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A REVIEW OF THE CALANOID COPEPOD FAMILY PSEUDODIAPTOMIDAE WITH REMARKS ON THE TAXONOMY AND DISTRIBUTION OF THE SPECIES FROM THE INDIAN OCEAN*

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ABSTRACT

Among the various families of calanoid copepods, Pseudodiaptomidae—a predominantly warm water neritic family is important in view of the preference which the members of the family show to coastal waters. No attempt has hitherto been made to investigate the intra-specific relationships of the species belonging to the family Pseudodiaptomidae from the Indian Ocean. In the present communication, a list of those species which have either been described or previously recorded from the Indian Ocean has been given with a brief description on their taxonomy. The validity of the two genera, namely *Pseudodiaptomus* Herrick and *Schmackeria* Poppe and Richard, with a view to separate the different species of the family has been discussed. The paper also gives information on the spatial distribution of the species of the family in the Indian Ocean.

INTRODUCTION

PERTINENT literature of the systematics of pseudodiaptomids of the Indian seas are not extensive. Except for the pioneering works by Sewell (1919, 1924, 1932, 1934) from Indian seas, very little attention has been paid to investigate the taxonomy and biogeography of the different species of Pseudodiaptomidae from the Indian Ocean. At present the family contains more than 62 nominal species, both valid and synonyms, described originally either under *Pseudodiaptomus* or *Schmackeria* or assigned under either one of the genera by subsequent workers. Of these, 23 species, and one sub-species were recorded from the Indian Ocean. Existing records of the species of the family in the Indian Ocean are all from the coastal waters of the bordering countries including the brackish and freshwater habitats and the inshore regions of the oceanic islands between the latitudes 23°N and 40°S. The predominant localisation in their distribution is evident in that not more than 18% of the species from the Indian Ocean are reported to have a wide occurrence. However, no attempt has hitherto been made to investigate the intra-specific relationships of the species of the family Pseudodiaptomidae from the Indian Ocean. The taxonomic status and validity of the two genera, namely *Pseudodiaptomus* and *Schmackeria* with a view to separate different species of the family has been discussed in this report. The present communication also deals comprehensively with the taxonomy and spatial distribution of different species of the family, and includes brief notes on the fourteen species of *Pseudodiaptomus* collected from the coastal waters of India and from around the Andaman and Nicobar Islands.

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P. andamanensis collected from the Andaman Sea is described as new to science and the hitherto unknown male of *P. burckhardti* Sewell recorded and described. *P. marinus* Sato is reported here for the first time from the Indian seas.

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Remarks on the Status and Validity of the Genera

Pseudodiaptomus and *Schmackeria*

The genus *Pseudodiaptomus* was first included under the family Pseudodiaptomidae by Sars (1903) and this arrangement was followed by A. Scott (1909) and Fruchtl (1923). But Sewell (1932) and Wilson (1932) included this genus under Diaptomidae. However, the highly complex fifth pair of legs without a developed endopod of the species under the genus *Pseudodiaptomus* separates the genus *Diaptomus* from the former under the family Diaptomidae.

The species assigned under the genus *Pseudodiaptomus* was reviewed by Marsh (1933), who removed a number of species to an older genus *Schmackeria* described by Poppe and Richard (1890). The following characters distinguish the genus *Pseudodiaptomus*: urosome of three or four segments, usually four in female and five in male; A-1 20 to 22-segmented, right A-1 in male geniculate with two terminal segments beyond hinge; Ri of P1 to P4 three-segmented; P5 of female symmetrical or nearly so without a developed Ri; P5 of male asymmetrical, with or without an Ri. According to Marsh (1933) the genus *Schmackeria* differs from *Pseudodiaptomus* by, (i) the presence of a long curved projection on the inner border of B2 of the left P5 of female and (ii) the rounded nature of the last prosome segment of the female. Johnson (1939) created the sub-genus *Pseudodiaptallous* to accommodate the new species *euryhalinus* described by him from off California Coast, but he assigned all known species under the genus *Pseudodiaptomus*.

A perusal of the literature and the results of the study of the available specimens indicate that many species cannot be assigned under *Schmackeria sensu stricto* Marsh, as in species such as *salinus*, *hickmani* and *ardjuna* the left P5 of the male while possessing a ' curved process ', the posterior corners of T-V in female are distinctly produced posteriad. Eventhough the females show two types of P5 configurations, it is apparently difficult for generic separation as species such as *aurivillii* show overlapping characters. It is obvious therefore, that based on the group of characters, namely the angular or blunt nature of the prosome and the nature of the P5 the species cannot be assigned into two genera. A critical study of some of the taxonomic characters carried out justifies this assumption.

Posterolateral corners of T-V in different species have been described in detail and considered as one of the criteria for generic separation (Marsh, 1933). In some species it is evenly rounded (*masoni*, *lobipes*) and in others obtuse (*jonesi*), or drawn out into spines that are directed posteriad or posteriolaterally (*marinus*, *hickmani*, *ardjuna*). As regards the latter condition, *burckhardti*, *clevei* and *dauglishi* are interesting species as they possess an additional pair of spines dorsally and subterminally on the T-V and the point of insertion of these spines is considered as indicative of the place of fusion of T-IV and T-V (Sewell, 1932). Other structures

that are found in the posterior margin are : short spinules (*serricaudatus, tollingerae*), coarse curved teeth (*annandalei*) and small spines above the abdominal insertion (*binghami*).

Female P5 are structurally very homogeneous but they can be separated into two broad groups based on the characters of the spines on the terminal Re-segment (Sewell, 1932). Additional characters noticed are : inner marginal process on Re 1 (*binghami, b. malayalus, tollingerae*), outgrowths present on the inner distal margin of B2 (*pauliani, clevei, stuhlmani, charteri*) and spinules along the inner margin of Re 1 as found in *dauglishi*. Terminal Re-segment of *binghami malayalus* has only three spines instead of the usual four.

An important part of the specific distinction is found in the modification of the constituting parts of the male P5. In the male P5 specific diversity is clear in the structure of the Re. Typically, it has a two-segmented basipod, Re of 2 to 3 segments with or without a developed Ri. B1 shows little differences specifically except that it is provided with outgrowths in the form of blunt spines in species such as *aurivillii, mertoni* and *dauglishi*. B2 is generally longer than the preceding segment and is usually provided with a group of spinules at its mid-outer margin, and along its inner margin the vestigeal Ri is produced in the form of a process or spinulous outgrowth. A comparison of the pattern of Ri-configuration in the P5 of the species from the Indian Ocean shows that when Ri is present on the left leg only, it is in the form of a blunt process (*lobipes, binghami*). In those species with the Ri on right leg only, it is in the form of a spinous process, usually divided apically (*aurivillii, mertoni, dauglishi*). When Ri is present on both the legs, the same condition is retained, with a single blunt process on left leg and a simple or complex spinous process on the right leg (*hickmani, salinus, ardjuna, jonesi*). In the male of *burckhardti* Ri is very much reduced as a simple spinous process on both the legs. In *serricaudatus* the Ri of the right leg is in the form of a dentate plate and on the left leg it is a slender, sigmoid structure.

From the foregoing discussion it is evident that many species grouped under *Schmackeria sensu* Marsh shows the characteristics of *Pseudodiaptomus* also. Thus a group of species can be recognised which can be differentiated from *Pseudodiaptomus sensu stricto* and which cannot be grouped under a known genus. It is felt opportune here that the species from the Indian Ocean may well be assigned under different 'species groups' within the genus *Pseudodiaptomus*, groups that can be separated based on the modifications of appendages supplimented by other morphological features. Various species which were recorded from the Indian Ocean are tabulated below and assigned under different 'species groups' as they have been considered plausable in this discussion :

'*AURIVILLII*' GROUP

FEMALES	MALES
* *Pseudodiaptomus aurivillii* Cleve, 1901 [*P. (P.) aurivillii* Cleve, 1901]	*P. aurivillii* Cleve, 1901
* *Pseudodiaptomus mertoni* Fruchtl, 1923 [*P. (P.) mertoni* Fruchtl, 1923]	*P. mertoni* Fruchtl, 1923
Pseudodiaptomus dauglishi Sewell, 1932 [*P. (P.) dauglishi* Sewell, 1932]	*P. dauglishi* Sewell, 1932

* denotes species recorded or described during the present study.

'*ANNANDALEI*' GROUP

FEMALES	MALES
* *Pseudodiaptomus annandalei* Sewell, 1919	*P. annandalei* Sewell, 1919
[*P.* (*Schmackeria*) *annandalei* Sewell, 1919]	
— *P. dubius* Kiefer, 1936	
— *P. nostradamus* Brehm, 1933	
* *Pseudodiaptomus tollingerae* Sewell, 1919	*P. tollingerae* Sewell, 1919
[*P.* (*S.*) *tollingerae* Sewell, 1919]	
Pseudodiaptomus pauliani Brehm, 1951	*P. pauliani* Brehm, 1951
[*P.* (*P.*) *pauliani* Brehm, 1951]	
Pseudodiaptomus batillipes Brehm, 1954	*P. batillipes* Brehm, 1954
[*P.* (*P.*) *batillipes* Brehm, 1954]	

'*BURCKHARDTI*' GROUP

* *Pseudodiaptomus burckhardti* Sewell, 1932	*P. burckhardti* Sewell, 1932
[*P.* (*P.*) *burckhardti* Sewell, 1932]	

'*CLEVEI*' GROUP

* *Pseudodiaptomus clevei* A. Scott, 1909	*P. clevei* A. Scott, 1909
[*P.* (*P.*) *clevei* A. Scott, 1909]	

'*SERRICAUDATUS*' GROUP

* *Pseudodiaptomus serricaudatus* (T. Scott), 1894	*P. serricaudatus* (T. Scott), 1894
[*P.* (*S.*) *serricaudatus* (T. Scott), 1894]	
— *Heterocalanus serricaudatus* T. Scott, 1894	

'*LOBIPES*' GROUP

Pseudodiaptomus lobipes Gurney, 1907	*P. lobipes* Gurney, 1907
[*P.* (*S.*) *lobipes* Gurney, 1907]	
* *Pseudodiaptomus binghami* Sewell, 1912	*P. binghami* Sewell, 1912
[*P.* (*S.*) *binghami* Sewell, 1912]	
* *P. binghami* Sewell *malayalus* Wellershaus, 1969	*P. binghami* Sewell *malayalus* Wellershaus, 1969

'*SALINUS*' GROUP

Pseudodiaptomus salinus (Giesbrecht), 1896	*P. salinus* (Giesbrecht), 1896
[*P.* (*P.*) *salinus* (Giesbrecht), 1896]	
— *Schmackeria salina* Giesbrecht 1896	
Pseudodiaptomus charteri Grindley, 1963	*P. charteri* Grindley, 1963
[*P.* (*P.*) *charteri* Grindley, 1963]	
Pseudodiaptomus cornutus Nicholls, 1944	*P. cornutus* Nicholls, 1944
[*P.* (*P.*) *cornutus* Nicholls, 1944]	

FEMALES	MALES
Pseudodiaptomus hickmani Sewell, 1912 [*P.* (*P.*) *hickmani* Sewell, 1912]	*P. hickmani* Sewell, 1912
Pseudodiaptomus stuhlmani (Poppe and Mrazeck), 1895 [*P.* (*P.*) *stuhlmani* (Poppe and Mrazeck), 1895] — *Schmackeria stuhlmani* Poppe and Mrazeck, 1895	*P. stuhlmani* (Poppe and Mrazeck), 1895
* *Pseudodiaptomus jonesi* Pillai, 1970 [*P.* (*P.*) *jonesi* Pillai, 1970]	*P. jonesi* Pillai, 1970
* *Pesudodiaptomus ardjuna* Brehm, 1953 [*P.* (*P.*) *ardjuna* Brehm, 1953]	*P. ardjuna* Brehm, 1953
* *Pseudodiaptomus marinus* Sato, 1913 [*P.* (*P.*) *marinus* Sato, 1913]	*P. marinus* Sato, 1913

DUBIOUS AND UNASSIGNED SPECIES

Pseudodiaptomus masoni Sewell, 1932	?
Pseudodiaptomus heterothrix Brehm, 1953	?

KEY FOR THE IDENTIFICATION OF 'SPECIES GROUPS'

1. Female T-V with posterior margin rounded 2
   Female T-V with posterior margin obtuse or produced 3

2. Male with vestigeal Ri present on left leg only; Re 1 of female P 5 with blunt outgrowths along inner margin .. .. .. '*lobipes*' group
   Male with vestigeal Ri present on both legs; Re 1 of female P 5 without inner marginal expansions .. '*annandalei*' group

3. Vestigeal Ri present on male P 5 4
   Vestigeal Ri absent on male P 5 .. .. '*clevei*' group

4. Male with Ri on both legs; female A-1 with modified seta on 19th segment; terminal Re segment of female P 5 with spines of equal length 5
   Male with Ri on right leg only; female A-1 without modified seta on 19th segment; terminal Re segment of female P 5 with one spine much longer than others .. .. '*aurivilli*' group

5. Right Ri of male P5 bifurcate at tip; left Ri present as a blunt curved process 6
   Right and left Ri of male P 5 simple spinous processes with notched tips .. .. '*burckhardti*' group

6. Posterior margin of T-V obtuse .. .. '*serricaudatus*' group
   Posterior margin of T-V bluntly produced or acute .. '*salinus*' group

Pseudodiaptomus aurivillii Cleve, 1901 (Fig. 1 c, d)

Pseudodiaptomus aurivillii Cleve, 1901, pp. 48-50, pl. 6, figs. 11-22 ; pl. 7, figs. 1,2 (Description of Female) (Type locality : Malay Archipelago).

(non) *P. aurivillii* Cleve, Thompson and Scott, 1903, p. 248, pl. 2, figs. 24-26 ; Kasthurirangan, 1963, pp. 36, 37, figs. 31 a-d ; Ummerkutty, 1964, pp. 48-52, pl. 2, figs. 23, 24.

P. aurivillii Cleve, Sewell, 1932, pp. 240, 241, fig. 85a ; Bayly, 1966, pp. 54, 55, figs. 2 d-f, 3 c-d ; Wellershaus, 1969, pp. 254-257, figs. 21, 22.

Material Examined

Cochin Backwater, March, 1969, surface (8F, 6M) ; Bombay Coast, April, 1967, surface (4F, 3M) ; Andaman Sea, April, 1968, surface (6F, 3M).

Size

	No.	Range (mm)	Mean (mm)	P : UR ratio
Adult Female : ..	18	1.20-1.31	1.28	1.8 : 1
Adult Male : ..	12	0.94-1.01	0.98	2.0 : 1

Remarks

P. aurivillii was originally described by Cleve (1901) based on females collected from Malay Archipelago. Thompson and Scott (1903) figured the male P5 of a specimen which they regarded as belonging to *P. aurivillii*, but this figure agrees more closely with that of *P. mertoni*, a species later described by Fruchtl (1923, 1924) based on specimens collected from the Aru Archipelago. Sewell (1932) figured the male P5 of *P. aurivillii* (p. 241, fig. 85a) based on material collected from Andaman and Nicobar waters, which has not been figured before. Bayly (1966) collected material of both *P. aurivillii* and *P. mertoni* from the Brisbane River Estuary (east coast of Australia) and discussed their differential characters. Wellershaus (1969) figured the male P5 of both these species collected from Cochin Backwater.

The male specimens of *P. aurivillii* collected during the present study from the Cochin Backwater, Bombay Coast and from the Andaman Sea shows close resemblance to *P. aurivillii* figured by Sewell (1932) and Wellershaus (1969) but differs from Bayly's (1966) figures in : (i) inner margin of Re1 of right P5 has three blunt outgrowths ; (ii) a clusture of five finger-like outgrowths are present on the inner distal border of B1 of the left leg. These differences may perhaps represent ecophenotypic variations.

Distribution

Indo-Pacific. From Indian Ocean : Malay Archipelago ; Aru Archipelago ; Karun River, Perak ; coast of Burma ; Andaman and Nicobar waters ; Bay of Bengal ; Salt Lakes, Calcutta ; Lawson's Bay, Waltair Coast ; Madras Coast ; Gulf of Mannar ; Cochin Backwater ; Arabian Sea ; Bombay Coast and east coast of South Africa.

Pseudodiaptomus mertoni Fruchtl, 1923 (Fig. 1 a, b)

Pseudodiaptomus mertoni Fruchtl, 1923, pp. 455, 456, pl. 26, figs. 23, 24 (Type locality : Aru Archipelago) ; 1924, pp. 71-75, figs. 31-36.

Pseudodiaptomus aurivillii (nec Cleve, 1901) Thompson and Scott, 1903, p. 248, pl. 2, figs 24, 26 ; Kasthurirangan, 1963, pp. 36, 37, figs. 31, 32 ; (part) Marsh, 1933, p. 46 ; Ummerkutty, 1964, pp. 48-52, pl. 2, figs. 23, 24.

Pseudodiaptomus mertoni Sewell, 1932, p. 241, fig. 85b ; Bayly, 1966, pp. 55-57, figs. 2 g-i, 3 e, f ; Wellershaus, 1969, pp. 256-258, fig. 23.

Material Examined

Cochin Backwater, January to May, 1968 ; March to June, 1969 and January to May, 1970, surface (186F, 92M) ; Gulf of Mannar, January, 1969, surface (10F, 8M) ; Palk Bay, December, 1967, surface (14F, 8M) ; Bombay Coast, December, 1967, surface (9F, 2M) and from the Andaman Sea, April, 1968, surface (14 F, 3M).

Size

	No.	Range (mm)	Mean (mm)	P : UR ratio
Adult female : ..	83	1.20-1.28	1.25	2.0 : 1
Adult male : ..	52	1.08-1.22	1.12	1.9 : 1

Remarks

The present material show close resemblance to *P. mertoni* as figured by Fruchtl (1924), Sewell (1932) and Wellershaus (1969). It is evident that the male P5 figured as that of *P. aurivillii* by Thompson and Scott (1903) belongs to that of *P. mertoni*, which species was later described by Fruchtl.

Bayly (1966) described *P. mertoni* collected from the Brisbane River estuary. According to him, the male specimens collected by him differed from the form figured by Sewell (1932) in that : (1) an inner spine present on the distal margin of B1 on specimens from Brisbane ; (2) apparently shorter outer proximal process from right Re 1, and (3) a more pronounced outgrowth from the inner basal portion of Re 3 of right leg. In the present specimens, the inners spine on the distal margin of B 2 is absent. As in *P. aurivillii* these minor differences may represent ecophenotypic variations.

Distribution

Indo-Pacific. From Indian Ocean : Karun River, Perak, Burma ; Andaman and Nicobar waters ; Gulf of Mannar ; around Sri Lanka ; Trivandrum Coast ; Palk Bay ; Cochin Backwater and Bombay Coast.

Pseudodiaptomus annandalei Sewell, 1919 (Fig. 1 g, h, i)

Pseudodiaptomus annandalei Sewell, 1919, pp. 5-7, pl. 10, fig. 9 (Type locality : Chilka Lake, East Coast of India).

Pseudodiaptomus nostradamus Brehm, 1933, p. 138 (Java Coast).

Pseudodiaptomus dubia Kiefer, 1936, pp. 227, 231 (Vizaghapatinam Coast, India).

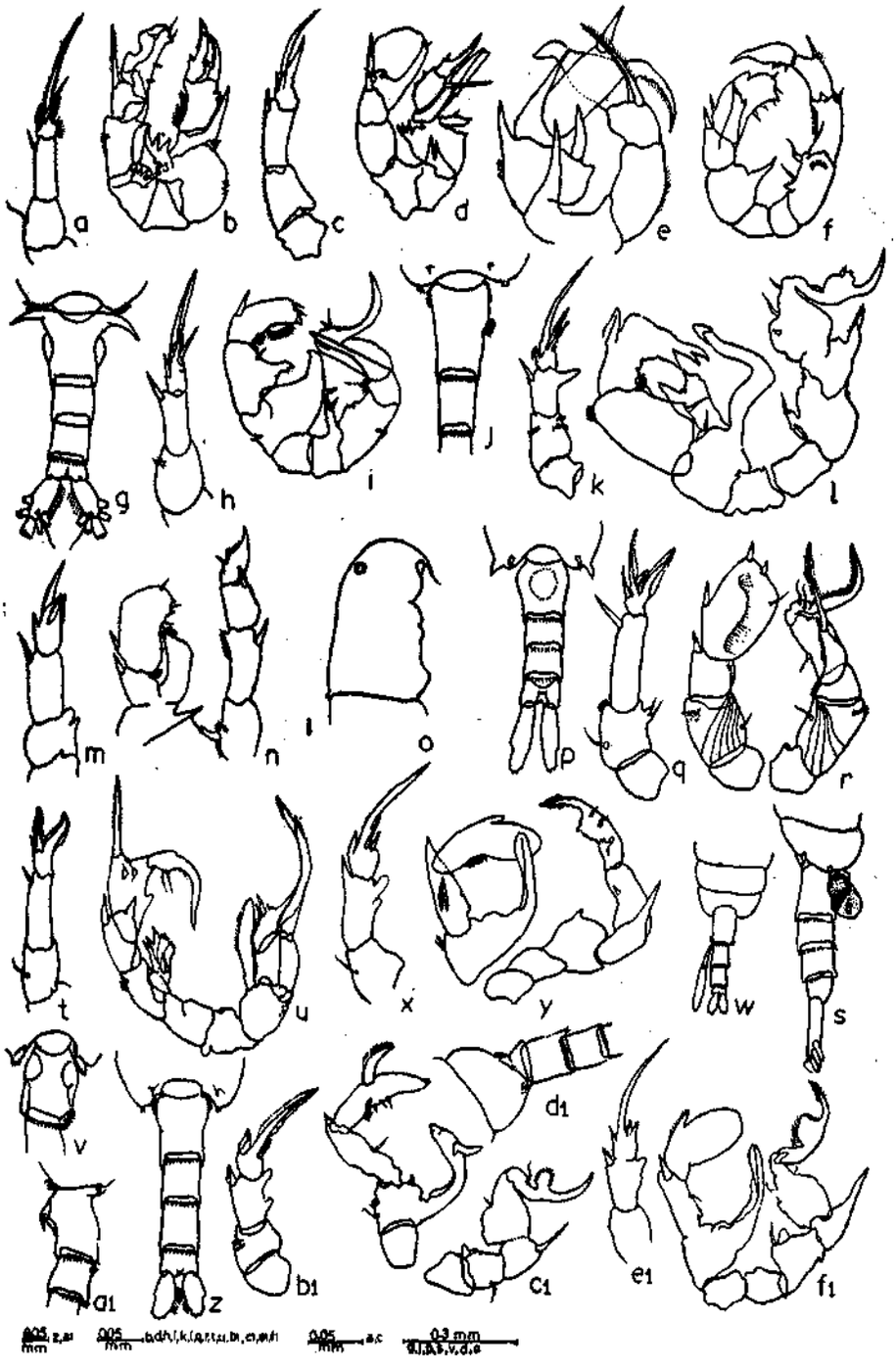

Fig. 1. *a. Pseudodiaptomus mertoni*, female, P5 ; *b.* male P5 ; *c. P. aurivilli*, female P5 ; *d.* male P5 ; *e. P. dauglishi* male P5 ; *f. P. batilipes*, male P5 ; *g. P. annandalei*, female urosome, dorsal view ; *h.* female P5 ; *i.* male P5 ; *j. P. tollingerae*, female urosome, dorsal view ; *k.* female P5 ; *l.* male P5 ; *m. P. pauliani*, female P5 ; *n.* male P5 ; *o. P. clevei*, cephalon of female, lateral view ; *p.* female urosome, dorsal view ; *q.* female P5 ; *r.* male P5 ; *s.* female urosome, lateral view ; *t. P. serricaudatus*, female P5 ; *u.* male P5 ; *v.* female urosome, lateral view ; *w. P. lobipes*, female urosome, dorsal view ; *x.* female, P5 ; *y.* male P5 ; *z. P. binghami malayalus*, female urosome, dorsal view ; *a* 1 : female urosome, lateral view ; *b* 1 : female, P5 ; *c* 1 : male P5 ; *d* 1: *P. binghami*, male urosome, lateral view ; *e* 1 : female, P5 ; *f* 1 : male P5. Figs. e (after Sewell, 1932) ; *f* (after Brehm, 1951) ; m & n (after Brehm, 1954) ; w-y (after Gurney, 1907).

Material Examined

Cochin Backwater, during all months except August in 1969 and 1970, surface (80F, 68M) ; Vizhinjam inshore waters, October, 1968, surface (83F, 24M) ; Gulf of Mannar, January to April, 1969, surface (20F, 21M).

Size

	No.	Range (mm)	Mean (mm)	P : UR ratio
Adult Female : ..	40	1.20-1.38	1.26	1.9 : 1
Adult Male : ..	29	1.02-1.09	1.04	2.0 : 1

Remarks

Brehm (1933) described *P. nostradamus* from the Java Coast and Kiefer (1936) described *P. dubia* from the Vizaghapatinam Coast, India, but no morphological differences could be noted between these species nor when compared to *P. annandalei*. The latter species has been recorded from the coastal waters and brackish water areas between Bombay and eastern Java Sea. Slight differences in the total lengths of females and males were noted between the specimens collected from the estuarine environment and from the adjacent neritic waters (Estuarine waters : F=1.20-1.32 mm ; M=1.02-1.14 mm ; Marine area : F=1.28-1.38 mm ; M=1.12-1.17 mm). Sewell (1934) opined that this difference in size is associated with the salinity of the environment, smaller specimens occurring in the brackish water environment.

Distribution

Indian Ocean ; Java Coast : Karun River, Perak, Burma ; Salt Lakes, Calcutta ; Chilka Lake ; Vizaghapatinam Coast ; Cooum Estuary and Madras Coast ; Trivandrum Coast ; Vizhinjam inshore waters ; Quilon Coast ; Cochin Backwater ; Calicut Coast ; ' Bandra, Isle de salsette ' (Bombay waters).

Pseudodiaptomus tollingerae Sewell, 1919 (Fig. 1, J, K)

Pseudodiaptomus tollingerae (Sewell, 1919, pp. 2-5, pl. 10, fig. 8 (Type locality : Chilka Lake and from Port Canning in the Gangetic Delta).

Schmackeria tollingerae Marsh, 1933, pp. 48, 49, pl. 23, fig. 2.

Pseudodiaptomus tollingerae Brehm, 1953, pp. 309-312, figs. 72-78.

Material Examined

Cochin Backwater, July, 1969 and June, 1970, surface (5F) ; Rangoon River opposite Syriam Point, Burma, January, 1971, surface (2F, 1M).

Size

	No.	Range (mm)	Mean (mm)	P : UR ratio
Adult Female :	7	1.39-1.45	1.41	1.5 : 1
Adult Male : ..	1	..	1.16	1.5 : 1

Remarks

Some minor differences in the structure of the male P5 have been noted in the present material from the figure of the same given by Sewell (1919, pl. 10, fig. 8) as follows : (1) inner process of Re3 of right leg with a single spine and not with a bunch of spinules as shown by Sewell ; (2) inner proximal margin of Re 2-3 of left P5 bears a distinct swelling with small setae which is shown as absent in Sewell's figure ; apparently his figure on the male P5 lacks in finer details.

Distribution

Indian waters : Chilka Lake and Port Canning ; Salt Lakes of Calcutta ; Pondicherry Lagoon ; Madras Coast ; Cochin Backwater and from Rangoon River, Burma Coast.

Pseudodiaptomus binghami Sewell, 1912 (Fig. 1 d 1, e 1, f 1)

Pseudodiaptomus binghami Sewell, 1912, pp. 337-338, pl. 17, figs. 8-11 (Female) (Type locality : Rangoon River Estuary) ; Sewell, 1919, pp. 7-9 ; Sewell, 1924, p. 786, pl. 14, fig. 2 (Chilka Lake).

Material Examined

Rangoon River opposite Syriam Point, Burma, January, 1971, surface (1M).

Size

	No.	Range (mm)	Mean (mm)	P : UR ratio
Adult Male : ..	1	=	0.91	1.9 : 1

Remarks

This species appears to be confined to the brackish water habitats. The male P5 shows close resemblance to that of *P. lobipes*, a freshwater species of the genus but distinct differences separate this species from the former.

Distribution

Indian seas : Salt lakes of Calcutta ; Chilka Lake ; Rangoon River, Burma.

Pseudodiamptomus binghami malayalus Wellershaus, 1969
(Fig. 1 z, a 1, b 1, c 1)

Pseudodiaptomus binghami Sewell s.sp. *malayalus* Wellershaus, 1969, pp. 262, 263, figs. 27-30 (Type Locality : Cochin Backwaters).

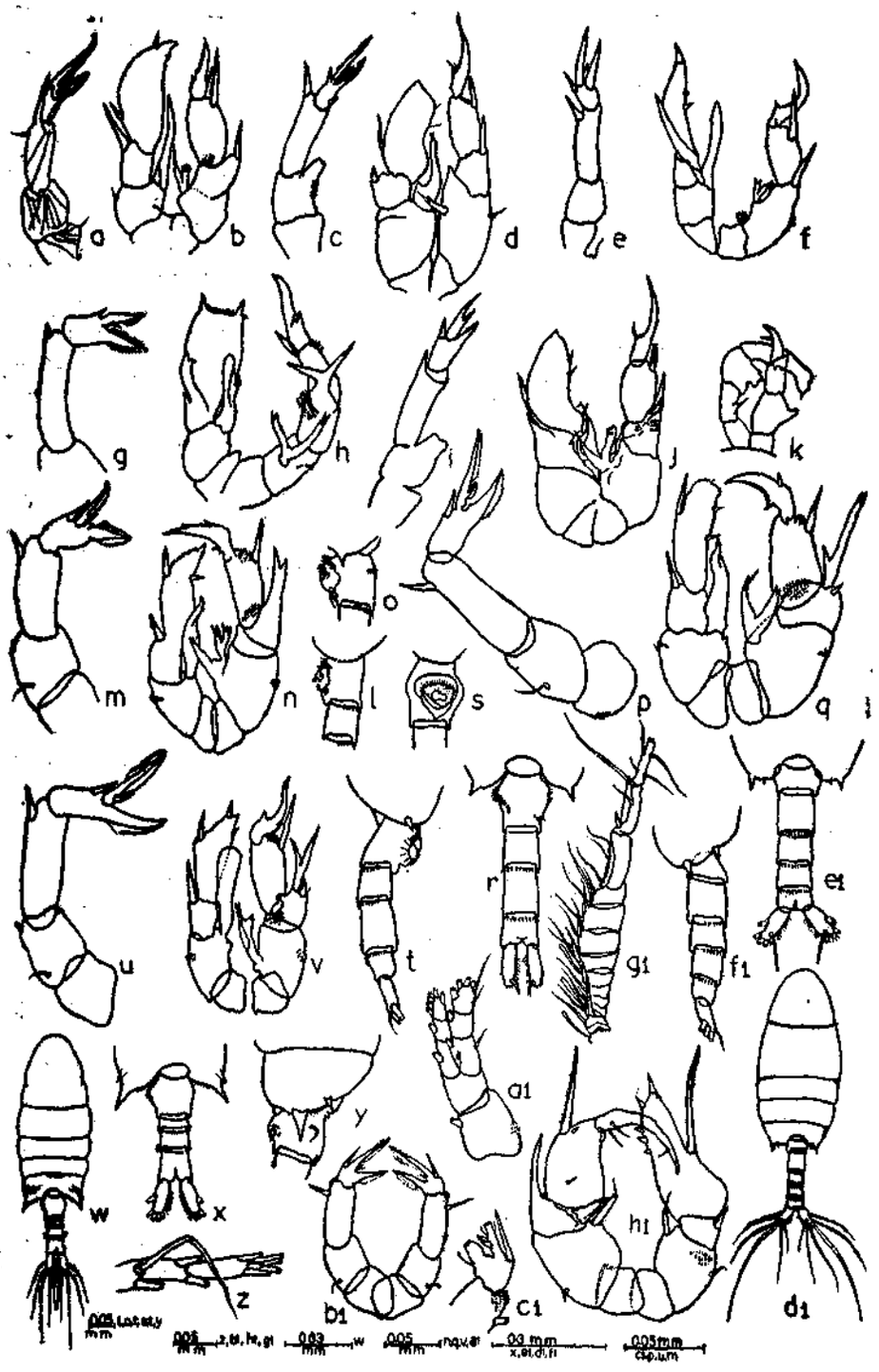

Fig. 2. *a. Pseudodiaptomus salinus*, female P5 ; *b.* male P5 ; *c. P. charteri*, female P5 ; *d.* male P5 ; *e. P. cornutus*, female P5 ; *f.* male P5 ; *g. P. hickmani*, female P5 ; *h.* male P5 ; *i. P. stuhlmani*, female P5 ; *j.* male P5 ; *k. P. heterothrix* male P5 ; *l. P. jonesi*, female urosome, lateral view ; *m.* female P5 ; *n.* male P5 ; *o. P. ardjuna*, female urosome, lateral view ; *p.* female, P5 ; *q.* male P5 ; *r. P. marinus*, female urosome, dorsal view ; *s.* female, genital segment, ventral view ; *t.* female urosome, lateral view ; *u.* female P5 ; *v.* male P5 ; *w. P. burckhardti*, female dorsal view ; *x.* female urosome, dorsal view ; *y.* female TV and genital segment, lateral view ; *z.* female, A-1 distal segments enlarged ; *a* 1. female, P4 ; *b* 1. female P5 ; *c* 1. Re of female P5, distal segment enlarged ; *d* 1. male, dorsal view ; *e* 1. male urosome, dorsal view ; *f* 1. male urosome, lateral view ; *g* 1. male A-1 ; *h* 1. male P5.

a (after Giesbrecht, 1896) ; b (after Thompson and Scott, 1903) ; c &d (after Grindley, 1963) ; e & f (after Nicholls, 1944) ; g & h (after Sewell, 1912) ; i & j (after Poppe and Mrazek., 1895).

together, posterior margin of latter produced into acute spines ; an additional spine present on either side of dorso-lateral region besides the terminal spine ; urosome five-segmented, with caudal rami having the following proportionate lengths : 15 : 23 : 16 : 16 : 10 : 20% ; U-II to U-IV with posterior marginal triangular spikes dorsally ; CR symmetrical, its length : width ratio =2.2 : 1 ; middle caudal seta highly elongated, the proportionate lengths of caudal setae from outside being, 10 : 16; 50 : 13 : 11% ; A-1 : right A-1 geniculate and with 21 segments ; segments 13-17 swollen, segments 14-17 provided with slender dorsal spines ; segments 10 and 13 with stout spines ; segment 18 with a denticulated plate dorsally carrying well developed tubercles, and segment 19 produced along its distal margin ; segmentation between last two segments indistinct giving the appearance of only two segments beyond hinge ; A-2, Mnd, and Mx-2 with usual characters of genus ; Mxp with segments 3-5 carrying peculiar setae ; P1 to P4 with the following setation and spinulation :

(*Setae in Arabic and spines in Roman numerals*)

	B1	B2	Re1	Re2	Re3	Ri1	Ri2	Ri3
P1 ..	: : 1+0	0	I+1	0+1	II+I+3	1+0	1+0	6
P2 ..	: 1+0	0	I+1	I+1	II+I+5	1+0	2+0	8
P3 ..	1+0	0	I+1	I+1	II+I+5	1+0	2+0	8
P4 ..	1+0	1	I+1	I+1	II+I+5	1+0	2+0	7

P5 : Right leg : B2 as long as wide with a seta and four to five spinules along its outer mid-margin ; proximally inner corner produced into a digitiform Ri which bears a seta at its tip ; Re 1 with an inner triangular process sinuate at its distal three-fourth length ; externally Re 1 is produced into a conical spine which reaches beyond half length of Re2 and with a tooth-like spine at its base ; Re2 proximally enlarged and with two surface spines and one long outer marginal plumose spine which is as long as segment itself ; Re3 in the form of a sickle, and with two setae along its enlarged basal portion internally and one subterminal seta ; left leg : B2 enlarged, longer than broad, and provided with setae and small spinules along its outer mid margin ; internally it is produced into a digitiform Ri with a seta at its tip ; Re 1 with a spine at outer distal corner, length of which equals to that of segment itself, and which is inserted at mid-outer margin of segment ; distally segment with two spines and having some interspace between spines ; towards distal half along inner margin three blunt teeth-like processes are present.

Female : The female specimens collected from the Andaman Sea fit closely to the description of *P. burckhardti* given by Sewell (1932), but an examination of the topotypes and comparison of the material with the previously published description by Sewell (1932) indicate that there are some minor descrepancies in the original description as shown below :

(1) Figures and descriptions of *P. burckhardti* as given by Sewell (1932, pp. 235-237, figs. 83 a-e) depicts U-II as longer than U-III ; measurements made on 16 females (topotypes) show U-III as distinctly longer than U-II ; the proportionate lengths of

urosomal segments given by Sewell is 29 : 13 : 10 : 24 : 24% whereas those of the present material are 26 : 11 : 15 : 23 : 25%.

(2) Female A-1 is observed to contain 21 segments with discernible fusion between three proximal and two distal segments.

(3) Sewell observed a ' rounded swelling ' on the outer margin of B1 of P1 ; but during the present study only nine spinules were observed dorso-laterally instead of the rounded swelling.

(4) The needle-like swellings present between the distal spine of Re 1 and insertion of the terminal Re segment of P5 in the present specimens have not been mentioned in the original description. Apparently the original description lacks finer details.

Distribution

Indian Ocean (Andaman and Nicobar Islands).

Pseudodiaptomus clevei A. Scott, 1909 (Fig. 1 o-s)

Pseudodiaptomus clevei A. Scott, 1909, pp. 116-117, pl. 37, figs. 1-8, (*Type locality* : Bay of Kankamaran, 115°24.7'E., 6°59'S.)

Material Examined

Andaman Sea, April, 1968, surface (56F, 40M).

Size

	No.	Range (mm)	Mean (mm)	P : UR ratio
Adult Female : ..	53	1.71-1.85	1.76	2.8 : 1
Adult Male : ..	36	1.49-1.60	1.53	2.8 : 1

Remarks

Both females and males collected from near the type locality show close resemblance to the type described by A. Scott. Hardly any difference could be noticed between these two except for the slight differences observed in the proportionate length of spines on P5 of both sexes studied. In most of the females collected the genital ' boss ' was found to be well developed, indicative of active breeding period.

Distribution

Indo-Pacific. From Indian Ocean : Andaman Sea, Malay Archipelago, Aru Archipelago.

Pseudodiaptomus andamanensis sp. nov. (Fig. 3 a-p)

Material Examined

4 Females, 4 Males and 6 copepodid stages collected from the Andaman Sea during April, 1968.

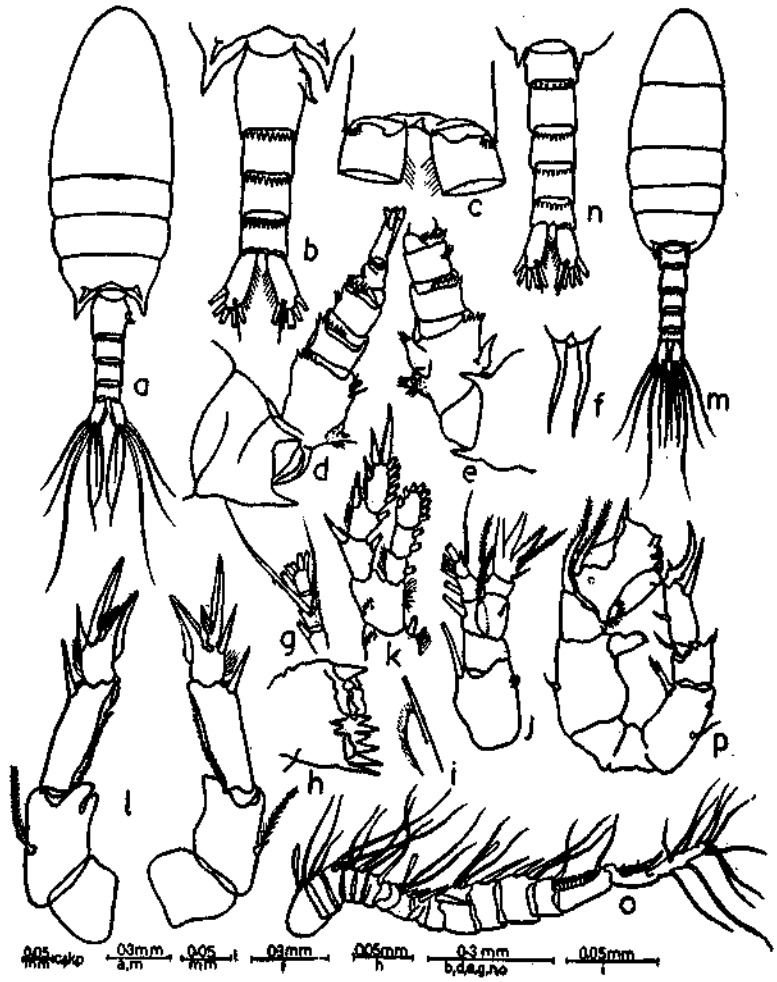

Fig. 3. *Pseudodiaptomus andamanensis* sp. nov. *a.* female, dorsal view ; *b.* female urosome, dorsal view ; *c.* female, TV and caudal rami, enlarged ; *d.* female urosome, right lateral view ; *e.* female urosome, left lateral view ; *f.* rostrum, female ; *g.* distal segment of female A-1 enlarged ; *h.* Mnd ; *i.* distal enlargement of seta on Mxp ; *j.* female P1 ; *k.* female P2 ; *l.* female P5 ; *m.* male dorsal view ; *n.* male urosome, dorsal view ; *o.* male A-1 ; *p.* male P5.

HOLOTYPE: Female, 2.17 mm, *Allotype*: Male, 1.86 mm, collected on 1-4-1968 between 1745 and 1840 Hrs from the Marine Bay, Port Blair, Andaman Sea.

Size

	No.	Range (mm)	Mean (mm)	P : UR ratio
Adult Female : ..	4	2.16-2.20	2.18	3.2 : 1
Adult Male : ..	4	1.83-1.88	1.86	2.8 : 1
Copepodite V—Male : ..	4	1.50-1.88	1.69	3.3 : 1
Copepodite IV—Female : ..	2	1.32-1.33	1.32	3.5 : 1

Description of Type material

HOLOTYPE : Cephalon distinct from T-I and rounded anteriorly ; rostrum with two long filaments, strongly developed ; T-IV and T-V fused, posterior angles of latter produced asymmetrically into outwardly directed spines, left spine reaching to posterior two-third of the genital segment being longest ; an additional spine present on either side of dorsolateral region indicative of fusion between T-IV and T-V segments ; four-segmented urosome and CR with following proportionate lengths :

35 : 17 : 14 : 12 : 22%.

Genital segment longest, asymmetrical and with lateral swellings ; anteriorly at right lateral margin it is produced externally into a recurved peg-like structure ; when viewed dorsally, the left lateral margin appears uneven ; ventrally genital segment has a prominent genital boss ; genital pore paired, is guarded anteriorly by two sets of fine spines and with a median genital groove ; at the posterior margin ventrally a cluster of 5-6 small needle-like spines present ; postero-dorsal margins of U-I to U-III beset with triangular spikes ; latter with two additional spines on the mid-dorsal margin ; U-IV dorsally at its postero-lateral angles with finely serrated shields, partly overlapping CR anteriorly ; CR symmetrical, its length : width ratio = 2.8 : 1 ; middle seta of both rami highly elongated and proportionate lengths of caudal setae from outside=13 : 14 : 40 : 19 : 14 ; A-1 with 21 discernible segments, when extended reaches the anterior margin of genital segment and with the following proportionate lengths for the segments :

Segments :	1	2	3	4	5	6	7	8	9	10	11	12	13
% :	4.6	3.0	2.7	3.3	3.0	4.7	3.9	3.3	4.9	5.4	5.8	6.5	6.9
	14		15		16	17		18		19	20	21	
	6.9		7.2		5.7	4.1		4.1		4.1	4.1	5.8	

Separation between segments 6 and 7 indistinct ; specialised seta, which is armed in the middle with 8 comb-like spinules near its middle, present on segment 19 ; last segment terminally produced into a blunt process ; brown pigmentation was observed soon after preservation on segments 9, 13, 15 and 18 ; A-2 as in genus ;

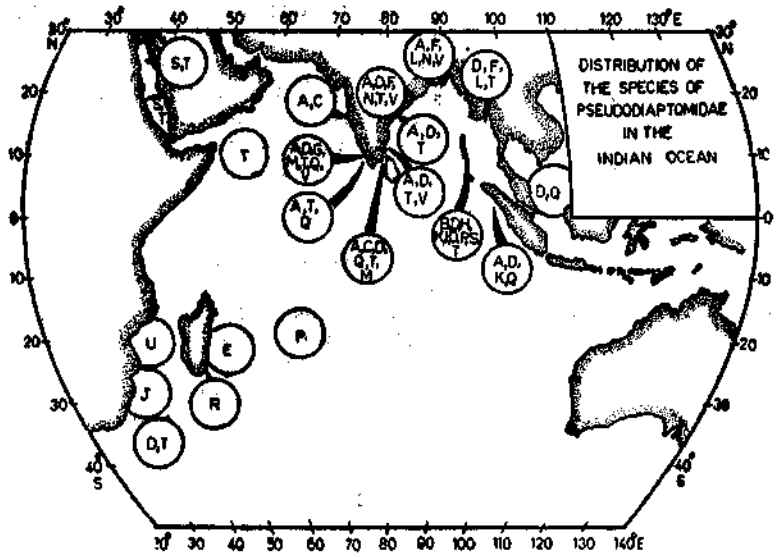

Fig. 4. Spatial distribution of the species of Pseudodiaptomidae in the Indian Ocean.

(A) *Pseudodiaptomus annandalei*, (B) *P. andamanensis*, (C) *P. arjuna*,
(D) *P. aurivilli*, (E) *P. batillipes*, (F) *P. binghami*,
(G) *P. binghami malayalus*, (H) *P. burckhardti*, (I) *P. masoni*,
(J) *P. charteri*, (K) *P. clevei*, (L) *P. dauglishi*,
(M) *P. jonesi*, (N) *P. hickmani*, (O) *P. lobipes*,
(P) *P. marinus*, (Q) *P. mertoni*, (R) *P. pauliani*,
(S) *P. salinus*, (T) *P. serricaudatus*, (U) *P. stuhlmani* and
(V) *P. tollingerae*.

Mnd gnathal lobe with 7 teeth, the area between 6th and 7th tooth irregularly lobate ; Mx-1 and Mx-2 resembles those of *P. clevei* ; Mxp with third, fourth and fifth segments carrying peculiarly divided setae each bearing a short spatulate branch near their middle, fringed with fine bristles ; setation and spinulation of P1 to P4 as follows :

(*Spines in Roman and setae in Arabic numerals*)

	B1	B2	Re1	Re2	Re3	Ri1	Ri2	Ri3
P1 ..	1+0	0	I+1	0+1	II+2+2	1+0	1+0	6
P2 ..	1+0	0	I+1	I+1	II+I+5	1+0	2+0	8
P3 ..	1+0	0	I+1	I+1	II+I+5	1+0	2+0	8
P4 ..	1+0	1	I+1	I+1	II+I+5	1+0	2+0	7

P5 : asymmetrical, with B2 of both legs produced internally ; Ri structure of left side asymmetrically bifid, whereas that of right leg is bluntly rounded; Re 1 with length : width ratio = 3 : 1, and with coarse inner marginal serrations and a distal outer spine ; outer margin of segment beyond the distal spine provided with 4-6 spinules ; distal Re segment with three subequal spines inner distal spine foliaceous, middle one bearing a small spine near its base and a third long spine on outer margin of segment ; proximal outer margin of terminal segment with a few scattered setae.

ALLOTYPE : (1 Male) General morphology resembles that of the female ; T-V produced posteriorly into two acuminate processes on either side ; five-segmented urosome with CR showing proportionate lengths as : 13 : 18 : 18 : 19 : 13 : 19 %; U-I with a small tubercle on left mid-margin ; posterior dorsal margins of U-II to U-IV with triangular spikes, those on U-IV relatively larger ; U-V with postero-lateral shields as in female ; CR symmetrical, with length : width ratio=2.8 : 1 ; A-1 with 19 discernible segments ; four spines present on segments 10-13 ; segments 14-17 enlarged and with slender dorsal spines ; serrated plate on 18th segment carrying stout denticulations dorsally ; segment 19-21 with a small proximal dorsal spine and a long spine originating from its mid-margin extending over succeeding segment ; only two segments present beyond hinge ; P5 : Right P5 with B2 (length : width=3 : 1) with a row of minute spines at its outer mid-margin ; B2 produced internally at its proximal inner margin into a digitiform Ri process which is asymmetrically bifid at tip; Re 1 (length : width=1 : 1) with three stout spines distally; one spine directed outwards and the rest directed inwards ; Re2 (length : width=3 : 1) with an outer distal, partly plumose marginal spine and with a seta along inner mid-margin ; Re3 sickle-shaped, thick basal portion of which bears a short spine ; inner margin of Re3 being beset with fine setules ; left leg : B2 approximately as long as wide with a few spinules near its mid-outer margin ; a posterior outer seta and an Ri structure grown along inner distal margin in the form of a peg ; Re 1 (length : width=1 : 1) bears a curved plumose spine on its outer distal angle towards the base of which a small spine is present ; Re 2-3 flattened, lamelliform (length : width=1.5 : 1), with long plumose outer marginal spine at the proximal half of the segment ; another spine present at distal outer margin ; distal half of the inner margin irregularly fringed ; a patch of small hairs present towards proximal inner margin of Re 2-3.

Remarks

The new species described herein shows apparent affinities to *P. clevei*, an insular tropical species described from Malay Archipelago, than to any other species of this genus. However, it can be distinguished from *P. clevei* by (1) body proportions, (2) asymmetrical posterior corners of T-V, (3) modification of the genital segment, (4) the possession of the highly elongated caudal setae, and (5) the nature and ornamentation of the constituting parts of the fifth pair of legs in both sexes.

Pseudodiaptomus ardjuna Brehm, 1953 (Fig. 2 o-q)

Pseudodiaptomus ardjuna Brehm, 1953, pp. 313-315, figs. 79-82 (*Type locality* : Salsette Islands, Thana Dt., Bombay Coast).

Material Examined

Palk Bay, SE coast of India, June, 1959, surface (66F, 52M).

Size

	No.	Range (mm)	Mean (mm)	P : UR ratio
Adult Female : ..	66	1.20-1.23	1.21	1.8 : 1
Adult Male : ..	49	1.03-1.10	1.07	2.0 : 1

Description

Female : Cephalon and T-I fused, T-V produced posteriorly into asymmetrical spines, right spine slightly longer than left ; U-I to U-III beset with triangular spikes on their disto-dorsal margins ; U-I barrel shaped, and provided with clusters of spinules on anterior half of lateral and dorsal margins ; U-IV bears on its dorso-lateral posterior angle finely serrated shields on either side ; A-1 : 21-segmented, and with a specialised seta with 8-9 small spinules on its mid margin, on the 19th segment ; P5 : Re 1 with an outer distal spine, Re 2 reduced at the inner distal corner into a foliaceous, stout spine ; and articulated spine, finely serrated along the inner margin and with a secondary spine at its mid-length present on segment ; another small spine present on outer edge proximal to point of insertion of articulated spine.

Male : Posterior corners of T-V pointed ; U-I short, U-II longest and U-IV with a serrated shield as in female ; posterior margins of U-II to U-IV fringed with small spinules ; *A*-1 : 21-segmented ; 4 large spines, one each on segments 10-13 ; spine on segment 10 recurved at its tip and with a small secondary spine ; segment 18 carries a finely denticulated plate at its dorsal margin ; P5 : Right leg with B2 produced internally into a double spinous process (Ri), one with a bifid tip and the other with a small hairy projection at its tip ; Re 1 with a cluster of small blunt teeth along inner distal margin and a long 'Y' shaped process, with an inner short arm, and an outer long arm, latter with a bifid tip ; a small spine present at its base ; Re2 with a long outer spine distally, and a few teeth in front of its base ; Re3 sickle shaped, with a blunt tooth and a bristle on proximal inner margin and a small seta on mid-outer margin ; left leg : with B2 produced at its inner distal corner into a digitiform inwardly curved process—the Ri ; Re 1 with a distal outer spine ; Re 2-3 plate-like, twice as long as broad, with a spine on its inner distal margin ; its distal margin is serrated and produced into a beak-like structure on its finer extremity.

Remarks

This species has been redescribed by Ummerkutty (1961) and Desai and Bal (1961). *P. ardjuna* shares with *P. hickmani*, *P. salinus*, *P. marinus*, *P. stuhlmani*, *P. cornutus* and *P. colefaxi* the characteristic bifurcated Re on the right leg. The specimens described as *P. ardjuna* by Wellershaus, (1969) actually is *P. jonesi* Pillai. The larval development of *P. ardjuna* was studied by Alvarez and Kevalramani, (1970).

Distribution

Indian seas. From Indian waters : Bombay Coast and Palk Bay.

Pseudodiaptomus marinus Sato, 1913 (Fig. 2 r-v)

Pseudodiaptomus marinus Sato, 1913, pp. 28,29, figs. 69-71 (*Type locality* : Oshoro and Takashima in the Japanese waters).

Material Examined

Andaman Sea, April, 1968, surface (18F, 4M)

Size

	No.	Range (mm)	Mean (mm)	P : UR ratio
Adult Female : ..	16	1.21-1.26	1.23	1.8 : 1
Adult Male : ..	3	0.96-1.07	1.02	1.8 : 1

Description

Female : Cephalon and T-I fused ; T-V produced posteriorly into sharp spines directed slightly outwards ; genital segment with slight lateral swelling ; small patches of fine hairs scattered over lateral and ventral sides of segment ; U-I to U-III with triangular spikes on their postero-dorsal margins ; U-IV with serrated shield on disto-lateral corners ; A-1 : of 21 segments ; P5 : with B2 bearing two small spinules on outer angle and a seta on posterior surface ; Re1 bears a spine at distal outer margin ; terminal segment with a spine on outer distal angle, and is produced into a medially serrated curved spiniform process ; terminal spine bears a short serrated spine near its base.

Male : General characteristics resemble that of female ; T-V posterior corners produced into acuminate spines ; U-II to U-IV with triangular spikes, U-V with a serrated shield at its distal outer corners ; CR symmetrical ; A-1 : with 21 segments ; 4 large spines on segments 10-13 of which that on segment 12 is recurved at its tip and has a secondary spine as in P. *ardjuna* ; segment 14-16 each with a slender spine ; segment 18 with a denticulated plate carrying fine teeth ; P5 : Right leg with B2 carrying spinules on its outer margin, a posterior seta and a forked Ri ; Ri with one slender pointed ramus and one shorter stouter ramus which ends in three points ; Re 1 bears a few spinules on its inner and outer margins and on its outer distal corner a ' Y ' shaped spine with a subsidiary spinule in the fork ; Re2 bears a long straight spine on distal part of its outer margin and a small bunch of scattered spinules anterior to it ; Re3 sickle-shaped and bears a blunt process at its mid-length ; left leg : with B2 carrying a few spinules on its outer margin, a posterior seta and a longe lub-shaped naked Ri ; Re 1 bears a spine on its outer distal angle ; Re2-3 elongate, truncate, distally bearing a short terminal spine and an outer marginal spine opposite to the tip of Ri ; margin between these two spines fringed with numerous spinules ; inner margin of terminal segment is straight and bears two short spinules.

Remarks

Since its original description, this species had been recorded from Japanese waters (Brodsky, 1956 ; Tanaka, 1966) ; 51°48'N., 174°21'E, (Chiba, 1956) ; brackish waters of Hawaii (Jones, 1966) and from Indian Ocean (Mauritius Islands : Grindley

and Grice, 1969). The present isolated occurrence of this species in the Andaman Sea is interesting as it considerably extends its known distributional range and fills in a gap.

Grindley and Grice (1969) while redescribing this species from Mauritius brought to light some of the minor variations. A comparison of some diagnostic characters of the present specimens with those of the previously published descriptions is presented here to draw attention to the variations observed in the species.

		MALE P5			
	Length (mm)	Forked spine on Re2	Subsidiary spine on Re2	Slender Ri ramus on right P5	Stouter Ri ramus on right P5
Sato, 1963 (Japan)	F=1. 3-1.6 M=1.3	asymmetrically bifid, outer ramus longer	short	shorter than stouter ramus	ends in three spinous points
Brodsky, 1956 (Japan)	F=1.25 M=0.07	..	..	longer than shorter ramus	..
Chiba, 1956 (Pacific)	F=1.4-1.6 M=1.0-1.4	..	..	..	..
Jones, 1966 (Hawaii)	F=1.08-1.31 M=0.94-1.01	..	..	..	..
Tanaka, 1966 (Japan)	F=1.32	..	..	equal in length	..
Grindley & Grice, 1969 (Mauritius)	F=1.28-1.31 M=0.96-1.07	symmetrically bifid, both rami of equal length	relatively longer	..	ends in two points
Specimens from Andaman Sea	F=1.21-1.26 M=0.96-1.07	asymmetrically bifid, outer ramus longer	short	longer than stouter ramus	ends in three points

As noted by Grindley and Grice (1969) the minor variations presented above may be attributed to ecophenotypes or only minor geographical variations.

Distribution

Indo-Pacific. From Indian Ocean : Mauritius Island and Andaman Island.

Pseudodiaptomus jonesi Pillai, 1970 (Fig. 2 l-n)

Pseudodiaptomus jonesi Pillai, 1970, pp. 78-80, fig. 1 a-1, (*Type locality* : Cochin Backwater).

P. ardjuna (nec Brehm, 1953) Wellershaus, 1969, pp. 259, 262, fig. 24 (Cochin Backwater).

Remarks

The female and male of this species has been described from Cochin Backwater by Pillai (1970).

Distribution

From Indian waters (Cochin Backwater, Palk Bay).

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