

NEW RECORDS OF THE PONTELLID SPECIES (COPEPODA: CALANOIDA) IN INDOONESIAN WATERS, WITH NOTES ON ITS SPECIES-GROUPS

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Abstract

During taxonomic studies on the pelagic copepods of the Indonesian seas, 15 species of Pontellidae were identified for the first time from the area. The species recorded are: Calanopia australica Bayly & Greenwood, 1963, Labidocera bengalensis Krishnaswamy, 1951, L. sinilobata Shen & Lee, 1963, Pontella diagonalis Wilson, 1950, P. forcicula Scott, 1909, P. latifurca Chen & Zhang, 1965, P. spinipes Giesbrecht, 1889, P. tridactyla Shen & Lee, 1963, P. valida Dana, 1849, Pontellopsis herdmanni Scott, 1909, P. inflatodigitata Chen & Shen, 1974, P. scotti Sewell, 1932, P. yamadae Mori, 1937, Pontellina morii Fleminger & Hulsemann, 1974, and P. sobrina Fleminger & Hulsemann, 1974.

Descriptions, measurements and figures are given for those species, along with a review of their distribution over the world's oceans, and with taxonomic remarks, ecological notes, and restricted synonymies.

Keywords: Taxonomy, new records, Pontellidae, Indonesia.

Introduction

Pontellid copepods form spectacular and biogeographically important component of neritic plankton. Species of Pontellidae generally predominate or concentrate in the surface layer in tropical to warm temperate latitudes, provide excellent materials for zoogeographic investigation. Because of the importance of Pontellidae in such studies, systematic studies of this family were carried out.

Currently, the literature has indicated 140 species of Pontellidae as widely accepted taxa world-wide. The contributions to the knowledge of Indonesian pontellid copepods have been brought almost exclusively from various expedition reports (A. Scott, 1909; Delsman, 1949; Fleminger *et al.*, 1982; Ohtsuka *et al.*, 1987). The major work is still that of Siboga Expedition (1899-1900). Scott (1909) dealt with pontellid copepods in Indonesian waters using the samples collected from this expedition, but he did not provide figures

or adequate descriptions of the most of captured species. There are also some doubtful records, which need to be studied more accurately. The objectives of this study are to provide accurate information on the taxonomy of all recorded species and to clarify some problems of synonymy, to provide figures and keys to identification of genera and species, and then to discuss their distribution in Indonesian waters and the world oceans.

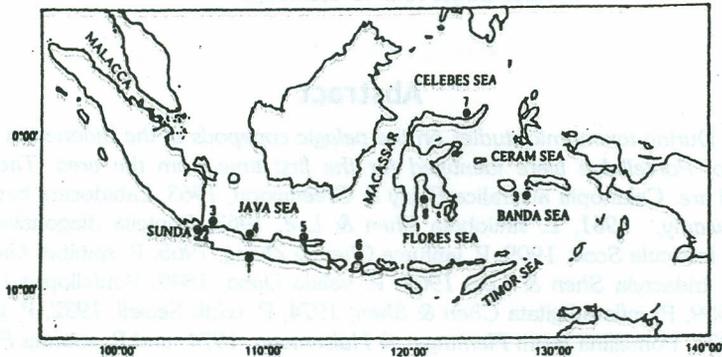


Figure 1. Indonesian waters showing sampling sites 1-9.

Table 1. Sampling sites, dates depth of hauls and number of samples in Indonesian waters

| No. | SITES Position | Date | Depth of hauls | Number of samples |
|-----|---|--|----------------------|-------------------|
| 1 | Cilacap Bay, Central Java (07°40'S 109°00'E) | 15-20 May 1993 6-10 June 1994 | 10-25 m | 100 |
| 2 | Off Labuan, West Java (06°10'S 160°E) | 17-19 June 1994 18-22 March 1998 | 10-25 m | 100 |
| 3 | Jakarta Bay, West Java (06°00'S 106°45'E) | 1-2 June 1994; 22 July and 5 August 1999 | 10-25 m | 100 |
| 4 | Off Tegal, Central Java (06°00'S 109°10'E) | 3-4 June 1994, 28 March 1998 | 5-15 m | 100 |
| 5 | Off Surabaya, East Java (07°10'S 109°10'E) | 7-9 June 1994, 2-5 June 1998, 10-12 November 2000 | 10-20 m | 100 |
| 6 | Lombok Sea (08°40'S 116°00'E) | 4-6 September 1993* 18-20 September 1999 | 50-100 m | 100 |
| 7 | Off North Celebes (01°30'S 124°00'E) | 6-9 October 1994* 15-25 September 1997 | 10-25 m and 100 m | 100 |
| 8 | Bone Bay, South Celebes (03°40'S 121°40'E) | 14-17 June 1999 | 10-25 m | 100 |
| 9 | Ambon Bay (03°40'S 128°10'E) | 18 July., 12 Dec 1993* 13-15 March 1995 | 25-50 m | 100 |

NOTES : * Samples provided by collections of Research Center for Oceanology-LIPI

Materials and Methods

The present plankton samples were provided from the collections of the Research Center for Oceanology-LIPI, had earlier been collected by vertical hauls from 50 m or 100 m depth to the surface with a NORPAC. Sampling done by the author included surface towing and vertical hauls from 10-25 m depth to the surface with conical plankton nets (0.1 mm and 0.33 mm mesh size; 0.35 m and 0.45 m diameter mouth aperture). The samples were collected from 9 sites in Indonesian waters during 1989-2000 (Figure 1). The samples were fixed and preserved in 5% formalin/sea water solution.

Abbreviations used are as follows: A1 antennule; A2, antenna; Ms1-Ms5, metasomal somites 1-5; Ur1-Ur5, urosomal somites 1-5; CR, caudal rami; P1-P5, legs 1-5; B1-B2, basipodal segments 1-2; Re1-Re3, exopodal segments 1-3; Ri1-Ri3, endopodal segments 1-3; Se, outer spine; Si, inner spine; St, terminal spine. Length of prosome and urosome were taken dorsally from the anterior of head to the posterior end of Ms5, and from anterior margin of Ur1 to posterior end of CR excluding setae.

Descriptions

Genus *Calanopia* Dana, 1853

Calanopia australica Bayly & Greenwood, 1966

(Figure 2)

Calanopia sp. Bayly, 1965: 330-339, 342.

Calanopia australica Bayly & Greenwood, 1966: 99, tex-figs. 1a-f (Type locality: Moreton Bay, Queensland); Silas & Pillai, 1973: 791-793, fig. 7a-h.

Material examined.- Ten females (1.80-2.05 mm), 10 males (1.72-1.95 mm) collected off Tegal, Central Java by surface tow of 0.1 mm mesh plankton net at night on 28 March 1998.

Female.- Prosome robust, cephalon triangular in outline, with lateral hooks, Ms4 and Ms5 fused, posterolateral ends symmetrical and reaching middle of Ur1. Rostrum forked, tapers to tip with subterminal notch. Urosome symmetrical, genital complex 1.7 times length of anal somite. CR asymmetrical,

left ramus slightly longer than right, with 5 plumose normal setae, of which outer seta with spur-like spinule arising laterally about 1/5 length of proximal end, and 1 small seta.

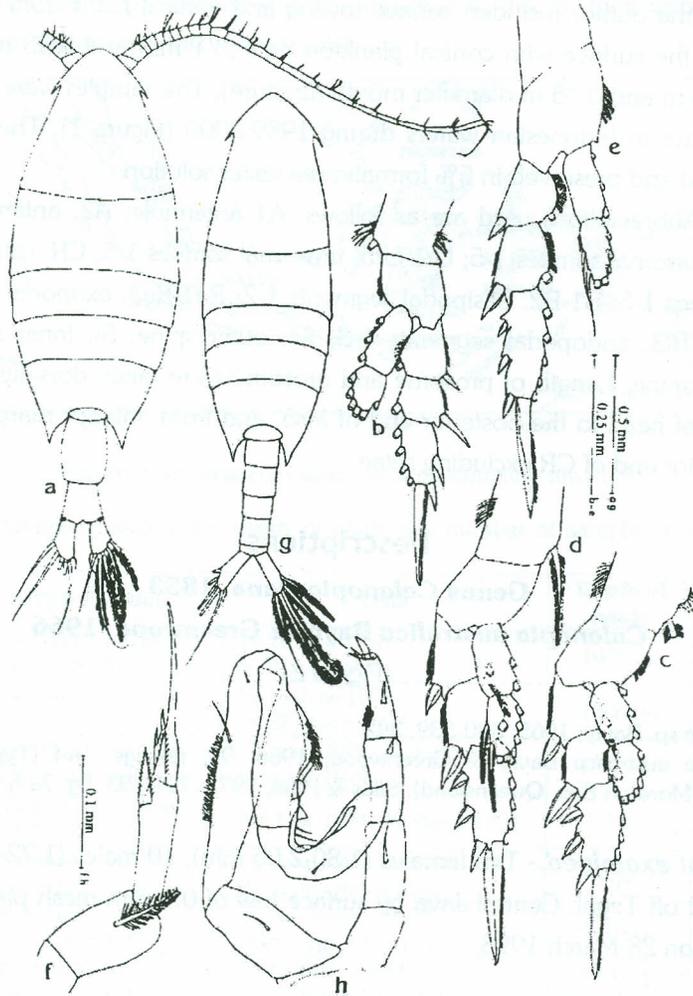


Figure 2. *Calanopia australica*. Female a, whole animal, dorsal view; b-e, swimming legs 1-4; f, 5th leg. Male. g, whole animal, dorsal view; h, 5th legs.

A1 20-segmented, reaching distal end of Ms3 when folded backwards. P5 symmetrical, 4-segmented (2 basal and 2 exopodal segments); B2 with 1 plumose seta on posterior surface; Re1 elongated and longer than B2, with 2 unequal spiniform processes close together on distal end; Re2 less than half length of Re1 (excluding terminal process), terminated into long, straight, serrated spine, and 2 small outer spines with fine marginal serration, near base of terminal spine.

Male.- Prosome as in female. Genital somite as long as wide; anal somite shortest, 3.5 times as long as wide; CR symmetrical, divergent posteriorly, about 2.6 times as long as wide and apparently longer than Ur4 and Ur5 combined. Other appendages except right A1 and P5 as in female.

Pair of P5 resembles *C. thompsoni*. Right P5 4-segmented, B2 longer than B1, with 1 long seta on distal 1/3 of length on posterior surface, and 1 small distolateral spine on inner margin; Re1 broadened, with cluster of needle-like spines near outer margin in region of maximum width, outer margin of distal to spine-cluster with indentation, protuberance, and 1 spine, inner margin of it consisting of 2 smoothly curved portions with incomplete suture line passing outwards from point of junction; Re2 (dactylus) sharply recurved outwards onto Re1, tapering to pointed extremity, extending back to region of Re1 spine-cluster, with 2 small unequal spines near inner proximal margin. Left leg 4-segmented and thinner than right leg; B1 shortest; B2 with 1 seta on posterior surface; Re1 with 1 distolateral spine; Re2 with row of fine setules along proximal half of inner margin and 4 unequal spines, one on middle of outer margin, and 3 at distal extremity; outermost spine directed inwards, crossing other 2 anteriorly near base and almost at right angles, serrated along margins, 2nd and 3rd spines parallel and directed distally, 2nd spine broader than 3rd with smooth outer edge, 3rd spine serrated along both margin.

Remarks.- *C. australica* belongs to the *C. thompsoni* species group by the characters of (1) the female P5 4-segmented, 4th segment shorter than 3rd segment, (2) the male P5 without any processes, left leg with broad terminal

process instead of long spine, inner margin of chela of right leg convex or flat, and (3) the rostrum with distinctive subterminal notch. This species group, hitherto, composed of 4 known species, *C. australica*, *C. parathompsoni* Gaudy, 1969, *C. seymouri* Pillai, 1969 and *C. thompsoni* A. Scott. 1909, *C. australica* resembles with other species of the group *C. thompsoni* but it is distinguishable from the latter by the modifications in the genital complex, the spur-like spinule on outermost seta of right CR and the form of P5 in the female; and the form of P5 in the male. This species was abundant at the Cilacap Bay and off Tegal, two locations of mangrove estuaries. It has a tendency to occur abundantly in the upper reaches of the rivers having low salinity.

Distribution.- *C. australica* was first described from the Moreton Bay, east coast of Australia (Bayly & Greenwood, 1966) and latter from the Gulf of Carpentaria (Othman *et al.*, 1990). It has also been reported from the Andaman Sea (Silas & Pillai, 1973) and Ogasawara Island, Japan (unpublished data), Cilacap Bay and Java coastal areas (present records).

Genus *Labidocera* Dana, 1849

***Labidocera bengalensis* Krishnaswamy, 1951**

(Figure 3)

Labidocera bengalensis Krishnaswamy, 1951: 321-323, fig. 1a-I (Type locality: Madras coast); Silas & Pillai, 1973: 802-803, fig. 13a-g; Othman *et al.*, 1990: 564.

Material examined.- Ten females (1.40-1.65 mm), 10 males (1.09-1.25 mm) collected off Labuan, West Java by surface tow of 0.1 mm mesh plankton net at night on 18 April 1998.

Female.- Cephalon squarley rounded anteriorly, with lateral hooks; Ms4 and Ms5 fused, posterolateral ends produced into asymmetrical rounded lobes, right margin with a lobular projection, in lateral view. Urosome composed of 3 somites; Ur1 asymmetrical, elongated, longer than Ur2, Ur3 and CR combined, right margin swollen with a numbers of ventral papillae, lengthened posteriorly

and covering part of Ur2; Ur2 slightly produced posteriorly on right margin; Ur3 very short; CR asymmetrical, left ramus longer and wider with 5 plumose and 1 small setae, 2nd seta from inner margin being longest.

P5 asymmetrical, Re long, slender and bifurcate, 4 times as long as Ri, with 2 outer spines, and 2 unequal apical spines; Ri short, stout and pointed.

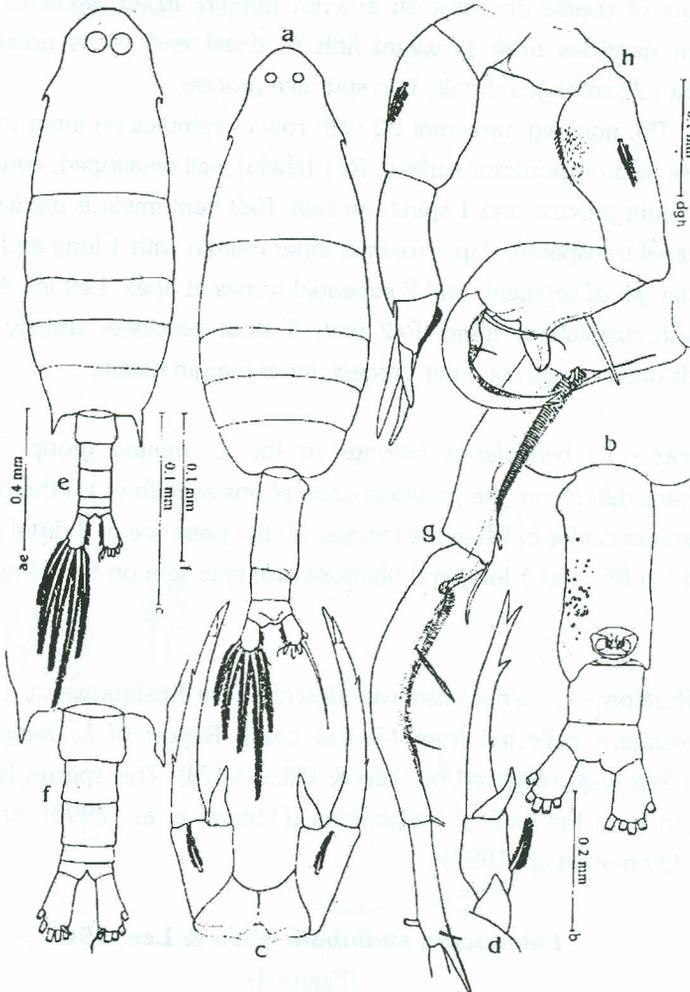


Figure 3. *Labidocera bengalensis*. Female. a, whole animal, dorsal view; b, Ms5 and urosomal somites, ventral view; c, 5th legs; d, 5th leg. Male. e, whole animal, dorsal view; f, Ms5 and urosomal somites, dorsal view; g, geniculate region of right A1.

Male.- Cephalon as in female, dorsal eye lenses well developed and in contact with each other. Posterolateral ends of Ms5 produced into asymmetrical pointed lobes, left side sharply pointed, right side sword-like shape extending beyond distal end of Ur1. Urosome composed of 5 somites, Ur1-Ur4 without any processes; CR symmetrical. Right A1 geniculate, fused segments 17-18 with row of coarse denticles on anterior margin; fused segments 19-21 with villiform denticles from proximal fifth to distal end of its anterior margin, segment 22 prolonged distally into spur-like process.

P5, right leg, proximal B2 with row of spinules on inner margin and 1 plumose seta on posterior surface; Re1 (chela) well developed, concave surface with 1 blunt process and 1 spiniform seta. Re2 bent inwards medially and with 1 marginal transparent flap, proximal inner margin with 1 long and 1 short seta at 1/3 length of segment, and 2 subequal spines at apex. Left leg 4-segmented, Re1 with distolateral spine; Re2 with 3 stout processes distally and 1 seta towards outer margin of inner process, inner margin hirsute.

Remarks.- *L. bengalensis* belongs to the *L. minuta* group. The present specimens differ from the previous descriptions as follows (1) the presence of 2 outer spines on Re of P5 in the female, (2) the presence of 3 distal processes on Re2 of left P5, and 1 long and plumose proximal seta on Re₂ of right P5 in the male.

Distribution.- *L. bengalensis* was described by Krishnaswamy (1951) based on specimens collected from Madras coast. Report of *L. bengalensis* from Indian Sea were reviewed by Silas & Pillai (1973). This species has also been reported from the Gulf of Carpentaria (Othman et al., 1990), and Malaysian coast (Othman et al., 1987).

***Labidocera sinilobata* Shen & Lee, 1963**

(Figure 4)

Labidocera sinilobata Shen & Lee, 1963: 594, figs. 20-25 (Type locality: East China Sea); Chen & Zhang, 1965: 42, figs. 8-14; Zheng et al., 1989.

Material examined.- Ten females (2.50-2.55 mm), 10 males (2.10-2.20 mm) collected off Surabaya, east Java by surface tow of 0.33 mm mesh plankton net at night on 2 June 1998.

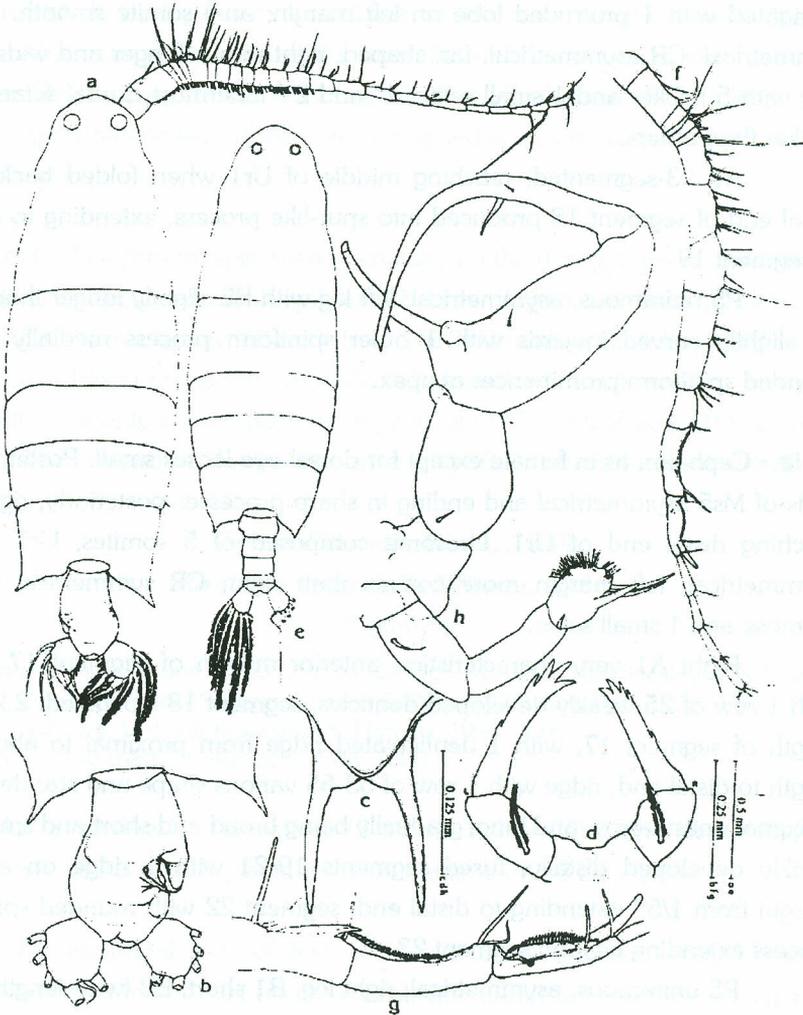


Figure 4. *Labidocera sinilobata*. Female. a, whole animal, dorsal view; b, Ms5 and urosomal somites, ventral view; c, rostrum, ventral view; d, 5th legs. Male. e, whole animal, dorsal view; f, right A1; g, geniculate region of right A1; h, 5th legs.

Female.- Body elongated, cephalon rounded in dorsal and lateral views, without chepalic hooks, dorsal eye lenses moderately small. Posterolateral ends of Ms5 produced into asymmetrical strong spiniform processes, reaching middle of Ur1. Urosome composed of 2 somites; Ur1 asymmetrical, smooth and elongated with 1 protruded lobe on left margin; anal somite smooth, almost symmetrical. CR asymmetrical, fan shaped, right ramus longer and wider than left, with 5 thicker and 1 small setae, 1st and 2nd innermost caudal setae much thicker than others.

A1 23-segmented, reaching middle of Ur1 when folded backwards, distal end of segment 18 produced into spur-like process, extending to middle of segment 19.

P5 uniramous, asymmetrical; left leg with B2 slightly longer than right, Re slightly curved inwards with 1 outer spiniform process medially and 4 rounded spiniform prominences at apex.

Male.- Cephalon as in female except for dorsal eye lenses small. Posterolateral ends of Ms5 asymmetrical and ending in sharp processes posteriorly, right side reaching distal end of Ur1. Urosome composed of 5 somites, Ur1 slightly asymmetrical, left margin more convex than right; CR symmetrical with 5 plumose and 1 small setae.

Right A1 very characteristics, anterior margin of segment 17 armed with 1 row of 25 weakly developed denticles; segment 18 elongated, 2.2 times length of segment 17, with 1 denticulated ridge from proximal to about 1/5 length to distal end, ridge with 1 row of 53-55 various shape and size denticles, proximal ones narrow and long, gradually being broad and short and small and weakly developed distally; fused segments 19-21 with 1 ridge on anterior margin from 1/5th extending to distal end; segment 22 with rounded spiniform process extending beyond segment 23.

P5 uniramous, asymmetrical; right leg, B1 short, B2 twice length of B1 with 1 seta on proximal posterior surface; Re1 (chela) elongated, 1.4 times length of B2, thumb of chela narrow, conical, curved outwards; 0.43 times length of chela. Outer margin between thumb and distal end of Re1 with semi-

circular lamella arising near base of thumb, and 2 minute setae, one on 1/3 length from proximal end, and another on anterior surface near base of finger. Re2 narrow, cylindrical, elongated, medially curved and ending in a pointed tip, main curvature at about 2/5 length from proximal end, the direct line length 1.5 times of chela, finger with 1 medial large seta and 2 small setae, 1 at middle and another near apex. Left leg, B1 short; B2 with 1 seta on proximal posterior surface; Re1 as long as B2 with 1 small distolateral spine; Re2 bulb-shaped, inner margin hirsute with 3 stout, round-tipped spines on outer margin, one of these shortest.

Remarks.- The present specimen is similar with the descriptions of Shen & Lee (1963) with additional details presented. *L. sinilobata* has been placed in *L. detruncata* species group. Shen & Lee (1963) described and illustrated briefly this species based on specimens collected from the East China Sea. So far *L. sinilobata* was only known from the type locality (Chen & Zhang, 1965; Zheng *et al.*, 1989), extends to Java Sea, particularly off Surabaya (present records).

Genus *Pontella* Dana, 1849

***Pontella diagonalis* Wilson, 1950**

(Figure 5)

Pontella diagonalis Wilson, 1950: 292, pl. 28, figs. 410-413 (Type locality: Albatross St. 5553, off Jolo, Philippines); Silas & Pillai, 1973: 824, figs. 21-22; Pillai, 1975: 131, fig. 1d-I; Madhupratap & Haridas, 1986: 109.

Pontella spinipes (part), Wolfenden, 1906: 1020.

Material examined.- Two males (3.95 mm) collected from Jakarta Bay by surface tow of 0.33 mesh plankton net at daytime on 22 July 1999.

Male.- Posterolateral ends of Ms5 produced into acuminate lobes. Urosome composed of 5 somites, Ur1 asymmetrical, with lobe-like projection on left side; CR asymmetrical, right ramus larger and broader distally with 5 plumose and 1 small setae, outer seta with spur-like spinule arising laterally about 1/5 length of proximal end. Right A1 geniculate, segment 14 with stout, elongated spine and

claw-like at apex; anterior margin from distal margin of segment 16 to middle of segment 18 with toothed ridge of triangular denticles; fused segments 19-21 with an elevated process on proximal anterior part, with 3 stout and conspicuous unequal teeth, middle one longest, proximal plate with row of denticles and ending in falcate spur distally; segments 22-25 completely fused.

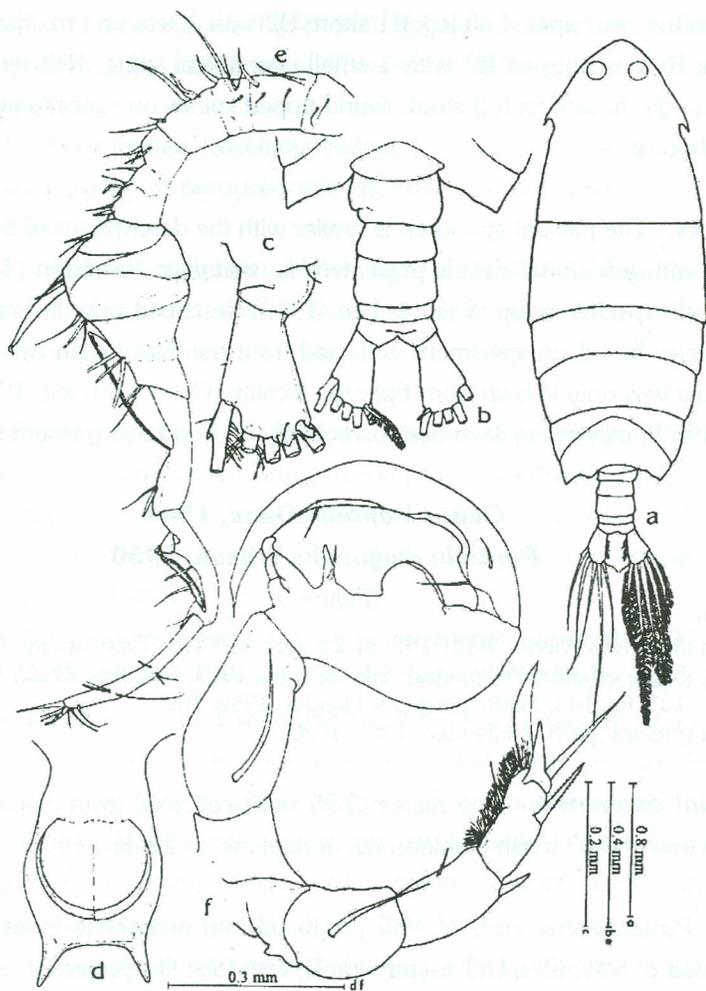


Figure 5. *Pontella diagonalis*. Male. a whole animal, dorsal view; b, Ms5 and urosomal somites, dorsal view; c, left CR, dorsal view; d, rostrum, ventral view; e, right A1; f, 5th legs.

P5, right leg, Re1 well developed, thumb with 2 unequal processes; concave surface with 1 spine-like process armed with 1 seta near base, and 1 large rounded process; Re2 slender, elongated, pointed, with 2 inner setae and 1 seta on posterior surface. Left leg, B2 with plumose seta on posterior surface; Re1 with distolateral outer spine and 1 inner seta; Re2 with 2 outer spines at apex and 2 patches of fine setae on inner margin.

No females was found in the present study.

Remarks.- Wilson (1950) described *P. diagonalis* based on the female specimens from off Jolo, Philippines. The male of *P. diagonalis* was described by him as *P. securifer* (Wilson, 1950, pl. 28, fig. 425). Silas & Pillai (1973) discussed in detail the diagnostic features of this species from Indian Ocean and according to them the male of *P. spinipes* described by Wolfenden (1906) belongs to this species. The present male specimen is similar with the description of the species by Wilson (1950) but slight differences were noted in having the proximal outer seta of the left CR with a spur-like spine, and in the form of P5.

Distribution.- An Indo-West Pacific warm water epiplanktonic form. Indian Ocean records include Sewell (1912), Bay of Bengal; Silas & Pillai (1973), Andaman Sea, west coast of India and the Laccadive; Wolfenden (1906), Maldive Archipelagoes; Decker & Mombeck (1964), South African coast; and Jakarta Bay (present records). No records from Australian region.

***Pontella forcicula* A. Scott, 1909**

(Figure 6)

Pontella forcicula A. Scott, 1909: 162, pl. 53, figs. 1-7 (Type locality: St. 93 Siboga Expedition, Sulu Sea, Philippines).

Material examined.- Two males (2.59 mm) collected from Pari Island, Jakarta Bay by surface tow of 0.33 mm mesh plankton net at daytime on 2 July 1999.

Male.- Posterolateral ends of Ms5 produced into asymmetrical rounded lobes. Rostrum bifurcate, asymmetrical, right side short and broader than left. Urosome composed of 5 somites, CR asymmetrical, right ramus being longer. Right A1 inflated medially, without processes, proximal hinge of segment with 1 large saucer-like process with blunt teeth, dorsal hinge of segment short, upper margin with 2 simple plates. Left A1 19-segmented, reaching distal end of Ms2 when folded backwards.

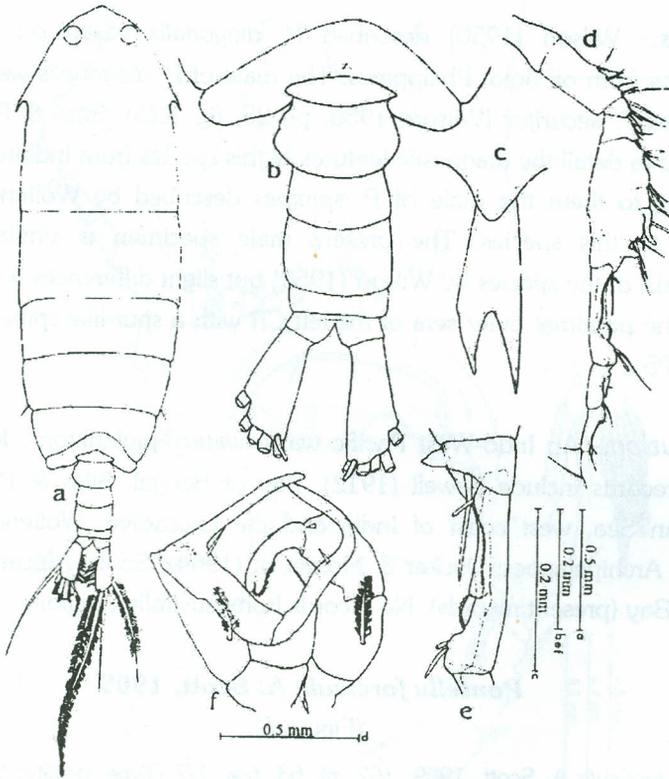


Figure 6. *Pontella forcicula*. Male. a, whole animal, dorsal view; b, Ms5 and urosomal somites, dorsal view; c, rostrum, ventral view; d, right A1; e, geniculate region of right A1; f, 5th legs.

P5 rather small, right leg, thumb of Re1 long and spiniform, curved inwards distally with 1 long seta on base, without process on middle segment. Re2 long and curved with 1 apical and 2 unequal marginal spines. Left leg with short B1, B2 with 1 long plumose seta, Re1 with 1 spine at distal end, Re2 curved and slender, bifurcate at apex and 3 outer spinules, inner margin hirsute.

Remarks.- Scott's (1909) original description of *P. forcicula* was based on 2 males specimens collected from the Sulu Sea, southern Philippines. *P. forcicula* may ultimately prove to be the males of some species now founded upon females alone. Before it can be proven, however, Scott's species remains valid.

Distribution.- No other geographical records of this species available, so this species might be restricted in the southern Philippine waters, particularly in Sulu Sea and extends to Java Sea.

***Pontella latifurca* Chen & Zhang, 1965**

(Figure 7)

Pontella latifurca Chen & Zhang, 1965: 105, pl. 46, figs. 1-8 (Type locality: Gulf of Pohai, Yellow Sea, China); Zheng *et al.*, 1989: 155; Kim, 1985: 127-129, pl. 43, fig. a-f.

Material examined.- One female (2.90 mm) collected off Surabaya, east Java by surface tow of 0.33 mm mesh plankton net at daytime on 2 June 1998.

Female.- Body robust, cephalon obtusely triangular anteriorly with lateral hooks, separated from Ms1; Ms4 and Ms5 separated, posterolateral ends produced into triangular lobes, asymmetrical, left lobe longer than right, in lateral view, right lobe reaching middle of Ur1. Rostrum bifid, thickened basally, without lenses. Urosome composed of 2 somites, asymmetrical, Ur1 globular, dorsal surface rather swollen with ventral small process; anal somite short; CR asymmetrical, right ramus much larger and longer than left, right ramus with swollen setae basally. A1 24-segmented, extending to distal end of Ms3 when folded backwards; segment 11 with a small process on anterior margin. A2, Ri much larger and longer than Re.

P5 biramous, asymmetrical, with 1-segmented rami (unjointed Re and Ri), Re claw-like, twice length than Ri.

No male was found in the present study.

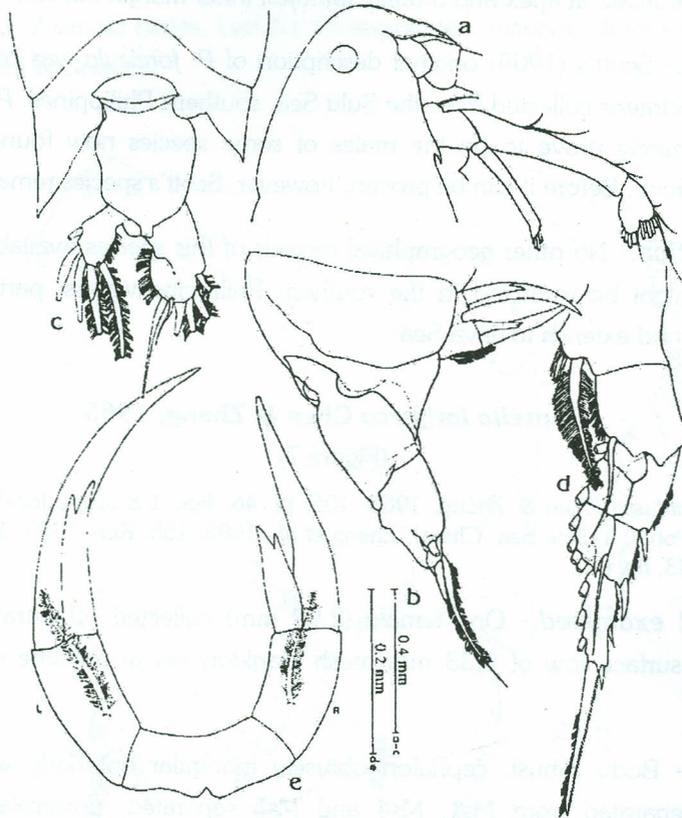


Figure 7. *Pontella latifurca*. Female. a, forehead, lateral view; b, Ms5 and urosomal somites, lateral view; c, Ms5 and urosomal somites, dorsal view; d, 1st leg; e, 5th legs.

Remarks.- Only a female was found from off Surabaya, East Java. Chen & Zhang's (1965) description of *P. latifurca* was based on 4 females and 3 males collected from Gulf of Pohai, Yellow Sea in summer and autumn. The present

female is similar with their figured in the following, (1) the A1 with 24 segments, (2) the P5 asymmetrical, without spinules or prominences on inner and outer margins, (3) the Ur1 without any processes. The difference between Chen & Zhang's descriptions from the present female is the asymmetrical Ur1, right margin more swollen than left and armed with 1 process posteriorly.

Distribution.- This species was widely distributed in the South China Sea and Korean coast, but not in numbers (Chen & Zhang, 1965; Zheng *et al.*, 1989; Kim, 1985), and off Surabaya, East Java, Indonesia (present records).

***Pontella spinipes* (Giesbrecht, 1889)**

(Figure 8)

Pontella spinipes Giesbrecht, 1889: 28 (Type locality: Arabian Sea at 60°E and 140°N); 1892: 461-463, pl. 24, fig. 30, pl. 40, figs. 2, 23, 24; Wolfenden, 1906: 1020-1021; Silas & Pillai, 1973: 826, figs. 21, 22; Pillai, 1975: 133, fig. 2a-b; Madhupratap & Haridas, 1986: 109.

Material examined.- One male (3.10 mm) collected off Surabaya by surface tow of 0.33 mm mesh plankton net at daytime on 2 June 1998.

Male.- Body robust, dorsal and ventral eye lenses well developed, posterolateral ends of Ms5 produced into symmetrical lobes with inner flanges and rostral lenses. Urosome composed of 5 somites, CR symmetrical and rather elongated. Right A1 geniculate, segment 18 with larger toothed plates, extending beyond segment 17 and reaching middle of segment 16. Segment 14 with a stout and long spine with a flagellum at its tip; fused segments 19-21 with 2 toothed plates, proximal one shorter than distal and both with villiform teeth, segment ending in falcate spur.

P5, right leg chelate, Re1 chela well developed, thumb stout and curved inwards, concave surface with 3 blunt rounded processes and a median seta. Re2 (claw) elongated, curved and with 3 rounded processes on its inner margin; claw provided with 3 inner setae. Left leg, Re1 with distolateral spine; Re2 short, ending in 2 subequal spine-like processes and 1 long flagellum process, and 1 outer spinule, inner margin hirsute.

No female was found in the present study.

Remarks.- Only a male was found from off Surabaya, East Java. Sewell (1912) remarked the differences between the male of *P. spinipes* and *P. securifer*, and the relation between the size and the length of toothed plates on the fused segments 19-21. He concluded that in the smaller specimens of *P. spinipes*, the distal plate of fused segments 19-21 will be longer than the proximal one. Wolfenden's (1906) description of the male *P. spinipes* was referred to variation of *P. securifer* by Sewell (1912).

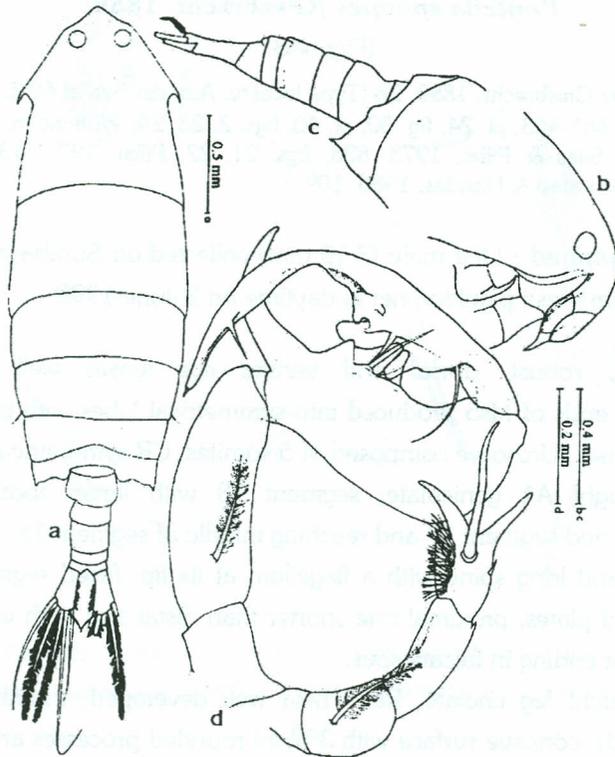


Figure 8. *Pontella spinipes*. Male. a, whole animal, dorsal view; b, forehead, lateral view; c, Ms5 and urosomal somites, lateral view; d, 5th legs.

Distribution.- An Indo-Pacific warm water epilanktonic form. Indian Ocean records include (Giesbrecht, 1889, 1892; Wolfenden, 1906; Sewell, 1912, 1932; Veronina, 1962; Silas & Pillai, 1973; Pillai, 1975; and Madhupratap & Haridas, 1986). Oriental Pacific: Wilson (1950).

***Pontella trydactyla* Shen & Lee, 1963**

(Figure 9)

Pontella latifurca Shen & Lee, 1963: 581, figs. 26-29 (Type locality: Chiekong estuary, the South China Sea); Zheng *et al.*, 1989: 255.

Material examined.- Ten males (2.45-2.50 mm) collected off Labuan, West Java by surface tow of 0.33 mm mesh plankton net at night on 18 April 1998.

Male.- Cephalon rounded anteriorly, separated from Ms1; Ms4 and Ms5 separate, posterolateral ends produced into symmetrical lobes. Urosome composed of 5 somites, Ur1 with 1 process on left side, as long as Ur3; Ur4 shortest; CR almost symmetrical with 5 plumose and 1 small setae. P5, right leg, B2 with 1 long plumose seta, Re1 with claw-like hook and 1 short spine on proximal corner externally, inner margin with 4 unequal lamella and 1 long seta on third length; Re2 claw-like, distal half elongated, inner margin produced into a rounded process near base and 3 setae along inner margin. Left leg, 4-segmented, B2 with 1 plumose seta; Ri1 with distolateral spine and 1 small seta in a half its length; Re2 short, ending in 3 unequal spine-like processes and 1 flagellum process, inner margin hirsute.

No female was found in the present study.

Remarks.- Shen & Lee (1963) have been established *P. tridactyla* based on 13 females and 10 males collected from the South China Sea. They described and figured the species too briefly, and their female appears to be a copepodid stages of the male by the structure of a 3-segmented urosome and not a yet developed P5. The present male specimen differs from Shen & Lee's (1963) figures by (1) the presence of 1 short spine on proximal corner of chela near

the thumb, (2) the 4 unequal lamella and 1 long seta on third length of chela of right P5, and (3) the presence 3 unequal spine-like processes and 1 flagelliform process on Re2 of left P5.

Distribution.- So far *P. tridactyla* is only known from the type locality, Chiekong estuary, South China Sea, and extends to Java Sea (present records).

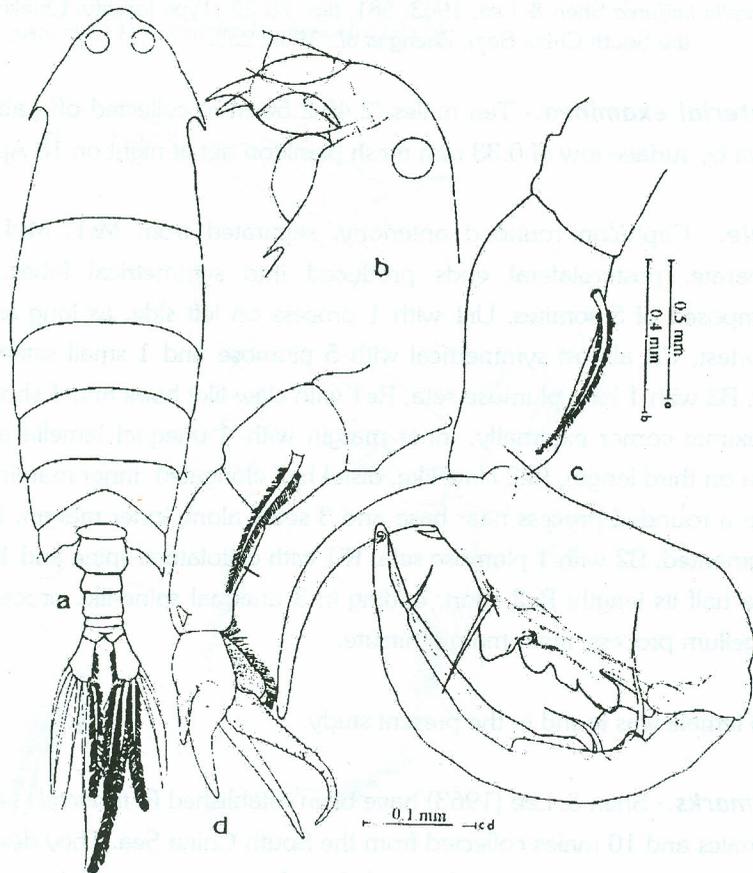


Figure 9. *Pontella tridactyla*. Male. a, whole animal, dorsal view; b, forehead, lateral view; c, right 5th leg; d, left 5th leg.

***Pontella valida* Dana, 1853**

(Figure 10)

Pontella valida Dana, 1853: 1171, pl. 82, fig. 6a-g (Type locality: north of New Zealand); Wilson, 1950: 301, pl. 29, figs. 432-434.

Pontella elephas, Brady, 1883: 94-95, pl. 37, figs. 7-14.

Pontellina (Ivellopsis) elephas Claus, 1893: 274.

Ivellopsis elephas Giesbrecht & Schmeil, 1898: 139; Silas & Pillai, 1973: 852.

Pontella surrecta (male) Wilson, 1950: 300, figs. 428, 430.

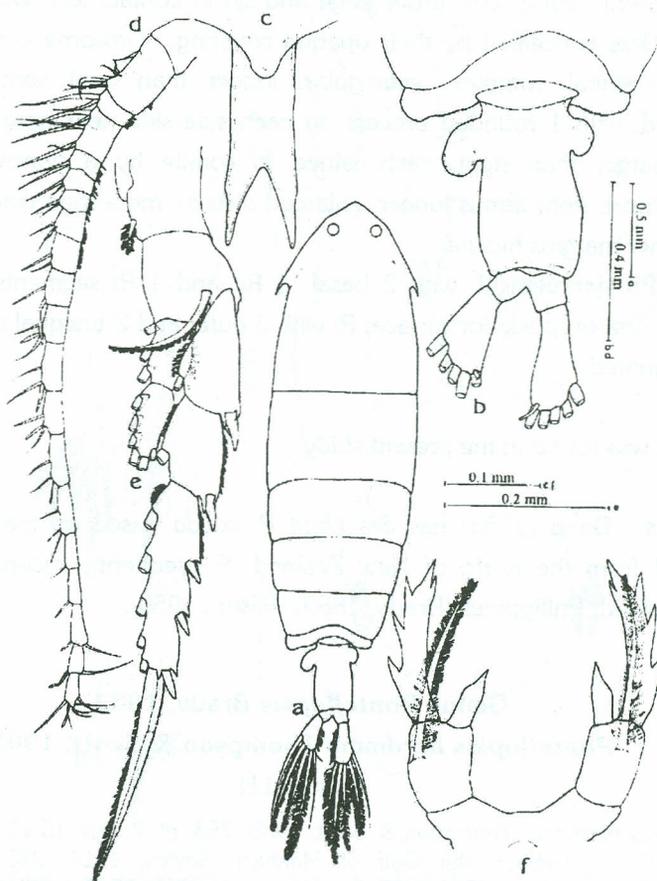


Figure 10. *Pontella valida*. Female. a, whole animal, dorsal view; b, Ms5 and urosomal somites, dorsal view; c, rostrum, ventral view; d, antennule; e, 4th leg; f, 5th legs.

Material examined.- Ten females (2.97-3.00 mm) were collected from Jakarta Bay by surface tow of 0.1 mm mesh plankton net at daytime on 2 June 1994.

Female.- Cephalon triangular and rather sharply pointed in front but without median crest, Ms4 and Ms5 metasomal somites separate, posterolateral ends rounded. Rostrum bifurcated, stout and pointed, directed downward, rostral lenses absent. Dorsal eye lenses large and set in contact with each other and more or less concealed by their opaque covering. Urosome composed of 2 somites, genital complex rectangular, longer than anal somite and CR combined, with 1 rounded process on each side side near base, left process slightly larger than right, each joined to somite by a narrow neck. CR asymmetrical, right ramus longer, enlarged distally, more than twice as long as wide, inner margins hirsute.

P5 symmetrical, with 2 basal, 1 Re and 1 Ri segments; B2 with 1 plumose seta on posterior surface; Ri with 3 outer and 2 unequal apical spines; Ri acuminate.

No male was found in the present study.

Remarks.- Dana (1853) has described *P. valida* based on male specimens collected from the north of New Zealand. Subsequently recorded from off Sibago Island, Philippines (Brady, 1883; Wilson, 1950).

Genus *Pontellopsis* Brady, 1883

***Pontellopsis herdmani* Thompson & Scott, 1903**

(Figure 11)

Pontellopsis herdmani Thompson & Scott, 1903: 253, pl. 2, figs. 15-17 (Type locality: Galle Harbour, the Gulf of Mannar); Sewell, 1914: 285, fig. 128a-b; Krishnaswamy, 1953: 137; Kasturirangan, 1963: 57, fig. 58a-b; Saraswathy, 1967: 84; Silas & Pillai, 1973: 843, fig. 31; Greenwood, 1979: 109, fig. 9. Non *Pontellopsis herdmani* sensu Sewell, 1912: 375, pl. 24, fig. 5; Vervoort, 1946: 10.

Material examined.- Ten females (1.90-2.05 mm) were collected from off Labuan, west Java by surface tow of 0.33 mm mesh plankton net at daytime on 18 April 1998.

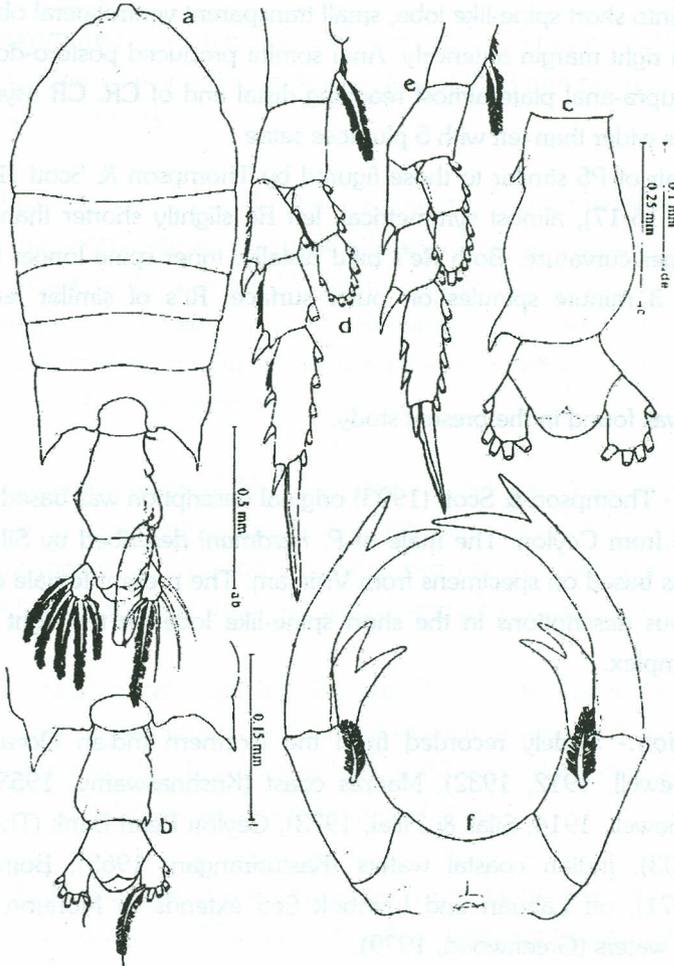


Figure 11. *Pontellopsis herdmani*. Female. a, whole animal, dorsal view; b, Ms5 and urosomal somites, dorsal view; c, urosomal somites, ventral view; d-e, 2nd-3rd legs; f, 5th legs.

Female.- Posterolateral ends of Ms5 produced into acuminate lobes, right side slightly longer than left not reaching middle of Ur1. Urosome composed of 2 somites, Ur1 asymmetrical, greatest width at distal quarter, tapering uniformly to anterior of somite, abruptly to distal quarter; right postero-dorsal region produced into short spine-like lobe, small transparent ventrolateral obtuse spine present on right margin anteriorly. Anal somite produced postero-dorsally into rounded supra-anal plate almost reaching distal end of CR. CR asymmetrical, right ramus wider than left with 5 plumose setae.

Pair of P5 similar to those figured by Thompson & Scott (1903: 253, pl. 2, figs. 15-17), almost symmetrical, left Re slightly shorter than right and with stronger curvature. Both Re's bifid distally; inner spine longer than outer one, with 3 minute spinules on outer surface; Ri's of similar length, bifid distally.

No male was found in the present study.

Remarks.- Thompson & Scott (1903) original description was based on female specimens from Ceylon. The male of *P. herdmani* described by Silas & Pillai (1973) was based on specimens from Vizinjam. The present female differs with the previous descriptions in the short spine-like lobe on the right margin of genital complex.

Distribution.- Widely recorded from the Northern Indian Ocean; Bay of Bengal (Sewell, 1912, 1932), Madras coast (Krishnaswamy, 1953), Gulf of Mannar (Sewell, 1914; Silas & Pillai, 1973), Ceylon Pearl Bank (Thompson & Scott, 1903), Indian coastal waters (Kasturirangan, 1963), Bombay coast (Pillai, 1971), off Labuan and Lombok Sea extends to Moreton Bay, east Australian waters (Greenwood, 1979).

***Pontellopsis inflatodigitata* Chen & Shen, 1974**

(Figure 12)

Pontellopsis inflatodigitata Chen & Shen, 1974: 132-133, 136, figs. 35-43 (Type locality: the South China Sea).

Material examined.- Ten females (1.65-1.80 mm), 10 males (1.50-1.70 mm) were collected from Jakarta Bay by surface tow of 0.33 mm mesh plankton net at daytime on 22 July 1999.

Female.- Rostrum forked, rami long and spiniform. Posterolateral ends of Ms5 produced into asymmetrical acuminate lobes, right side smaller than left. Urosome composed of 2 somites, Ur1 asymmetrical, right margin with 2 equal spines on proximal and medial margins; left margin with 2 very unequal spines, posterior one being longer than left; anal somite asymmetrical, right side being longer than left; CR almost symmetrical.

Male.- Posterolateral ends of Ms5 asymmetrical, left side broadly triangular, right side sword-shaped, much longer than left. Ur1 with small process on right margin; right margin of Ur2 and Ur3 produced into rounded knob, densely crowned with short spinules. Right A1 with 3 segments on middle region much enlarged.

P5 asymmetrical, right leg, B2 with 2 setae on upper half of outer margin; Re1 with 1 lateral, long and curved digitate process with its distal end enlarged, and 1 seta; Re1 1.5 times as long as B2 with 1 long distolateral seta; Re2 very small with 2 distal setae, inner margin hirsute.

Remarks.- So far this species was only known from the type locality, the South China Sea (Chen & Shen, 1974), and extends to Java Sea (present records).

P5 asymmetrical, right leg, Re with 3 outer spinules of which distal one much larger than anterior one; inner with 1 large spine; left Re pointed at apex with 2 outer spinules, Ri bifid at apex.

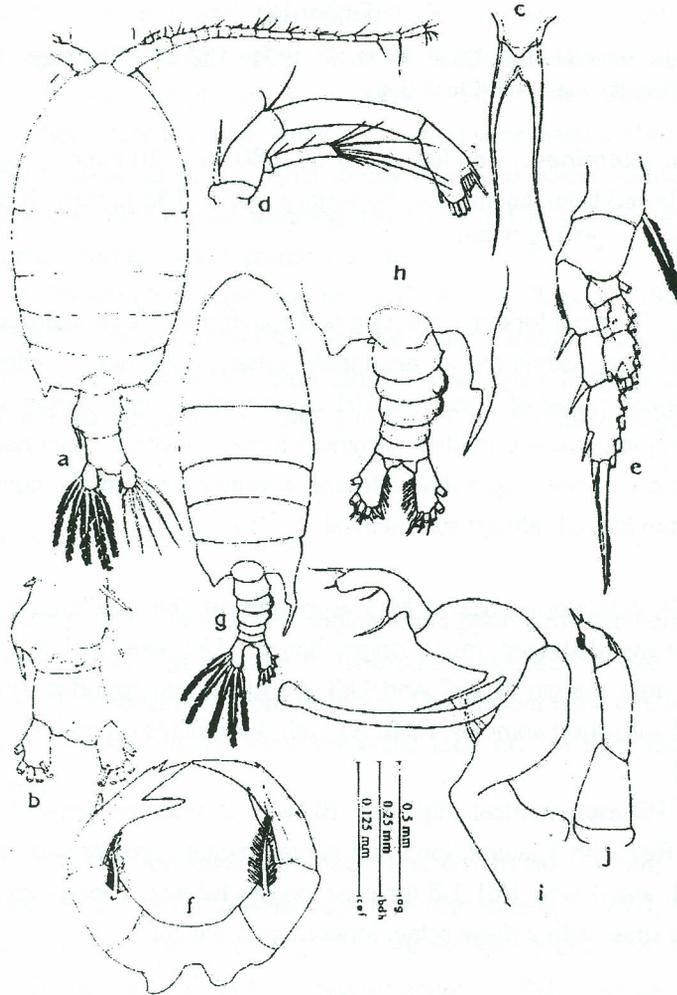


Figure 12. *Pontellopsis inflatodigitata*. Female. a, whole animal, dorsal view; b, urosomal somites, dorsal view; c, rostrum, ventral view; d, antenna; e, 1st leg; f, 5th legs. Male. g, whole animal, dorsal view; h, Ms5 and urosomal somites, dorsal view; i, right 5th leg; j, left 5th leg.

***Pontellopsis scotti* Sewell, 1932**

(Figure 13)

Pontellopsis scotti Sewell, 1932: 388-390, fig. 129a-f (Type Locality: Burmese Coast);
 Silas & Pillai, 1973 : 844, figure 32.

Pontellopsis herdmani (part) Sewell, 1912: 375, pl. 24, fig. 5.

Material examined.- Two females (1.70-1.75 mm) collected from Cilacap Bay, Central Java by surface tow of 0.33 mm mesh plankton net at daytime on 6 June 1998.

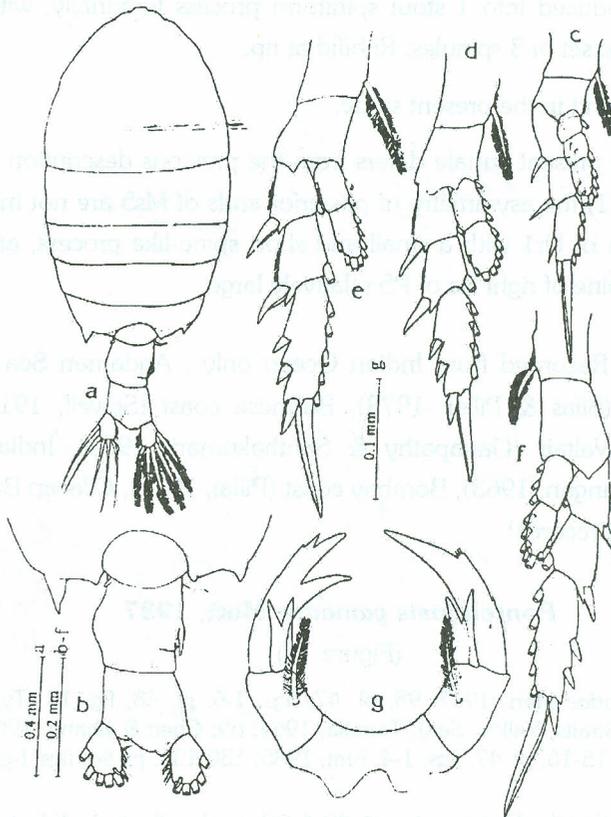


Figure 13. *Pontellopsis scotti*. Female. a, whole animal, dorsal view; b, Ms5 and urosomal somites, dorsal view; c-f, 1st-4th legs; g, 5th legs.

Female.- Cephalon broadly rounded with a projection over base of rostrum, separated from Ms1; rostral ramus long and spiniform. Posterolateral ends of Ms5 asymmetrical, right side longer than left. Urosome composed of 2 somites, Ur1 asymmetrical, proximal right margin with medial swelling and 1 transparent setules proximally; Ur2 asymmetrical, right side being longer; CR slightly asymmetrical, right ramus broader and longer.

Pair of P5 resembles *P. macronyx*, asymmetrical, right leg with 2 outer spinules and 3 distal spines of which innermost spine is longer and broader, inner margin of Re at its distal half produced into 1 stout thick spinous process. Left leg, Re produced into 1 stout spiniform process terminally, with 2 outer spines, distal one set in 3 spinules. Ri bifid at tip.

No male was found in the present study.

Remarks.- The present female differs from the previous description by Sewell (1932) in that, (1) the asymmetry of posterior ends of Ms5 are not marked, (2) the right margin of Ur1 with a small and short spine-like process, and (3) the middle apical spine of right Re of P5 relatively large.

Distribution.- Recorded from Indian Ocean only : Andaman Sea and west coast of India (Silas & Pillai, 1973), Burmese coast (Sewell, 1912, 1932), Lawson Bay, Waltair (Ganapathy & Santhakumari, 1961), Indian coastal waters (Kasturirangan, 1963), Bombay coast (Pillai, 1971), Cilacap Bay and off Labuan (present records).

***Pontellopsis yamadae* Mori, 1937**

(Figure 14)

Pontellopsis yamadae Mori, 1937: 98, pl. 47, figs. 1-6, pl. 48, fig. 13 (Type locality: Saishu Straits, Yellow Sea); Tanaka, 1964: 69; Chen & Zhang, 1965: 107, pl. 46, figs. 15-16, pl. 47, figs. 1-4; Kim, 1985: 130-131, pl. 44, figs. f-g.

Material examined.- Eight males (1.72-1.78 mm) collected off Labuan, West Java by surface tow of 0.33 mm mesh plankton net at daytime on 18 June 1994.

Male.- Prosome broadly rounded anteriorly, cephalon and Ms1 separated. Posterior ends of Ms5 asymmetrical, left lobe rounded, right lobe produced into an acuminate, elongate spine reaching distal end of Ur4. Urosome composed of 5 somites, genital somite widest with small spine posteriorly; Ur2 and Ur3 with knob on right margin, each armed with 1 set of denticles; Ur5 longer than Ur4; CR slightly asymmetrical, right ramus being longer. Right A1 geniculate, segments 13-17 enlarged, segment 13 with elongated hooked spine; segments 17 and 18 with serrated plates on anterior margin; segment 17 prolonged distally into spur-like process; base of segments 19-21 with serially arranged spinules.

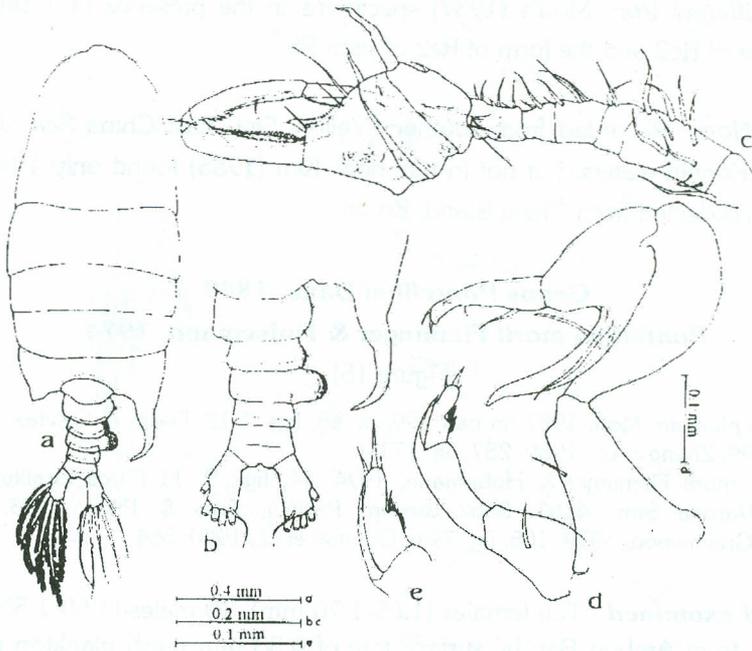


Figure 14. *Pontellopsis yamadae*. Male. a, whole animal, dorsal view; b, Ms5 and urosomal somites, dorsal view; c, right A1; d, 5th legs; e, distal segment of left 5th leg.

P5 asymmetrical, right leg, Re1 broader with elongated thumb, inner base with 1 seta; Re2 (finger) with bent tip, armed with 2 inner and 1 outer apical setae. Left leg, Re1 with elongated distolateral outer spine; Re2 with 3 apical spines, middle one longest, inner margin hirsute.

No female was found in the present study.

Remarks.- Mori (1937) has described this species based on 4 females and 1 male specimens collected from the Saishu Strait, Yellow Sea. The male of *P. yamadae* resembles *P. regalis*, but it is distinguished from the latter by the absence of spine on the right margin of Ur1, the posterior end of right Ms5 not reaching to distal end anal somite, and the form of P5. The present specimen is slightly different from Mori's (1937) specimens in the presence of 1 seta on inner base of Re2 and the form of Re2 of right P5.

Distribution.- Recorded from southern Yellow Sea, East China Sea, Japan Sea and Korean waters, but not in numbers. Kim (1985) found only 1 female specimen collected from Cheju Island, Korea.

Genus *Pontellina* Dana, 1849

Pontellina morii Fleminger & Hulsemann, 1974

(Figure 15)

Pontellina plumata, Mori, 1937 (in part): 99, pl. 48, figs. 1-12; Dakin & Colefax, 1940: 99; Zheng *et al.*, 1989: 257, fig. 173f-j.

Pontellina morii Fleminger & Hulsemann, 1974: 74, figs. 9, 11 (Type locality: R.V. Varuna Stns. 4161, 3562 western Pacific); Silas & Pillai, 1973: 851; Greenwood, 1979: 105, fig. 7a-b; Othman *et al.*, 1990: 564.

Material examined.- Ten females (1.65-1.70 mm), 10 males (1.50-1.55 mm) collected from Ambon Bay by surface tow of 0.33 mm mesh plankton net at daytime on 13 March 1995.

Female.- Body hairy. Cephalon narrowed anteriorly, separated from Ms1; Ms4 and Ms5 not completely fused, posterolateral ends produced into symmetrical short spiniform processes. Urosome composed of 2 somites, posterior margin of

genital complex fringed by coarse hairs; Ur2 short; CR, left ramus separated from Ur2, but right ramus fused with Ur2 and posterior corner not produced into acute spine. A1 17-segmented, reaching distal end of Ur2 when folded backwards.

P5 symmetrical, B2 with 1 plumose seta; Re with 1 medial seta and ending in 3 long unequal setae and 1 serrated falgella medially, inner margin hirsute. Ri bifurcated at apex.

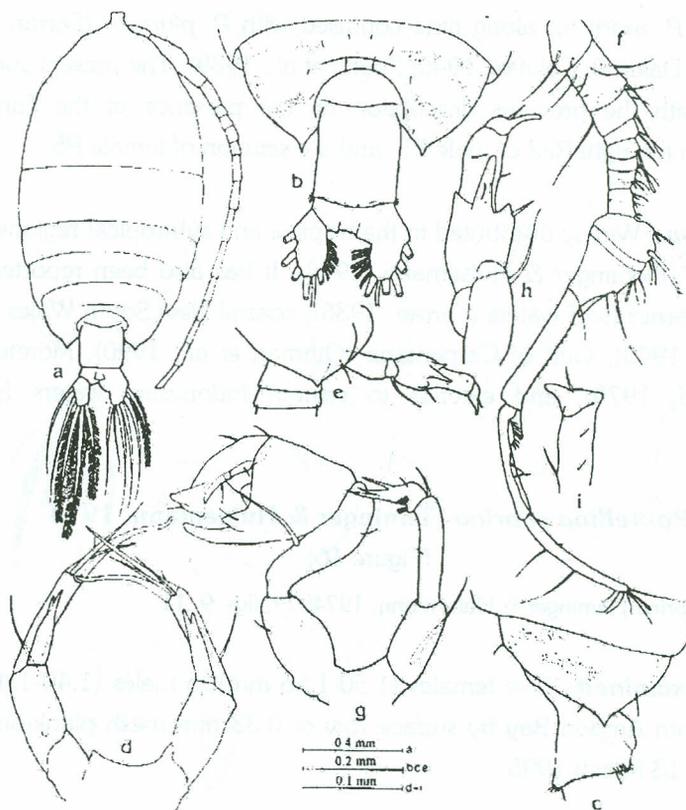


Figure 15. *Pontellina morii*. Female. a, whole animal, dorsal view; b, Ms5 and urosomal somites, dorsal view; c, Ms5 and Ur1, lateral view; d, 5th legs. Male. e, Ms5 and Ur1-Ur2, lateral view; f, right A1; g, 5th legs; h, right 5th leg; i, distal segment of right 5th leg.

Male.- Cephalon as in female. Posterolateral ends of Ms5 produced into symmetrical small spiniform processes. P5, right leg, Re1 (chela) with long thumb, concave surface with 2 small lamella and 1 seta at proximal one; Re2 (claw) short, not reaching thumb on proximal segment, with 1 flange-like extension at apex armed with 1 seta at tip, and 2 outer and 2 inner setae. Left leg, Re1 with 1 distolateral spine; Re2 short, ending in 3 spine-like processes, 1 seta present on medial anterior surface, proximal inner margin with 2 tuft of hairs.

Remarks.- *P. morii* for along time confused with *P. plumata* (Farran, 1936; Mori, 1937; Dakin & Colefax, 1940; Zheng *et al.*, 1989). The present specimen is similar with the previous description by the presence of the flange-like extension on the right Re2 of male P5, and the setation of female P5.

Distribution.- Widely distributed in the tropical and subtropical regions of the Indo-Pacific (Fleminger & Hulsemann, 1974). It has also been reported from the Great Barrier Reef waters (Farran, 1936), coastal New South Wales (Dakin & Colefax, 1940), Gulf of Carpentaria (Othman *et al.*, 1990), Moreton Bay (Greenwood, 1979), and extends to eastern Indonesian waters (present records).

***Pontellina sobrina* Fleminger & Hulsemann, 1974**

(Figure 16)

Pontellina sobrina Fleminger & Hulsemann, 1974: 79, figs. 9, 11.

Material examined.- Five females (1.50-1.55 mm), 5 males (1.40-1.45 mm) collected from Ambon Bay by surface row of 0.33 mm mesh plankton net at daytime on 13 March 1995.

Female.- Cephalon narrowed anteriorly, separated from Ms1; Ms4 and Ms5 completely fused, posterolateral ends almost symmetrical, produced into short spine-like processes. Urosome composed of 2 somites, Ur1 with posterolateral cluster coarse hairs both margin, posterior margin of somite fringed by hairs.

CR, right ramus fused with Ur2, somewhat shorter than wide, posterolateral end with broad point immediately anterior to base of outer seta. P5, Ri bifurcated, more than a half length of Re, Re ending in 3 long setae and 1 serrated flagella medially and 1 seta on posterior surface at 1/3 distal end.

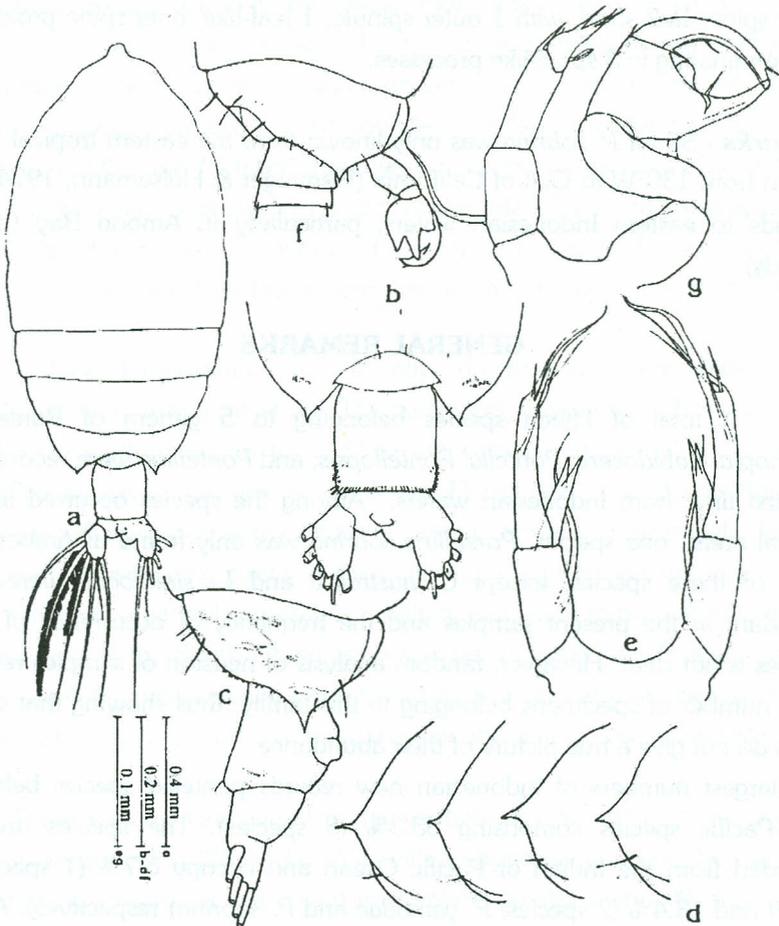


Figure 16. *Pontellina sobrina*. Female. a, whole animal, dorsal view; b, Ms5 and urosomal somites, dorsal view; c, Ms5 and urosomal somites, lateral view; d, variations of female Ms5, lateral view; e, 5th legs. Male. f, Ms5 and Ur1-Ur2, lateral view; g, 5th legs.

Male.- Cephalon as in female. CR, right ramus fused with anal somite, less than 2 times as long as wide; left ramus separated from anal somite. P5 asymmetrical, right leg, thumb of Re1 (chela) stout with 1 seta at base, concave surface with 1 rounded lamella and 1 distal seta; Re2 (claw) curved inwards rounded at apex with 2 inner and 1 outer setae. Left leg, Re1 with distolateral outer spine; Re2 short, with 1 outer spinule, 1 leaf-like inner spine proximally, and terminating in 3 spine-like processes.

Remarks.- So far *P. sobrina* was only known from the eastern tropical Pacific Ocean from 130°W to Gulf of California (Fleminger & Hulsemann, 1974), and extends to eastern Indonesian waters, particularly in Ambon Bay (present records).

GENERAL REMARKS

A total of fifteen species belonging to 5 genera of Pontellidae, *Calanopia*, *Labidocera*, *Pontella*, *Pontellopsis*, and *Pontellina* were recorded for the first time from Indonesian waters. Among the species occurred in Java coastal areas, one species, *Pontellina sobrina* was only found at Ambon Bay. Most of these species, except *C. australica* and *L. sinilobata*, were never abundant in the present samples and the frequency of occurrence of many species is not clear. However, random analysis of neuston of samples revealed large number of specimens belonging to this family, thus showing that vertical hauls do not give a true picture of their abundance.

The largest numbers of Indonesian new records pontellid species belong to Indo-Pacific species comprising 53.3% (8 species). The species are only recorded from the Indian or Pacific Ocean and occupy 6.7% (1 species, *P. scotti*) and 13.4% (2 species, *P. yamadae* and *P. sobrina*) respectively. Among the remaining species 26.6% (4 species, *L. sinilobata*, *P. latifurca*, *P. tridactyla*, and *P. inflatodigitata*) and 6.7% (1 species, *P. forcicula*) have been thought to be endemic species for the China Sea and for the Sulu Sea, Philippine waters before this study, respectively.

Many of the species appear to be chiefly neritic albeit also occurring rarely in oceanic waters. Records of *P. spinipes* from the Atlantic was based on misidentification. *P. herdmani* was considered to be endemic to the Indian Ocean, now occurs off eastern tropical Australia, New Guinea and across the Indo-Malayan Seas (Madhupratap & Haridas, 1986). *P. scotti* was endemic to the Indian Ocean also occurs in the Indian Ocean side of southern Java.

Relative abundance of pontellid species, expressed as percentage of total numbers present per m^3 of water strained, varied among species. Adult form of *C. australica* were the most abundant (36%), *L. sinilobata* (22%), *L. bengalensis* (10%), and *P. morii* (5%) were most numerous. *P. inflatodigitata* and *P. tridactyla* were less numerous (2% of the total). The remaining species, *P. diagonalis*, *P. forcicula*, *P. latifurca*, *P. spinipes*, *P. valida*, *P. herdmani*, *P. scotti*, *P. yamadae*, and *P. sobrina* were rare, each comprising less than 1% of the adults.

Surface temperature and salinity distributions were based on observations taken during the study. The mean temperature was 29°C, ranging from 31°C in western region to 27°C in the eastern region. Salinity ranged from 22‰ at Java Sea sites to 33‰ at Flores Sea. The distribution of pontellids is influenced by temperature or salinity. However, the specific factor or group of factors limiting pontellid distribution has not been determined.

Of the two variables measured, salinity was more important in limiting the distribution of the South China Sea's species, *L. sinilobata*, *P. latifurca*, *P. tridactyla*, and *P. inflatodigitata* were found only from the Java Sea sites. *L. sinilobata* was only found off Surabaya in great abundance, but absent at other sites.

These species were found in aggregation of 1 per m^3 or more over a wide temperature range (26.5°-31.5°C), with no apparent concentration at any temperature. *C. australica* was found in numbers greater than 100 inds/ m^3 in salinities less than 20‰, to sites where salinities were >30‰ (less than 1 inds/ m^3 or absent). *P. morii* occurred in concentrations exceeding 10 ind/ m^3 throughout a wide range of salinities (29-33.5‰), with no abrupt reduction in low salinity waters except for 5 or fewer per m^3 found at several sites located in

salinities 24‰. In relation to temperature, *P. morii* was found to be less numerous (less than 5 inds/m³) in Java Sea sites (>30° C). *L. bengalensis* was more numerous (up to 10 inds/m³) in higher salinity (>30‰), and lower temperature (<28° C) off Labuan waters.

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REFERENCES

- Brady, G. S. 1883. Report on the Copepoda collected by H.M.S. Challenger during the years 1873-1876. *Rep. Sci. Res. H.M.S. Challenger, Zool.*, 8: 1-142.
- Bayly, I.A.E. & J.G. Greenwood, 1966. A new species of *Calanopia* (Copepoda: Calanoida) from Moreton Bay, Queensland. *Proc. Roy. Soc. Queensland*, 77(11): 99-105.
- Carl, J. 1907. Copepodes d'Amboine. *Rev. suisse Zool.*, 15: 7-18.
- Chen, Q.C. & S.Z. Zhang, 1965. The planktonic copepods of the Yellow Sea and the East China Sea I. Calanoida. *Studia Marina Sinica*, 7: 20-131, 53 pls.
- Cleve, P.T. 1901. Plankton from the Indian Ocean and Malay Archipelago. *Kongl. Svenska Vetenskaps-Akademiens. Handl.*, 35(5): 1-58, 8 pls.
- Dakin, W.J. & F.J. Colefax, 1940. The plankton of the Australian coastal waters off New South Wales. *Monogr. Dep. Zool. Univ. Sydney*, 1: 1-215.
- Delsman, H.C. 1939. Preliminary plankton investigations in the Java Sea. *Treubia*, 17: 139-181.

- Fleminger, A. 1967. Taxonomy, distribution and polymorphism in the *Labidocera jollae* group with remarks on evolution within the group (Copepoda: Calanoida). *Fish. Bull.*, 71(4): 965-1010.
- Fleminger, A. 1986. The Pleistocene equatorial barrier between the Indian and Pacific Oceans and a likely cause for Wallacea's line. *UNESCO techn. Pap. Mar. Sci.*, 49: 84-97.
- Fleminger, A., B.H.R. Othman & J.G. Greenwood, 1982. The *Labidocera pectinata* group: an Indo-West Pacific lineage of planktonic copepods with descriptions of two new species. *Journ. Plank. Res.*, 4(2): 245-269.
- Greenwood, J.G. 1978. Two new species of *Labidocera* (Copepoda; Calanoida) from Queensland. *Journ. Nat. Hist., London*, 12: 535-543.
- Greenwood, J.G. 1979. Calanoid copepods of Moreton Bay (Queensland) IV. Family Pontellidae. *Proc. Roy. Soc. Queensland*, 90: 93-111.
- Mori, T. 1937. The pelagic Copepoda from the neighbouring waters of Japan: 1-150. (Koniya Printing Co., Tokyo; reprinted in 1964 by Soyo Co. Inc., Tokyo).
- Ohtsuka, A., A. Fleminger & T. Onbe, 1987. A new species of *Pontella* (Copepoda: Calanoida) from the Inland Sea of Japan with notes on its feeding habits and related species. *Journ. Crust. Biol.*, 7(3): 554-571.
- Othman, B.H.R., J.G. Greenwood & P.C. Rothlisberg, 1990. The copepod fauna of the Gulf of Carpentaria and its Indo-West Pacific affinities. *Netherlands Journ. Sea Res.*, 25(4): 561-572.
- Scott, A. 1909. Copepoda of the Siboga Expedition. Part 1. Free swimming, littoral and semi-parasitic Copepoda. *Siboga Expeditie Monografieen*, 29a: 1-323, pls. 1-69.
- Sewell, R.B.S. 1912. Notes on the surface Copepoda of Bay of Bengal I and II. *Rec. Indian Mus.*, 7(4): 313-382, pls. 14-14, 5 textfigs.
- Sewell, R.B.S. 1914. Notes on the surface Copepoda of the Gulf of Mannar. *Spolia Zeylan.*, 9: 191-262, pls. 17-21, 1 map, 1 tab.
- Sewell, R.B.S. 1932. The Copepoda of Indian Seas. Calanoida. *Mem. Indian Mus.*, 10: 1-407.

- Silas, E.G. & P.P. Pillai, 1973. The calanoid copepod family Pontellidae from the Indian Ocean. *Journ. mar. biol. Ass. India*, 15(2): 771-858.
- Tanaka, O. 1964. The pelagic copepods of the Izu region, middle Japan. Systematic account XII. Families Arietellidae, Pseudocyclopidae, Candaciidae and Pontellidae. *Publs. Seto mar. Biol. Lab.*, 12: 231-271.
- Thompson, I. C. & A. Scott, 1903. Report on the Copepoda collected by Prof. Herdman at Ceylon. *Ceylon Pearl Oyster Fisheries*, (Suppl. Rept.), 7: 227-307.
- Vervoort, W. 1946. Biological results of the Snellius Expedition. XV. The bathypelagic Copepoda Calanoida of the Snellius Expedition I. Fms. Calanidae, Eucalanidae, Paracalanidae and Pseudocalanidae. *Temminckia*, 8: 1-81.
- Wilson, C. B. 1950. Copepods gathered by U.S. Steamer Albatross from 1907 to 1909, chiefly in the Pacific Ocean. *U.S. natn. Mus. Bull.*, 100, 14(4): 141-441.
- Wolfenden, R.N. 1906. Notes on the collection of Copepoda. *The fauna and geography of the Maldive and Laccadive Archipelagoes*, 2(1): 989-1040.