateral margin. The disto-lateral spine is not yet developed. The absence of this spine and the setae halfway down the lateral margin of the antennal scale are unusual features. The endopod consists of one short joint and one longer, unjointed flagellum.



Figs. 164–168. *Solenocera* sp. larva *nodulosa*. Second Mysis. Figs. 164–166, first, second and third maxillipedes. — Fig. 167, first pereiopod. — Fig. 168, first pleopod.

The labium is stout and square. The labrum consists to each side of an arm and a plate, so that the latter can be moved below or laterally of the mouth and up to the labium and the mandible.

The mandible is very large with strong muscles. The incisor part of the corpus mandibulae is well developed with about ten pointed teeth in a line followed by a large pars molaris forming an actual chewing-lobe. The mandible has a two-jointed palp of which the proximal joint is by far the longest and rather swollen. The distal joint is short, much more delicate and tipped with two short setae.

The first maxilla is of the strong carnivorous type with a mandibular basi-endite with teeth placed in two lines and behind these a line of stiff setae, which continues along the free margin of the posterior part of the lobe. The coxa-endite is much smaller and has stiff, plumose setae to brush up against the teeth of the basi-endite. The endopod is of the usual three-jointed type.

The second maxilla has four well-shaped endital lobes on the protopod, a five-jointed endopod and a large exopod with one long anterior and one long posterior lobe, the latter is very large. On the endites and the exopod is a dense brim of plumose setae, and the endopod has the usual two plumose setae on each joint.

The first maxillipede has the usual two-jointed protopod developed into a high bar with many setae on the medial margin. On the coxa is one very large mastigobranchia with an anterior and a posterior lobe. The endopod is small and four-jointed. The exopod is very small and not of any use as a swimmeret.

The second maxillipede has also a strong two-jointed protopod, however, not nearly as high as that of the first maxillipede. On the coxa is placed both a mastigobranchia and a podobranchia. The mastigobranchia is divided into two parts, a distal lobose and a proximal leaf-shaped section. The following appendages have only the leaf-shaped section of the mastigobranchia, but on each of them extends from the distal margin of the gill a group of long, thin and hairy setae. The podobranchiae are also different from those in the other species by missing a stem running through the whole gill, they consist of a short, thick peduncle from which extends a line of short gill-filaments. This special type of mastigobranchiae and podobranchiae is remarkable and very characteristic, and is among the here or elsewhere described larvae of *Solenocera* only known for *S.* sp. larva *sumatransis* and *S.* sp. larva *nodulosa.* I think this gill-development must be a

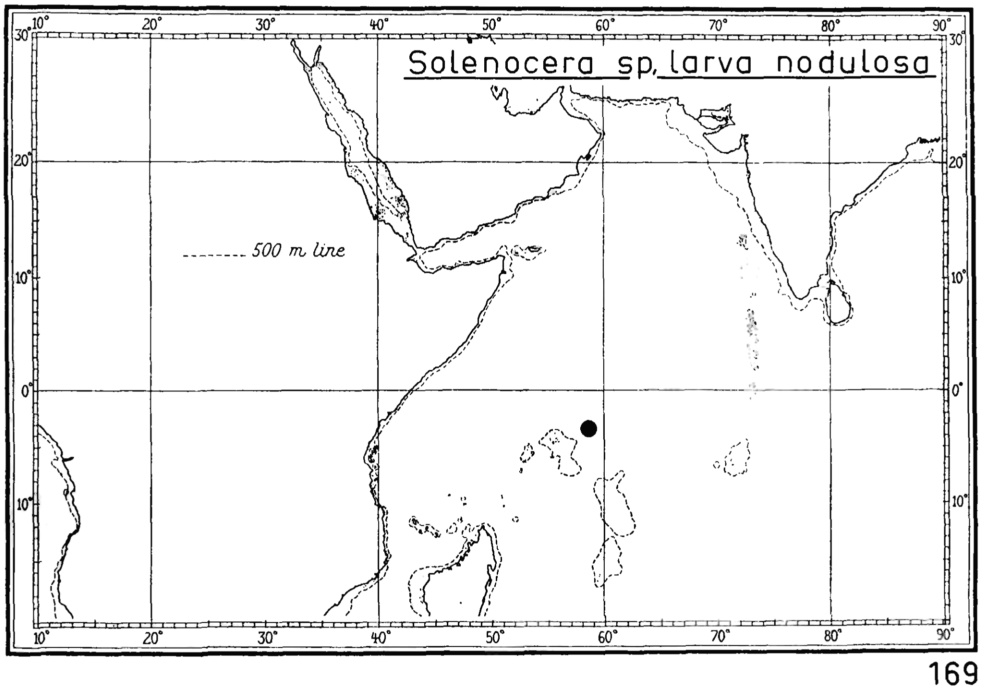


Fig. 169. Map of distribution.

generic character which separates these two species from the rest and unites them in one group. When more *Solenocera* larvae are known it may turn out to be a much more common feature than the present knowledge suggests. The endopod is five-jointed, and the last three joints form a sort of hook as the second and third endopodial joints are very movably connected so that the three distal joints can be bent towards the proximal joints. The exopod of the limb is very small and rudimentary, just hanging as a small appendix to the limb.

The third maxillipede has a two-jointed protopod. The coxa has a mastigobranchia furnished with long, hairy setae at its distal margin and proximally of it a podobranchia. The third maxillipede and all the following thoracopods have a basis with a characteristic lobe from its basal medial corner. This lobe serves as a fastening for the swimming muscles of the exopod which are extraordinarily well developed in this species. In spite of its clumsy and bulbous carapace this larva must be a very good swimmer because the exopods, their swimming setae and adductor muscles are very strongly developed. The endopod of the third maxillipede is five-jointed as common for this appendage. The following three thoracopods have each a chela on the five-jointed endopod, but the chela has still long setae and is not yet in proper function. The fourth and fifth pairs are without chelae. The first four thoracopods are furnished with a mastigobranchia and with the podobranchia of the type for the species as described above. The fifth thoracopod has no gills.

The pleopods are short with an unjointed protopod, and an unjointed exopod and endopod, the two latter are tipped with embryonic setae. The exopods are much longer than the endopods. This difference in length is strongest for the first pleopod and descreases gradually backwards so that on the fifth pleopod the lengths of the two branches are nearly equal.

Dimensions:

Total length 14 mm; length of carapace 6 mm; width of same 4 mm; length of rostrum 2 mm; length of abdomen 5 mm.

Distribution and Remarks.

Fig. 169.

This species was found by "Dana" on a single station a little north of the Seychelles in the Indian Ocean. It is a most remarkable animal with its six large, conical bulbs on the carapace and the flattened leaf-shaped telson. Also the limbs differ a little from those of most of the other species. The mandible is very large with single, very pointed, conical teeth in the incisor part. The mastigobranchia of the first maxillipede is extremely large like in the later stages of *S.* sp. larva *sumatransis*; from the third maxillipede to the fourth thoracopod the mastigobranchiae have long, flexible hairs. The podobranchiae, when present, have a short shaft from which extends a line of gill filaments. The same type of gills is also found in *S.* sp. larva *sumatransis*, but in no other of the investigated species.

Solenocera sp. larva *elongata*

Figs. 65, 170–180.

Localities.

Protozoea III.

"Terra Nova" St. 43. 22°06′ S–39°40′ W. Surface. 3.5.1913. B.M. 2 spec.

Description.

Protozoea III.

Figs. 170–180.

Carapace.

Formula: 2. 3. 5. 7. 10. 11*. 12. 13*. 15. 16*. 18. 19. 22. 23. 24. 25. 28. 29. 30.

This is the smallest of the species described in this paper with a total length, including rostrum, of 3 mm. The carapace is slightly longer than wide or the length and width are the same. Usually in the third Protozoea it is wider than long. This is the more remarkable as there either is no rostral plate or the rostral plate is only a very narrow ledge in front of the carapace, hardly to be termed a plate. The dorsal organs are unusually well-developed and the anterior one is a very long, cylindrical tube a little wider at the end than at the base. The name *elongata* is partly referring to the length of this organ. Also the rostrum is very long, 0.8 mm, compared with the rest of the body, and strongly barbed like all the spines of the carapace, as also in the following species described, *Solenocera* sp. larva *barbata*, which it resembles also in many other aspects, one could say that these two species although their localities are wide apart together form a group judged from the Protozoea only. The pair of supra-orbital spines is very large reaching forward about to the same line as the tips of the rostrum and the first antenna. The rostrum is nearly twice as long as the supra-orbital spines, but these are more straightly pointing forward, whereas the rostrum is strongly bent ventrally. The antennal process is placed behind the supra-orbital spines, and is rather short and tipped with long, filamental teeth, in the following stage it will be replaced by the antennal spine. About midway, still at the margin of the carapace, are two branchiostegal processes, rather dominant and long, both with a toothed marginal brim. In front of the anterior process, two filamental teeth are placed directly on the margin of the carapace. On the postero-lateral corner is a pair of process-like spines, the latero-posterior marginal spines, these are long, pointed and barbed mainly at their lateral side. This and the first Mysis of *S. muelleri* are the only species of the known *Solenocera* larvae with a spine in this place. Therefore, this spine can—as long as future research does not reveal its presence in other species—be considered as characteristic for these two species.

Above the latero-posterior marginal spine is a comb-shaped postero-branchial groove spine still extending from the margin, and from the base of the spine the branchio-cardiac groove runs forward for the posterior third of its length or a little less. In the comb of the postero-branchial groove spine the main part of the teeth are placed along the dorso-anterior margin and only a few at the ventro-posterior margin. Finally posteriorly on both sides of the medial line of the carapace a pair of medio-posterior marginal spines extends from its margin. These are, as always when present in the third Protozoea, tipped with long filamental teeth, but in this species these teeth are placed along the lateral side of the spine.

Inside the margin are several barbed spines. An unpaired epicardiac or dorsal spine, placed midway between the two dorsal organs, is present. Behind this spine are the following paired spines placed symmetrically to the longitudinal mid-line. Two spines on each side extending from the branchio-cardiac groove, named branchio-cardiac spines, or lateral spines, because of a possible homology between the dorsal spine and the lateral spines in the *Solenocera* and in the Zoea of the Brachyura, only the lateral spine in the Brachyura has been multiplied in number in the *Solenocera*. Behind the anterior dorsal organ are the pre-hepatic spines, postero-laterally of them the latero-hepatic spines, and finally the post-antennal spine between the latero-hepatic spines and the antennal process. The already mentioned filamental teeth include the teeth on the antennal process, the only two supra-antennal teeth placed immediately in front of the anterior branchiostegal process, further the teeth on these processes, the teeth on the latero-posterior marginal spine, the postero-branchial teeth, and the teeth on the medio-posterior marginal spines.

Abdomen.

Formula, segments I–V: 1. 2., segment VI: 1. 2. 4.

Of the usual six segments number six is twice as long as any of the others. Each of the first five segments has a long curved dorsal spine which increases in size backwards for each segment. All six segments have a pair of long backwards curved lateral spines, also these spines increase in size posteriorly. Only on the sixth segment is also a pair of shorter ventro-lateral spines.

Telson.

The furca is very open, about 145°, with a convex arch at the bottom of the cleft. The plumose setae are eight on each branch, four on the inner margin, two at the distal end, and two on the lateral side close to the tip of the branch.

Appendages.

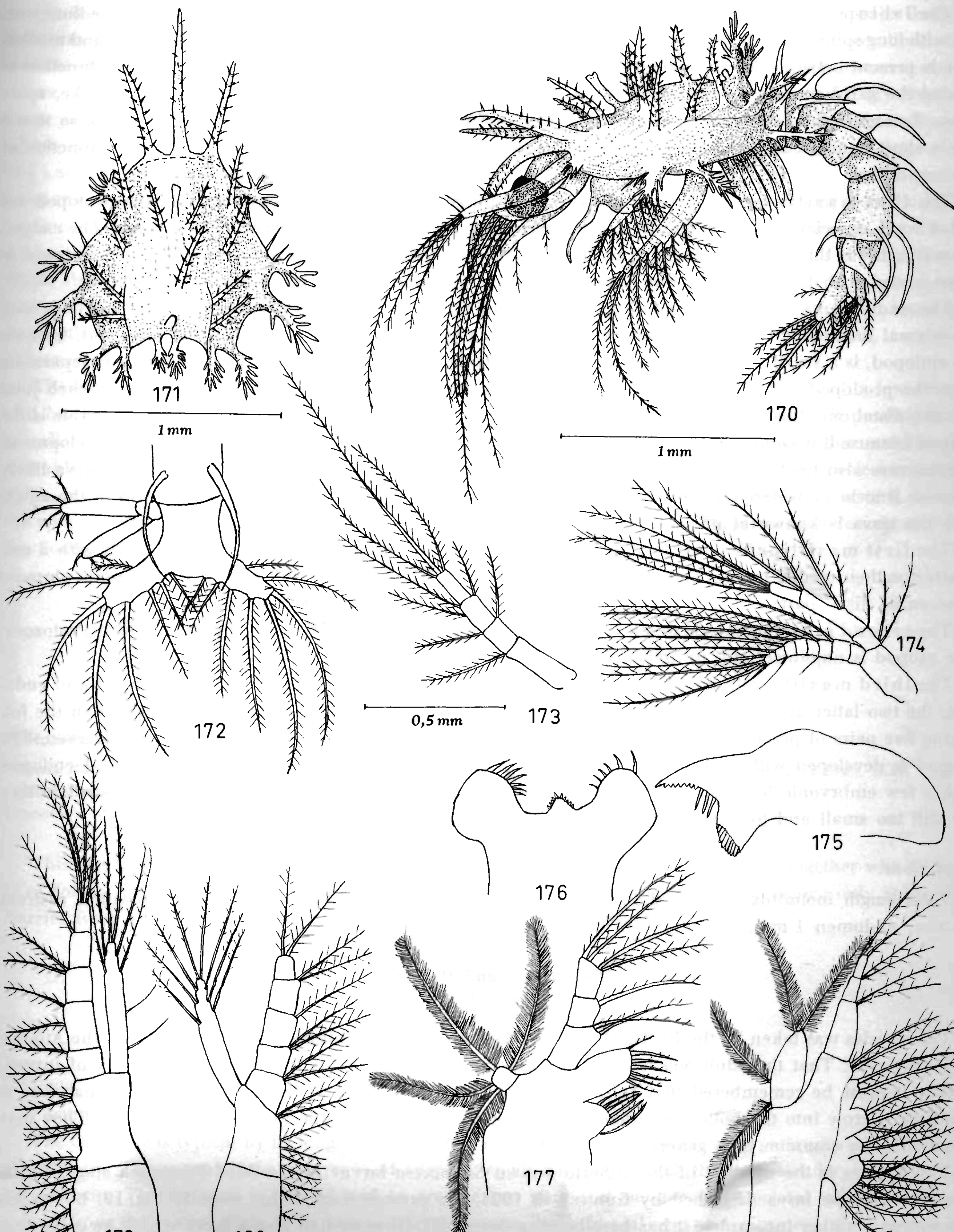
The first antenna consists of the usual four joints in this stage, the basal joint is the largest. The setae are unusually long and flexible especially the most distal one, and their numbers are on the lateral side 1, 1, 2, and 3 at the tip, on the medial side 0, 1, 1.

The second antenna is also furnished with long and flexible plumose setae. The protopod is unjointed. The endopod consists of three joints, but judging from the setae and their placement—two setae extending from a little bulb halfway up the joint—the second joint is coalesced from two joints. The last joint is as usual tipped with five setae, only these setae are unusually long and slender. The exopod is divided into many small joints and provided with long and flexible swimming setae.

The labrum or upper lip is very large and as in the other *Solenocera* species shaped like a hollow, semiglobular cup. Whereas the other species have a short spine or none anteriorly on the ventral side, this species has here a long S-curved spine (Fig. 170), reaching down in front of the area of the mouth appendages.

The mandible is weak, but with a clear separation between the incisor and molar parts; the molar part has already a distinct chewing pad. Between the two parts are placed three long and movable teeth. As always in this stage no palp is yet developed.

Figs. 170–180. *Solenocera* sp. larva *elongata*. Third Protozoea. Fig. 170, larva from lateral with characteristic shape of labium with its large spine. — Fig. 171, carapace from dorsal. — Fig. 172, telson. — Fig. 173, first antenna. — Fig. 174, second antenna. — Fig. 175, mandible. — Fig. 176, labium. — Fig. 177, first maxilla. — Fig. 178, second maxilla. — Figs. 179–180, first and second maxillipedes.


171
1 mm
170
1 mm
172
173
0,5 mm
174
175
176
177
178
179
180
0,5 mm
0,5 mm

The labium or lower lip is also characteristic for this species. Its two lateral lobes are of medium size, but with long spiny comb-hairs on the inner margin. Further, only observed in this species, a third and median lobe is present between the two lateral lobes, this third lobe is very short and small, but it does function in closing the gab between the two lateral lobes, because its surface is covered with short papilla-like, spiny hairs. To secure the co-operation of all three lobes the basal part of the labium is relatively long so that it like a short handle can bring the three lobes together in the wanted position for supporting the function of the mandibles.

The first maxilla has the typical shape for this stage, only the two endite lobes on the protopod are rather weak especially the coxa-endite, and the setae on both endites are short and not yet spiny. The exopod is small (this is the last stage where it exists) and has the usual four very plumose setae. The endopod is three-jointed with two, one and four setae on the 1st, 2nd, and 3rd joints, respectively.

The second maxilla is a slender appendage with no clear division between coxa and basis, but with the normal four endital lobes, two belonging to coxa and two to basis. At the tip of the protopod, towards the endopod, is a small lobe with two setae, this may be the first endopodial joint without a clear separation from the prodopod in this stage. The endopod is only three-jointed and with only two setae on each joint also the distal one, this is a reduced stage for this branch in a third Protozoea. But more remarkable is the exopod because it is lacking the posterior directing lobe (Fig. 178). If this is not only a retarded development, but the case also for the following stages, it is together with the other diverging features in the larva likely to cause it to be considered a separate genus, the more so as these features surely will remain in the adult; only the larva is known at present. The exopod carries four plumose setae.

The first maxillipede consists of a two-jointed protopod and a five-jointed endopod, both with a row of setae on their medial margin and at the tip of the endopod. The exopod is still weak and with some plumose setae on its distal part.

The second maxillipede is much like the first one, only a little smaller as usual in the third Protozoea. The exopod is unjointed, still unfunctioning.

The third maxillipede is only a small bifurcate rudiment with unjointed protopod, exopod and endopod, the two latter are tipped with short, embryonic bristles, and the limb is not much larger than the following five pairs of pereiopods hanging down from the thorax as brushes. Pleopods were not observed. The uropod is developed with a short, unjointed protopod and a fleshy, sausage-shaped exopod and endopod with a few embryonic hairs at the tip. Although the uropods are placed at the side of the telson plate they are still too small and too undeveloped to be a functional part in the tail-fan.

Dimensions:

Total length including rostrum 2.8 mm, carapace 0.9 mm long and about the same in width, rostrum 0.8 mm, abdomen 1 mm.

Distribution and Remarks.

Fig. 65.

This species was taken by the British Antarctic "Terra Nova" expedition 1910 at station 43 off the Atlantic coast of Brazil. That the adult *Solenocera* is not known from this locality is possibly due to lack of investigation; it must be remembered that *Solenocera* never has been found in large numbers,* and that they at day time burrow into the bottom in water of 300–800 m, where very little investigation is done. They may be much more common than generally assumed.

This species is the smallest of the hitherto known *Solenocera* larvae in the third Protozoea stage, and is identical with the larva described by GURNEY in 1924, the present stage is his stage II Fig. 12, but as his description is rather incomplete it has here been re-described. GURNEY had also a larva which he calls stage I, but only in one specimen which was "too distorted for its structure" to be accurately made out, he gives no figure of it. It had no uropods, the third maxillipede was only rudimentary, which shows that it must

* After this paper has gone to press its author has located an area in the Mediterranean, near Naples with large quantities of *Solenocera membranacea.*

be the second Protozoea, if it is the same species as suggested by GURNEY, but against this speaks GURNEY's following remark "it is important to note that there is a pair of large spines on either side between the rostrum and the supra-ocular pair. These spines are branched like those of Sergestids and are lost at the next moult." There is only one *Solenocera*, *S. membranacea*, for which we know the second Protozoea or any *Solenocera* larva younger than the third Protozoea. In *Solenocera membranacea* are no such branched spines or spines which later are lost. On the contrary the numbers of spines remain the same or increase in later stages. We know of no *Solenocera* larva with branched spines, these are only known in Sergestids. So this problem must remain unsolved until more material is collected as unfortunately GURNEY's specimen seems to be lost.

GURNEY mentions in the same paper a third larva, which he calls stage III and figures in Fig. 13. It is a Mysis larva of the same species as the one in Fig. 12, and its length of 4.3 mm indicates that it is the first Mysis stage, but the development of the appendages and especially the uropods and the number of spines and hairs on the carapace, point to the second Mysis stage. As GURNEY, however, gives an incomplete description this can not be decided with certainty until another specimen can be examined, as also the existence of this specimen has not been possible to trace.

The larva of this species is of morphological interest. It is adapted to tropical waters with a low viscosity and has long spines and very long and delicate setae. With the median lobe on its labium it possibly is able to collect detritus, this is also indicated by the well-developed molar part of the mandible and the three movable teeth between the molar and incisor parts. Further this species has a larger latero-posterior marginal spine, a spine which hitherto only is known in the *S. muelleri* larva, also from Brasilian waters, but here the spine is only a small, vestigial process except in the first Mysis and in *S.* sp. larva *aequatorialis* also from the South Atlantic, but from the African side.

Solenocera sp. larva *barbata*

Figs. 181–192.

Localities.

Protozoea III.

"Great Barrier Reef" Exped. St. 46. 14°32′ S–145°32′ E. Inside Cooks Passage. Depth 33 m. 28.2.1925. B.M. 1 spec.
"Great Barrier Reef" Exped.: "Great Barrier Reef." (no further data) B.M. 3 spec.
Discovery St. 276. 5°54′00″ S–11°19′00″ S. 110–0 m, 5.8.1927 B.M. 1 spec.?

This last locality is given with a question mark. The specimen was found in a tube together with 17 Mysis II of *Solenocera membranacea* subsp. *capensis*. It is very unlikely for a species to be known only at the Great Barrier Reef Australia and at the Atlantic coast of Loanda, W. Africa.

Description.

Protozoea III.

Figs. 181–191.

Carapace.

Formula: 1. 2. 3. (4). 7. 10. 11*. 12. 13*. 15. 16*. 18. 20. 24. 25. 26. 27. 29. 30.

The carapace is typical by its long, barbed spines and the very large lateral wing partly covering the mouth appendages. The rostral plate is narrow, of average length and tipped with the long, slender, ventrally curving rostrum. The rostrum is barbed and so are the two long and slender supra-orbital spines, which also extend from the rostral plate at its antero-lateral corners. Both frontal organs are present, the anterior is of average size, but the posterior one is rather small and placed like a cone in a sattle-shaped bridge between and in front of the basis of the medio-posterior marginal spines. These are rather long, slender and have long, toothed filaments at their tips. The antennal spine is not yet present, but in its stead is a long lobe which not only is toothed as usually at the tip, but also furnished along the whole frontal margin forward to the root of the antennal plate with long pointed, filamental teeth. Two of the branchiostegal spines are present, also not yet as proper spines, but as filamental lobes with teeth on their margins. The teeth do not extend posteriorly to the lobes as usually, but begin only on the carapace margin a little in front of the first lobe, and no teeth are found in the space between the two lobes. From the second lobe and back to the postero-branchial groove spine the margin of the carapace has a line of long, curved branchio-lateral spines which is characteristic for this species and not found in any other species dealt with in this or earlier papers. When other species have toothed spines in this place the spines are all in the shape of short, rounded teeth. The postero-branchial groove spine is long, slender and furnished with spine-shaped teeth on both sides so that the branchio-lateral teeth continue directly into the series of teeth of the postero-branchial groove spine. On the surface of the carapace inside the margin behind the anterior dorsal organ can be seen the beginning of a cervical groove. The dorsal or epi-cardiac spine is placed in the medial line midway between the two dorsal organs, it is barbed as all the other spines. Behind the antennal lobes, a little towards the mid-line of the carapace, is a pair of post-antennal spines, and a little farther back nearer the mid-line and the anterior dorsal organ is a pair of pre-hepatic spines. Postero-laterally of these are the supra-hepatic spines.

Abdomen.

Formula, segments I–V: 1. 2. 4., segment VI: 2. 4.

Of the six segments the last one is 2–3 times as long as any of the other segments. Each of the first five segments bears a dorsal spine, which on the first two segments is straight and extended at a right angle from the segment, but on segments three to five backwards curved. The dorsal spine of the second segment is very stout and larger than the other spines. The sixth segment is without a dorsal spine. All six segments have a pair of long lateral spines. These are all slender and, like the dorsal spines, barbed at their tips. A pair of ventro-lateral spines are present on all the abdominal segments, but they are very short except on the sixth segment where they extend ventro-laterally of the uropods.

Telson.

The telson-plate is shorter with a more closed furca than in the preceding species. The cleft of the furca is about 115° and has a small convex lobe at the bottom. Each branch of the furca is furnished with eight plumose setae. Four of these setae are placed on the median or inner margin of the branch, these four setae are decreasing in size towards the bottom of the cleft. The two longest of the eight setae are placed at the tip, and two other, a little shorter, laterally on the exterior side of the branch.

Appendages.

The first antenna is divided into the four joints as usual for the third Protozoea and with 1, 1, 2, 2 setae on the medial side and 0, 1, 1, 2 on the lateral side. The setae on the tip of the distal joint are placed in two groups.

The second antenna is also typical for the third Protozoea with its unjointed protopod. The exopod is also still unsegmented and provided with its swimming setae at the tip and along the more distal part of the medial margin. The endopod is also unjointed, but the setae on its medial margin indicate a division into four joints, as far as they are being placed in three pairs along the margin; five long setae are present at the tip.

The eye balls with the ocelli are of a globular shape, and the eye-stalk or base of the eye is a long cylinder with an only small ocular papilla.

The upper lip is semiglobular.

The mandible is rather small for the stage with a not yet clear division between incisor and molar parts in so far as the proper molar teeth are not yet developed on the molar part, which at this stage still is furn-

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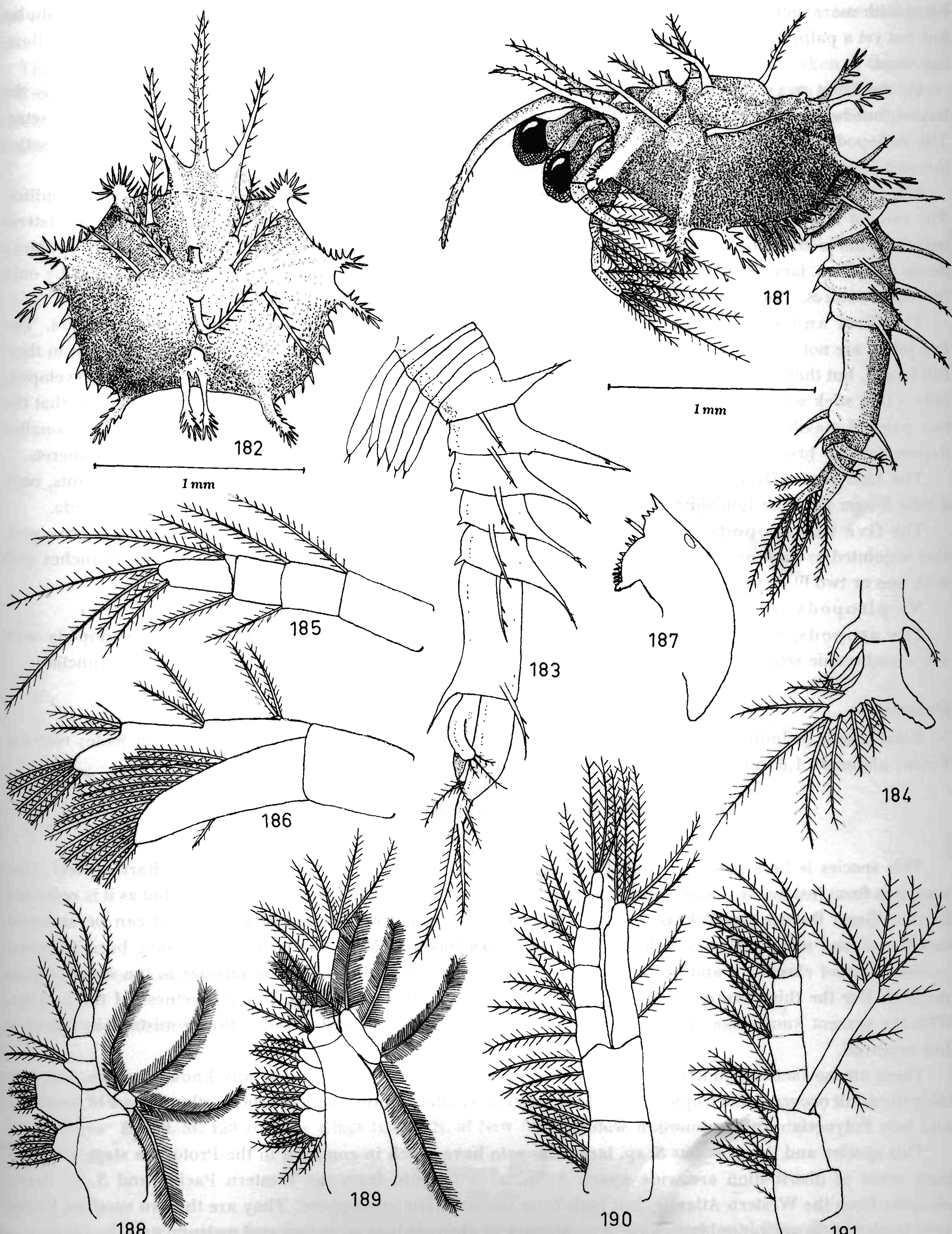
Figs. 181–191. ***Solenocera*** **sp. larva** ***barbata*****. Third Protozoea. Fig. 181, larva from lateral. — Fig. 182, carapace from dorsal. — Fig. 183, free thorax segments, abdomen and telson, all from lateral. — Fig. 184, last part of sixth abdominal segment with uropod and telson. — Fig. 185, first antenna. — Fig. 186, second antenna. — Fig. 187, mandible. — Fig. 188, first maxilla. — Fig. 189, second maxilla. — Figs. 190–191, first and second maxillipedes.**


182
1 mm
181
1 mm
183
185
186
187
184
188
189
190
191
0,5 mm

ished with more incisor-shaped teeth. Between the two parts is a single stalked tooth. The corpus mandibulae has not yet a palp, but a small impression can be seen on its surface where the palp will appear in the following stage.

Of the first maxilla the protopod is two-jointed with a coxa-endite and basi-endite, the latter is the largest, but both show a clearly embryonic stage. The exopod is vestigial, but has still all four plumose setae. The endopod is divided into the usual three joints for this larval stage. The proximal joint with two setae, the mid-joint with a single seta and the distal joint with four terminal setae.

The second maxilla has a two-jointed protopod, each joint has two small yet not well developed endites. The exopod is a small lobe with five, plumose setae: two on each end, and one at the middle of the lateral margin. This is the same as in *Solenocera membranacea* in the third Protozoa, but one more than *S.* sp. larva *danae* and *S.* sp. larva *elongata*. The endopod is long, slender and seems to be divided into five joints by only indistinct sutures. The number of the setae of the endopod are 3, 2, 2, 2, 3.

The first and second maxillipedes have a two-jointed protopod and a five-jointed endopod. The five joints are not yet very clearly seen on the second maxillipede, and the joints are not yet stretched to their full length, but they have already many marginal setae. The exopods of the two limbs are even less developed, only a thin stick with a few, not yet functioning, swimming setae. It is clear, especially in this species, that the two pairs of maxillipedes have not yet taken on any of their proper functions. The endopod can to a smaller degree help by brushing the food to the mouth, but the exopods are not yet much worth as swimmerets.

The third maxillipede is only a small, rudimentary, two-branched limb without separate joints, only a little longer than the following thoracopods, see Fig. 183 where the first limb is the third maxillipede.

The five thoracopods are only very rudimentary as usual in this stage, with an unjointed protopod, and unjointed exopod and endopod, often without sutures between the protopod and the two branches and with one or two embryonic setae at the tip of the branches.

No pleopods are visible in this stage except the sixth pair.

The uropods, which consist of a short unjointed protopod and lobe-like exopods and endopods with a few embryonic setae at their tips, are placed at the side of the telson, but are still without any function.

Dimensions:

Total length including rostrum 4 mm; carapace without rostrum 1 mm long and 1.2 mm wide; rostrum 1 mm; abdomen 1,6 mm.

Distribution and Remarks.

Fig. 192.

This species is here recorded from Queensland in Eastern Australia, inside the Great Barrier Reef. One sample is from just inside Cooks Passage, for the other one is only stated Great Barrier Reef, but as it is collected by the "Great Barrier Reef" Expedition 1928–29 which did not collect in a wider area, it can be assumed that the second sample also is collected close to Cooks Passage. Most likely the larvae have been spawned outside the reef close to it and by the tide or other currents carried through the passage to the waters inside the reef. For the third sample from W. Africa one may be allowed to doubt the correctness of the locality. With the present knowledge of the species and the distribution it is well possible that a mistake in labelling has occurred.

There are no facts for judging to which adult species the larva belongs, if to any known species, but possibly the adult occurs in the tropical part of the western Pacific Ocean ranging to the northern coast of Australia and into Polynesian and Indonesian waters.

This species and the previous *S.* sp. larva *elongata* have much in common in the Protozoea stage although their areas of distribution are wide apart: *S.* sp. larva *barbata* from the Western Pacific and *S.* sp. larva *elongata* from the Western Atlantic, but both from the southern hemisphere. They are the two smallest Protozoea larvae in the collection, both have a carapace with strongly barbed spines and rostrum, and the filamental teeth along the margin of the carapace are not small and rounded as in the other species, but long, pointed and awl-like. They have both like the following species two branchiostegal spines. It would be interesting to learn whether the Mysis stage will change the number up or down.

This larva seems to have much resemblance to FRITZ MÜLLER's larva Fig. 18 from 1863 taken at the coast of Brazil, but the telson in the two species MÜLLER's and *S.* sp. larva. *barbata* are of quite different types which should exclude that they belong to one and the same species, also the great distance between the two localities makes this unlikely.

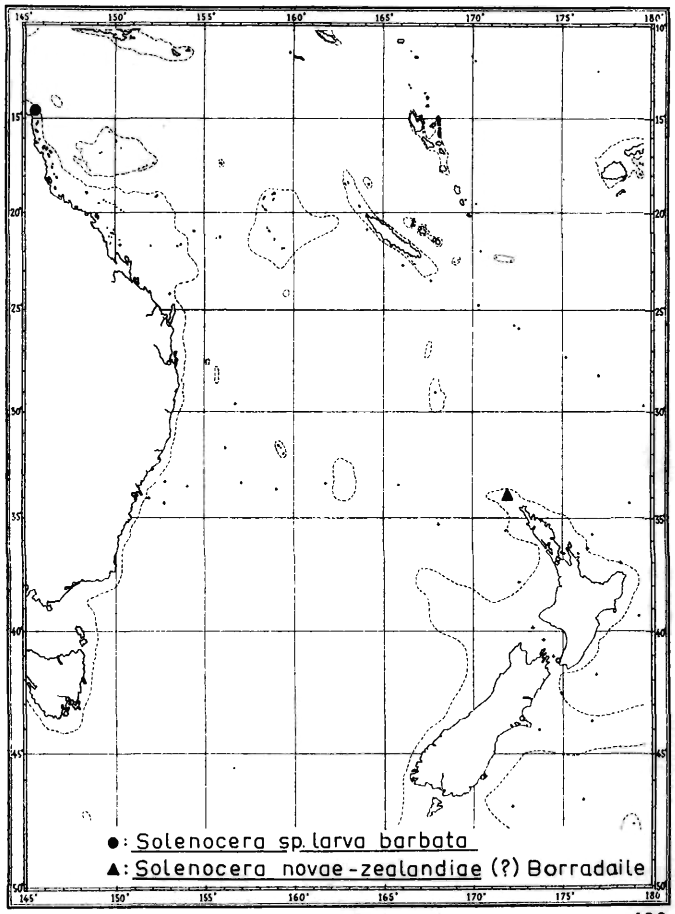


Fig. 192. Map of distribution.

Solenocera novae-zealandiae (?), BORRADAILE.

Figs. 192–204.

Solenocera novae-zealandiae BORRADAILE 1916, pp. 79–80, Fig. 1.

Larvae:

Solenocera novae-zealandiae(?) GURNEY 1924, pp. 76–77, Figs. 14, 15.

Localities.

Protozoea III.

"Terra Nova" Exped. St. 129 at Three Kings Islands N. of New Zealand. B.M. 1 spec.

Protozoea III.

Figs. 193–204.

A single third Protozoea in a bad state of conservation was observed in the material from British Museum. Due to the poor state of preservation the figure of the whole larva (Fig. 193) is taken from GURNEY's figure.

Description.

Carapace.

Formula: 2. 3. 7. 10. 11. 12. 13*. 16*. 18. 20. 24. 26. 27. 30.

This small Protozoea has a short, squarish carapace, a little wider than long and not nearly covering the thorax. The rostrum is long and slender and as usual in this stage without teeth. The eye-stalks are long; above them are the supra-orbital spines. The antennal spines are only a broad process with filamental teeth. Farther back on the margin are two branchiostegal processes of which the anterior is short and rounded, the posterior elongate and curved backwards, both are lined with filamental teeth. A little behind the posterior one the filamental teeth start again along the margin. These branchio-lateral teeth, continue until the postero-branchial groove spines which also are covered with filamental teeth; between this last pair of spines is an unpaired, rather wide medio-posterior marginal spine. The spine itself is very short, but its broad tip is covered with filamental teeth.

On the inner surface of the carapace are an anterior and a posterior dorsal organ, both relatively small. Between these organs and in the medial line are the dorsal or epi-cardiac spine and between this and the anterior dorsal organ the pair of pre-hepatic spines, one on each side. No more spines are found on the carapace of the first Protozoea. The thorax is divided into its segments, but these are not yet all covered by the carapace.

Abdomen.

Formula, segments I–V: 1. 2., segment VI: 1. 4.

All six segments are developed each with one dorsal and one lateral spine, except for the last segment where the lateral spine is substituted by a pair of ventro-lateral spines. The lateral spines are large, nearly as large as the dorsal spine, and make only a small angle of about 30° with this spine.

Telson.

The furca is wide open and has only seven setae on each branch, the normal is eight setae, one is missing on the lateral margin.

Appendages.

The first antenna is slender and four-jointed. The division between the second and third joint is not so strongly developed as the rest, and no setae are attached to the 2nd joint, but only to the latero-distal corners of joints one and three. The last joint has three terminal setae.

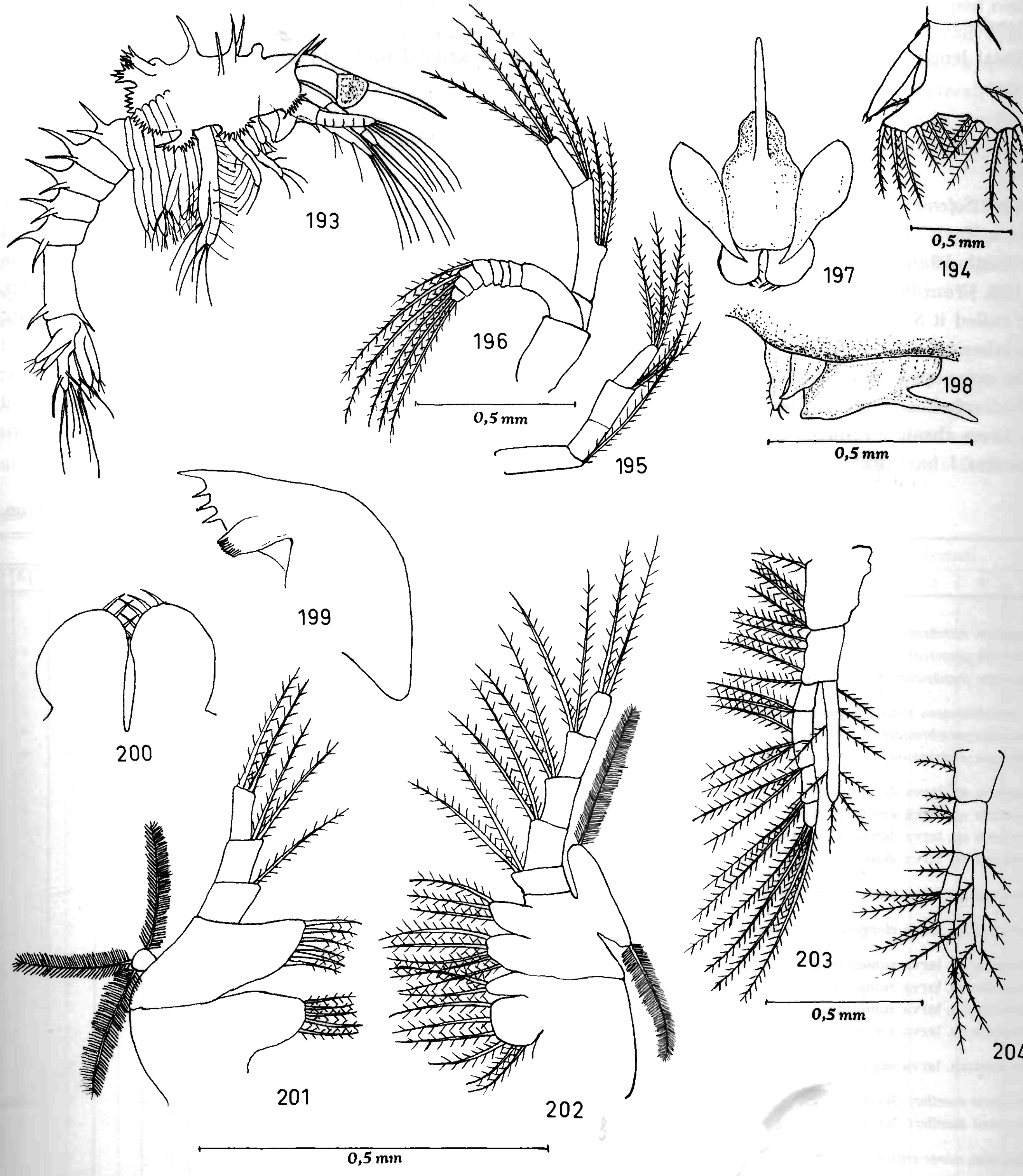
The second antenna has an unjointed protopod and a several-jointed exopod with long swimming setae at the distal end. The endopod is three-jointed with a short first joint and a long second joint, the latter has a notch midway on the lateral side with two setae, which indicates a coalescence of two joints. This joint is also twice as long as the following joint, which is tipped with three setae.

The labrum is large and with a spine on its surface, the spine is a little curved and points forward. A similar spine on the labium was also found in the third Protozoea of *Solenocera* sp. larva *elongata*, only here it was much longer and S-shaped. But there is a great distance between their localities: *elongata* from the coast of Brazil and the other from north of New Zealand.

The mandibles are stout and strongly bent, with three pointed teeth in the incisor part, one larger corner tooth and a strongly developed molar lobe. The labium or lower lip is relatively short and split right to the base.

The first maxilla is normal with two lobes of about equal sizes, a three-jointed endopod and a small exopod with three plumose setae. Also the second maxilla is as typical for the stage. The four endites are of nearly equal sizes, only the most proximal is a little larger than the rest. The endopod is five-jointed and the exopod is still fleshy with an anterior and a posterior lobe each tipped with a single seta; there may have been more setae as one or two setae may have been lost due to the preservation.

The first and second maxillipedes are not yet swimmerets, the first is sooner functioning as a mouth appendage with many catching setae on its medial margin. The protopod is two-jointed, the endopod five-jointed in the first maxillipede and only four-jointed in the second maxillipede. The exopod is short and unjointed and still without proper swimming setae. No gills or gillbuds were yet seen on the protopod.



Figs. 193–204. *Solenocera novae-zealandiae?* Third Protozoea. Fig. 193, larva from lateral (drawn after GUERNEY's figure). — Fig. 194, telson. — Fig. 195, first antenna. — Fig. 196, second antenna. — Fig. 197, labrum. — Fig. 198, same from lateral. — Fig. 199, mandible. — Fig. 200, labium. — Fig. 201, first maxilla. — Fig. 202, second maxilla. — Figs. 203–204, first and second maxillipedes.

The third maxillidepe and the five pairs of thoracopods are only in a rudimentary state consisting of an unjointed protopod with exopod and endopod, the last two branches are tipped with a few embryonic setae; these limbs have not yet reached a functional size.

Of the pleopods there are only the uropods which are small, not quite reaching the tip of the telson furca and unfunctioning.

Dimensions:

Total length 4 mm; length of carapace 1 mm, width of same 1 mm; rostrum length 0,8 mm; abdomen 1,5 mm.

Distribution and Remarks.

Fig. 192.

This *Solenocera* larva was described by GURNEY in 1924, but not in detail. He had his material from the "Terra Nova" Expedition Station 93, 120, and 129, around the Three Kings' Islands at the northern tip of the North Island of New Zealand. The one specimen available for this description is from that expedition St. 129. From the same expedition BORRADAILE described a new species of *Solenocera* on an adult specimen, and called it *S. novae-zealandiae.* There was only a single specimen, a male, of *Solenocera* in his collection, also taken close to the position where the larvae were taken. This caused GURNEY to suggest that they belonged to the same species and he therefore gave the larvae the name of the adult. The adult has the following spines: orbital spine, antennal spine, post-antennal spine and hepatic spine. The larva has only the two first, but this is no absolute indication that more may not develop in later stages. Thus, not being able to decide pro or contra I have followed GURNEY and for the present kept the name.

Placement of Spines and Filaments on Carap

	Carapace														
	1	2	3	4	5	6	7	8	9	10	11	11*	12	13	13*
Solenocera membranacea Protozoea III	+	+	+		+		+			+	+		+		+
Solenocera membranacea Mysis I	+	+	+	(+)	+	(+)	+	+	+	+	+		+	+	
Solenocera menbranacea Mysis II	+	+	+	+	+	+	+	+	+	+	+		+	+	
Sol. membranacea subsp. *capens.* Protozoea III	+	+	+		+		+			+	+		+		+
Solenocera membranacea subsp. *capens.* Mysis I	+	+	+	(+)	+	(+)	+	+	+	+	+		+	+	
Solenocera membranacea subsp. *capens.* Mysis II	+	+	+	+	+	+	+	+	+	+	+		+	+	
Solenocera sp. larva *danae* Protozoea III		+	+	+			+					+	+		
Solenocera sp. larva *danae* Mysis I		+	+	+			+		+				+	+	
Solenocera sp. larva *danae* Mysis II		+	+	+			+		+				+	+	
Solenocera sp. larva *danae* Mysis III		+	(+)	+			+		+				+	+	
Solenocera sp. larva *barbata* Protozoea III	+	+	+	(+)			+			+		+	+		+
Solenocera sp. larva *elongata* Protozoea III		+	+		+		+			+		+	+		+
Solenocera sp. larva *sumatransis* Mysis I	(+)	+	+		(+)		+	+	+	+	+		+	+	
Solenocera sp. larva *sumatransis* Mysis II		+	+	(+)	(+)		+	+	+	+	+		+	+	
Solenocera sp. larva *sumatransis* Mysis III		+	+	(+)	+		+	+	+	+	(+)		+	+	
Solenocera sp. larva *sumatransis* Mysis IV		+	+	(+)	(+)		+	+	+	+	(+)		+	+	
Solenocera sp. larva *aequatorialis* Mysis II		+	+	+	+	+	+	+	+	+	+		+	+	
Solenocera muelleri Mysis I	+	+	+	+	+		+	+	+	+		+	+	+	
Solenocera muelleri Mysis II	+	+	+	+	+		+	+	+	+	+		+	+	
Solenocera novae-zealandiae Protozoea III		+	+				+			+	+		+		+
Solenocera sp. larva *nodulosa* Mysis II		+	+	+		+	+		+		+		+	+	

Numbers in second line refers to numbers on Figs. 1 and 2. A bracket around the + for the section on carapace means that the organ in que[...] dominal segment. An asterisk after the number indicates that the organ is furnished with a toothed filament.

Relation between the Species of Solenocera.

The material is still too small for defining the relation between the different species based on the larvae. Only some suggestions can be made. We first have the group which may be called the *membranacea* group to which belong *S. membranacea*, *S. membranacea* subsp. *capensis*, and *Solenocera muelleri*, the last possibly the larva of *S. vioscai*. These have all in the Mysis a long rostrum with two dorsal teeth, a well-shaped rostral plate, three branchiostegal spines, a branchio-cardiac groove with lateral spines, medio-posterior spines, latero-hepatic spines and pre-hepatic spines besides the spines of the larvae of most other *Solenocera* species. They have in their second Mysis all five types of spines on the abdominal segment, viz: dorsal, lateral, dorso-lateral, ventro-lateral and ventral spines. The ventral spine is apart from this group only found in the Protozoea of *S.* sp. larva *sumatransis*, not in later stages, and in *S.* sp. larva *nodulosa*. They are carnivorous and all Atlantic forms from both sides of this ocean.

Partly alone, a little separated from the rest stands *S.* sp. larva *nodulosa* and *S. crenatus* (Bate). The first species is the most carnivorous of all the larvae to judge from its mouth appendages. It has developed six most characteristic cones on the carapace, two dorsal and two on each side of the carapace. The gills are different from the others by their finger-shaped form; the telson plate is very wide and flattened. The species is from the Indian Ocean at the Seychelles.

Nearest *S.* sp. larva *nodulosa* stands another species also from the Indian Ocean *S.* sp. larva *sumatransis* from near the North Western point of Sumatra towards the Nicobares. They are both together with *S.* sp. larva *danae* the most carnivorous of the larvae. The gills of *S.* sp. larva *sumatransis* are of an intermediate shape between *S.* sp. larva *nodulosa* and the rest by in a way also being finger-shaped, but with an oblique arrangement of the fingers which are slanting toward the proximal part of the gill where the fingers are longer

…apace and Abdomen of *Solenocera* larva.

	Carapace																		Abdomen				
14	15	16	16*	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5
	+	+		+	+	+	+			+	+	+	+	+		+	+		+	+			
	+	+		+	+	+	+			+	+		+	+			+		+	+	+	(+)	+
	+	+		+	+	+	+			+	+			+					+	+	+	(+)	+
	+	+		+	+	+	+			+	+	+	+	+		+	+		+	+			
	+	+		+	+	+	+			+	+		+	+			+		+	+	+	(+)	+
	+	+		+	+	+	+			+	+			+					+	+	+	(+)	+
	+				+	+					+	+	+	+			+		+	+			
	+	+			+	+					+			+				+	+	+			
	+	+			+	(+)					+			(+)				(+)	+	+			
	(+)	+			+	(+)					+								+	+			
	+		+		+		+				+	+	+	+		+	+		+	+		+	
	+		+		+	+			+	+	+	+			+	+	+	+	+	+		(+)	
	+			+	+		+				+	+	+	+	+	+	+		+	+	+	(+)	+
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+		+			+	(+)			(+)	+	+			+		(+)	(+)		+	+	+	+	+
			+		+						+		+	+			+		+	+		(+)	
	+	+								+	+			+					+	+		(+)	+

…question was only vestigial. A bracket around the + for the abdomen indicates that for this section the spine in question is only present on the sixth aband branched. Further both species have hairs on the mastigobranchiae. The exopods on the first and second maxillipedes are very small. The exopods on the following thoracopods are extraordinarly large, especially in *S.* sp. larva *nodulosa* where coxa has developed an extra process for the fastening of the very strong adductor muscles of the exopod. *S.* sp. larva *nodulosa* is the only known species without a dorsal spine on the carapace. *S.* sp. larva *nodulosa* has a single branchiostegal spine, *S.* sp. larva *sumatransis* is lacking this spine, but has developed strong branchiostegal lobes.

Solenocera sp. larva *danae* also from the Indian Ocean is very characteristic with its extremely long postero-branchial groove spines which are well developed already in the third Protozoea, but become larger and larger with each moulting and in the last known instar, the third Mysis, they reach backwards behind the abdomen. This species, together with *S.* sp. larva *sumatransis,* both from the Indian Ocean, are the only two species for which we know with certainty that they have more than two Mysis stages. Of *S.* sp. larva *sumatransis* are here described four Mysis stages, and they may even be followed by still more Mysis stages. *S.* sp. larva *barbata* and *S.* sp. larva *elongata,* for both of which only the third Protozoea is known, have two branchiostegal spines and all the spines of the carapace are strongly barbed. But they have also other features of the carapace in common viz. a dorsal spine, paired medio-posterior marginal spines, post-antennal spine, pre-hepatic spine and very slender dorsal spines. Both have further lateral spines on the abdomen. They are not strongly carnivorous, but sooner feaders of detritus or of smaller plankton organisms.

Near these two species stands *S. novae-zealandiae* which has no barbed spines, but like *S.* sp. larva *elongata* a spine on the labrum; it seems also in several other, minor, points near to these two species.

More aside stands *S.* sp. larva *aequatorialis,* but with certain relations to the first group, *S. membranacea.*

Although the number of known larval species described is rather limited the following grouping of them is ventured:

I. The Atlantic group.

a. *Solenocera membranacea*
— — subsp. *capensis.*
— *muelleri*
b. *Solenocera* sp. larva *aequatorialis.*
c. *Solenocera (Platysacus) crenatus* (BATE) 1888.

In this group we find the largest number of spines placed on a more or less haired carapace. All species are from the Atlantic Ocean but from both sides. The three first (a) are very closely related so it can be discussed whether they are to be looked upon as separate species or only as geographical subspecies of one and the same species. Close to them stands *S.* sp. larva *aequatorialis* (b) and *Solenocera crenatus* (BATE) (c), both from the aequatorial region of the Atlantic Ocean.

II. The Indian Ocean group.

a. *Solenocera* sp. larva *nodulosa*
— — — *sumatransis*
b. *Solenocera* sp. larva *danae.*

These are all three from the Indian Ocean. From the development of their mouth appendages, they are the most carnivorous of the *Solenocera* larvae, and in the two last species we have more than two Mysis stages. In the present paper are described four Mysis stages in *S.* sp. larva *sumatransis* and three Mysis stages in *S.* sp. larva *danae.* Of *S.* sp. larva *nodulosa* the material only includes a single specimen in the second Mysis stage, so nothing definitely can be stated as to number of Mysis stages, but because the specimen is very larval in several features, e.g., the mandibular palp and the pleopods, it is certain that also here at least one more Mysis stage must follow before reaching the post-larva.

In *S.* sp. larva *nodulosa* and in *S.* sp. larva *sumatransis* the gill filaments extend from a stalk in a finger-shaped arrangement, but in *S.* sp. larva *danae* the gill-filaments are arranged as in the *membranacea* group with a main stem and the filaments extending dicotomally along the sides of the stem.

III. The Austral-Asian group.

a. *Solenocera* sp. larva *barbata.*

— — — *elongata.*

b. *Solenocera novae-zealandiae*?

The two first are only known in the third Protozoea stage in which they have strongly barbed spines on the carapace and long, delicate dorsal and lateral spines on the abdomen. Their mouth parts seem more adequate for a food of detrius and smaller plankton organisms than for a strongly carnivorous life. Close to them stands *S. novae-zealandiae*? Borradaile, however, without barbed spines on the carapace.

CERATASPIS AND CERATASPIDES

History.

The genera *Cerataspis* and *Cerataspides* include some large oceanic larvae of which we at present know three different species: *Cerataspis monstrosa, C. petiti,* and *Cerataspides longiremis,* all the rest so far described are synonyms to one or the other of these three species. The first description is by Gray in 1828 in his album of "New and unfigured animals". He gives a short description of and figures a crustacea under the Schizopoda family Nebalidae, which was found in the stomach of a dolphin off the coast of Brazil. The crustacea was named *Cerataspis monstrosa* referring to its unusual appearance. – In 1837 *Cerataspis monstrosa* was again figured by H. Milne-Edwards in Cuvier's Règne Animal as *Cryptopus defrancei,* and by Quoy 1839 under the name *Lepsia tuberculosa.* In 1889 a *Cerataspis* was described, this time by Spence Bate and given the name *Ophthalmeryon transitionalis* and was referred to the Brachyura. The specimen was also from the stomach of a dolphin, caught at the British Islands, it was badly damaged and in a dried state when received by Bate. This possibly caused some differences in the appearance of the sculpture of the carapace from the previous records of *Cerataspis monstrosa,* to which it probably belongs. There is, however, a slight possibility that it represents a fourth species, only recorded this single time and not since. This view was held by Bonnier (1899, p. 48) who listed it as a *Cerataspis transitionalis.* By a peculiar mistake Bouvier (1917, p. 31) refers it to *Cerataspis longiremis. Cerataspis monstrosa* was again described and more detailed by Dohrn (1871, pp. 362–66, Figs. 33–34).

The next species *Cerataspis petiti* was first described by Guerin in 1844 p. 18 in his Iconographie du Règne Animal du Cuvier. Two specimens were taken from the stomach of a dolphin caught in the Indian Ocean. Unfortunately I have not been able to obtain access to the text of this book, but in the plates, Pl. 23, Fig. 3. *Cerataspis monstrosa* is figured. In 1892 *Cerataspis petiti* was again described, but not figured, by A. Giord and J. Bonnier on the two specimens from the Indian Ocean.

The third species *Cerataspides longiremis* was first described by Dohrn (1871, pp. 366–372, Figs. 35–47) and later by Boas 1880, and Pesta (1916, p. 80, Fig. 14) figures a new specimen under Decapod larva (Mysis stage). In 1899 Bonnier suggested the generic name of *Cerataspides* for this species to separate it from the two others. In 1888 p. 323 it was described by Bate under the name *Peteinura gubernata.*

Boas 1880 (pp. 42–47) considers *Cerataspis* as larval forms belonging to the Penaeidae. He gives full reason for this, and his view has been accepted by all following authors.

Giard and Bonnier (1892) refer *Cerataspis* to Penaeids and suggest that the genus holds a position to the other Penaeids similar to that which the Brachyura hold to the Macrura. They further suppose that the Protozoea larva described by Dohrn (1871, p. 377) and by Claus (1876, p. 17) may be the Protozoea of *Cerataspis.* Bouvier (1908) finds that the peculiar shape of *Cerataspis* with a tuberculous thorax and a small, reduced abdomen is caused by a long, pelagic life of the larva. He mentions that the small abdomen may have caused Giard and Bonnier to find a resemblance to the Brachyura and concludes that *Cerataspis* most likely is a larva of *Aristeomorpha* or at least belongs to the subfamily Aristeidae.

Burkenroad (1936 p. 85) declares without reference to previous investigators and without any further explanation that *Cerataspis monstrosa* Gray is the larval form of *Aristeomorpha foliacea* (Risso), that *Cerataspis petiti*, Guerin, is the Mysis stage of *Aristeomorpha wood-masoni* Calman, and that *Cerataspis longiremus* Dohrn is the Mysis stage of *Plesiopenaeus*, concluding: "If the present allocations are confirmed *Aristeomorpha* is a synonym of *Cerataspis* and *A. wood-masoni* of *C. petiti*". However, in 1956 Mme Heldt described the larval development of *Aristeomorpha foliacea* which was of the normal Penaeid type and with no closer resemblance to *Cerataspis*.

Description.

Carapace.

Both in *Cerataspis* and in *Cerataspides* the carapace is provided with various spines, bulbs and tubercles as floats for supporting their pelagic life in the oceans, mainly over great depths of more than 2000 m.

Both genera are furnished with dorsal tubercles on the carapace. *Cerataspis* has four pairs of large tubercles placed dorsally in a longitudinal line on each side of the mid-line from just behind the cephalic groove to the posterior margin of the carapace. In *Cerataspides* only the anterior pair of tubercles are developed. Further both genera have on each side of the carapace a large oval swelling. In *Cerataspis* the swelling is of rather large dimensions, with a velvet surface of different patterns in the two known species, in *Cerataspides* the swelling is still considerable, in comparison with the size of the individuals, although less dominant (in comparative size).

In *Cerataspis* the carapace further has two pairs of very characteristic spines developed into large, curved horns (which also are supporting the buoyancy of the larva) these are both placed anteriorly representing the dorsally pointing post-orbital spines and the ventrally pointing pterygostomian spines. These spines are both missing in *Cerataspides* which instead has several more, but minor, spines of which the supra-orbital, the post-antennal, one of the hepatic, and the ventro-cardiac spines are the largest. All these four spines are paired with one on each side. An additional number of still smaller spines are present on the carapace. The rostrum is in *Cerataspis* short, smooth and bent ventrally, whereas it is long, spiny, straight and forwards pointing in *Cerataspides*. In both genera the carapace extends latero-posteriorly in a pair of alae which are largest in *Cerataspis*, and both genera have an anterior and a posterior dorsal organ like those in *Solenocera*. The margin of the carapace is smooth in both genera in difference to what is the case in *Solenocera*.

Abdomen and Telson.

The six-segmented abdomen is short in *Cerataspis* and bent in underneath the thorax. It has lateral pleura on the first five segments, but no spines except one ventral spine on the sixth segment. In *Cerataspides* all the segments have spines, both dorsal, ventral and lateral spines, and the sixth segment is enormously elongated, being longer than the whole thorax.

The telson is of the general penaeid shape in both genera with a furcal cleft and three lateral spines on each side. In *Cerataspis* the older stages have two longitudinal keels on the dorsal side of the telson running from the root of the telson to the first lateral spine. *Cerataspis* has six setae on each side of the furcal cleft. *Cerataspides* has no keels, and as many as seven setae on each side inside the furcal cleft.

Appendages.

First Antenna.

In *Cerataspis* the first antenna has a three-jointed peduncle throughout the five Mysis stages, with a statocyst starting to develop in the basal joint. The two flagella are of equal lengths in the first Mysis. The olfactory, lateral one grows a little thicker in the following stages but remains otherwise the same, whereas the medial one grows in length for each stage adding more and more rings to the already existing ones.

In *Cerataspides* both the first and the second antennae are much elongated. The first antenna is to begin with tipped with a brush of setae, and when the two flagella appear in the first Mysis the medial one is very short and unjointed. The lateral and olfactory flagellum is jointed already in this stage with a large basal joint and some small distal joints. In the following stages the lateral flagellum develops most rapidly and when reaching the fifth Mysis we have a very characteristic flagellum with two sections (Fig. 331): a basal thick and olfactory part and a long and slender distal part. A large hook-shaped spine, which not is the later statocyst spine, is already present in the first Mysis placed far up the stem, but of the statocyst nothing is present before in the fourth Mysis.

Second Antenna.

The second antenna has in *Cerataspis* already in the first Mysis a short, annulated, endopodial flagellum and the beginning of an antennal scale. The antennal scale enlarges with each stage, and so does the endopodial flagellum, which in the fifth Mysis is longer than the thorax. It is characteristic that the spine of the antennal scale is missing in *C. monstrosa* and is vestigial in *C. petiti* but large in *Cerataspides.*

In *Cerataspides* the second antenna has throughout the Mysis stages a large lateral spine on the antennal scale and an endopodial flagellum which does not become nearly as elongate as in *Cerataspis.* The distal margin of the antennal scale is rounded in *Cerataspis,* but nearly square-cut in *Cerataspides.*

Eye.

The eyes are large and stalky in both genera.

Labrum.

The labrum is both in *Cerataspis* and *Cerataspides* a large, semiglobular body, and the labium is provided with the usual two lobes.

Mandible.

The mandible is large in both genera with a single tooth in the incisor part and a small molar part which is smaller in *Cerataspides* than in *Cerataspis.* Both parts have a cutting ridge from the single incisor tooth to the molar part. This ridge is more curved in *Cerataspis* and nearly straight in *Cerataspides.* Both genera have a three-jointed palp which develops more and more setae with each ecdycis; the three joints must be looked upon as a primitive character.

Maxillae.

The first maxilla is non-characteristic. The endopodial palp is small and the protopod has a basi-endite with toothshaped setae and a smaller coxa-endite with more bushy setae.

The second maxilla is also ordinarily built, only in the fifth Mysis of *Cerataspides* the lateral margin of the endopod is provided with a series of setae which is very characteristic and unusual.

Maxillipedes.

The first maxillipede is much alike in both genera. The protopod is large and only partly divided, only in later stages of *Cerataspides* it develops an extra series of setae on the lateral side behind the marginal setae. The endopod is always five-jointed, and the exopod has at its base a lateral setal lobe which is bent in over the endopod so that the originally laterally pointing setae point in a medial direction. This lobe appears later in the development, but attains a larger size, in *Cerataspides* than in *Cerataspis.* The first maxillipede bears in both genera a large double mastigobranchia and a small arthrobranchia.

The second and third maxillipedes are both very setose catching legs, which especially in *Cerataspides* develop several lines of long, stiff setae almost all pointing medially. The gills are one mastigobranchia, one podobranchia, one arthrobranchia and two pleurobranchiae, in *Cerataspides* I could only find one pleurobranchia on the second maxillipede. Here it is interesting to note that in the younger stages the podobranchia starts as a branch from the mastigobranchia, but later it separates from this and moves a little higher up on the coxa. The exopods from the second maxillipede and backwards are all strong swimmerets in both genera throughout the Mysis stages.

Pereiopods.

The three first pereiopods develop in *Cerataspis* already from the first Mysis a beginning chela. In *Cerataspides* this chela is less developed in the fifth Mysis than in the first Mysis of *Cerataspis.* Instead *Cerataspides* develops far more long, stiff setae on both endopod and protopod than any of the stages of *Cerataspis.* The gills on pereiopods one to four are the same as on the third maxillipede.

The fourth and fifth pereiopods never develop chelae, and they grow to their maximal length much later than the three first pairs. In *Cerataspis* they never reach a length comparative with that of the three anterior ones, and in *Cerataspides* they first reach such a length in the fifth Mysis. As already mentioned the exopodial swimmerets are very strongly developed on all pereiopods in the Mysis stages. The fifth pereiopod has only a single pleurobranchia and no other gills.

Pleopods.

The pleopods develop later than the pereiopods. In the first Mysis they are only small limb-buds. In *Cerataspis* they all become bifurcate in the second Mysis, but in *Cerataspides* the last three pairs only reach this stage with the fourth Mysis. The two first pairs develop first a small endopodial branch in the fifth Mysis.

Gills.

In Boas' description of the gills (1880) he made no distinction between the arthrobranchiae and the pleurobranchiae. Further the podobranchia was by Boas described as a gill branch from the epipod here called the mastigobranchia. I have also seen how the later podobranchia first starts as a gill-branch from the mastigobranchia, and in later stages of the larvae it separates from this and grows out independently from the coxa itself. To indicate the difference of this I have in the formulae placed the number of podobranchiae inside a bracket when the gill still is a side-branch from the epipod or mastigobranchia. The number without a bracket indicates that the gill extends from the coxa itself separated from the mastigobranchia. Further from the localities given by Boas it can be stated that his *Cerataspis monstrosa* was a second Mysis and his *Cerataspides longiremus* a third Mysis stage.* In *Cerataspides* I found no podobranchia in the second Mysis, in the third Mysis the material did not allow a clear counting of the gills, but in the fourth Mysis the podobranchiae were found independent from the mastigobranchiae on maxillipede two to pereiopod one and attached onto the mastigobranchia on pereiopod two and three, which indicates as mentioned by Boas that the three free podobranchiae in the fourth Mysis were attached to the mastigobranchiae in the third Mysis.

Uropods.

The uropods are normally built in *Cerataspis* and fairly well developed already in the first Mysis. In *Cerataspides* they are also developed already in the first Mysis, the endopod is normally developed, but the exopod is shaped into an enormous long band or float about twice the total length of the whole larva.

Larval Stages

Mysis I.

This stage is the youngest known stage in both genera and can be recognized not only by its size but also by its unjointed flagella of the first antenna in *Cerataspis* and by the unjointed medial flagellum and the lateral flagellum with a large basal joint and a few small distal joints in *Cerataspides.* Further in *Cerataspides* the first Mysis has four joints in the peduncle of the first antenna. The flagellum of the second antenna is in

* The author has examined both Boas' specimens.

Cerataspis nearly twice the length of the antennal scale, in *Cerataspides* it is jointed but very short less than one fifth the length of the antennal scale. The mandibular palp is three-jointed, but has only a few setae. The pereiopods four and five have each only a short, unjointed endopod. The pleopods are small, uniramous and unjointed limb-buds in both genera.

Mysis II.

The larva has grown in size, especially in *Cerataspides* it has been much elongated. The flagella of the first antenna are still unjointed in *Cerataspis,* and in *Cerataspides* the first and second joints of the peduncle have coalesced. The flagellum of the second antenna is in *Cerataspis* nearly reaching the tip of the pterygomian spine or horn, in *Cerataspides* it has only enlarged a little. In *Cerataspis* the first maxillipede has developed an arthrobranchia, and the fourth and fifth pereiopods have both a five-jointed endopod. In *Cerataspides* all the periopods have developed more stiff setae, the gills are only small gill-buds, the endopods of the fourth and fifth pereiopods are now also five-jointed in *Cerataspides,* the pleopods are still small limb-buds.

Mysis III.

Only small changes have taken place except about 50 per cent growth in size in *Cerataspis* and a little less in *Cerataspides.* In the latter species the first antenna has still two unjointed flagella, but the medial one which in the two preceding stages were even a little shorter than the lateral one is now the longest, about fifty per cent longer than the lateral one. In *Cerataspides,* however, the lateral, olfactory, flagellum is about 50 per cent longer than the medial one, and in both the large basal joint has grown, and more smaller distal joints have been added. In *Cerataspis* the flagellum of the second antenna is now about twice as long as the pterygostomian spine. The mandible shows a clear separation between the incisor and molar parts, and a suture divides caput mandibulae from corpus mandibulae. In *Cerataspis* the fifth pereiopod has developed a pleurobranchia, and in *Cerataspides* the endopod of the fourth pereiopod which became five-jointed in the preceding stage, has developed several setae, the endopod of the fifth pereiopod has still only very few setae.

The pleopods in *Cerataspis* are small, but they are now all divided into protopods and exopods, and the last two ones have also a diminutive endopod. In *Cerataspides* the last two pairs have enlarged, but are still both unjointed and uniramous consisting of a non-divided protopod and exopod.

Mysis IV.

Cerataspis has grown to a total length of 22–23 mm, *Cerataspides* has grown to not less than 40 mm, but the rostrum and the last abdominal segment count for the larger part of the growth. Only smaller changes occur. In *Cerataspis* the medial flagellum of the first antenna has grown and developed a few rings. The flagellum of the second antenna has enlarged further, the antennal scale has developed more setae along its margin, and the statocyst has continued its development since the second Mysis. In *Cerataspides* the statocyst first starts in the fourth Mysis, the statocyst spine now appears, placed at the lateral base of the first antenna, thus this has two spines: the characteristical medial spine found in *Cerataspides* and the lateral statocyst-spine below. In the second antenna of this genus the endopodial flagellum has become nearly as long as the antennal scale, and the later has a large lateral spine and a brim of setae from the spine around the distal tip and down along the medial margin.

The second and third maxillipedes have developed long, stiff setae on the endopod along the medial and lateral margins. The first three pereiopods have grown a lateral swelling on the fourth joint, the beginning of the fixed finger in the coming chela.

The pleopods of *Cerataspis* have developed further in size. The exopods are long and with embryonic setae on the distal half. The endopods are much shorter and thinner and without setae except at the tip. In *Cerataspides* a suture has appeared between the protopod and the exopod. In number one and two are no endopods present, but number three has developed a small bud for the endopod, and number four and five has a short endopod. Exopods and endopods (where developed) are only tipped with a few embryonic setae, no marginal setae on the exopods, as in *Cerataspis*, were observed.

Mysis V.

This stage is the last known Mysis stage and of much interest because it shows that Penaeids can also have five Mysis stages like the up to five Furcilia stages in the Euphausids. In *Cerataspis* the abdomen remains still very small as in the Brachyuran and some Reptantian larvae. The flagella of both first and second antennae have grown in length, but the olfactory lateral flagellum of the first antenna is still unjointed which is rather remarkable in so late a larval stage. The antennal scale is rounded off at the tip and has either a vestigial or no lateral spine. In *Cerataspides* the statocyst in the first antenna has now got the statical sensecells in its wall and a ventral lobe is growing up to close the groove. The two flagella are of equal lengths and annulated, but the lateral one is divided in a thick basal part with olfactory hairs and a slender distal part without such hairs. The flagellum of the second antenna has also enlarged being now longer than the antennal scale. The latter has a well-shaped lateral spine, marginal setae, and a nearly square-cut tip. The mandibular palp, still three-jointed, has developed many setae in both genera. The endopod of the second maxilla has in *Cerataspides* grown a line of setae also along the lateral margin. In both genera the exopod of the first maxillipede has developed a fan-shaped lobe on its basal half with a line of stiff setae along its lateral margin; this lobe is bent in over the stem so that the setae point medially. In *Cerataspides* the endopods of the two last maxillipedes and of the pereiopods have grown several lines of stiff setae all turned medially. The chelae of the three first pereiopods are still undeveloped with only a small lobe on the fourth endopodial joint for the coming fixed finger.

In *Cerataspis* the pleopods have enlarged. The endopods of number one and two are only small notches, but the exopods are very long. In the following three pairs the exopods decrease and the endopods increase in length, although the exopod on the last pair still is longer than the endopod. In *Cerataspides* the pleopods are developed as in *Cerataspis*, only the protopods of the two last pairs are very swollen.

DIAGNOSIS FOR THE LARVAE OF *CERATASPIS*

Large penaeid Mysis larvae with both post-orbital and pterygostomian horns; short, ventrally bent rostrum without teeth. Four pairs of dorsal tubercles and lateral swellings on the carapace, and both anterior and posterior dorsal organs. Short abdomen without spines, a penaeid telson with three lateral spines and six setae on each side inside the furca. Large eyes. Short lateral flagellum on the first antenna. None or only vestigial lateral spine on the antennal scale. Mandible with a single incisor tooth and a cutting ridge combining it with the molar part. Three-jointed mandibular palp. Mastigobranchiae on all maxillipedes and pereiopods except the fifth. The three first pereiopods with a beginning chela. Gills lobose, and in older stages the margins of the single lobes are again divided into lobes.

Ceralaspis petiti GUERIN.

Figs. 206–262.

Ceralaspis petiti, GUERIN 1844, p. 18.
Ceralaspis petiti, GIARD-BONNIER 1892a, pp. 350–354.
Ceralaspis petiti, BONNIER 1899, pp. 27–49, pl. 3, Figs. 1–4.

Localities.

Mysis I.

Dana St. 343, 24°53′ N–56°13′ W. St. Croix 40–48 mW. 18.8.1911, 1 spec.
— — 1162, 13°35′ N–30°11′ W. 40–48 mW. 6.11.1921, 1 spec.
— — 3720 IV, 21°10′5″ N–124°31′ E. 50 mW. 25.5.1929, 1 spec.

Mysis II.

Dana St. 343, 24°53′ N–56°13′ W. St. Croix 40–48 mW. 10.8.1911, 2 spec.
— — 345, 35°15′ N–44°9′ W. 40–48 mW. 9.9.1911, 3 spec.
— — 884, 28°49′ N–54°10′ W. 50 mW. 15.7.1920, 1 spec.
— — 3543 III, 21°50′ N–50°12′ W. 100 mW. 12.8.1928, 1 spec.

Mysis III.

Dana St. 345, 35°15′ N–44°9′ W. 40–48 mW. 9.9.1911, 1 spec.
— — 1110 IV, 34°18′ N–8°10′ W. 50 mW. 15.9.1921, 1 spec.
— — 1160 II, 15°50′ N–26°32′ W. 1000 mW. 4.11.1921, 1 spec.

Mysis IV.

Dana St. 3665 III, 29°37′ S–156°46′ E. 300 mW. 25.2.1929, 1 spec.

Mysis V.

Dana St. 3999, 3°45′ S–10°00′ W. 300 mW. 2.3.1930, 1 spec.

Description.

Mysis I.

Figs. 205–223.

No younger stage than the first Mysis is known.

This larva is very characteristic with its swollen, tubercular carapace, provided with long horns and a small, in size reduced, abdomen bent in under the thorax. The whole animal looks like a small squarish box with tubercles all over and with five long horns at the anterior end.

Carapace.

The carapace is provided with four pairs of large tubercles along its dorsal side, and laterally it runs out in an ala on each side pointing backwards beyond the abdomen which is bent ventrally under the thorax. The eyes are stalked, and the rostrum is ventrally curved reaching down towards the middle of the eye-globe. The rostrum is smooth without any spines over the eyes. The carapace has over the eye-stalks a pair of flat supra-orbital spines reaching to near the base of the eye-globe. Behind these spines the enormously developed post-orbital spines extend dorsally as a pair of very long and bulbous processes or spines like a pair of horns, hence the name of the genus. In the opposite direction, pointing ventrally, are the pterygostomian spines, also these are extremely large, even larger than the post-orbital spines, and they are S-shaped curved with the distal tip pointing a little forward. Laterally the carapace is also tubercular, but here the tubercles on each side are placed like pyramide-stubs upon each other ending in a short conical spine pointing latero-posteriorly. In front of this spine a ridge runs from the dorsal base of the pterygostomian spine above the lateral swellings until or close to the dorsal border of the lateral ala, dividing the lateral part of the carapace from the dorsal part with its eight tubercles and giving the carapace a squarish appearance. Just before the ridge reaches in line with the pyramidal swellings it is itself shaping a compressed cone. Ventrally of this is a second, much smaller cone, and one or two more are placed just in front of the pyramidal swellings, but ventrally to them. Further the carapace has a clearly defined cephalic part with a clearly visible anterior dorsal organ in the middle. Near the posterior border of the carapace between the fourth, most posterior pair of dorsal tubercles is a smaller posterior dorsal organ.

Abdomen.

The normal six segments and the abdomen are in the first Mysis large compared with the following stages during which they increase not nearly as much as the size of the carapace. The first segment has a ring-shaped depression in the middle, which divides it into an anterior and a posterior section, of which the anterior one mostly is hidden underneath the carapace. The following four segments are about equal in size, and the fifth segment as usual, especially in Penaeids, much longer, about three times the length of the preceding segments. All segments are smooth without any kind of spines or tubercles, only the lateral pleura have started to develop, and the last segment has a large ventral spine.

Telson.

The telson plate is elongated and flattened, about four times as long as wide and ends in a cleft. The two lobes of the cleft terminate with a long spine, further three shorter spines are placed on the lateral margins of the telson, with the most distal spine just anteriorly of the terminal spine, the next in line with the bottom of the cleft, and the third spine with an equal distance farther forward on the telson, its distance from the tip being about one fourth of the total length of the telson; along each margin of the cleft are placed six spines.

Appendages.

The peduncle of the first antenna is divided into the three joints usual for the Mysis stages and later stages. The basal joint is far the largest, at its base is the beginning swelling for the statocyst. The statocyst spine is present as well as the arch for the later opening, the arch has a few short hairs. The second joint is less than half the length of the first one. The third joint is only half the length of the second joint and tipped with the rudiments of the two flagella which both are unjointed and of about equal lengths. The lateral one has a row of sensory hairs along its medial margin which not are found on the medial lobeshaped flagellum. The last is tipped with two setae. The second and third joints of the peduncle are furnished with two and three stiff hairs placed with about equal intervals along their medial margins. On the disto-lateral corner the first and the second joints have each a short stiff seta.

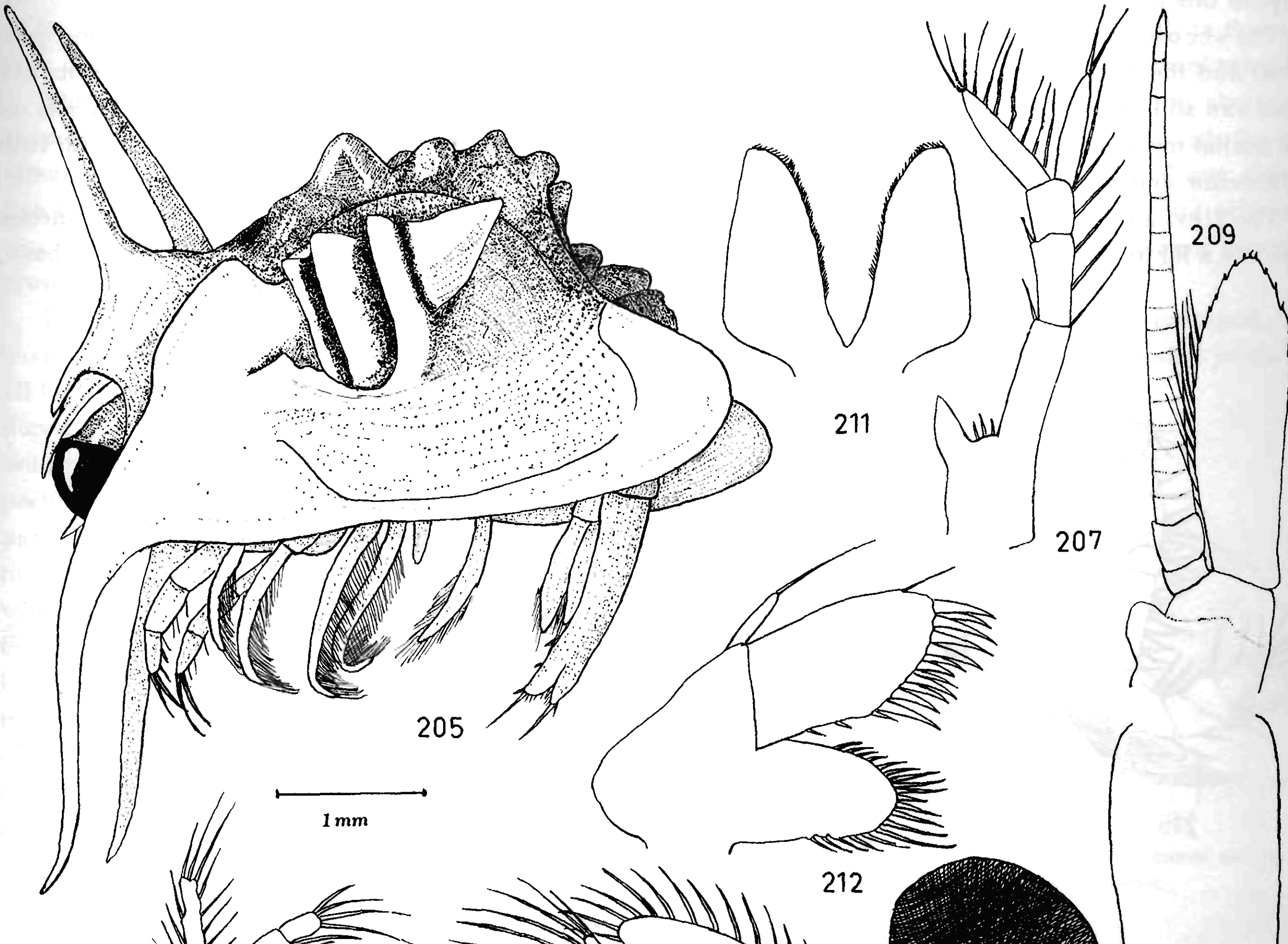
The second antenna has a weakly two-jointed protopod which is about to coalesce into one joint. The exopod is a flattened, elliptical plate, the beginning of the antennal plate. Along its medial margin a line of stiff hairs has started to develop, around its rounded distal margin one can see where the hairs appear only as short buds each in an incision of the margin. Laterally the two most proximal ones have developed as short hairs, about in line with the two most distal ones on the median margin. The endopod is a conical flagellum twice as long as the exopod, and its annulation has started.

The labrum is large and flat with a small anteriorly directed cone.

The mandible has a large corpus mandibulae which includes both a part molaris and a pars incisor. The latter is large, and its cutting part is an S-shaped edge, its teeth have not yet appeared, but a little behind the edge an irregular swelling is observed. Also the molar part is more like a ridge but wider and not sharp with an edge like the incisor part. The palp of the mandible is three-jointed with the second joint being the longest. Both joints are tipped with setae, the first joint on the distal corner toward the corpus mandibulae and the second one on its whole tip, but most densely on the corner towards the corpus mandibulae.

The labium covers the mouth-opening posteriorly, it consists of a short peduncle and two long, movable lobes tipped as usual with fine hairs at their distal and medial borders.

The first maxilla has no clear separation in coxa and basis, but is furnished with two endital lobes. The distal lobe, basi-endite, is by far the largest and lined at its medial margin with conical spines and with a line of fine hairs behind these on the lateral side of the lobe. The basi-endite, is very strong and seems to function partly as a cutting or tearing organ partly as a second mandible. The coxa-endite is much smaller

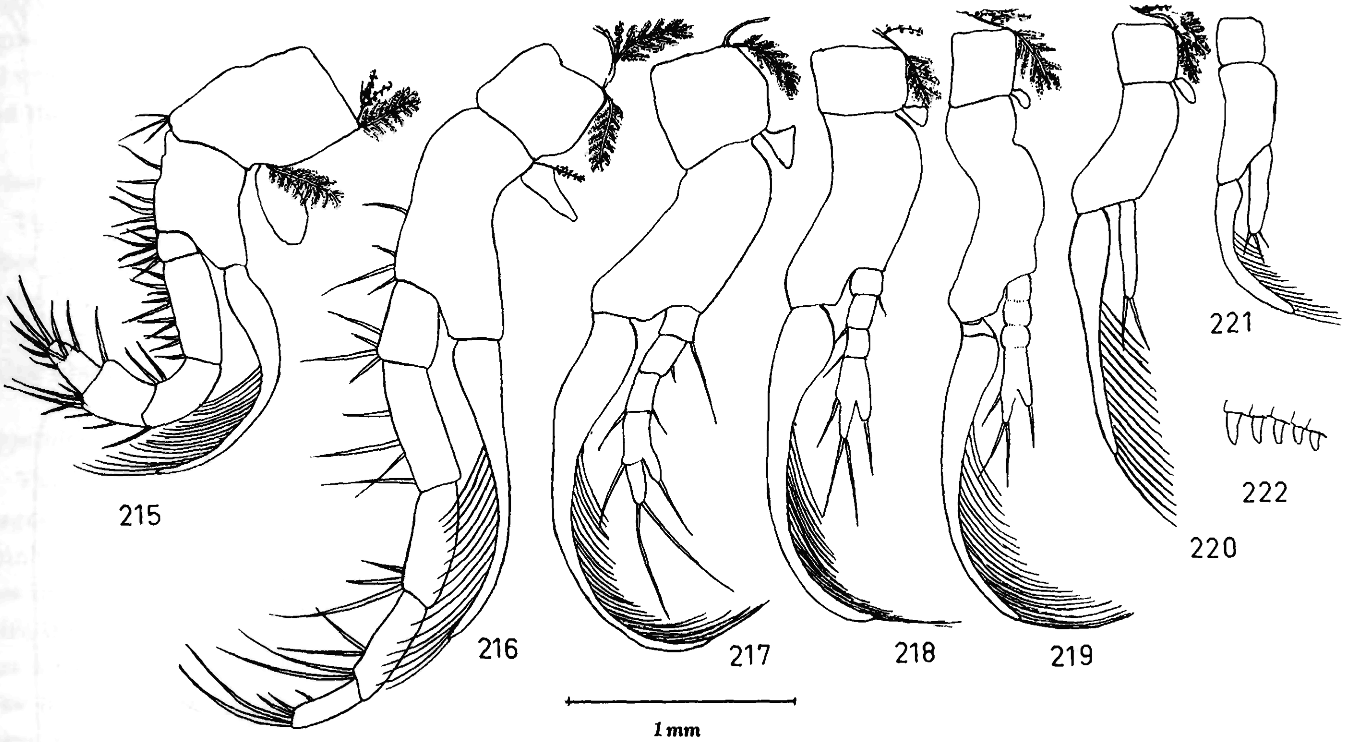


Figs. 205–214. *Cerataspis petiti*. First Mysis. Fig. 205, larva from lateral. — Fig. 206, telson. — Fig. 207, first antenna. — Fig. 208, eye. — Fig. 209, second antenna. — Fig. 210, mandible. — Fig. 211, labium. — Fig. 212, first maxilla. — Fig. 213, second maxilla. — Fig. 214, first maxillipede.

and judging from the shape of its setae more a brushing organ. Distally on the protopod is a small endopodial palp, in this stage tipped with a single seta. The exopod is not present.

The second maxilla has the usual four endites: two coxa-endites and two basi-endites. The most proximal and the most distal endites are the largest. The endopod is already in this stage vestigial, but its five joints can still be seen, although not very distinctly. Each of the four proximal joints is tipped with a seta on the medial margin, the fifth joint with three setae. The exopod is already flattened and leaf-shaped with both an anterior and a posterior lobe, and fringed along the free margins with plumose setae.

The first maxillipede has a squarish, thin protopod, semiglobular with the concavity on the anterior side like a lid to prevent food from escaping backwards. There is no clear distinction between coxa and basis,



Figs. 215–222. *Cerataspis petiti.* First Mysis. Figs. 215–216, second and third maxillipedes. — Figs. 217–221, first to fifth pereiopods. — Fig. 222, buds of pleopods.

the latter extends into a distal lobe. The whole medial margin is fringed with short, plumose setae. The mastigobranchia is as usually large, it is divided into two lobes of nearly equal sizes. The endopod is four-jointed with the basal joint almost as long as the two following ones together, or three times as long as the second joint. The joint is on its medial margin provided with a lamellar lobe tipped by three setae. The second joint is short with two terminal setae at its medial corner. The third joint is twice as long and seems to include the later joints three and four, it has two medio-terminal setae. The distal joint is short with two pairs of terminal setae of which the medial pair is the largest. The exopod is about as long as the endopod, but not with any clear joints in its proximal part; the lateral margin is widened into a lunate lobe fringed with setae. The distal half of the exopod has a line of original swimming setae on both sides, but the setae are rather vestigial and unfunctional.

The second maxillipede has a strong protopod with well-defined coxa and basis and with setae on the medial margin especially on basis. The coxa has a mastigobranchia which is divided into a leaf-shaped elliptical part closest to basis and a filamental branch posteriorly of it. A similar division is also found in the mastigobranchia of this limb in *S.* sp. larva *nodulosa,* but not in any of the other *Solenocera.* In *S.* sp. larva *nodulosa,* however, there is a true podobranchia halfway up on coxa, whereas in *Cerataspis* the podobranchia starts to branch off from the mastigobranchia for in later stages to be separated from it, although still placed close to it. *S.* sp. larva *nodulosa* must thus have two podobranchiae on the second maxilliped, only here the filiform part is placed distally of the leafshaped part and has no shaft, contrary to the other gills in that species. The coxa is further furnished with a well developed arthrobranchia and two budding pleurobranchiae.

The basis is a little smaller than the coxa, but nearly as long. The first endopodial joint is very short, and the second one is the longest. The following three equally long joints are bent like a subchela towards the proximal part of the limb. On the last, fifth, joint the setae are placed in two rings, the proximal one along a fine line in the cuticle dividing the joint into a distal and proximal part indicating that the joint originally was two-jointed, and that thus a sixth joint has existed. A sixth joint is known from some of the most primitive crustacea. The exopod is a well-developed swimming branch.

The third maxillipede has like the rest of the original, thoracal limbs a two-jointed protopod. The coxa is short and squarish, the basis is more than twice as long as the coxa. The five endopodial joints are all long and slender, and in the Mysis stages this long endopod on the extended protopod is used by the larva to hold the prey and especially to push the torn or cut food particles into the mouth, as well as for cleaning the mouthparts mainly the first and second maxillae and when turned backwards also the thoracopods. This function, which persists through all the Mysis stages, was several times noticed in *Solenocera* where the endopod is still longer compared to the other limbs. On coxa is a small mastigobranchia with a budding podobranchial branch one third from its base, a well developed arthrobranchia at the proximal corner of the joint, and two pleurobranchiae, the one nearest to the limb is fully developed, the other is only about to develop.

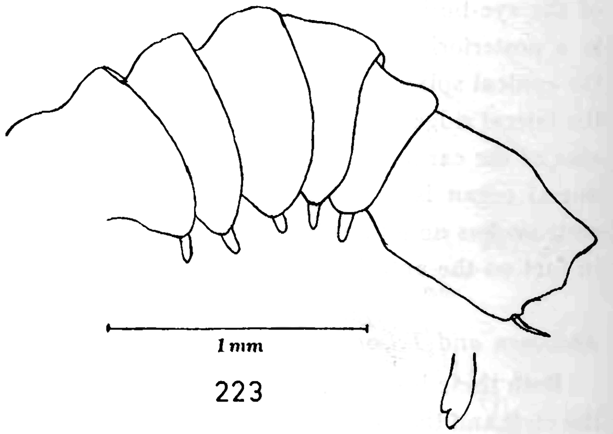


Fig. 223. *Cerataspis petiti.* First Mysis, abdomen and one of the pleopods from anterior.

The three first thoracopods have developed beginning chelae. All thoracopods have a small squarish coxa and an elongate basis, two to three times as long as coxa. The endopod is short and without any function, the food is entirely managed by the maxillipedes and the true mouth-appendages. The exopods are well developed swimming organs. Number four and especially number five are much smaller than the others. The gills are varying on the different thoracopods. A mastigobranchia is present on numbers one to four, but a podobranchial branch or a free podobranchia is lacking. Numbers one to four have each one arthrobranchia, one pleurobranchia on number four is placed so close to the arthrobranchia that it may look as a second arthrobranchia. Number five has no branchiae at all. No pleurobranchiae were observed on the first thoracopod, one was budding out, but not much developed, on the second, two small ones were present on the third and fourth, and none on number five.

The gills for the first Mysis stage can be summarized in the following formula:

	Mxp_1	Mxp_2	Mxp_3	Pe_1	Pe_2	Pe_3	Pe_4	Pe_5
Mastigobranchia	1	1	1	1	1	1	1	0
Podobranchia.............	0	(1)	(1)	0	0	0	0	0
Arthrobranchia	0	1	1	1	1	1	1	0
Pleurobranchia	0	2	2	0	1	2	2	0

The pleopods are all present but only as very tiny simple limb-buds; the uropods are about fully developed only the numbers of setae are still a little low, on the ventral side of the protopod is placed a large spine.

Dimensions:

Total length 8,5 mm; length of carapace without rostrum 4 mm, elevation of same 2,5 mm; rostrum 1 mm; abdomen 2 mm; telson 1,5 mm.

Mysis II.

Figs. 224–237.

The second Mysis shows no larger changes. It is somewhat larger and several parts of its body and appendages have developed further.

Carapace.

A large median cephalic swelling is developed in front of the eight dorsal tubercles of which the most anterior pair is by far the largest. The rostrum is enlarged and still bent ventrally, but it now reaches in front of the eye-bulbs. The post-orbital spines which pointed nearly straight dorsally in the first Mysis are bent in a posteriorly directed curve, and so are the pterygostomian spines. The lateral box-shaped swellings and the conical spine at their apex, as well as the lateral ridge from the pterygostomian spine have become larger, the lateral ridge forms a posterior elongation of this spine along the lateral side of the carapace. The posterior alae of the carapace are almost unchanged, extending backwards on each side of the abdomen. The anterior dorsal organ is placed much more anteriorly than it is in *Solenocera*, just behind the rostrum, and as the rostrum has no long ridge on the carapace as in *Solenocera*, its placement appears even more anteriorly being in fact on the anterior part of the cephalic swelling and not backwards of it near the cervical groove.

Abdomen and Telson.

Both these body parts are about unchanged from the first Mysis, only the telson has narrowed a little behind the cleft and the two longitudinal, dorsal ridges from the base of telson to the first lateral spine are appearing, although still only little prominent. A dark pigmented spot at the tip of each lobe of the telson was especially clear in the figured individual, but as this specimen is close to moulting it may not be a real pigment spot, but sooner a concentration of new cells.

Appendages.

In the first antenna very small changes occur. The statocyst arch and spine are a bit more prominent, and the sensory setae on the lateral flagellum are more numerous. Both flagella are still unjointed.

The second antenna has a few more marginal setae on the antennal plate, and the endopodial flagellum is now well twice the length of the rostrum and reaches to near the tip of the pterygostomian spine.

The mandible is still without clear teeth along the incisor ridge, but more buds for coming teeth are visible. The molar part of the mandible is a little more well-defined.

The lobes of the labium are a little more rounded with a more distinct division in a peduncle and a rounded leaf which by closing in on the mandibles and the labrum makes a perfect external mouth-cavity.

The first maxillipede has an unchanged protopod, a small arthrobranchia has been added to the large, double mastigobranchia. The endopod has increased its number of joints to five by a division of the third joint into two joints. The exopod is unchanged.

In the second and third maxillipedes no remarkable changes have taken place, only the distal joint in the endopod of the second maxillipede seems a little shorter, and its setae therefore appear as more densely placed.

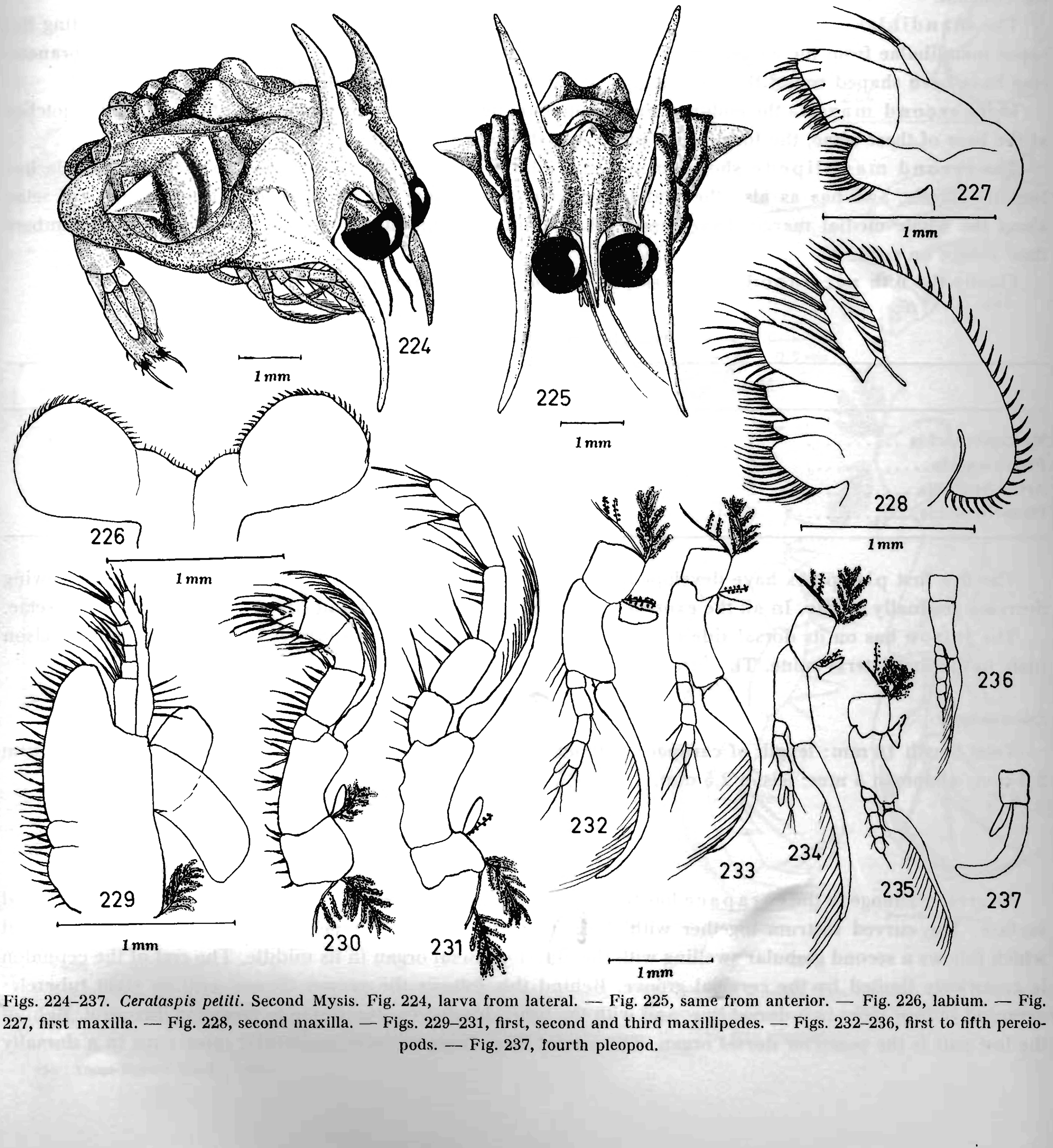
The first four thoracopods have each added a small budding podobranchia and have started to develop two small pleurobranchiae. The fifth thoracopod has as usual no gills. Its endopod is now five-jointed as in the other thoracopods.

The pleopods have each developed from a little bud to a bifurcate limb with unjointed protopod, endopod and exopod. The exopod is much larger than the endopod, this is especially the case for the most anterior pairs, because the general decrease in size backwards first and foremost affects the exopod with the effect that the two branches are of nearly equal size on the most posterior segments.

The uropods are fairly unchanged from the last stage.

Gill formula:

	Mxp_1	Mxp_2	Mxp_3	Pe_1	Pe_2	Pe_3	Pe_4	Pe_5
Mastigobranchia	1	1	1	1	1	1	1	0
Podobranchia.............	0	(1)	(1)	(1)	(1)	(1)	0	0
Arthrobranchia	1	1	1	1	1	1	1	0
Pleurobranchia	0	2	2	2	2	2	2	0



Figs. 224–237. *Ceratαspis petiti.* Second Mysis. Fig. 224, larva from lateral. — Fig. 225, same from anterior. — Fig. 226, labium. — Fig. 227, first maxilla. — Fig. 228, second maxilla. — Figs. 229–231, first, second and third maxillipedes. — Figs. 232–236, first to fifth pereiopods. — Fig. 237, fourth pleopod.

Dimensions:

Total length 10,5 mm; length of carapace without rostrum 4,5 mm, height of same 2,5–3 mm; rostrum 2 mm; abdomen 2,5 mm, telson 1,5 mm.

Mysis III.

Figs. 238–249.

Except for the larger size only small changes take place from the second to the third Mysis.

In the first antenna the statical nerve has grown into the statocyst and the sensory hairs have developed, but the statocyst itself is still open on the ventral side of the antenna. The hairs along the medial side of the peduncle have increased in number, but the two flagella are about unchanged and still unjointed.

In the second antenna the endopodial flagellum has grown and is now three to four times as long as the rostrum.

The mandible shows a clear distinction between incisor and molar parts, and a ridge is dividing the caput mandibulae from the corpus mandibulae, and with the thickening of the cuticle a clear, membranous ring have been shaped round the base of the mandibular palp to ensure its more free movement.

In the second maxilla the endopod has become unjointed, but by the placement of the setae and notches at the base of these setae, the former five joints can still be recognized.

The second maxillipede shows in its distal joint a clear division into two. The mastigobranchia has become elliptic, and has as also the podobranchia grown larger. On all three maxillipedes the stiff setae along the whole medial margin have increased in numbers; they are now also placed in larger numbers than before on coxa.

Finally the fifth pereiopod has developed a small pleurobranchia.

The gill formula is as follows:

	Mxp_1	Mxp_2	Mxp_3	Pe_1	Pe_2	Pe_3	Pe_4	Pe_5
Mastigobranchia	1	1	1	1	1	1	1	0
Podobranchia.............	0	1	1	1	1	1	0	0
Arthrobranchia	1	1	1	1	1	1	1	0
Pleurobranchia	0	2	2	2	2	2	2	1

The five first pleopods have developed further. The most anterior pair is the largest and the following decrease gradually in size. In all the exopod is by far the largest branch and has developed embryonic setae.

The telson has on its dorsal side developed two longitudinal ridges running from the base of the telson plate to the first lateral spine. The furcal cleft has become a little more open.

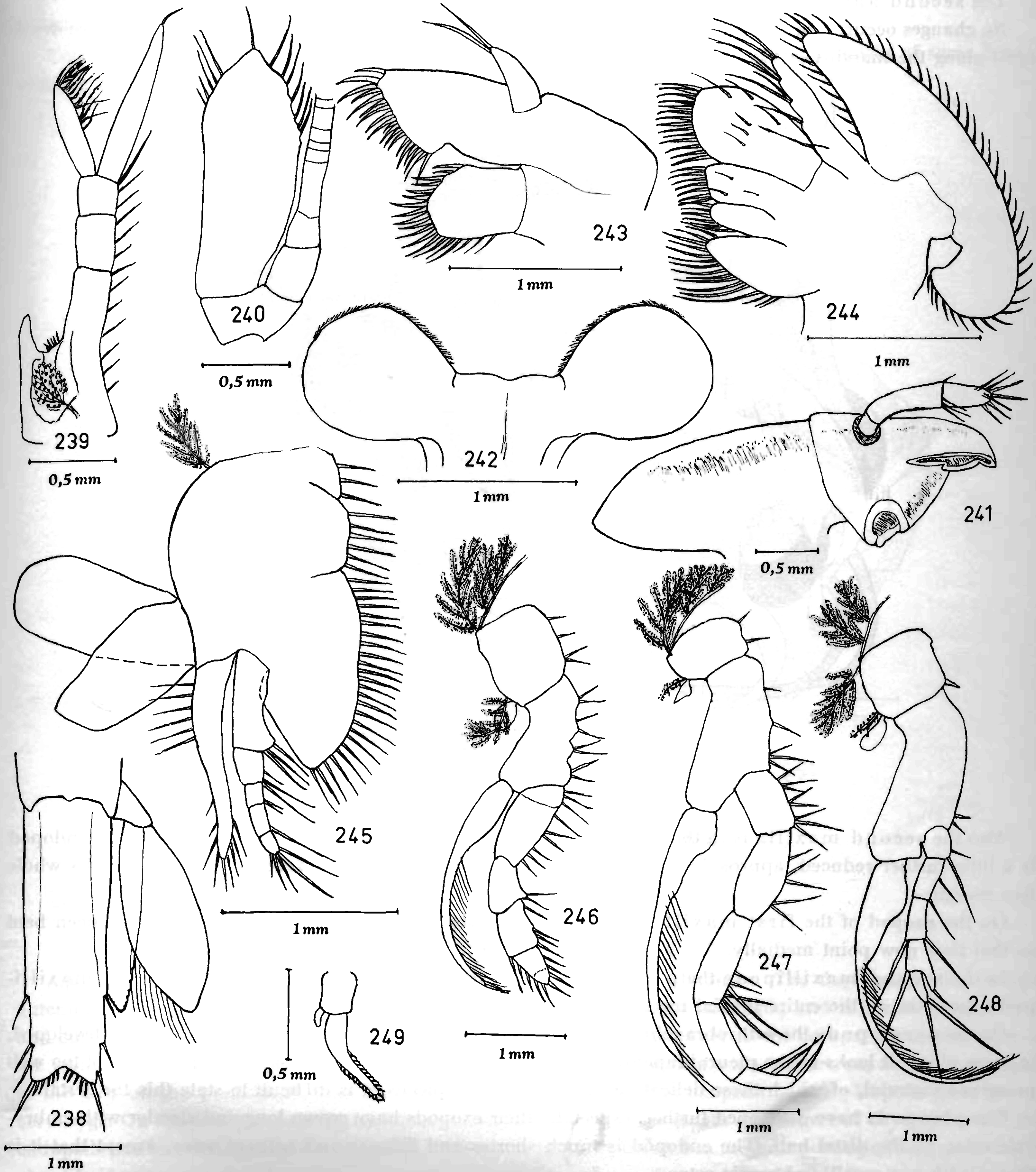
Dimensions:

Total length 16 mm; length of carapace without rostrum and alae 7 mm, height of same 4 mm; rostrum 2,5 mm; abdomen 4 mm; telson 2,5 mm.

Mysis IV.

Fig. 250.

No greater change in the carapace has taken place except an increase in size and perhaps a more rounded surface. The curved rostrum together with the supra-orbital spines shape a curved frontal shield behind which follows a second globular swelling with the anterior dorsal organ in its middle. The rest of the cephalon is posteriorly limited by the cervical groove. Behind this follows the proper thorax with its eight tubercles arranged in four pairs in a dorsal line, and with the tubercles decreasing in size in posterior direction. Behind the last pair is the posterior dorsal organ. The lateral ridge from the pterygostomian spine runs in a dorsally pointing curve towards the anterior tubercle, below the dome of this are three small tubercles in a line parallel to the basal part of the pterygostomian spine. The lateral pyramids with a spine on the top have increased in size. Also the abdomen is now larger in comparison with the rest of the animal, but still bent in under the thorax.



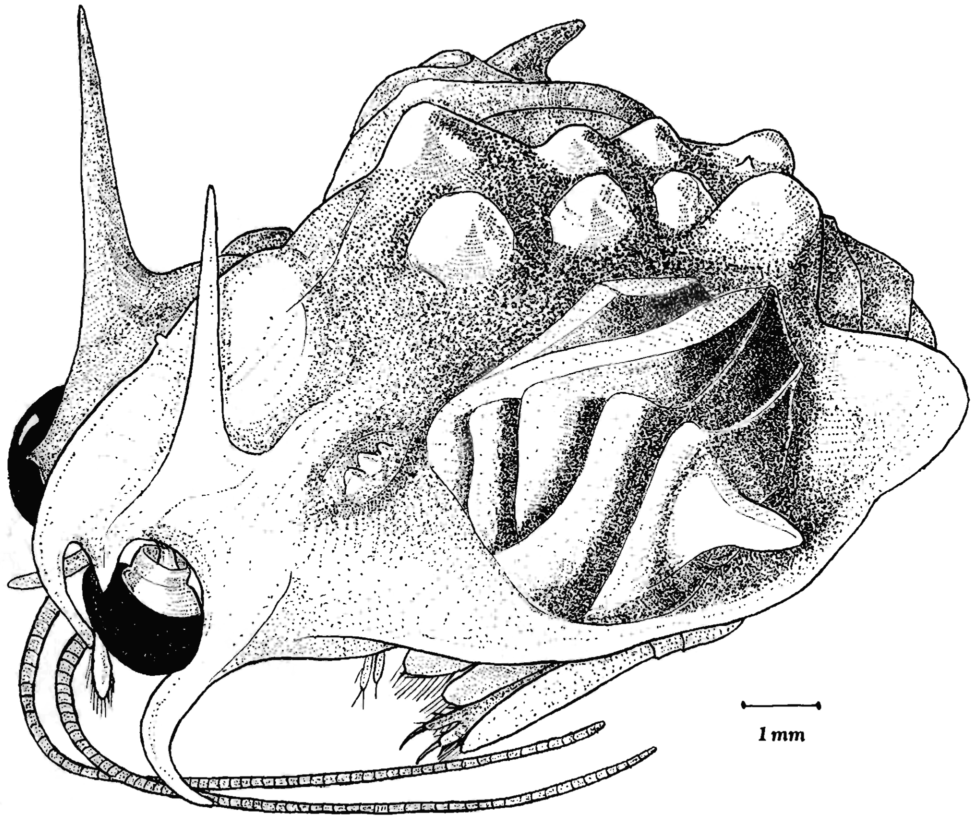
Figs. 238–249. *Cerataspis petiti*. Third Mysis. Fig. 238, telson with rigth uropod. — Fig. 239, first antenna from ventral. — Fig. 240, second antenna. — Fig. 241, mandible. — Fig. 242, labium. — Fig. 243, first maxilla. — Fig. 244, second maxilla. — Figs. 245–247, first, second and third maxillipedes. — Fig. 248, first pereiopod. — Fig. 249, fifth pleopod.

The Appendages.

The first antenna is about unchanged, and the median lobe for the coming medial flagellum has enlarged to about twice the length of the lateral lobe and has started to become annulated. The lateral lobe is still short and unjointed, provided with sensory hairs on its medial margin.

The second antenna has now a long endopodial flagellum about as long as the thorax.

No changes occur in the mandible or in the first maxilla except that a few more stiff setae have developed along the margins of the lobes.



250

Fig. 250. *Cerataspis petiti.* Fourth Mysis from lateral.

Also the second maxilla is in the main unchanged, only the endites have enlarged a little, the endopod is a little further reduced, approaching the adult state, and the exopod has developed setae along its whole free margin.

On the exopod of the first maxillipede the setae along the base of its lateral margin have been bent so that they now point medially.

In the second maxillipede the podobranchiae have enlarged, and in this and in the third maxillipede the setae on the entire medial margin have increased in length and number.

On the pereiopods the arthrobranchiae and pleurobranchiae have grown very large and well-developed, in some places it looks as the pleurobranchiae have multiplied by side-branching, but due to the not too well preserved material, of which these delicate parts easily fall to pieces, it is difficult to state this for certain.

The pleopods have developed further, especially their exopods have grown long and slender with embryonic setae on the distal half. The endopod is much shorter and thinner and without setae, except that it is tipped with two small embryonic setae.

The uropods are nearly of the same length as the telson, and their exopods have started to develop distally the characteristic lateral tooth.

The furca of the telson is more open, and the setae in the furcal cleft are becoming vestigial, but still present in full number. The lateral teeth have moved farther forward so that the most distal one is in line with the bottom of the cleft.

The gill formula is unchanged.

Dimensions:

Total length 23 mm; length of carapace without rostrum and lateral alae 10 mm, height of same 5 mm; rostrum 3 mm; abdomen 7 mm; telson 3 mm.

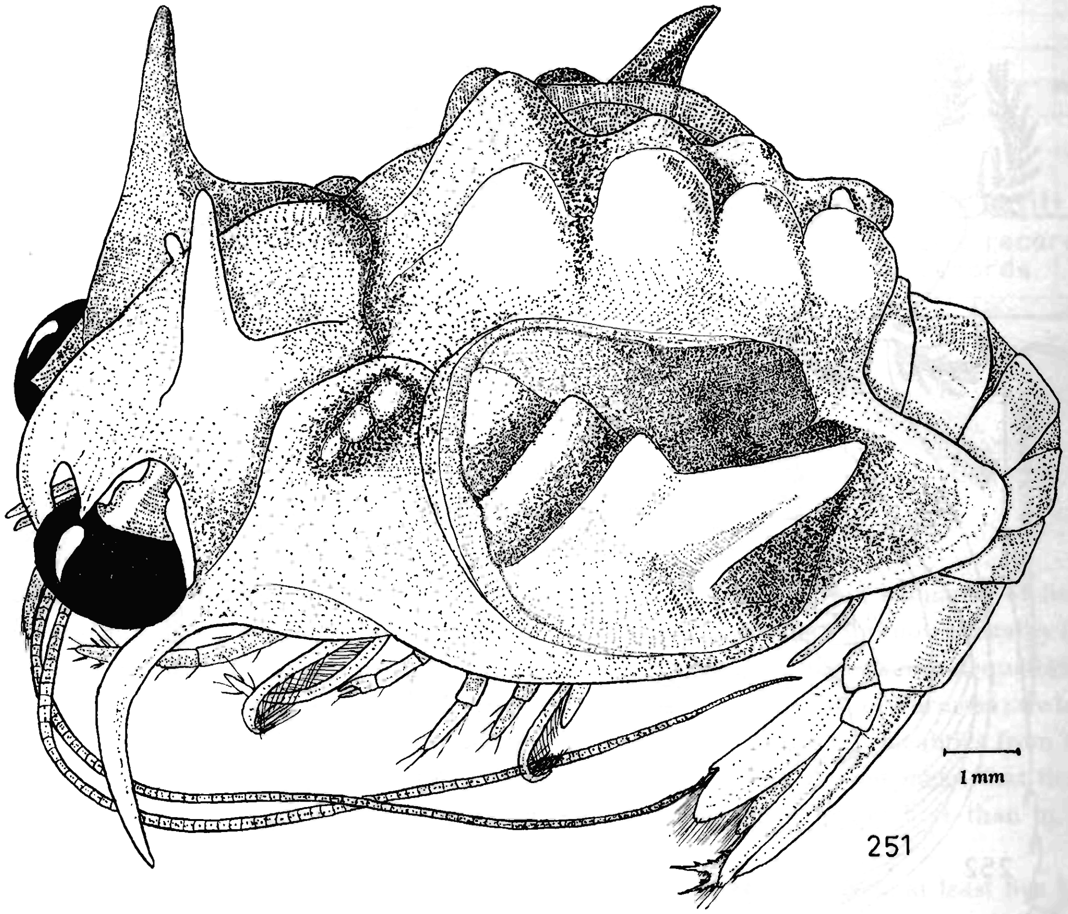
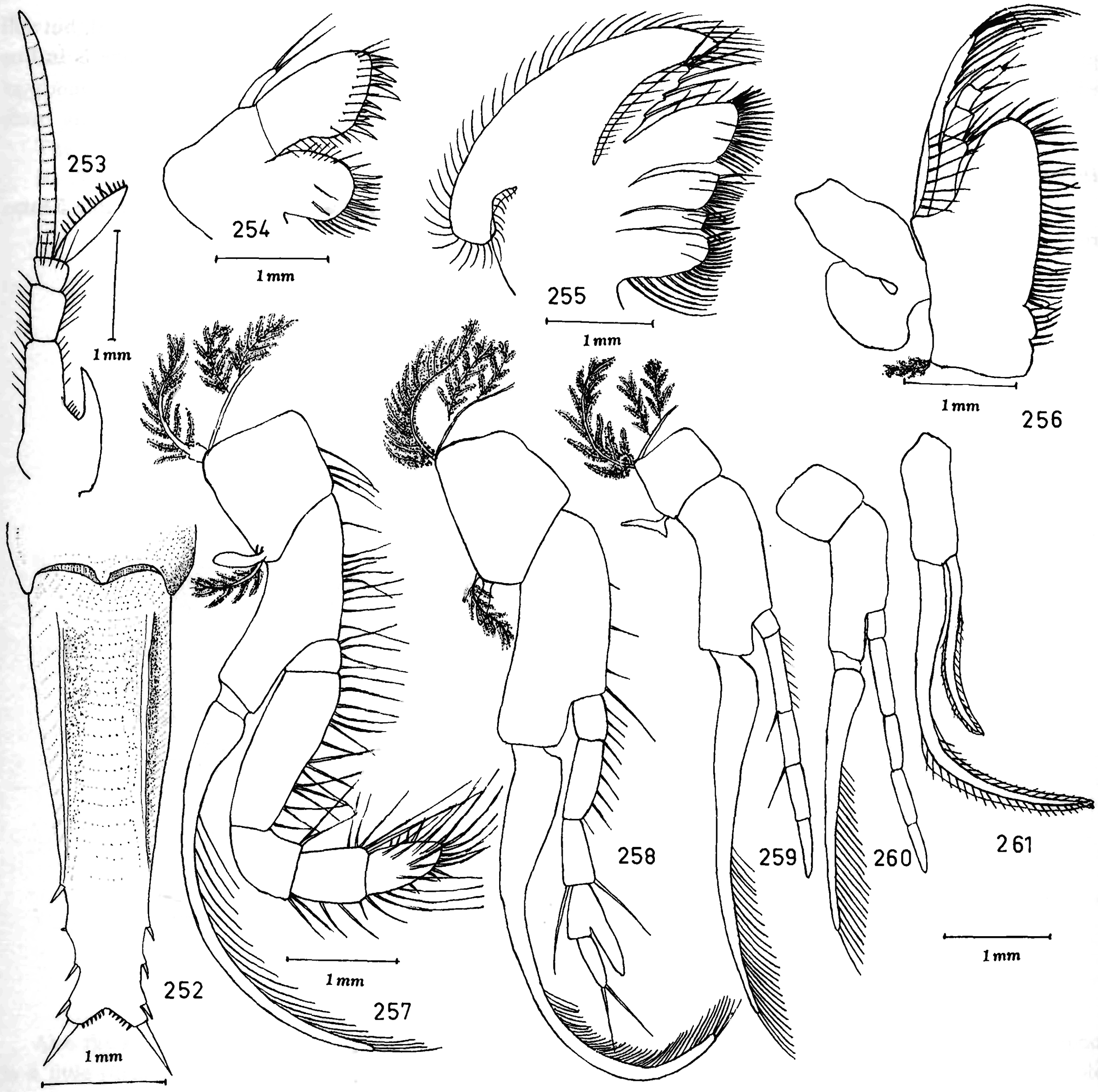


Fig. 251 *Cerataspis petiti.* Fifth Mysis from lateral.

Mysis V.

Figs. 251–261, 263.

Again we have an increase in size, relatively strongest for the abdomen. The flagellum of the second antenna has increased in length. The rostrum has only increased little in length, and it is still without teeth and curved ventrally between the eyes. It is flattened, but has a small keel on the carapace reaching close to the frontal dorsal organ. On the first maxillipede the double mastigobranchia has grown, and so have most of the gills on the pereiopods, but their formula is unchanged. The exopods of the pleopods have grown very large. On the first pleopod the endopod is only a small bud, the length and degree of development of the endopods are increasing backwards so that on the fifth pleopod which has the best developed endopod, this is about half as long as the exopod. In the uropods the exopod has a distinct lateral tooth distally, and the keels on the telson have become rather prominent. The two spines terminating the lobes of the furca are strong and well-developed and by far the largest of the spines of the telson.



Figs. 252–261. *Cerataspis petiti.* Fifth Mysis. Fig. 252, telson. — Fig. 253, first antenna. — Fig. 254, first maxilla. — Fig. 255, second maxilla. Figs. 256–257, first and second maxillipedes. — Fig. 258, first pereiopod. — Figs. 259–260, fourth and fifth pereiopods. — Fig. 261, fifth pleopod.

Dimensions:

Total length 27 mm; length of carapace 12 mm, height of same 7 mm; rostrum 4 mm; abdomen 7,5 mm; telson 3,5 mm.

Average measurements of different Mysis stages in mm.

Mysis stage:	I	II	III	IV	V
Total length	8.5	10.5	16	23	27
Carapace	4 × 2.5	4.5 × 3	7 × 4	10 × 5	12 × 7
Rostrum	1	2	2.5	3	4
Abdomen	2	2.5	4	7	7.5
Telson	1.5	1.5	2.5	3	3.5

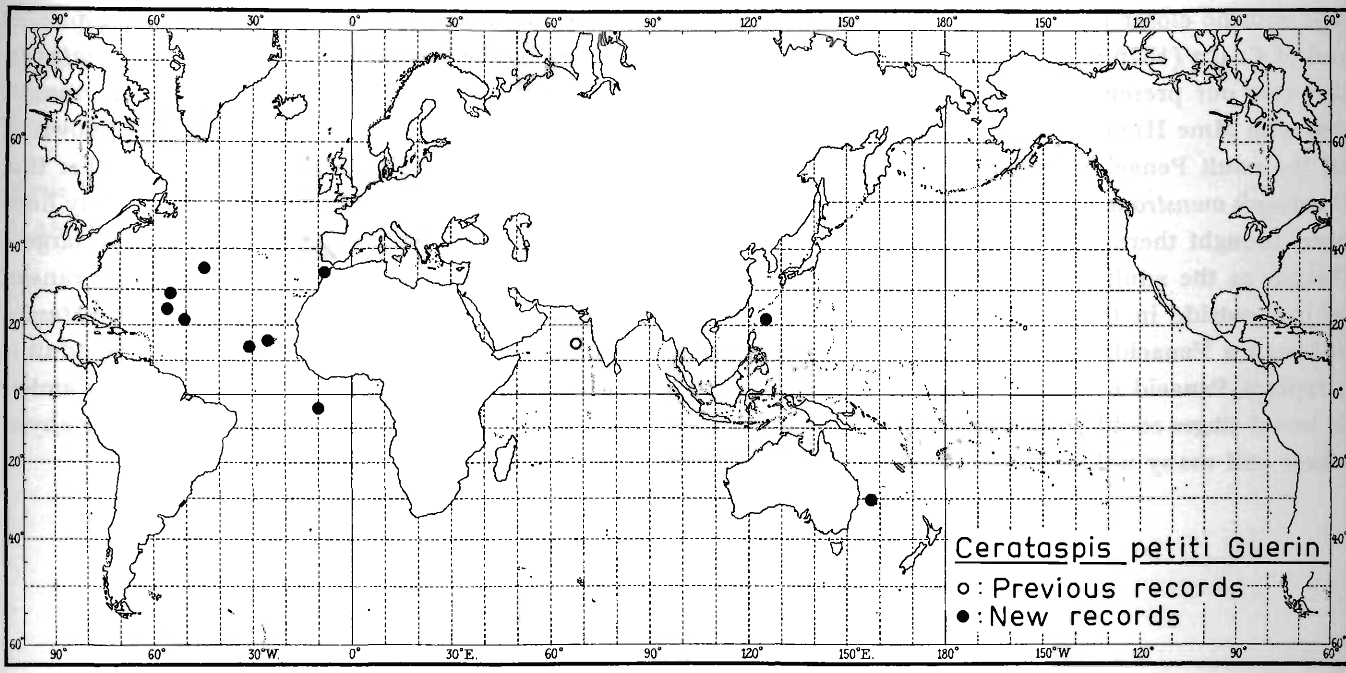


Fig. 262. Map of distribution.

Distribution and Remarks.

Fig. 262.

From previous records in the literature are only known two specimens from stomachs of fish captured in the Indian Ocean and described by Guerin (1839) and one specimen from an unknown locality (lab. Wimereux). This new material shows that this penaeid larva is a tropical species with a circum-aequatorial distribution. From the Pacific it is recorded near the East coast of Australia and from east of Formosa; we have further Guerin's old record from the Indian Ocean and to these are added eight "Dana" localities from the tropical part of the Atlantic Ocean; these larger numbers from the Atlantic Ocean do not mean that the species is more frequent here, but are caused by the number of stations being much higher here than in other parts of the oceans where "Dana" has cruised.

The species is a true pelagic form which also is shown by the many larval stages: at least five Mysis stages are recorded here, and possibly there may be one or two stages more before the first post-larval stage is reached. In coastal forms of *Caridea* and *Penaeidae* two Mysis stages are most common.

The coastal and subtropical species, e. g. *S. membranacea*, have only two Mysis stages, but the true tropical species *S.* sp. larva *sumatransis* at least four and *S.* sp. larva *danae* at least three Mysis stages. That consumption of much food does not give a shorter period between the instars is understandable from the fact that the larvae are able within certain limits to grow inside their cuticle, because of the soft and partly elastic membranes between the segments. The result is a certain variation in development of the larvae of the same species in the same larval stage. They are actually in a slightly different stage of development, when moulting takes place.

Boas (1880) has without any doubt placed the *Cerataspis* species in the Penaeidae. Bouvier (1908) has suggested that they were larvae of *Aristeomorpha*, and Burkenroad (1936, p. 85) without referring to Bouvier states without any explanation that *Cerataspis petiti* is the larva of *Aristeomorpha wood-masoni* Calman 1925 and *Cerataspis monstrosa* the larva of *A. foliacea* (Risso). Now this statement can not be true because *Cerataspis* and *Aristeomorpha* after our present knowledge not have the same distribution, and further Heldt (1955) described the larval stages of *Aristeomorpha foliacea*, and they agreed with larvae of the normal penaeid type with no closer resemblance to *Cerataspis*. Further we have the unknown larva of DOHRN (1871 p. 377) and of CLAUS (1876 p. 17) from the Strait of Messina, which may be the second Protozoea stage of *Cerataspis*. However our present knowledge only indicates that it belongs to the Penaeidae. It must here be mentioned that with Mme HELDT's description of the larval stages of *Aristeomorpha foliacea*, Mysis stages are known of all the adult Penaeids observed in the Mediterranean. Against BURKENROAD's statement speaks further that *Cerataspis monstrosa* has been recorded from the Mediterranean (Wimereux), although it may possibly have been brought there through the Strait of Gibraltar. However, it is even then hardly possible that so large a shrimp as the adult must be, judging from the size of *Cerataspis*, can live pelagically in the Mediterranean or just outside in the Atlantic without being known. It is therefore possible that the adult of *Cerataspis*, although a Penaeid, is not to be looked for among the Natantia but among the Reptantia, that the adult is a reptant Penaeid living in the abyss of the ocean. Also the very small abdomen and the size and number of larval stages could point this way. It must have reached a certain size before it can descend into the abyss, where still many unknown animals may be expected to live.

Cerataspis monstrosa GRAY.

Figs. 264–295.

Cerataspis monstruosus, J. E. GRAY 1828, p. 8, pl. 4, Fig. 5.
Cryptopus defrancii, LATREILLE 1829, p. 100.
Cerataspis monstruosus, MILNE-EDWARDS 1837, vol. 2, p. 238.
Lepsia tuberculosa, QUOY 1839, pp. 4–3, pl. 1.
Cerataspis monstruosus, DOHRN 1874, pp. 362–372, pl. 28, Figs. 23–34.
Cerataspis monstruosus, BOAS 1880, pp. 42–45, pl. 6, Fig. 189.
Cerataspis monstrosa, GIARD et BONNIER 1892, pp. 350–354.
Cerataspis monstrosa, BONNIER 1899, pp. 27–49, pl. 3–6.
Cerataspis monstrosa, BOUVIER 1908, pp. 13–14.

Localities.

Mysis I.

19°49′ N–69°15′ W. ANDREA 10–1862, C. Z. M. 12.1893, 1 spec.
8°10′ S–12°–13°20′ W. ANDREA 1864, C. Z. M. 12.1893, 1 spec.
9°40′ N–109°20′ E. ANDREA 1869, C. Z. M. 12.1893, 1 spec.

Mysis II.

34° N–32° W. HYGOM, C. Z. M. 12.1893, 1 spec.
31°–32° S–42°21′–47° E. ANDREA 1870, C. Z. M. 12.1893, 2 spec.
Dana St. 3536 III, 34°08′ N–13°05′ W. 100 m.W. 27.7.1928, 1 spec.
— — 3718 IV, 20°04′ N–123°59′ E. 100 m.W. 25.5.1929, 1 spec.

Mysis III.

8°10° S–12°–13°20′ W. ANDREA 1864, C. Z. M. 12.1893, 2 spec.
no locality, C. Z. M. 12.1893, 4 spec.

Mysis IV.

The Azores. (Horta), FRANCISCO S. CHAVES, C. Z. M. 8.1892, 1 spec.
34° N–32° W. Stomach of *Coryphaena*, HYGOM, C. Z. M. 8.1892, 2 spec.
"Dana" St. 1149 X, 33°22′ N–21°55′ W. 150 m.W. 21.10.1921, 1 spec.
No locality, C. Z. M. 12.1893, 1 spec.
No locality, C. Z. M. 12.1893, 3 spec.

Mysis V.

St. Miquel, the Azores from fish stomach. Dr. ALFONSO CHAVES, 14.12.1922, C. Z. M., 1 spec.
"Dana", St. 3535 III, 34°21′ N–12°19′ W. 100 m.W. 26.7.1928, 1 spec.
Japan (no further data) B. M. 45.37, 1 spec.

Mysis VI.

S. African waters, Dr. K. H. BARNARD, B. M. 1957, 11.6.26, 1 spec.

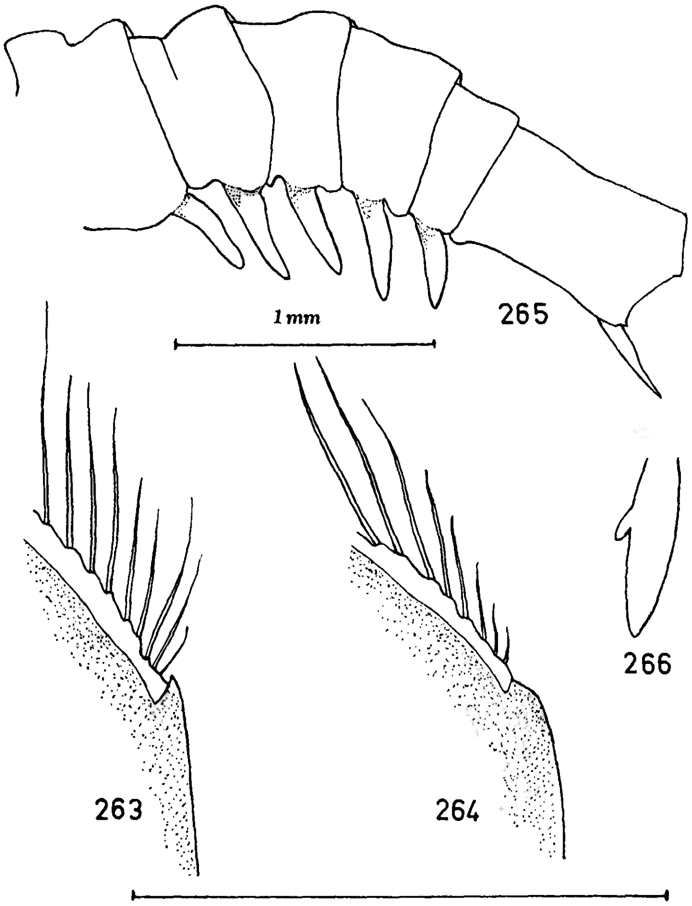


Fig. 263, *Cerataspis petiti*, fifth Mysis, latero-distal corner of antennal scale. — Fig. 264, same of *Cerataspis monstrosa*, fifth Mysis. — Figs. 265–266, *Cerataspis monstrosa*, first Mysis. — Fig. 265, abdomen. — Fig. 266, one of the pleopods, showing the large exopod and the tiny endopodial bud.

Description.

Mysis I.

Figs. 264–266.

No younger stages than the first Mysis are known.

This species is very similar to *Cerataspis petiti.* If it was not for the characteristic sculpture on the carapace in which the two species are distinctly different, there would hardly be any reason to separate them, also as both have about the same distribution. But due to this marked difference in carapace and some other minor differences it is necessary with the present knowledge to retain them as two separate species.

Carapace.

The carapace has the same four pairs of tubercles dorsally as in *C. petiti* and the same paired spines: fronto-dorsally a curved post-orbital spine, a perhaps a little more flattened supra-orbital spine, a curved pterygostomian spine, and posteriorly directed alae, one from each side of the carapace. The rostrum is a little longer, but this may be due to the species being a little larger than in *C. petiti*. The lateral sides of the carapace, however, differ considerably. The conical spine on the top of the pyramid stubs in *C. petiti* is absent in *C. monstrosa*, but the surface in this area is strongly convoluted and has the same function as a float for the larva. Figs. 267–268 show the arrangement of this convoluted surface in the second Mysis stage, viewed laterally and frontally. Also the three small tubercles placed in a line in front of the convoluted surface are absent in *C. monstrosa*.

Abdomen and Telson. Fig. 265.

The abdomen is much the same in the two species, perhaps the dorsal surface is a little more folded, and the ventral spine on the last segment larger and stouter in *C. monstrosa* than in *C. petiti* (Figs. 265, 223). On the telson the two terminal spines on the branches of the furca are a little curved towards each other in *C. monstrosa*. The number of setae inside the furca are 5–7 on each lobe, but 6 on all the examined specimens of *C. petiti*, the material is too small to state whether this is a true difference or not. In *C. monstrosa*, the most distal of the three lateral spines on the telson is placed in line with the bottom of the cleft of the furca already in the younger stages. The most proximal spine is placed only little more than one third of the length of telson from its distal point. In *C. petiti* the most distal spine is more distally placed in the younger stages, and the most proximal spine is situated nearly one fourth of the length of the telson from its distal point.

Appendages.

Also here the differences are very small. No important difference can be found in the first antenna. In the second antenna the lateral spine of the antennal plate is present, though very minute, *in C. petiti*, but not found in *C. monstrosa* where the external margin is rounded towards the beginning of the setae at the place where the spine should have been. (Fig. 263–264). This holds true only for the older stages from the third Mysis, in the first two Mysis stages no difference can be seen in this organ between the two species.

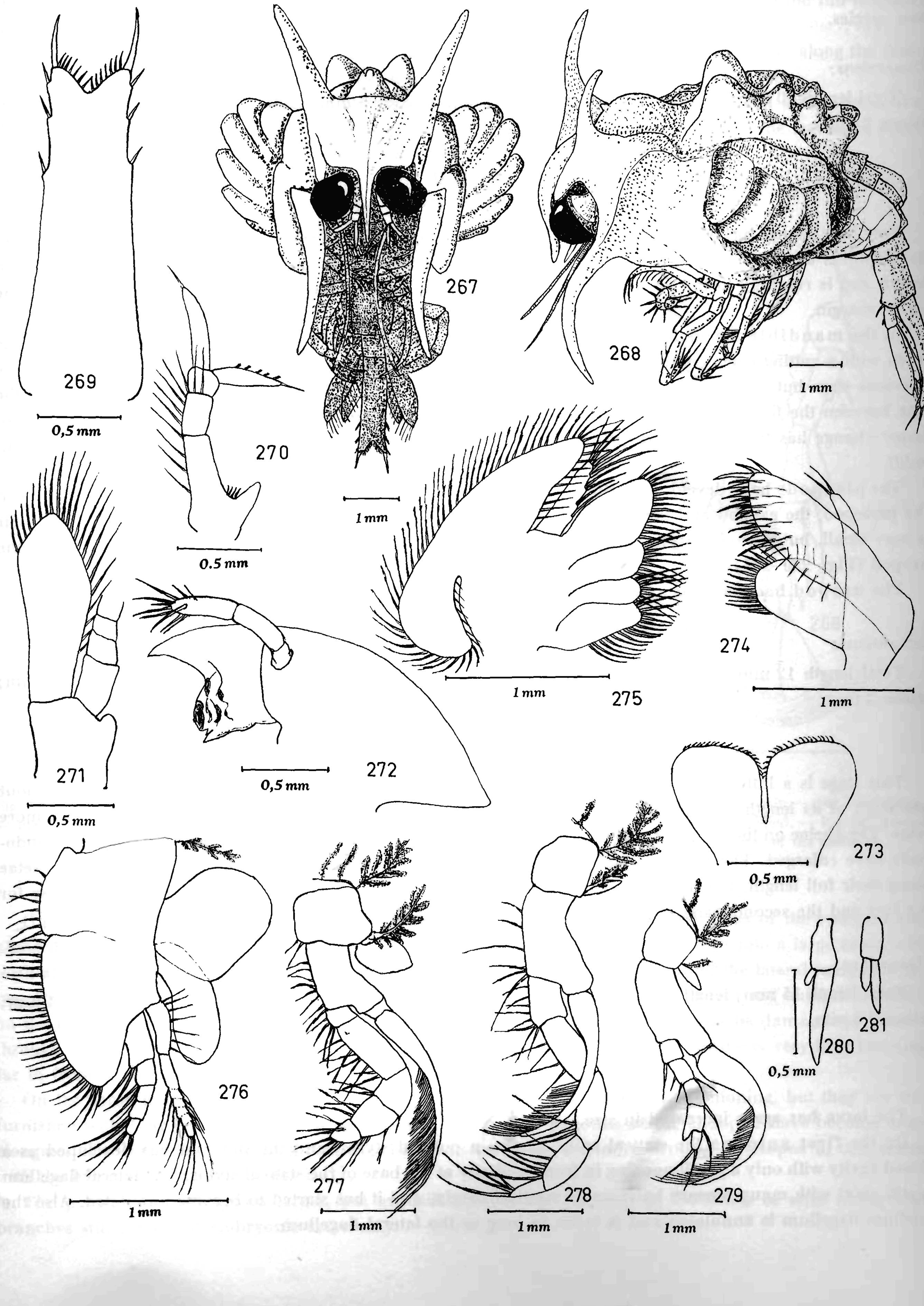
In the mandible the molar part is a little stronger and the palp a little longer in *C. monstrosa* than in *C. petiti*, but again here the differences are so small that they can not be recognized without having a specimen of each species to compare, and further it must be remembered that the mandibles always vary somewhat, even the right and left mandible of the same specimen are never true mirror replica of one another. The lips of the labium are a little shorter with a more rounded distal margin in *C. monstrosa* than in *C. petiti*, and the endites of the first maxilla are a little more setose in the former.

The gills on the thoracopods are in the same stages generally more developed and larger in *C. monstrosa*, but otherwise the gills and their development seem the same in the two species.

The pleopods are well developed in the first Mysis stage. They are beginning to be bifurcate, but are still unjointed. The axis of the limb continues from the protopod into the exopod, and the endopod is placed as a small bud on the medial margin, one third from the basis of the limb. The uropod has a spine on the ventral or medial side of the protopod.

This larva is a little larger than the same stage in *C. petiti*, but again it must be remembered that the material is too small to permit final conclusions. The larva is a little larger, but at the same time its development is slightly more advanced than in the first Mysis stage of *C. petiti*. In *C. monstrosa* the flagellum of the first antenna had 10–15 rings and is a little longer than the antennal scale. The molar part of the mandible is a little better developed, and so are the pleopods. But as it has been pointed out in the chapter on ratio of growth this can be explained by a larger and better development of the Protozoea in *C. monstrosa* than in *C. petiti*.

Figs. 267–281. *Cerataspis monstrosa*. Second Mysis. Fig. 267, larva from anterior. — Fig. 268, same from lateral. — Fig. 269, telson. — Fig. 270, first antenna. — Fig. 271, second antenna. — Fig. 272, mandible. — Fig. 273, labium. — Fig. 274, first maxilla. — Fig. 275, second maxilla. — Figs. 276–278, first, second and third maxillipedes. — Fig. 279, first pereiopod. — Fig. 280, first pleopod. — Fig. 281, fifth pleopod.



267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
0,5 mm
1 mm
0.5 mm

It must be remembered that the material includes only three specimens of the first Mysis in each of the two species.

Dimensions:

Total length 10 mm; length of carapace 4 mm, height of same 3 mm; rostrum 1,5 mm; abdomen 2,5 mm; telson 2 mm.

Mysis II.

Figs. 267–281.

Very little change has taken place from the first to the second Mysis, except an increase in size and a further development of limbs and limbparts. The endopodial flagellum of the second antenna has increased in length and is reaching to the tip of the pterygostomian spine. The antennal scale has developed more setae on its margin.

In the mandible the molar part is very strongly developed, and the incisor part is only a single large tooth with a cutting ridge combining it with the molar part. The mandibular palp is three-jointed as in the previous stage but in some specimens, as also in specimens of the other stages, it is difficult to observe the line between the first and the second joints. The first and the second maxillae are strongly setose. No larger change has taken place in the maxillipedes and thoracopods. The gills are the same as in *C. petiti.*

The pleopods have developed further, and they are now jointed so far as partitions are observed between the protopod, the exopod and the endopod. The exopod is the largest branch. The endopod of the first pair is very small, but it grows larger backwards, and in the last pair the endopod is only little smaller than the exopod (Figs. 280–281).

The uropod has the same spine ventrally on the protopod as in the previous stage.

Dimensions:

Total length 12 mm; length of carapace 5 mm, height of same 4 mm; rostrum 2 mm; abdomen 3 mm; telson 2 mm.

Mysis III.

This stage is a little larger than the previous one. The flagellum of the first antenna reaches with about one third of its length beyond the pterygostomian spine. The palp of the mandible has grown a few more setae. The chelae on thc three first pairs of thoracopods are more developed, and the various joints of the endopods have enlarged. The pleopods have grown, their exopods are now all furnished with embryonic setae along their full length, but the endopods are still behind in development, and this is especially the case for the first and the second pairs. The telson has developed the two dorsal ridges.

Dimensions:

Total length 15 mm; length of carapace 6 mm, height of same 4,5 mm; rostrum 2,5 mm; abdomen 4 mm; telson 2,5 mm.

Mysis IV.

Figs. 282–288.

The larva has again increased in size.

On the first antenna the statical spine is now a pointed stylus, and the statocyst has developed as a closed cavity with only a small opening in front medially at the base of the statical stylus. The lateral flagellum is still short with many sensory hairs on its medial margin, and it has started to become annulated. Also the medium flagellum is annulated and is twice as long as the lateral flagellum.

The second antenna has also developed further, and its flagellum has now grown to the full length of the carapace.

The mandible is well developed with a clearly folded molar part and with many setae along the distal part of the second joint as well as along the third joint, thus shaping a useful brush or fan.

On the first maxilla the setae on the basi-endite have become so short, spiny and almost teeth-like, that they can now definitely be used not only to hold the prey, but also to take part in the tearing of it into smaller pieces.

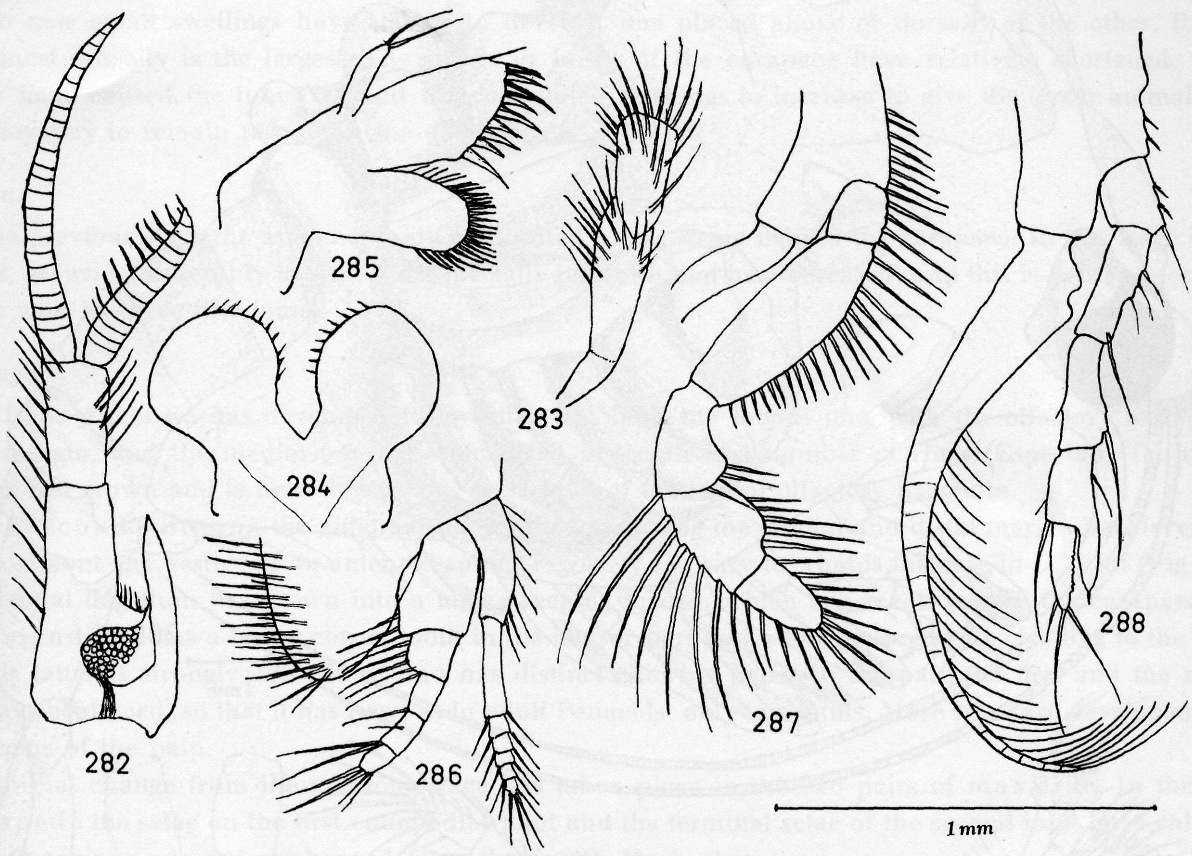


Fig. 282–288. *Cerataspis monstrosa.* Fourth Mysis. Fig. 282, first antenna from ventral. — Fig. 283, mandibular palp. — Fig. 284, labium. — Fig. 285, first maxilla. — Fig. 286, first maxillipede, showing distal part of protopod with exopod and endopod. — Fig. 287, second maxillipede, showing basis and endopod. — Fig. 288, first pereiopod except for the more proximal part of the protopod.

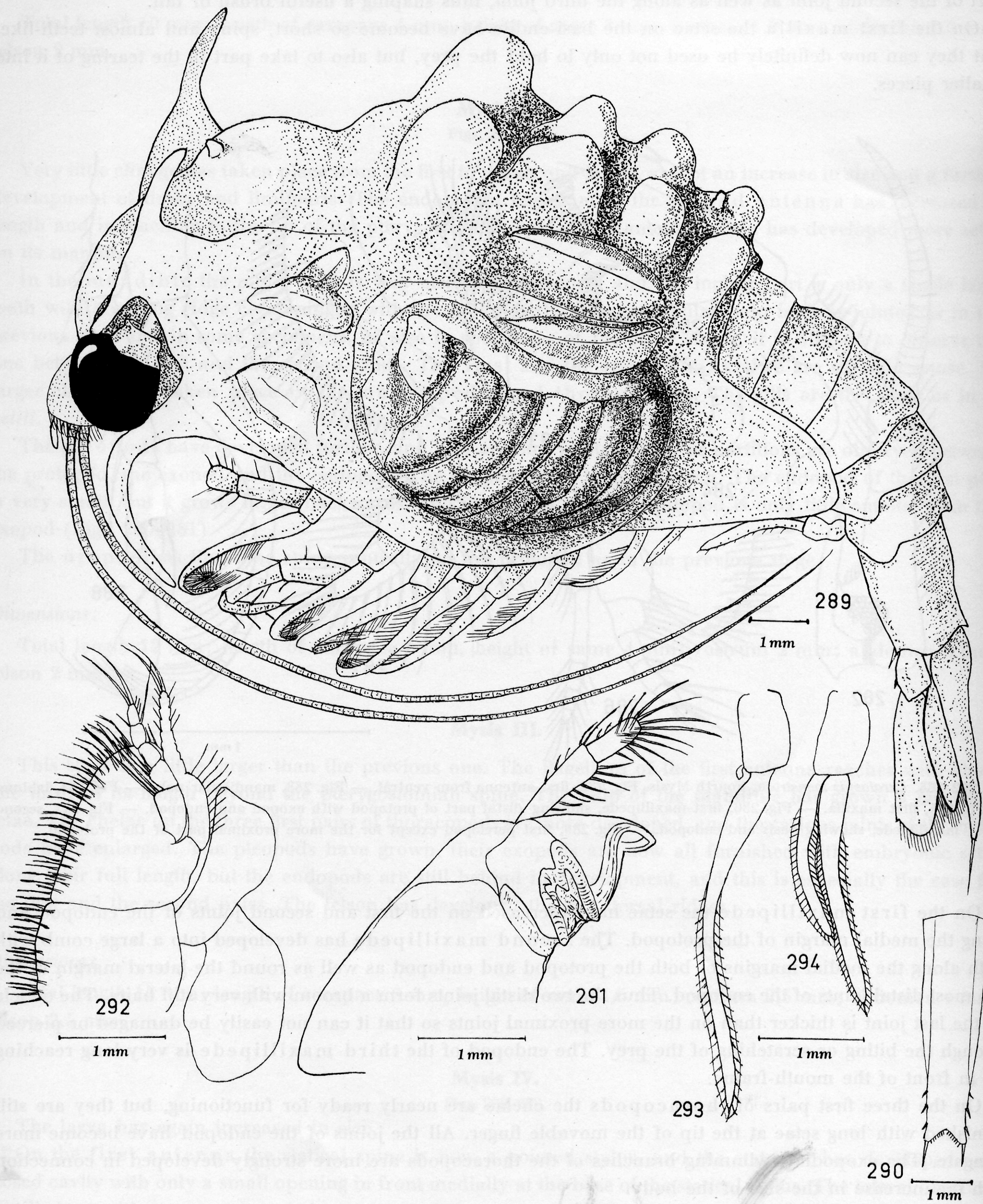
On the first maxillipede the setae have increased on the first and second joints of the endopod and along the medial margin of the protopod. The second maxillipede has developed into a large comb with teeth along the medial margins of both the protopod and endopod as well as round the lateral margin of the two most distal joints of the endopod. Thus the two distal joints form a broom with very stiff hairs. The cuticle on the last joint is thicker than on the more proximal joints so that it can not easily be damaged or pierced through the biting or scratching of the prey. The endopod of the third maxillipede is very long reaching far in front of the mouth-frame.

On the three first pairs of thoracopods the chelae are nearly ready for functioning, but they are still furnished with long setae at the tip of the movable finger. All the joints of the endopod have become more elongate. The exopodial swimming branches of the thoracopods are more strongly developed in connection with the increase in the size of the body.

The pleopods have grown larger, but are still without any function as the brims of setae along their branches still consist of embryonic setae only.

Dimensions:

Total length 22 mm; length of carapace 10 mm, height of same 6 mm; rostrum 3 mm; abdomen 6 mm; telson 3 mm.



Figs. 289–294. *Cerataspis petiti.* Fifth Mysis. Fig. 289, larva from lateral. — Fig. 290, telson. — Fig. 291, mandible. — Fig. 292, first maxillipede. — Fig. 293, first pleopod. — Fig. 294, fifth pleopod.

Mysis V.

Figs. 264, 289–294.

Carapace.

The larva has grown, but it has retained its peculiar form, and the sculpture on the carapace has developed further. The dorsal tubercles have enlarged, and so has the convoluted lateral surface of the carapace which now extends far laterally of the body proper as two big floats. A tubercle in the shape of an elongate pad was in the fourth Mysis placed between the swollen lateral areas of the carapace and the dorsal tubercles. In the present stage this pad-formed tubercle has grown larger. On the lateral side in front of the convoluted surface two new small swellings have started to develop, one placed above or dorsally of the other, the one placed most dorsally is the largest. The spines or horns of the carapace have relatively shortened, which possibly have caused the tubercles and the convoluted swellings to increase to give the larger animal sufficient buoyancy to remain pelagic in the deep oceans.

Abdomen.

In the previous stage the abdomen only constituted a thin string behind the carapace. In this stage it has, however, grown considerably in size. It is especially its width that has increased, and this is first and foremost the case with its three first joints.

Appendages.

The first antenna has developed its two flagella; both the lateral one, with the olfactory hairs on its medial margin, and the medial one have increased in length and number of rings. Especially the medial flagellum has grown and is now well double the length of the lateral olfactory flagellum.

In the second antenna the antennal scale with setae along the medial and distal margin has developed, but it is without any vestige of an antennal spine (Fig. 264) contrary to what is the case in *C. petiti* (Fig. 263). The antennal flagellum has grown into a long sweeping thread, which can reach behind the carapace.

The mandible has a larger corner-tooth in the incisor part and a long, curved ridge leading to the molar part, this latter is strongly convoluted and has distinct chewing pads. In the palp the first and the second joints have coalesced, so that it has now, as in adult Penaeids, only two joints. More setae are developed along the margins of the palp.

No special change from the previous stage has taken place in the two pairs of maxillae. In the first maxillipede the setae on the first endopodial joint and the terminal setae of the second joint have enlarged.

The thoracopods are unchanged from the fourth Mysis stage.

The pleopods have enlarged. In the first and second pairs the endopods are only small notches on the protopods, but their exopods are very long. In the following three pairs of pleopods the exopods become shorter and the endopods longer from pair to pair, so that the fifth pair has the longest endopod and the shortest exopod, although the exopod in the fifth pair still is a little longer than the endopod of the same pair. All these branches, the exopods and the endopods, except the two first pairs, have in spite of their further development still embryonic setae sticking through the cuticle, so of course they can still have no function.

The uropods have the ventral spine of the protopod and a notch instead of the lateral spine of the exopod. The telson is more elongate and narrow, with two strong, longitudinal keels.

Dimensions:

Total length 27 mm; length of carapace 11 mm, height of same 7 mm; rostrum 4 mm; abdomen 8 mm; telson 4 mm.

Mysis VI.?

Of this species I saw a large specimen, longer than the above described Mysis V, in the British Museum collections, which was sent in from South African Waters by the late Dr. Barnard, South African Museum in Capetown. I do not have the exact measures, but I have ranged it here as a possible sixth Mysis stage.

Average measurements of different Mysis stages in mm.

Mysis stage:	I	II	III	IV	V
Total length	10	12	15	22	27
Carapace	4 × 3	5 × 4	6 × 4.5	10 × 6	11 × 7
Rostrum	1.5	2	2.5	3	4
Abdomen	2.5	3	4	6	8
Telson	2	2	2.5	3	4

Distribution.

Fig. 295.

The species *Cerataspis monstrosa* seems to be a little more common than *C. petiti*. Whilst *C. petiti* only is known from one locality in the Indian Ocean and in two records without locality, we know *C. monstrosa* from five different localities. The first is GRAY's from the coast of Brazil, then LATREILLE's from the Mediterranean, and later it has been recorded from the Azores (CHAVES), the Indian Ocean (DOHRN) and south of Madagascar (BOAS). In this paper 16 new localities are added, which in general are in line with the previously known five localities.

To the Azores are added 6 new localities in the Eastern Atlantic off Gibraltar. Further are one record from the West-Indies and two from near St. Helena, i.e. on nearly the same latitude as GRAY's locality at the coast of Brazil. Two records from south of Madagascar and one from South African waters can be added to the one from BOAS's description. Of new localities are three from the western Pacific Ocean: one from the South China Sea, one from north of the Philippines and one from south of Japan.

These localities together indicate a circum-aequatorial distribution with possibly a little further spreading north and south than for *C. petiti*, but this wider range to the north and south may be just accidentally, caused by the number of records being considerably larger for *C. monstrosa* than for *C. petiti*.

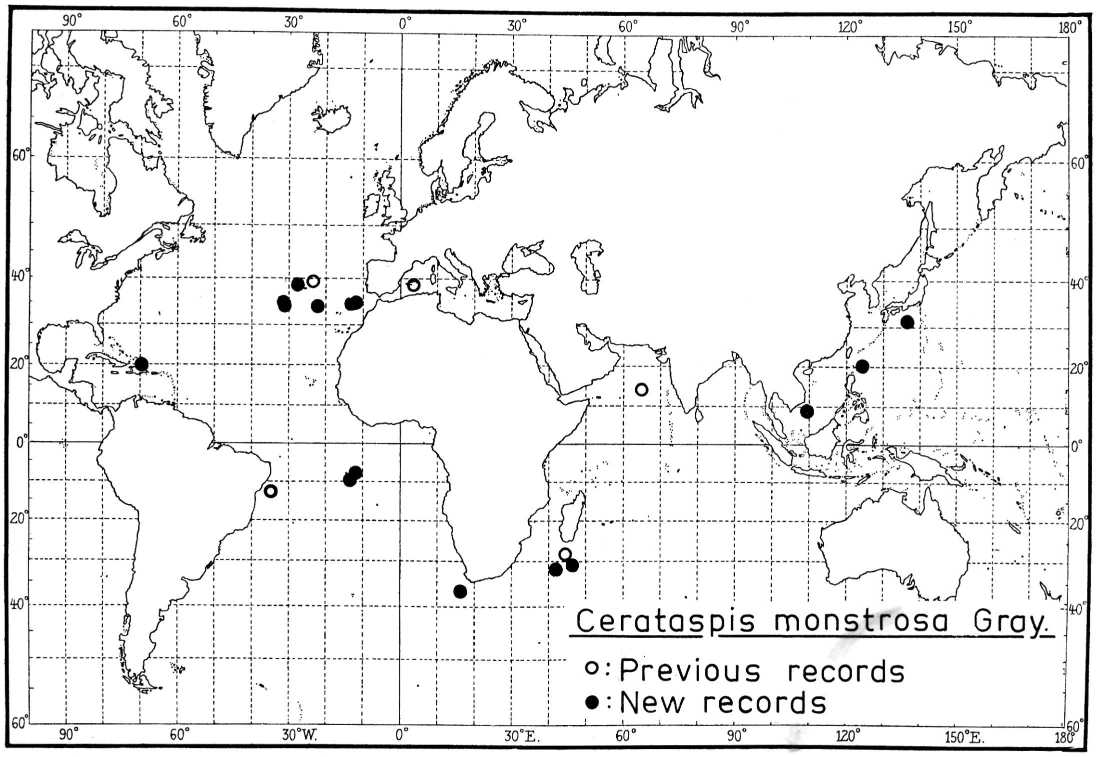


Fig. 295. Map of distribution.

DIAGNOSIS FOR THE LARVAE OF *CERATASPIDES*

Large penaeid Mysis larvae, much elongated, with a long, spiny rostrum and abdomen and with the exopods of the uropods developed as large buoyancy organs. One pair of dorsal tubercles. Carapace with smaller lateral swellings and spines, but no post-orbital or pterygostomian spines. Gills only non-lobose or lobose only in first order in older larvae. Abdomen with at least dorsal spines. Telson with open cleft and seven setae on each side of the furca. First antenna lateral flagellum in the older larvae in two sections: wider basal part, slender distal part. Eyes large; first and second antennae much elongated; antennal scale with lateral spine and a square-cut tip. Mandible with longer distance between single incisor tooth and molar part, the last very small. Three-jointed mandibular palp. Maxillipedes and thoracopods with long, stiff spines pointing forward shaping a trapping, catching and filtering basket. Chelae on the three first pereiopods first starting to develop in fifth Mysis.

Cerataspides longiremis (Dohrn).

Fig. 296–345.

Cerataspis longiremis, Dohrn 1871, pp. 366–372, pl. 29, 30, Figs. 48–67.
Cerataspis longiremis, Boas 1880, pp. 42–45, pl. 1, Fig. 1, 37, 38, pl. 2, Fig. 7, pl. 3, Fig. 100.
Peteinura gubernata, Bate 1888, p. 323, Pl. 53.
Cerataspides longiremis, Bonnier 1899, pp. 48–49.
Decapodenlarve, Pesta 1916, p. 80, Fig. 14.

Localities.

Mysis I.

25° N–35°30′ W. Andréa, 1862, C.Z.M. 12.1893, 1 spec.

Mysis II.

Atlantic Ocean, Collin, C.Z.M., 1 spec.
23°30′ N–35°30′ W. Andréa, 1862, C.Z.M. 12.1893, 2 spec.

Mysis III.

30° N–33° W. Hygom, C.Z.M. 12.1893, 1 spec.
24° N–32° W. Iversen, 10.9.1833, C.Z.M. 12.1893, 1 spec.
25° N–31° W. Iversen, 10.9.1833, C.Z.M. 12.1893, 1 spec.
25° N–35°30′ W. Andréa, 1862, C.Z.M. 12.1893, 1 spec.
27°24′ N–34°0′ W. Andréa, 1862, C.Z.M. 12.1893, 1 spec.

Mysis IV.

24° N–32° W. Iversen, 10.9.1833, C.Z.M. 12.1893, 1 spec.
25° N–31° W. Iversen, 10.9.1833, C.Z.M. 12.1893, 4 spec.
28° N–25° W. Iversen, 10.9.1871, C.Z.M. 12.1893, 1 spec.
27° N–27°40′ W. Andréa, 1864, C.Z.M. 12.1893, 1 spec.
26° N–28° W. Andréa, 1864, C.Z.M. 12.1893, 1 spec.

Mysis V.

25° N–31° W. Iversen, 10.9.1871, C.Z.M. 12.1893, 2 spec.

Description.

Mysis I.

Figs. 296, 301–314.

Carapace.

No younger stage than the first Mysis is known. The carapace of *Cerataspides* shows closer relation to *Solenocera* than that of *Cerataspis,* as also more of the for *Solenocera* characteristic spines on the carapace are found here. The rostrum is of an enormous length about twice the length of the carapace proper. The rostrum is flattened, furnished with thin spines at its two lateral edges and tipped with three large spines, two lateral and one medial one, the medial one is the largest. Near the base of the rostrum is a dorsally placed single spine. The anterior dorsal organ is rather small, the posterior organ is much larger. At the side of rostrum is a pair of curved supra-orbital spines and latero-posteriorly of them a pair of post-antennal spines which not emerge from the margin of the carapace like the supra-orbital spines. The margin has a small forward pointing lobe where the antennal spines should have been if present. Behind the anterior dorsal organ is a pair of small dorsal tubercles. Further back on the carapace and laterally is on each side a large, pear-shaped tubercle with the narrow part pointing forward. On the surface of this lateral tubercle are placed a few larger and smaller spines, anteriorly is a pair of hepatic spines close together, and with the dorso-anterior of them being the largest, and increasing still more in size during the following stages, soon making the second spine of the pair only an accessory spine. Posteriorly are two cardiac spines, a latero-cardiac and a ventro-cardiac. Contrary to what is the case for the hepatic spines it is here the ventral spine which is the largest, and it becomes in the later stages the largest spine of the carapace except for the rostrum, but the latero-cardiac, although smaller, never becomes only an accessory spine, it remains in all stages one of the larger spines. Both these spines are pointing posteriorly with their apices. The margin of the carapace is smooth, nothing can be seen of the dentated filaments so characteristic for the Protozoea of the *Solenocera* and which in *Solenocera* remained in parts also through the Mysis stages.

Abdomen and Telson.

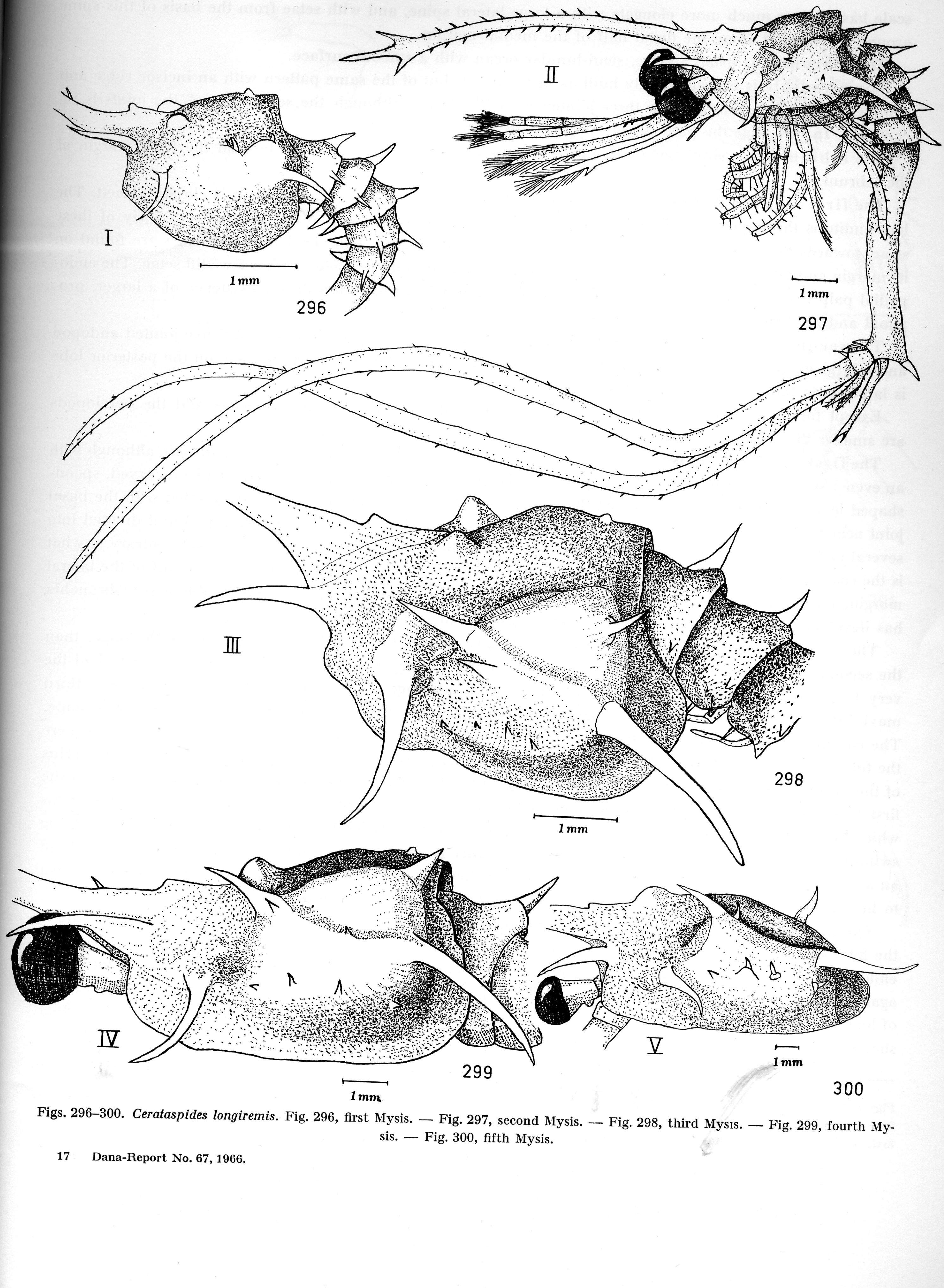
The abdomen has the normal six segments of which the first five are of about equal size, but the sixth segment is very long, about one and a half the length of the preceding five segments together. On each segment are placed a large dorso-posteriorly pointing dorsal spine, a smaller lateral spine and a ventral spine of medium size.

The telson is rather long with its smallest width near the middle of its length. From the place where the width is smallest the telson forks like a swallow-tail, showing a very open furca. Each of the two branches of the furca terminates with a spine and has along its inner margin seven setae. On the outer margin are the usual three spines: two small ones near the tip and the third one anteriorly of a line through the bottom of the furcal cleft.

Appendages.

The first antenna is—as also the second one—very long reaching far in front of the eyes, nearly to the three-forked tip of the strongly elongated rostrum. It has a four-jointed peduncle, but the first joint is not clearly defined. On the ventro-medial margin of the second, longest, joint is a forward pointing spine or hook. The third joint is a little more than half the length of the second, and the fourth joint is a short, nearly squarish joint, wider distally than proximally. On its distal margin are the lobes for the coming flagella together with a brush of stiff setae. The olfactory, lateral flagellum is the largest, contrary to what was found in the two species of *Cerataspis.* The olfactory flagellum has already started to be annulated with a large basal ring followed by half a dozen smaller rings. The medial flagellum is only short and not annulated.

The second antenna is also very elongate. Its short protopod has on the medial surface a small, circular bud. The endopod is already a small beginning flagellum with almost a dozen rings. The exopodial antennal



Figs. 296–300. *Cerataspides longiremis*. Fig. 296, first Mysis. — Fig. 297, second Mysis. — Fig. 298, third Mysis. — Fig. 299, fourth Mysis. — Fig. 300, fifth Mysis.

scale has become much more elongate with a large lateral spine, and with setae from the basis of this spine around the tip and along the distal half of the medial margin.

The labrum is as usual a large, semi-lunular organ with a smooth surface.

The mandible is not so strongly built as in *Cerataspis* but of the same pattern with an incisor ridge and a folded molar part. The palp is three-jointed as in *Cerataspis* although the separation of the joints is incomplete. In this stage the palp is only tipped with a few short setae.

The labium has a short peduncle and two rounded lobes reaching a little beyond the front margin of the labrum.

The first maxilla is with its lobes not much longer than the labium to which it is closely placed. The basi-endite is the largest endite and furnished with tooth-like setae at its distal margin, anteriorly of these setae, towards the endopodial palp, are two more seta-like bristles. Thinner, hair-like bristles are found on its margin and lateral surface. The coxa-endite is much smaller and provided with a few stiff setae. The endopodial palp is unjointed, but its shape and the placement of its setae indicate the existence of a larger, proximal and a smaller, distal joint in an earlier stage.

The second maxilla is of the normal shape with four protopodial endites, a still five-jointed endopod and a large exopod with both an anterior and a posterior lobe. The most posterior seta on the posterior lobe is larger than the others as is the case also for *Solenocera*.

Except for the first maxillipede the differences in shape between the maxillipedes and the pereiopods are smaller than is the case in *Cerataspis*.

The first maxillipede is rather small, but otherwise reminding much of that in *Cerataspis,* although with an even less clear division between the joints in the protopod. The protopod is shaped like a curved, spoon-shaped leaf with short, stiff setae along the whole medial margin. The endopod is five-jointed with the basal joint nearly half as long as the endopod. The exopod is somewhat longer than the endopod and divided into several joints, most of them with a vestigial seta on both the medial and lateral margins. But contrary to what is the case in *Cerataspis* the exopod has no lunular lobe fringed with setae on the proximal half of the lateral margin. The number of joints in the exopod is much higher than in *Cerataspis.* A large double mastigobranchia has developed in *Cerataspides* as also in *Cerataspis,* but there is still no arthrobranchia.

The second and third maxillipedes are almost equal in size with the third only a little longer than the second, whereas in *Cerataspis* the second was short but very massive and strong, and the third had the very long-reaching endopod reminding of the same appendage in *Solonecera.* Both the second and third maxillipedes have a coxa and a basis, basis is nearly twice as long as coxa, which has a more squarish shape. The endopod is five-jointed with the first joint rather short and the second joint the longest, and from there the following joints decrease in length, the fifth most distal joint being the shortest. Along the medial margins of the protopod and the endopod are lines of long, stiff setae. These setae form together with the setae of the first two, partly three, thoracopods a catching basket or sieve for smaller planktonic animals or detritus which are to serve as food for the larva. The exopods on both the second and the third maxillipedes are strong swimmerets, although that of the third maxillipede only is small. The mastigobranchia is double with both an anterior and a posterior leaf-shaped lobe. One of these lobes will later be transferred proximally on coxa to become the filiform podobranchia, which in *Cerataspis* from the beginning had the filiform shape.

The first three pairs of thoracopods—but mainly the first two pairs—are shaping the posterior half of the filtering and catching basket of the limbs. They have the normal two-jointed protopod and a five-jointed endopod of which the first joint is shorter than the second and third joints, the two most distal joints are again short. On the medial margin of the endopods, but not of the protopod as on the maxillipedes, is a series of long and very stiff setae which, when the legs are bent forward with their tips towards each other, together shape the basket through which only small particles can escape. It is of special interest to note the complete

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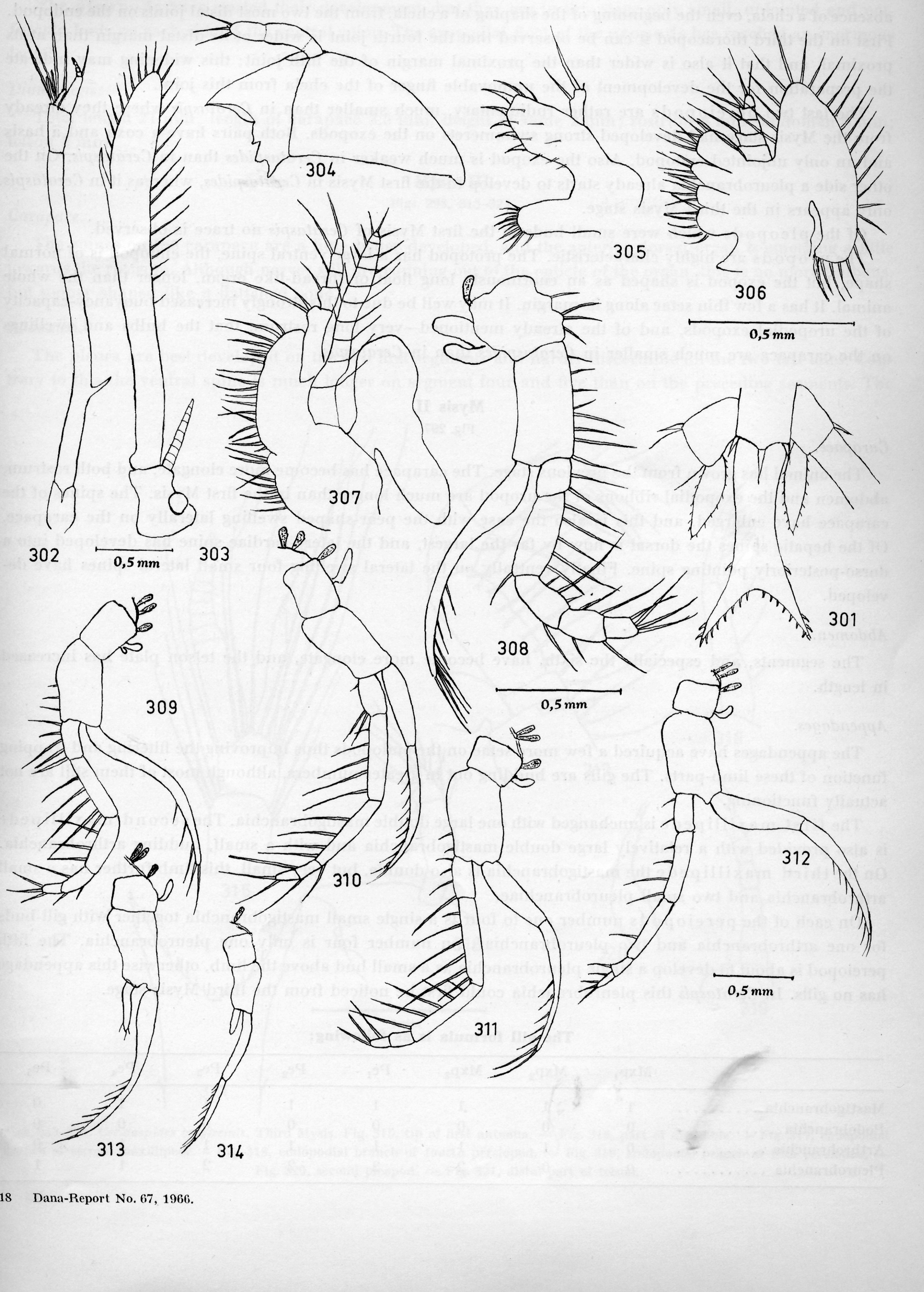
Figs. 301–314. *Cerataspides longiremis.* First Mysis. Fig. 301, tip of sixth abdominal segment with telson and part of uropods. — Fig. 302, first antenna. — Fig. 303, second antenna. — Fig. 304, mandible. — Fig. 305, first maxilla. — Fig. 306, second maxilla. — Figs. 307–309, first, second and third maxillipedes. — Figs. 310–314, first to fifth pereiopods.



301
302
303
304
305
306
307
308
309
310
311
312
313
314
0,5 mm
0,5 mm
0,5 mm
0,5 mm

absence of a chela, even the beginning of the shaping of a chela, from the two most distal joints on the endopod. First on the third thoracopod it can be observed that the fourth joint is wider at its distal margin than at its proximal, and that it also is wider than the proximal margin of the fifth joint; this widening may indicate the preparation for the development of the unmovable finger of the chela from this joint.

The last two pereiopods are rather rudimentary, much smaller than in *Cerataspis* where they already from the Mysis stage had developed strong swimmerets on the exopods. Both pairs have a coxa and a basis and an only unjointed endopod. Also the exopod is much weaker in *Cerataspides* than in *Cerataspis.* On the other side a pleurobranchia already starts to develop in the first Mysis in *Cerataspides,* whereas it in *Cerataspis* only appears in the third Mysis stage.

Of the pleopods which were small buds in the first Mysis of *Cerataspis* no trace is observed.

The uropods are highly characteristic. The protopod has a large ventral spine, the endopod is of normal shape, but the exopod is shaped as an enormously long float or thread-like organ, longer than the whole animal. It has a few thin setae along its margin. It may well be due to this strongly increased buoyancy-capacity of the uropodial exopods, and of the already mentioned—very long rostrum, that the bulbs and swellings on the carapace are much smaller in *Cerataspides* than in *Cerataspis.*

Mysis II.

Fig. 297.

Carapace.

The animal has grown from the previous stage. The carapace has become more elongate, and both rostrum, abdomen and the exopodial ribbons of the uropod are much longer than in the first Mysis. The spines of the carapace have enlarged, and this is also the case with the pear-shaped swelling laterally on the carapace. Of the hepatic spines the dorsal is now by far the largest, and the latero-cardiac spine has developed into a dorso-posteriorly pointing spine. Finally ventrally on the lateral swelling four small lateral spines have developed.

Abdomen.

The segments, and especially the sixth, have become more elongate, and the telson plate has increased in length.

Appendages.

The appendages have acquired a few more setae on the endopods thus improving the filtering and trapping function of these limb-parts. The gills are budding out in greater numbers, although most of them still are not actually functioning.

The first maxillipede is unchanged with one large double mastigobranchia. The second maxillipede is also provided with a relatively large double mastigobranchia and with a small, budding arthrobranchia. On the third maxillipede the mastigobranchia is also double, but very small, this limb further has a small arthrobranchia and two small pleurobranchiae.

On each of the pereiopods number one to four is a single small mastigobranchia together with gill-buds for one arthrobranchia and two pleurobranchiae, on number four is only one pleurobranchia. The fifth pereiopod is about to develop a single pleurobranchia as a small bud above the limb, otherwise this appendage has no gills. In *Cerataspis* this pleurobranchia could first be noticed from the third Mysis stage.

The gill formula is as following:

	Mxp_1	Mxp_2	Mxp_3	Pe_1	Pe_2	Pe_3	Pe_4	Pe_5
Mastigobranchia	1	1	1	1	1	1	1	0
Podobranchia.............	0	0	0	0	0	0	0	0
Arthrobranchia	0	1	1	1	1	1	1	0
Pleurobranchia	0	0	2	2	2	2	1	1

The pleopods have started their development, but they are in this stage only small, unjointed and not-furcate buds on each side of the ventral spine. The exopodial float of the uropods has reached an enormous length.

Dimensions:

Total length 21 mm; length of carapace 3,5 mm, height of same 2 mm; rostrum 8 mm; abdomen 8 mm; telson 2 mm.

Mysis III.

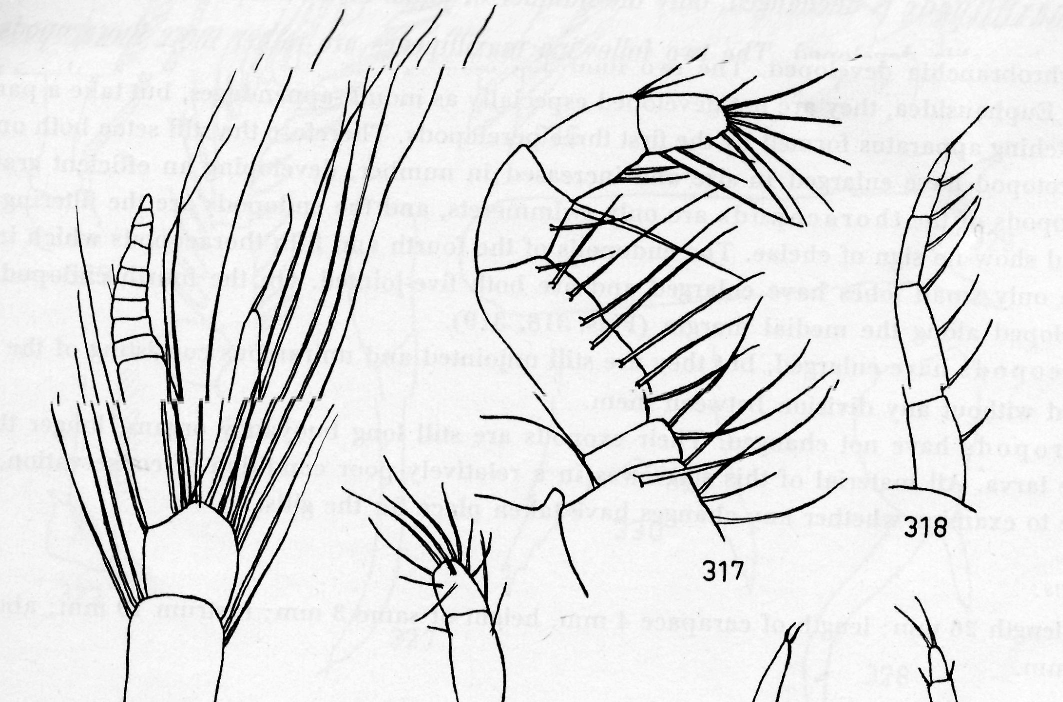
Figs. 298, 315–321.

Carapace.

The spines on the carapace are a little better developed, and the anterior dorsal organ is emerging a little towards the rostrum. Although nerves still are running out to the cuticle of the organ, this is no more bulbous, but sooner shaped like a flattened cone.

Abdomen.

The pleura are best developed on the two first segments and hardly discernible on the two last ones. Contrary to this the ventral spine is much longer on segment four and five than on the preceding segments. The



Figs. 315–321. *Cerataspides longiremis.* Third Mysis. Fig. 315, tip of first antenna. — Fig. 316, part of mandible. — Fig. 317, endopodial branch of second maxillipede. – Fig. 318, endopodial branch of fourth pereiopod. — Fig. 319, endopodial branch of fifth pereiopod. — Fig. 320, second pleopod. — Fig. 321, distal part of telson.

lateral spine seems still to decrease in size or rather not to grow together with the rest of the body. The telson plate is more elongate, and its furca is not quite so open. There are still seven spines on the inner margins of each furcal branch, and laterally the mid-spine and the most anterior spine seem to have moved a little forward (compare Fig. 301 with Fig. 319).

Appendages.

The first antenna is still very long (Fig. 315), its two basal joints have coalesced into one to the effect that the peduncle now consists of one longer basal joint and two shorter distal joints. From the third joint and from the tip of the second joint emerge many long hairs forming an anterior brush between the two flagella. These have both enlarged, the lateral one is still the largest and has developed near to ten rings at its tip. The medial flagellum is still unjointed, but tipped with a single seta.

The second antenna has also enlarged, and the endopodial flagellum is now reaching to about one third of the length of the antennal scale.

In the mandible there is a sharper division between the molar and incisor parts. The incisor part has only a single large tooth and a cutting edge, the molar part is becoming more compact than in the preceding stage, and the palp is still three-jointed, but it has increased the number of setae on its distal joint, and even the second joint is furnished with two small setae where there were none in the second Mysis.

The first maxillipede is unchanged, only the number of joints in the exopod have decreased, there is still no arthrobranchia developed. The two following maxillipedes are rather more thoracopods as is the case in the Euphausidea, they are not developed especially as mouth-appendages, but take a part in the filtering and catching apparatus formed by the first three pereiopods. Therefore the stiff setae both on the endopod and the protopod have enlarged in size and increased in number, developing an efficient grate. (Fig. 317).

The exopods of the thoracopods are only swimmerets, and the endopods are the filtering and trapping organs, and show no sign of chelae. The endopods of the fourth and fifth thoracopods which in the previous stage were only small lobes have enlarged and are both five-jointed. On the fourth endopod several setae have developed along the medial margin (Figs. 318, 319).

The pleopods have enlarged, but they are still unjointed and uniramous consisting of the protopod and the exopod without any division between them.

The uropods have not changed. Their exopods are still long buoyancy organs, longer than the rest of the whole larva. All material of this stage was in a relatively poor condition of conservation, so I have not been able to examine whether any changes have taken place for the gills.

Dimensions:

Total length 26 mm; length of carapace 4 mm, height of same 3 mm; rostrum 10 mm; abdomen 10 mm; telson 2 mm.

Mysis IV.

Figs. 299, 322–330.

Not only has the larva grown from about 26 mm to 40 mm in total length, from tip of rostrum to tip of telson, but also many of the appendages have developed further.

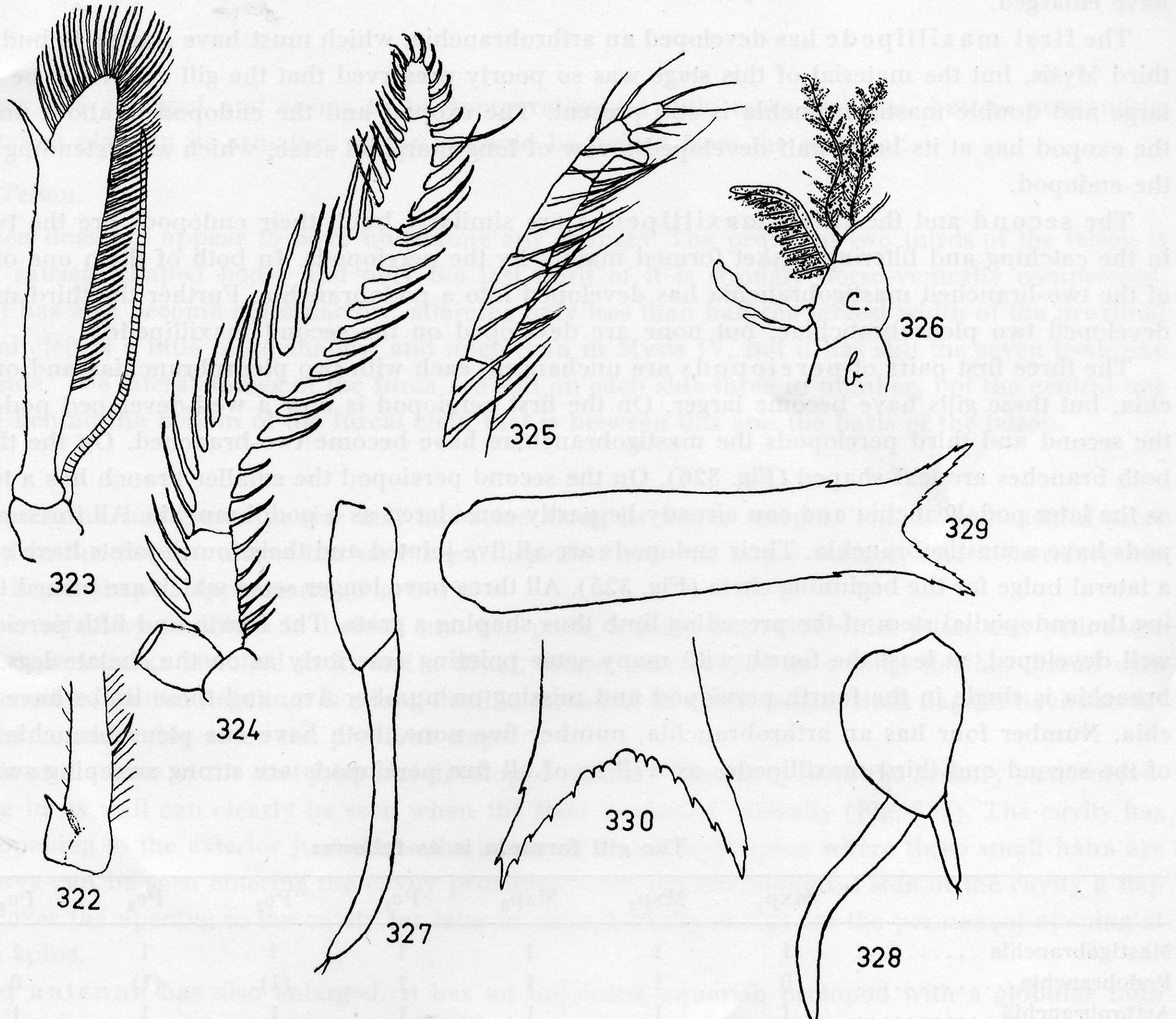
Carapace.

The size is now 6.5 by 4.5 mm, the rostrum has grown 40 % in length. The far most dominant spines are besides the rostrum the following five: the supra-orbital, the post-antennal and the dorso-hepatic spines, which all three are pointing anteriorly, and the two posteriorly directed spines, the latero-cardiac and the ventro-cardiac spines, of which the latter have become the largest after the rostrum. The rest of the spines are only very small or nearly disappearing. On the rostrum is still a single dorsal tooth. Behind rostrum, on the carapace, is the anterior dorsal organ in the shape of a widened tooth on the rostral carina. The posterior dorsal organ remains unchanged.

Abdomen and Telson.

The abdomen has grown from 10 to 16 mm in length. It is especially the sixth segment which has grown, and it is now a little longer than the preceding five segments together. The spines on each segment are still prominent, and the three first segments have developed large pleura, the last segment has no pleura and the fifth only small pleura.

The furcal cleft of the telson has become a little more shallow, and the proximal half of the telson has swelled into a sausage-shaped body tapering distally so that its distal third is shaped as a flattened plate.



Figs. 322–330. *Cerataspides longiremis.* Fourth Mysis. Fig. 322, basal part of first antenna from ventral. — Fig. 323, second antenna. — Fig. 324, endopodial branch of second maxillipede. — Fig. 325, endopodial branch of first pereiopod. — Fig. 326, protopod of third pereiopod with gill filaments. — Fig. 327, first pleopod, showing protopod and exopod and no endopod developed. — Fig. 328, fourth pleopod with the larger exopod and the smaller endopod. — Fig. 329, telson. — Fig. 330, tip of telson.

Inside the furca are still seven spines on each lobe, and laterally on the telson are on each side the characteristic three spines of the Penaeidae.

Appendages.

The first antenna has developed setae along nearly its whole length, laterally as well as medially (Fig. 322). These setae were in the previous stage only placed terminally on the second joint and from the third joint to the tip of the appendage. Laterally at the base is a well-developed statocyst spine, but the cavity for the statocyst is only very narrow. Both flagella of the first antenna have grown in length and are annulated from base to tip.

Also the second antenna has changed. The antennal scale has a large antennal spine more laterally pointed than in the younger stages, and from this spine along the rest of the lateral margin, around the tip, and almost to the basis of the medial margin is now the usual fan of setae. The endopodial flagellum is now nearly as long as the antennal scale.

The mandible has developed a few more setae on the palp. The palp on the first maxilla is now longer, but more delicate. The second maxilla has lost the segmentation of the endopod, and the four endites have enlarged.

The first maxillipede has developed an arthrobranchia, which must have started to bud already in the third Mysis, but the material of this stage was so poorly preserved that the gill could not be observed. The large and double mastigobranchia is still present. The exopod and the endopod is about unchanged, only the exopod has at its basal half developed a row of long marginal setae, which are extending medially over the endopod.

The second and the third maxillipedes are similarly built, their endopods are the two first "ribs" in the catching and filtering basket formed mainly by the pereiopods. In both of them one of the branches of the two-branched mastigobranchia has developed into a podobranchia. Further the third maxillipede has developed two pleurobranchiae, but none are developed on the second maxillipede.

The three first pairs of pereiopods are unchanged, each with two pleurobranchiae and one arthrobranchia, but these gills have become larger. On the first pereiopod is now a well-developed podobranchia. On the second and third pereiopods the mastigobranchiae have become two-branched. On the third pereiopod both branches are leaf-shaped (Fig. 326). On the second pereiopod the smaller branch has a toothed surface as the later podobranchia and can already be partly considered as a podobranchia. All three pairs of pereiopods have a mastigobranchia. Their endopods are all five-jointed and their fourth joints have each developed a lateral bulge for the beginning chela (Fig. 325). All three have longer setae which are turned forward reaching the endopodial stem of the preceding limb thus shaping a grate. The fourth and fifth pereiopods are now well developed, at least the fourth with many setae pointing anteriorly as on the chelate legs. The mastigobranchia is single in the fourth pereiopod and missing on number five, and these limbs have no podobranchia. Number four has an arthrobranchia, number five none, both have one pleurobranchia. The exopods of the second and third maxillipedes as well as of all five pereiopods are strong sweeping swimmerets.

The gill formula is as follows:

	Mxp_1	Mxp_2	Mxp_3	Pe_1	Pe_2	Pe_3	Pe_4	Pe_5
Mastigobranchia	1	1	1	1	1	1	1	0
Podobranchia.............	0	1	1	1	(1)	(1)	0	0
Arthrobranchia	1	1	1	1	1	1	1	0
Pleurobranchia	0	0	2	2	2	2	1	1

In the pleopods a division has taken place between the protopod and the rest of the limb. In the first and second pairs no trace of an endopod is visible, but there is a normal-sized protopod and a rather long exopod tipped with two small, embryonic setae (Fig. 327). On the third pleopod the protopod and the exopod are about the same as in the previous stage, but there is a minute bud on the protopod near the basis of the exopod representing the coming endopod. On the fourth pleopod the protopod is large and swollen, and the endopod has developed to about one third the length of the exopod (Fig. 328), both are tipped with two embryonic setae. The fifth pair of pleopods has a still larger endopod of about two thirds the length of the exopod. The protopod is here of the same shape as that of number four.

In the uropods the endopod has retained its normal shape, whilst the long, band-like exopod, serving as a buoyancy organ, has become even longer.

Dimensions.

Total length 40 mm; length of carapace 6.5 mm, height of same 4.5 mm; length of rostrum 14 mm; length of abdomen 16 mm; length of telson 4 mm.

Mysis V.

Figs. 300, 331–344.

This stage was represented by two badly damaged specimens, but from the size of the carapace and the further development of the appendages the stage can be assumed to be the stage following the last described stage.

Carapace.

The carapace has enlarged and seems to be comparatively a little more elongate, but no outstanding changes have taken place in its armature as far as could be judged from the material.

Abdomen and Telson.

The abdomen does not appear to have undergone any changes. The proximal two thirds of the telson is swollen into a sausage-shaped body, and only the last third of it is strongly dorso-ventrally compressed. This distal part has also become more narrow, attaining only less than half the largest width of the proximal part. The furcal cleft is a little more shallow and open than in Mysis IV, but it has still the seven teeth-like setae on each side. The lateral spines of the furca are still on each side three in number, but the central one is now situated behind the bottom of the furcal cleft, that is between this and the basis of the telson.

Appendages.

The first antenna has grown in size and has setae along its whole margin. The distal brush of setae which appeared in the younger stages has now been dispersed over the larger surface, and it therefore has lost part of its brush-shaped appearance (Fig. 331).

The lateral or olfactory flagellum is divided into two parts, a basal part with wider joints and with some olfactory hairs or aestetasks attached to it, and a distal, longer part shaped as a long, flexible thread with many rings. The other, medial flagellum is a long flexible thread in its whole length. Both flagella have increased their lengths considerably since the previous stage.

The statocyst at the base of the first joint has developed further. The cavity with the sensory-static nerve-cells developing in its wall can clearly be seen when the joint is viewed ventrally (Fig. 332). The cavity has its permanent opening to the exterior just above the antennal or statocyst spine where three small hairs are placed. The nerve can be seen entering the cavity proximally. On the latero-ventral side of the cavity a flap has started to cover the opening to the cavity for later to close it totally except for the permanent opening at the base of the spine.

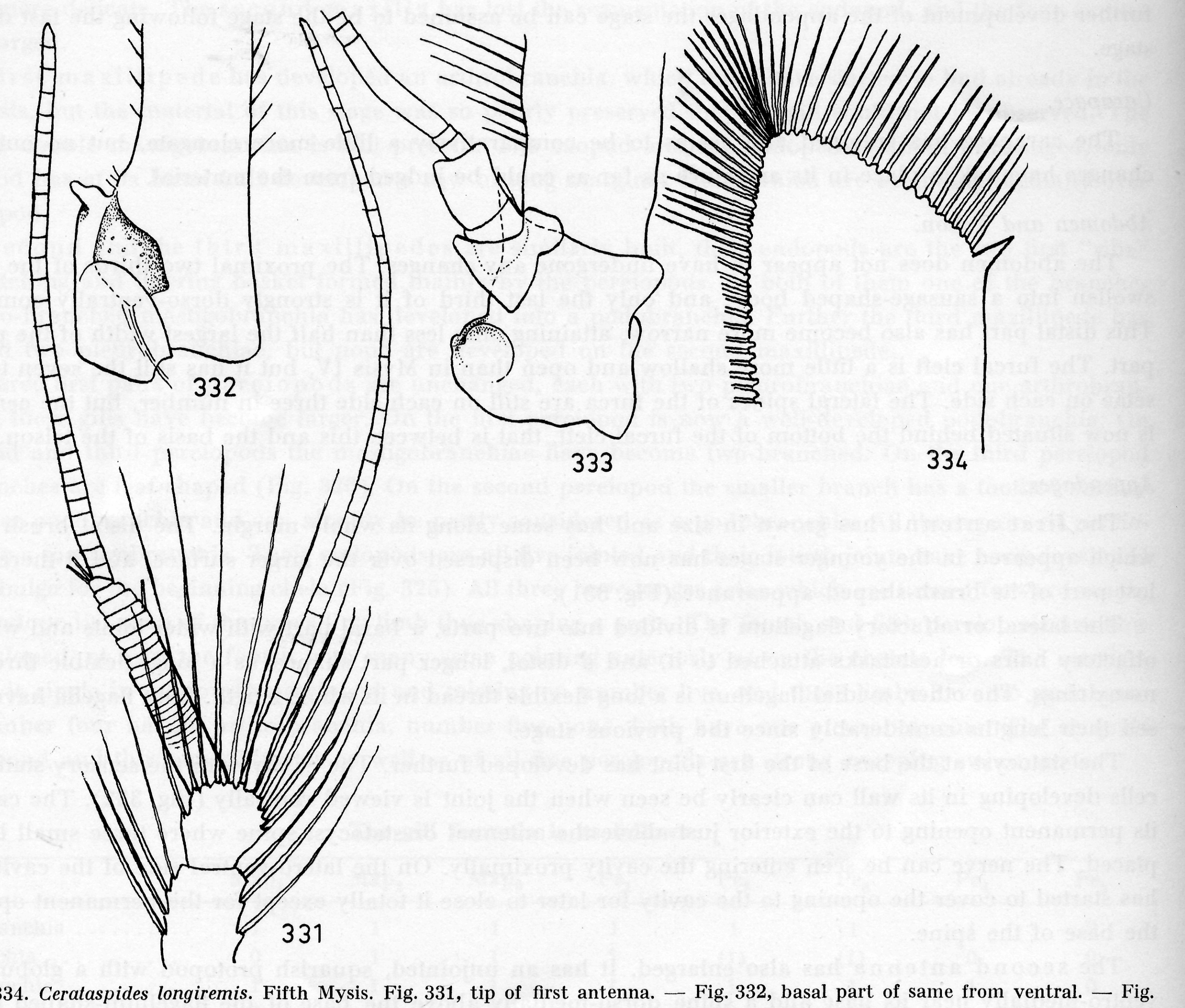
The second antenna has also enlarged. It has an unjointed, squarish protopod with a globular bulb ventro-medially near its base and a spine dorso-medially above the base of the flagellum-shaped endopod (Fig. 333). The endopod has three basal joints followed by a long flagellum which now is longer than the antennal scale. The exopod or antennal scale has become more squarish distally (Fig. 334) and has a well-developed disto-lateral spine, thus differing from *Cerataspis* where this spine either was missing or only vestigial.

The mandible has a large corpus mandibulae. The pars incisiva has still only a single tooth from which a long cutting edge runs to the molar part. This edge is merely knife-shaped without any single teeth, and is so very characteristic for both *Cerataspis* and *Cerataspides*. In *Cerataspides*, however, the edge is especially long and nearly straight. The molar part is only very small and seems rather unimportant. The palp is still three-jointed, and several more setae have developed on it.

On the first maxilla the basi-endite is the largest and furnished with strong, setiform cutting and tearing teeth. The coxa-endite has now several more brushing setae. The palp has grown a little longer and is tipped with three setae.

The second maxilla is provided with four long endites and an endopod which has become un-jointed, but the setae on its medial margin are placed in indentations indicating the previous divisions between the joints. Very characteristically the endopod has a series of setae along its lateral margin towards the exopod. The exopod is large and curved with both an anterior and a posterior lobe.

The first maxillipede has developed a second series of setae behind the marginal ones on the lateral side of the flattened protopod. The endopod is five-jointed with the basal joint being the largest. The exopod

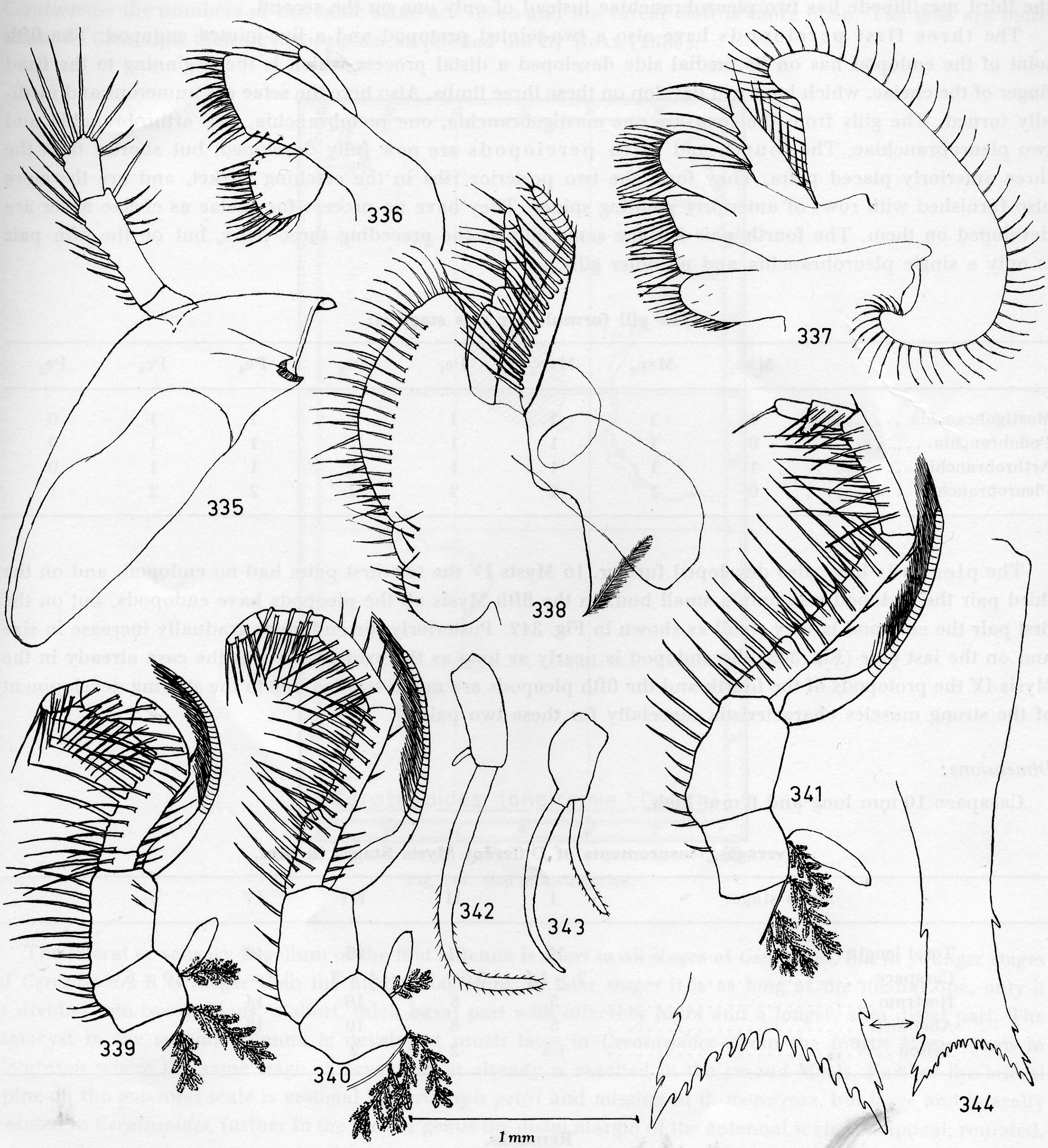


Figs. 331–334. ***Ceraspides longiremis*. Fifth Mysis. Fig. 331, tip of first antenna. — Fig. 332, basal part of same from ventral. — Fig. 333, basal part of second antenna from ventral. — Fig. 334, distal part of antennal scale.**

has a long, unjointed basal part terminating in a shorter and weakly jointed part with a pair of short, vestigial setae on each joint. This distal section is bent a little medially and appears with its small size as an only vestigial appendix. The lateral margin of the basal part of the exopod is extended into a lunular lobe with long setae along its margin and bent along its longitudinal axis over the stem of the exopod so that the lateral marginal setae are pointing medially. The appendage has a large double mastigobranchia and a smaller arthrobranchia.

The second maxillipede is a grasping and filtering organ. On the coxa is an elliptical mastigobranchia, a shorter podobranchia, a large arthrobranchia, and a small pleurobranchia. Especially in this stage it was very difficult to count the gills on the different limbs because some of them had decayed and a few had been lost, but I have tried as far as possible to examine their placement. For this stage I am in general agreement with Boas (1880), only he makes no distinction between arthrobranchiae and pleurobranchiae, and the podobranchiae he considers as part of the mastigobranchiae. The arthrobranchia on the first maxillipede is the one Boas refers to as: one little gill. With these explanations my countings of gills for this stage agree with those of Boas.

The endopod of the second maxillipede has developed numerous very long and stiff setae, which now are



Figs. 335–344. *Ceratáspides longiremis.* Fifth Mysis. Fig. 335, mandible. — Figs. 336–337, first and second maxillae. – Figs. 338–340, first, second and third maxillipedes. — Fig. 341, first pereiopod. — Fig. 342, first pleopod with a rudimentary endopod. — Fig. 343, fifth pleopod. — Fig. 344, telson.

found along the medial margins both of the protopod and the endopod, as well as along the endopod and here even in three lines. Most of those setae which do not extend from the medial margin are at their base turned so that their free tips point medially constituting a part of an extremely small-meshed basket. The exopod is a strong swimmeret.

The third maxillipede. What is noted for the second maxillipede is also valid for the third, only this limb is a little longer, but the setae on it are somewhat shorter than those on the second maxillipede. Further the third maxillipede has two pleurobranchiae instead of only one on the second.

The three first pereiopods have also a two-jointed protopod and a five-jointed endopod. The fifth joint of the endopod has on its medial side developed a distal process which is the beginning to the fixed finger of the chelae, which later will develop on these three limbs. Also here the setae are numerous and medially turned. The gills from the coxa are one mastigobranchia, one podobranchia, one arthrobranchia and two pleurobranchiae. The fourth and fifth pereiopods are now fully developed, but shorter than the three anteriorly placed pairs. They form the two posterior ribs in the catching basket, and are therefore also furnished with rows of anteriorly pointing spines. They have no process for chelae as chelae never are developed on them. The fourth pair has the same gills as the preceding three pairs, but on the fifth pair is only a single pleurobranchia and no other gills.

The gill formula for this stage is:

	Mxp_1	Mxp_2	Mxp_3	Pe_1	Pe_2	Pe_3	Pe_4	Pe_5
Mastigobranchia	1	1	1	1	1	1	1	0
Podobranchia.............	0	1	1	1	1	1	1	0
Arthrobranchia	1	1	1	1	1	1	1	0
Pleurobranchia	0	1	2	2	2	2	2	1

The pleopods have also developed further. In Mysis IV the two first pairs had no endopod, and on the third pair the endopod was only a small bud. In the fifth Mysis all the pleopods have endopods, but on the first pair the endopod is very small as shown in Fig. 342. Posteriorly the endopods gradually increase in size and on the last pair (Fig. 343) the endopod is nearly as long as the exopod. As was the case already in the Mysis IV the protopods of the fourth and the fifth pleopods are much swollen due to the starting development of the strong muscles characteristic especially for these two pairs.

Dimensions:

Carapace 10 mm long and 6 mm high.

Average Measurements of Different Mysis Stages in mm.

Mysis stage:	I	II	III	IV	V
Total length........................	13	21	26	40	
Carapace...........................	2 × 1.5	3.5 × 2	4 × 3	6.5 × 4.5	10 × 6
Rostrum	5	8	10	14	
Abdomen	5	8	10	16	
Telson	1.5	2	2	4	

Remarks.

It appears from the preceding pages that there is a clear distinction between *Cerataspis* with up to two now known species, *C. petiti* and *C. monstrosa,* and *Cerataspides* with only one known species *C. longiremis.*

It is therefore reasonable to retain the generic distinctions as they were made by BONNIER 1899 when naming the larvae.

The following differences can be mentioned: The characteristic post-orbital and pterygostomian horns found in *Cerataspis* but lacking in *Cerataspides;* further *Cerataspis* has a not-spiny abdomen, whereas *Cerataspides* has both dorsal, ventral and lateral spines on the abdominal segments. The telson is more penaeid in *Cerataspis* with a more closed furca which only has six setae along the medial margin of each lobe; in *Cerataspides* the numbers of the same setae are seven and the furcal cleft is more open. The gills are more obose in *Cerataspis* than in *Cerataspides* as pointed out by BOAS (1880).

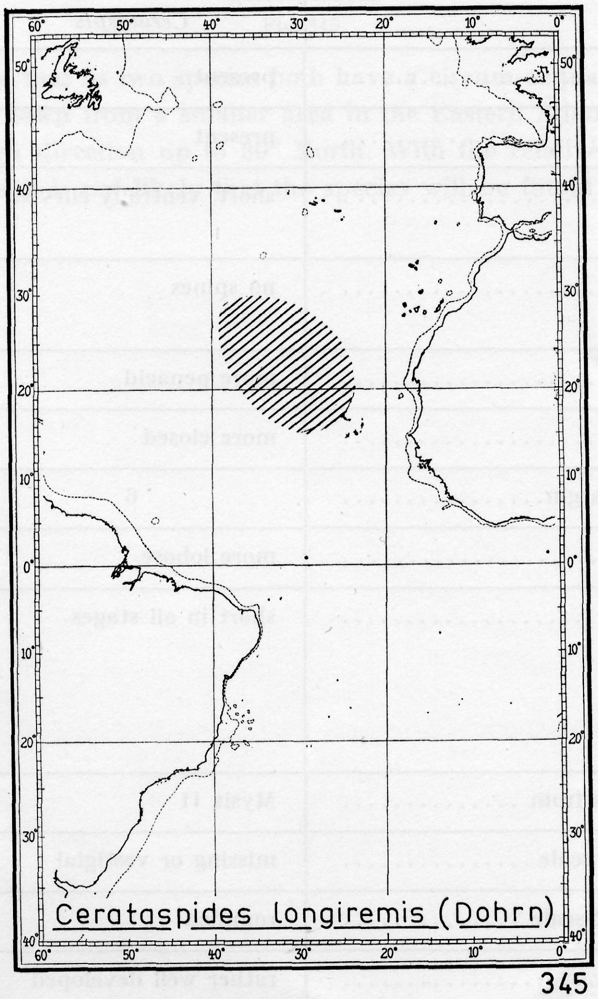


Fig. 345. Map of distribution.

The lateral or sensory flagellum of the first antenna is short in all stages of *Cerataspis,* but in younger stages of *Cerataspides* it is longer than the medial flagellum, in later stages it is as long as the medial one, only it is divided into two sections, a short, thick basal part with olfactory hairs and a longer, slim distal part. The statocyst in the second antenna is developed much later in *Cerataspides*—from the fourth Mysis—than in *Cerataspis* where the same stage of development already is reached in the second Mysis. Further the lateral spine on the antennal scale is vestigial in *Cerataspis petiti* and missing in *C. monstrosa,* but large and laterally pointed in *Cerataspides,* further in the former genus the distal margin of the antennal scale is elliptical, rounded, whereas it is nearly square cut in older stages of *Cerataspides.* In the mandible the molar part is much better developed in *Cerataspis* than in *Cerataspides,* in the latter it is only very small, and the incisor ridge is long and nearly straight against shorter and curved in *Cerataspis.* Both genera have three joints in the mandibular palp. On the second maxilla the fifth Mysis of *Cerataspides* has a most characteristic series of spines on the lateral margin of the endopod which is missing in *Cerataspis.* Also the first maxillipede has in *Cerataspides* more and better developed spines arranged in two lines on the protopod, in *Cerataspis* the number of spines is much lower.

The second and third maxillipedes in both genera are in the different Mysis stages much more pereiopods than in the Caridea larvae, but this is more or less the case with most Penaeid larvae. Both the maxillipedes and the following pereiopods have in *Cerataspides* an enormous armament of long and stiff spines in more

Summary of Main Differences between Mysis Larvae of:

	Cerataspis	*Cerataspides*
Carapace, post-orbital horns	present	absent
Carapace, pterygostomian horns	present	absent
Carapace, rostrum	short, ventrally curved	straight, very long and spiny
Abdomen	no spines	with dorsal, ventral, and lateral spines
Telson, form	more penaeid	less penaeid
Furcal cleft of telson	more closed	rather open
Furca, no. of setac on medial margin	6	7
Gills, form	more lobose	less lobose
First antenna, sensory flagellum	short in all stages	longer or of equal length with med. flag. In later stages divided in a thick proximal olfactory part and a slim distal part
First antenna, statocyst develops from	Mysis II	Mysis IV
Second antenna, lateral spine on scale	missing or vestigial	large
Second antenna, distal margin of scale	rounded	square-cut in Mysis V.
Mandible, molar part	rather well developed	very small
Mandible, incisor part	rather short and curved	longer and more straight
Second maxilla, endopod. Mysis V	no series of spines on lat. margin	a series of spines on lateral margin
First maxillipede, protopod	only marginal spines	larger spines in 2 series
Maxillipedes and pereiopods, catching and filtering basket is	rather weakly developed	strongly developed
First to third pereiopods, chelae	start developing in Mysis I	start developing in Mysis V
First and second pleopods, endopods	develop from Mysis I–II	develop in Mysis V

than one line and all pointing mainly in a medio-anterior direction, thus shaping an ideal catching and filtering basket for detritus and smaller animals. This basket is not nearly so well developed in *Cerataspis.* On the other side the chelae of the three first pairs of pereiopods have first started weakly to develop in the fifth Mysis stage of *Cerataspides,* a stage of development which already was reached in the first Mysis of *Cerataspis.*

Finally the endopods of the two first pleopods develop earlier in *Cerataspis* than in *Cerataspides.*

With all these differences the placing of the three species in two closely related genera is absolutely justifiable, *Cerataspis* with the two species *C. petiti* and *C. monstrosa* and *Cerataspides* with the single species *C. longiremis.*

Distribution.

Fig. 345.

For *Cerataspis* it was shown that its two species both have a circum-aequatorial distribution. *Cerataspides longiremis,* however, is only known from a smaller area in the Eastern Atlantic, from North of the Canarie Islands and in a north-western direction up to 30° North. With the relatively large number of specimens known from a so limited area it is not likely that the species will be found in the future in other parts of the oceans.

Summary Table of Measurements in mm of the Different Larval Stages described in this Paper.

		Protozoea III	Mysis I	Mysis II	Mysis III	Mysis IV	Mysis V
Solenocera membranacea	Total length	4.5	7	12			
	carapace	1.5 × 1.8	2.3 × 1.8	3.5 × 2.5			
	rostrum	0.7	1.5	2.3			
	abdomen	1.3	2.5	5.5			
Solenocera membranacea subsp. *capensis*..	total length	4.5	7.5	12			
	carapace	1.8 × 2.0	2.5 × 2.0	3.4 × 2.5			
	rostrum	0.6	1.6	2.2			
	abdomen	1.3	2.7	5.6			
Solenocera sp. larva *danae*	total length	6.0	12.5	22	30		
	carapace	2 × 2	3 × 3	6 × 6	9 × 7		
	rostrum	2	6	9	?		
	abdomen	2	3	6	8		
Solenocera sp. larva *barbata*	total length	4					
	carapace	1 × 1.2					
	rostrum	1					
	abdomen	1.6					
Solenocera sp. larva *elongata*	total length	2.8					
	carapace	0.9 × 0.9					
	rostrum	0.8					
	abdomen	1					
Solenocera sp. larva *sumatransis*	total length		6	10	17	22	
	carapace		2 × 2	3 × 3	5 × 5	7 × 5	
	rostrum		1	1.8	2.7	3.5	
	abdomen		2.5	3.7	7	11	
Solenocera sp. larva *aequatorialis*	total length			12			
	carapace			3.5 × 3			
	rostrum			2.2			
	abdomen			5.5			
Solenocera muelleri	total length	(1.2)	5	8.5			
	carapace		1.5 × 1	2.2 × 1.3			
	rostrum		1	1.5			
	abdomen		2	3.6			
Solenocera novae-zealandiae	total length	4					
	carapace	1 × 1					
	rostrum	0.8					
	abdomen	1.5					
Solenocera sp. larva *nodulosa*...........	total length			14			
	carapace			6 × 4			
	rostrum			2			
	abdomen			5			
Cerataspis petiti	total length		8.5	10.5	16	23	27
	carapace		4 × 2.5	4.5 × 3.0	7 × 4	10 × 5	12 × 7
	rostrum		1	2	2.5	3	4
	abdomen		2	2.5	4	7	7.5
Cerataspis monstrosa	total length		10	12	15	22	27
	carapace		4 × 3	5 × 4	6 × 4.5	10 × 6	11 × 7
	rostrum		1.5	2	2.5	3	4
	abdomen		2.5	3	4	6	8
Cerataspides longiremis	total length		13	21	26	40	
	carapace		2 × 1.5	3.5 × 2	4 × 3	6.5 × 4.5	10 × 6
	rostrum		5	8	10	14	
	abdomen		5	8	10	16	

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