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STUDIES ON INDIAN COPEPODS 4. DESCRIPTION OF THE FEMALE AND A REDESCRIPTION OF THE MALE OF *PSEUDODIAPTOMUS ARDJUNA* BREHM (COPEPODA, CALANOIDA) WITH NOTES ON THE DISTRIBUTION AND AFFINITIES OF THE SPECIES*

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In 1953, Brehm described a new species of calanoid copepod, *Pseudodiaptomus ardjuna* from Salsette Island, Thana District, Bombay. He had at his disposal only two male specimens, one of which was damaged. However, he could rightly identify it as a new species of the genus *Pseudodiaptomus* Herrick and gave a brief description of the male. The female of this species has not so far been described and there is no subsequent report of the male itself from anywhere. This short paper is meant to give a full account of both male and female collected from the South-East coast of India, off Mandapam.

The present study is based on the examination of numerous specimens obtained from the plankton hauls, in the Gulf of Mannar and the Palk Bay ; samples were also obtained from the saline creeks leading to the Central Marine Fisheries Research Station Experimental Fish Farm. No morphological differences were noticed between the three examples ; however, the present material differs in some details from the descriptions and diagrams given by Brehm for the specimens he collected from Bombay waters and these differences are discussed below. In describing the various parts of the body, I have adopted the terminology suggested by Gooding (1957) with some modifications (Ummerkutty, 1960 & 1960 a). In presenting the ornamentation of the swimming legs Sewell's suggestion (1949) to differentiate spines by Roman and setae by Arabic numerals is adopted.

All the drawings are made with the aid of a camera lucida.

Genus *PSEUDODIAPTOMUS* Herrick

Marsh, 1933, p. 46.

Sewell, 1956, p. 167.

Wilson, 1932, p. 101.

PSEUDODIAPTOMUS ARDJUNA Brehm

Brehm, 1953, p. 313.

Female

The body (Fig. I, 1) is rather narrow, smoothly rounded anteriorly. The pro-some consists of five segments. The first segment is the cephalothorax, formed

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by the fusion of the cephalosome and the first leg-bearing segment; it is the longest of prosomal segments and is widest at its posterior margin. The second segment is rectangular with the long axis being the width of the copepod body. The third and fourth segments are rather short and subequal; the latter is, however, wider than the former and is the widest part of the prosome. The fifth prosomal segment is armed on each of its postero-lateral corners with a sharp spine, directed backwards and slightly outwards; the right spine is slightly larger than the left one. The urosome consists of four joints, the genital segment and three abdominal segments. The genital segment is barrel-like and exceeds other urosomal segments both in length and width; it has a well-marked ventral swelling on which is borne the genital operculum; the latter does not bear any spine. The abdominal segments are subequal, each segment being about half as long as the genital segment. The caudal rami are narrow, cylindrical and more or less parallel. It is one and a half times longer than the last abdominal segment and bears numerous setules on its inner margin. Each ramus bears five setae, four of which are apical and one subapical on the outer side.

The antennule (Fig. I, 2) is moderately long reaching the posterior margin of the prosome. It has 23 segments which bear the following proportions (all measured through midline).

1	2	3	4	5	6	7	8	9	10
5.5	4.1	3.0	3.4	3.3	1.7	3.0	4.1	2.2	3.1
11	12	13	14	15	16	17	18	19	20
4.5	4.5	5.3	5.9	6.0	6.0	6.9	5.4	4.3	4.3
21	22	23							-
4.3	4.1	5.1	= 100						

Segments 1st to 15th and also the 18th and the 23rd segments bear each an aesthetaske besides one or more setae; the aesthetaske is short, but very distinctly developed. The 21st segment bears a specialized seta whose inner margin carries a row of teeth at about its mid-region. This last character is also met with in a number of other species of this genus (Sewell, 1932, p. 239). The antenna (Fig. I, 3) has the usual characters of the genus: a 2-articled protopod, a 2-segmented endopod and a 4-segmented exopod; it, however, differs from others in possessing two rows of small spinules on the distal inner margin of the last segment of the endopod. The mandibular palp (Fig. I, 4) is with 4-segmented exopod, 2-segmented endopod and a 2-segmented protopod; the masticatory blade normal with numerous teeth. The maxillule (Fig. I, 5) is probably the most conservative of all structures in this genus; it is quite normal and typical in the present species. The maxilla (Fig. I, 6) is apparently 3-segmented but consists of 7 endites, the first and second segments with 2 endites each and the third with 3 endites; the endites bear 3 or 4 fairly long setae. The maxilliped (Fig. I, 7) is 7-segmented; first and second segments are quite large and subequal and other segments are much smaller and their combined length is a little less than that of either first or second segment; the first segment bears 7 setae and a spine; the second only 3 setae and a number of minute hairs; and each of the distal 5 segments bears two or more setae.

The four pairs of swimming legs (Fig. I, 8, 9 and 10) are borne by the first 4 prosomal segments. All the legs are biramous and constructed on identical plans.

While the second and third legs resemble each other in all the structural details, the first and fourth segments show differences both in size and in setation. The ornamentation of the swimming legs are as follows :

	Protopod				Endopod						Exopod							
	1		2		1		2		3		1		2		3			
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	St	Se		
P ₁	1	0	0	0	1	0	1	0	3	2	1	1	I	1	0	3	I	II
P ₂	1	0	0	0	1	0	2	0	4	2	2	1	I	1	I	5	I	II
P ₃	1	0	0	0	1	0	2	0	4	2	2	1	I	1	I	5	I	II
P ₄	1	0	0	1	1	0	2	0	3	2	2	1	I	1	I	5	I	II

It may be seen that the terminal exopod segment of each leg is provided with two outer spines and that the other exopod segments each bears a single outer spine except the second segment of the first pair of legs which has no spine at all. There is a single inner seta on the first and second segments of each exopod. The terminal exopod segment of first legs bears 3 setae while the second, third and fourth legs bear each 5 setae on this segment. The first endopod segment in all the four pairs of legs each carries a single seta while the second segment in these legs carries 1 seta in the first leg and 2 setae each in the next three legs. The terminal endopod segment in the first legs bears 6 setae, in the second and third legs 8 setae each and in the fourth leg 7 setae. The basal protopod segment carries a single seta in all the four legs, while the second protopod segment does not bear any seta or spine except in the fourth leg where a small spine is present.

The fifth legs (Fig. I, 11) are uniramous, symmetrical and small. On each side it consists of 4 articles; the first segment is devoid of any seta or spine; second and third segments each bears a single setule; the last segment bears 2 setae of unequal length and 2 flattened spinelike structures, bearing minute teeth on the inner margin. In this genus the basal two segments of the fifth leg represent the protopod and the distal two segments the exopod; the endopod is entirely lacking.

The female carries a single ovisac, rather irregular in shape and containing about 25 eggs. Length of the female is 1.31 mm.

Male

The male (Fig. I, 12) shows sexual dimorphism in the antennule, the fifth pair of legs and in the urosome. It is smaller than the female but has the same general appearance. The spines on the posterior prosomal segments are, however, much less pronounced, although their slight asymmetry is maintained. The urosome is 5-segmented, of uniform width and more cylindrical than in the female; first segment is the shortest and second the longest while other three segments are subequal and of moderate length.

The right antennule (Fig. I, 13) is geniculate while the left is quite normal and resembles that of the female in all structural details, including the specialized seta

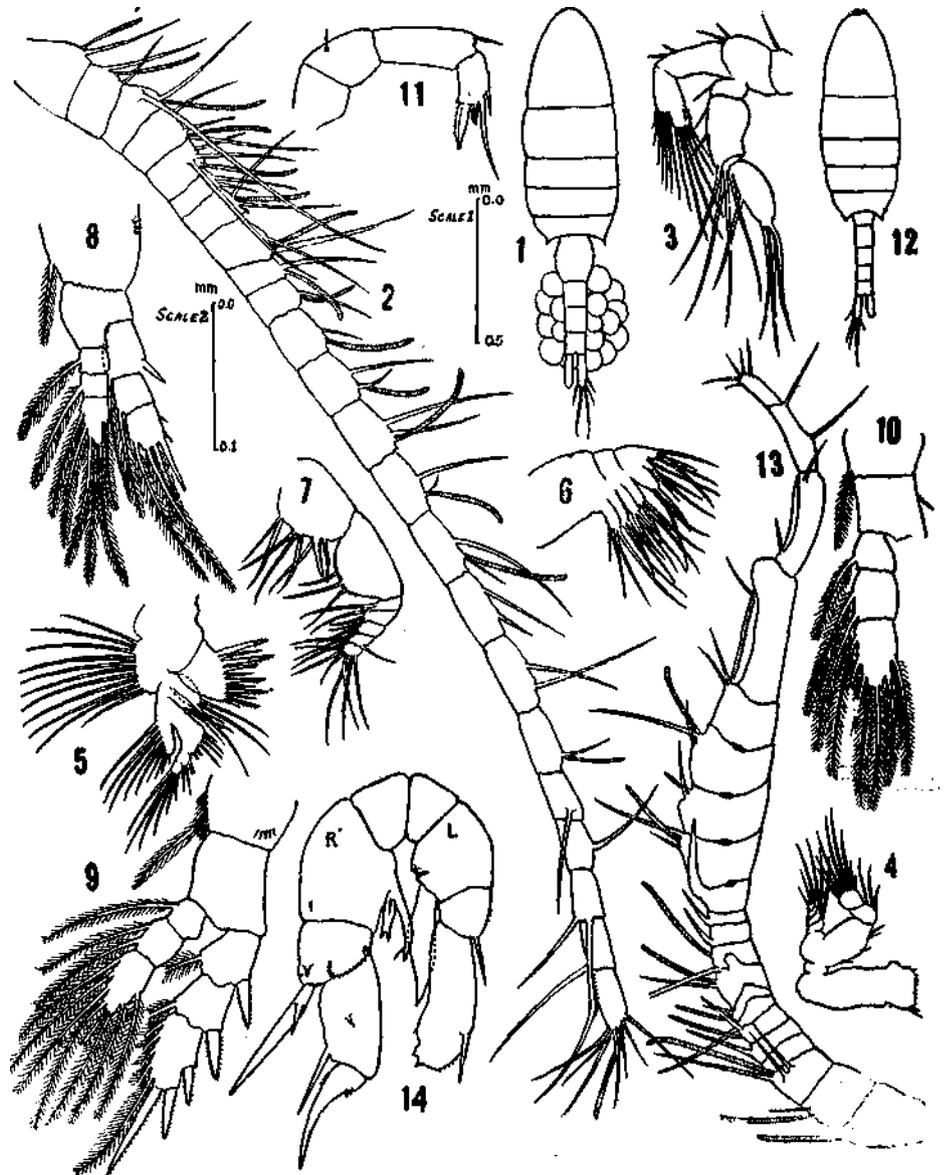


FIG. I, 1-14: *Pseudodiaptomus ardjuna* Brehm.

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|---|---------------------------------------|
| 1. Adult, egg-carrying female, dorsal view. | 8. " first swimming leg. |
| 2. Female, antennule | 9. " second swimming leg. |
| 3. " antenna | 10. " endopod of fourth swimming leg. |
| 4. " mandible, | 11. " fifth leg. |
| 5. maxillule | 12. Male, adult, dorsal view. |
| 6. maxilla, | 13. " " geniculate antennule. |
| 7. maxilliped. | 14. " " fifth pair of legs. |

of the twenty-first segment. The geniculate antennule consists of 21 segments which bear the following proportions :—

	1	2	3	4	5	6	7	8	9	10
	7.8	5.5	4.2	2.4	1.8	2.1	2.1	1.7	2.5	2.4
11	12	13	14	15	16	17	18	19	20	21
2.1	1.2	3.5	5.1	5.6	6.0	5.8	12.8	11.8	8.5	5.1 = 100

As the lines of separation are not exactly parallel in all cases and as the measurements are done through the midline of the segments, the proportions given for some segments are not accurate. The segments from 1st to 16th each bears an aesthetaske, except the fifth, seventh and eleventh to thirteenth segments; the latter 3 segments, however, each bears a stout spine.

Fifth legs (Fig. I, 14) are rather strongly built, asymmetrical and close together; the right leg is slightly longer than the left; right basal one is, of moderate size with no accessory process; basal two is very large and slightly longer than wide; it carries on its inner margin a 'y'-shaped spinous process with the arms of unequal length; this process represents the vestigial endopod; it also carries at its distal outer corner a small spine on the anterior face. Exopod is displaced into medial line and consists of 3 segments; the first segment is fairly large and much wider than long; three features are notable in this segment: (a) at the distal outer angle there is a spinous process which is quite long and which, in its turn, bears a smaller spine at one-sixth of its proximal length, thus giving a forked appearance to that region; (b) a small, almost conical spine, also borne on the distal outer corner, is present just below the preceding larger spine; and (c) a serrated edge is seen along the line of separation of the first and second segments; this edge curves down after the mid-width of the segment. The second exopod segment is much longer than the first segment, but distinctly less wide; it carries a fairly long spine on its distal outer angle and a smaller spine at about the centre of the segment on the anterior face. Exopod segment 3 is modified into a stout spine; its base is bulbous, bearing a few spinules on either side.

Left basal one is smaller than its right counterpart and with no accessory spines or processes. Left basal two is quite large with its breadth larger than the length. It bears at its inner distal angle a digitiform process which is fairly long almost equivalent to the length of the entire protopod. This process probably represents the endopod. In the left side, too, the exopod is displaced to a medial line and consists of only two segments; the first segment is quite short, the greatest length and breadth being almost equal; it bears a sharp spine at its latero-distal angle; the second segment consists of a thin plate, more or less rectangular in shape; on its outer margin it bears a spine at two-third of its length and a few minute spinules after that; on the left side the distal margin is provided with three spinules borne on small projections.

In the structure of other appendages and legs the male is identical with the female except in the smaller proportionate sizes. The length of the male is 1.1 mm.

A redescription of the male is provided above as it is found to show some variations in the structural details of the fifth legs from those of the specimens described by Brehm (/ c). The basal II of the right leg, in Brehm's diagram is shown to have a digitiform process, instead of the 'y'-shaped process seen in the present

specimens. The bifurcated spines on the outer distal angle of the basal exopod segment of the right fifth leg in Brehm's diagram appears to be only a different view of the same shown for the present material. In the left leg the terminal exopod segment is flat and leaf-like in both ; but in Brehm's diagram the proximal part is shown to be only half as wide as the distal area, whereas in the present example it is more or less of uniform breadth throughout. It is possible that these differences are real and are probably geographic variations within the same species ; it is also possible that these apparent differences do not exist at all and that Brehm's specimens exhibit deviations only because they would have been mounted and examined in a different angle. However, I feel that the species dealt with in this paper is the same as that erected by Brehm from Bombay waters.

Distribution—Until now this species is known only from the Bombay coast. Its occurrence both in the Palk Bay and in the Gulf of Mannar, off Mandapam extends its distribution to the south-east coast of India. It is likely that a careful examination would reveal its presence all along the west coast and possibly the east coast. It is an inshore dwelling species and gets into the saline creeks that are connected to the sea. In the Gulf of Mannar it is found in good numbers during the late winter months, February and March, majority of the females at that time carrying egg sacs. Rare individuals are caught almost throughout the year especially in the very inshore waters. The saline creeks, referred to above are on the Palk Bay side. They experience great variations in the salinity and temperature not only from season to season but in the different hours of the same day, depending upon the level of water present in them. Specimens were caught in April and May when usually there would be a fair amount of water in the creek. There is no information available as to its presence or absence in other months. The specimens taken from the creeks appeared to be actively reproducing as shown by the large number of ovigerous females and naupliar and copepodite stages.

Notes on the affinities of the species—The genus *Pseudodiaptomus* was established by Herrick in 1884 to receive a brackish water species, *pelagicus*, taken in Mississippi Sound, North America. Although this species has not been subsequently recorded from anywhere, there has been a steady increase in the number of known species of this genus, the total number at present being thirty-six. Marsh (1933) divided the species of this genus, placing a number of them in an older genus *Schmackeria* Poppe and Richard, (1890) in which the 'second segment of the basipod of the left fifth foot of the male is armed ; and its inner border is with a long curved projection' ; and in which the last prosomal segment of the female is rounded. Johnson (1939) obtained a new species *euryhalinus*, from the California Coast and created a new subgenus *Pseudodiaptallus* to accommodate it, so that its 'close relationship to the known *Pseudodiaptomus* species is well expressed'. This subgenus is easily distinguishable by the presence of only two free segments in the urosome. Sewell (1956) regards all these, namely, *Pseudodiaptomus* (*s. str.*), *Schmackeria* and *Pseudodiaptallus* as three subgenera of Herrick's original genus *Pseudodiaptomus* (*s. lat.*). However, the distinctions between *Pseudodiaptomus* (*s. str.*) and *Schmackeria* still appear to be far from clear, if there is any difference at all. If we accept Marsh's contention that *Schmackeria* has a vestigial endopod in the form of process, spine, etc., in both right and left legs of the male and has the posterior corners of the prosome rounded in both sexes, in contrast to *Pseudodiaptomus* (*s. str.*) which is said to have the vestigial endopod only in the right fifth leg of the male and to have the posterior corners of the prosome angular, it appears that some of the species are not assigned to their proper systematic places. *Pseudodiaptomus salinus* Giesb. and *P. hickmani* Sewell, both recorded from Indian waters, for example,

possess a vestigial endopod in both right and left male fifth legs ; Sewell, however, lists them in the subgenus *Pseudodiaptomus*. They can certainly be included in that subgenus if we take into account only the angular nature of the posterior corners of the prosome ; in the structure of the male fifth legs their affinities are with *Schmackeria*.

The present species is very closely related to *P. hickmani* and *P. salinus*. The fifth legs, both in the male and in the female are very identical in all these species and differ from each other chiefly in the proportionate dimensions of the constituting parts. Whether all the three species should be placed under the subgenus *Pseudodiaptomus* or the subgenus *Schmackeria*, it is not clear in the light of the present definitions given to the two groups. The genus has grown very large and the bizarre addition of the new species from time to time, many of them inadequately described, necessitates an urgent revision of the genus.

SUMMARY

The unknown female of a calanoid copepod *Pseudodiaptomus ardjuna* Brehm is described. A redescription of the male also is rendered as it is found that a few differences of structural details exist between male fifth legs of the present specimens and the male fifth legs described and sketched by Brehm (1953).

The systematic kinship of the species is briefly considered. It is very close to *Pseudodiaptomus salinus* and *P. hickmani*. A note is also given on the distribution of the species in the light of our present knowledge.

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