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CALANOID COPEPODS OF THE GENUS *CENTROPAGES* AND ITS SPECIES-GROUP FROM INDONESIAN WATERS

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ABSTRACT

The marine copepods of the genus *Centropages* form a very important component of tropical marine ecosystem, but are poorly known. In a continuing study of the copepods of Indonesian coastal waters, eight species of *Centropages* were collected from 11 sites during 1996-2006. Four out of five previously known species i.e., *C. calaninus* (Dana, 1849); *C. furcatus* (Dana, 1849); *C. gracilis* (Dana, 1849); *C. orsini* Giesbrecht, 1896, except *C. elongatus* Giesbrecht, 1869 have been recorded. Four species i.e., *C. brevifurcus* Shen and Lee, 1963; *C. dorsispinatus* Thompson and Scott, 1903; *C. sinensis* Chen and Zhang, 1965; and *C. tenuiremis* Thompson and Scott, 1903, are new records for the area.

Keywords: New records, *Centropages*, Copepoda, Indonesia, Taxonomy, Biogeography.

INTRODUCTION

The species of the genus *Centropages* Kroyer, 1849, are surface-living forms, and most of them are widely distributed in warm waters. Some of the species are primarily neritic, others are oceanic. Currently, the literature indicates 30 nominal species as widely accepted taxa world-wide. Vervoort (1964) pointed out that the genus required revision and that a number of poor, old descriptions had caused taxonomic confusion.

During the study of copepod in Indonesian waters, eight species of *Centropages* were found. Four previously reported species, *C. calaninus* (Dana, 1849); *C. furcatus* (Dana, 1849), *C. gracilis* (Dana, 1849), *C. orsini* Giesbrecht, 1896, (except *C. elongatus* Giesbrecht, 1896) have been found. Four other species, *C. brevifurcus* Shen and Lee, 1963; C. *dorsispinatus* Thompson and Scott, 1903; *C. sinensis* Chen and Zhang, 1965; and *C. tenuiremis* Thompson and Scott, 1903 are new records for this area.

This paper deals with description and illustration of all species collected. It provides a key for their identification, their species-group, and a discussion on their geographic distribution.

MATERIAL AND METHODS

The present plankton samples were obtained from 11 sites (55 stations) along Indonesian coastal waters, on the dry- and rainy season during 1994–2007. A map of study sites is shown on Figure 1. Sampling was done by surface and vertical hauls (from 5, 10 or 20 m deep to the surface) with plankton net (0.33 mm mesh size; 0.45 m diameter mouth aperture). The samples were fixed and preserved in 5% formalin/sea water solution. The *Centropages* were identified to species level by dissection and examination. Habitus and appendages were examined and measured using a compound microscope and detailed drawings were made with a camera lucida.

Reference slides of appendages were prepared using glycerin jelly and methyl blue and deposited at the Division of Zoology, Research Center for Biology, Indonesian Institute of Sciences (LIPI), Cibinong, Indonesia.

Abbreviations used in the text to describe morphological features are: A1 = antennule, A2 = antenna, Ms1-Ms5 = metasomal somites 1–5, P1-P5 = swimming legs 1-5, Ur1-Ur5 = urosomal somites 1–5, CR = caudal rami, B1 = coxa, B2 =

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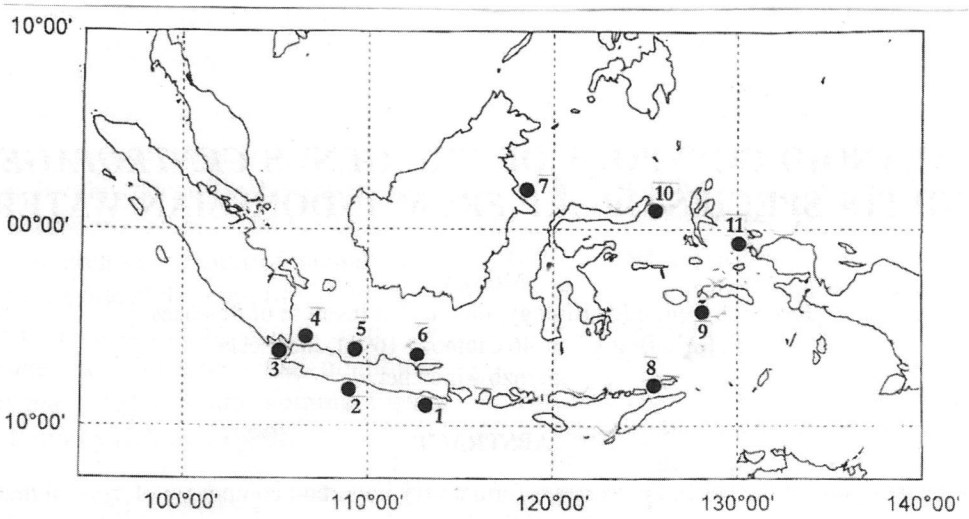


Figure 1. Map of Indonesian waters and sampling sites 1 - 11
1, Sempu Island; 2, Cilacap Bay; 3, Sunda Strait; 4, Jakarta Bay; 5, Off Tegal; 6, Off Surabaya; 7, Berau Bay; 8, Ombai Strait; 9, Ambon Bay; 10, Lembeh Bay, Bitung; 11, Waigeo Island

basis, Ri1-Ri3 = endopodal segments 1-3, Re1-Re3 = exopodal segments 1-3, Si = inner spine, Se = outer spine, St = terminal spine.

Taxonomy

Family **Centropagidae** Giesbrecht, 1892
Genus ***Centropages*** Kröyer, 1849
Centropages brevifurcus Shen and Lee, 1963
Centropages brevifurcus Shen and Lee, 1963: 593, figs. 11-14; Chen and Zhang, 1965: 127; Chen, 1986: 524.

Material examined.- Ten females(1.25–1.35 mm), 10 males (1.10-1.16 mm) collected off Tegal, Central Java by surface tow of 0.33 mm mesh plankton net at night on 3 June 1994.

Female.- Cephalosome narrowed anteriorly, distinctly separate from Ms1, with posterodorsal knob. Rostrum with long filaments and broad bases. Posterolateral ends of Ms5 asymmetrical, with 3 ventrolateral pairs of pointed processes, right dorsalmost process abruptly curved outward. Urosome with minute prominences dorsally. Ur1 asymmetrical, expanded anterolaterally, right dorsolateral side with 2 rows of spinules; left dorsolateral side with patch of spinules, and serration along posterodorsal margin; genital operculum located ventrolaterally on right side, with right distal corner produced posteriorly into round or somewhat pointed process. Ur2 with swelling ventrolaterally on right side; posterior margin of swelling concave; CR approximatelly twice as long as wide; caudal seta V longest. A1 22-segmented, reaching distal end of Ms5 when folded backwards, apparently several segments fused together to form 2nd segment, segments 8 and 9, and 24 and 25 partially fused.

P1-P4, Re and Ri 3-segmented, B1 with process. B2 of P1 with 1 distolateral seta. P5 asymmetrical, with 2 basal segments, Ri and Re 3-segmented. B1 with distolateral spine; B2 with small outer seta; Re2 with inner spine-like process, longer than the segment itself, serrated and swollen at apex; Ri as long as Re1 and Re2 combined, inner margin of Re1 with 1 rounded process on distal end.

Male.- Prosome similar to female, posterolateral ends of Ms5 sharply pointed, symmetrical; each armed with 2 spinules situated rather toward ventral side. In lateral view, posterolateral ends of Ms5 trifurcate. Ur1 short, slightly asymmetrical, left side slightly produced posterolaterally, as long as Ur4. Ur2 longest; Ur3 very short; CR as in female. Right A1 geniculate, 23-segmented, anterior margin of segment 17 with row of teeth, segment 18 with double rows of teeth. Fused segments 19–21 with double rows of teeth; segment 23 terminating in spine-like process with 6 terminal setae.

Other appendages except P5 as in female. P5 asymmetrical, right leg with 2 basal segments, Re and Ri 3-segmented. B1 with 1 small spine; B2 with outer seta distally; Re2 with 1 outer and 1 long spine, prolonged laterally over inner margin with denticles. St of Re3 with 1 inner seta medially, 1 outer and 1 terminal spine with double rows of spinules on outer margin. Left leg with 2 Re, Re1 with 1 outer spine; Re2 with 2 outer and 1 terminal spine. Right and left Ri's of P5 as in female.

Remarks.- The female of *C. brevifurcus* is easily identifiable by the asymmetrical posterolateral ends of Ms5, right side produced into acute and curved process, anterolateral swelling of Ur1 armed with spinules, and Ur2 with medial knob on right margin. The male is identifiable by the trifurcation of the Ms5 corner (visible in lateral view), the segment 23 of the right A1 terminating in spine-like process, and the form of P5. *C. brevifurcus* originally known from the Luichow Peninsula, Kwangtung Province, southern China (Shen and Lee, 1963), the Gulf of Thailand (Othsuka *et al.*, 2003), and Java Sea (present records).

***Centropages calaninus* (Dana, 1849)**

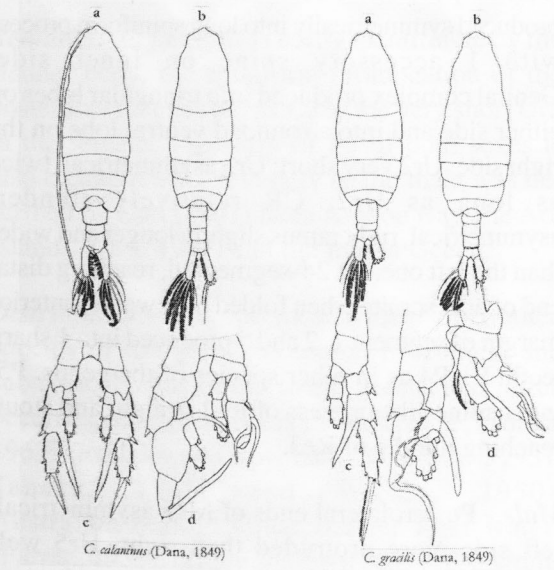
Cyclopsina calanina Dana, 1849: 25.
Hemicalanus calaninus Dana, 1852: 1105, pl. 78.
Centropages calaninus (Dana), Giesbrecht, 1892: 305; A. Scott, 1909: 112; Mori, 1937: 61–62, pl. 30, figs. 4–7; Tanaka, 1963: 8.

Material examined.- Ten females (1.85–1.90 mm), 10 males (1.65-1.70 mm) collected from Ambon Bay by surface tow of 0.33 mm mesh plankton net at night on 22 Dec. 1993.

Female.- Posterolateral ends of Ms5 rounded. Prosome 2.5 times as long as urosome. Genital complex somewhat swollen and symmetrical; Ur3 more than twice length of Ur2, with small ventral lamella near distal end; CR asymmetrical, right ramus longer and thicker than left one. A1 24-segmented, reaching distal end of CR by the last 2 segments when folded backwards. P1, Re2 with small notch on outer margin. P5, inner spine-like process of Re2 longer than Re3.

Male.- Prosome and urosome asymmetrical. Posterolateral ends of Ms5 rounded. Right A1,

CENTROPAGES CALANINUS GROUP



Characters	*C. calaninus*
Female	
Posterolateral ends of Ms5	symmetrical rounded process
Genital complex	symmetrical, bulbous
Genital opening	not produced
CR	asymmetrical, right ramus longer and thicker
P5	Re2 with symmetrical long inner extention, reaching beyond distal end of Re3
Male	
P5	
Right leg	Re2 with short inner spinal process, shorter than Re3. Re3 sharply bent inwards
Left leg	apex rounded with 2 unequal middle long processes

Figure 2. *Centropages calaninus* group. *C. calaninus* (Dana, 1849). female. a, whole animal, dorsal view; d, 5th legs; male. b, whole animal,dorsal view; d, 5th legs. *C. gracilis* (Dana, 1849). female. a, whole animal, dorsal view; c, 5th legs; male. b, whole animal, dorsal view; d, 5th legs.

segments 19-21 shorter than those of *C. gracilis*. P5, right leg, terimal spine of Re2 longer than thumb, sharply bent inwards. Left leg, Re2 (terminal segment) with 2 finely serrated plates at apex.

Remarks.- The female is identifiable by the small ventral knob on Ur3 and the long spine-like process on the Re2 of P5. The male is identifiable by the form of P5, especially the long and bent terminal claw of the chela.

Distribution.- An Indo-Pacific warm water epiplanktonic form. Indian Ocean records include Sewell, 1947; Krishnaswamy, 1953; De Decker and Mombeck, 1964; and Saraswathy, 1967. Pacific Ocean records (Mori, 1937; Tanaka, 1963; Wilson, 1950, Grice, 1962). Australian region: off New South Wales coast (Dakin and Colefax, 1940); Great Barrier Reef waters (Farran, 1936), Moreton Bay (Greenwood, 1977). Indo-Malaysian region (Cleve, 1901; A. Scott, 1909).

Centropages dorsispinatus **Thompson and Scott, 1903**

Centropages dorsispinatus Thompson and Scott, 1903

Material examined.- Ten females (1.10–1.30 mm), 10 males (1.0–1.10 mm) collected from Berau Bay, East Kalimantan by surface tow of 0.33 mm mesh plankton net at daytime on 22 September 2007.

Female.- Cephalosome oval, rounded and slightly narrowed anteriorly, posterodorsal margin with a median hook-like proces directed backwards, separate from Ms1. A large color spot of purple on around the hook-like process. Ms5 separate from Ms4, posterolateral ends slightly asymmetrical and sharp. Rostrum with short filament. A1 22-segmented, slightly extended CR when folded backward, anterior margin of segments 2 and 5 produced into a spine.
Urosome, Ur1 widened with bundles of hairs on its lateral side; Ur3 relatively long, CR slightly curved inward. P5 symmetrical, inner process on Re2 smooth, triangular, long and sharp, as long as Re3 and longer than Re2 itself.

Male.- Cephalosome same to female, but posterolateral ends of Ms5 much shorter. Right A1 segments 18 and 19 prehensile. P5 asymmetrical, middle of right Re1 with 1 inner small tooth. Left P5, inner margin of Re with a relatively long spine and a small process, distal outer margin of same segment denticulated.

Remarks. *C. dorsipsinatus* is easily identified by dorsal purple spot and dorsal hook-like process on cephalon. This species originally known from Ceylon Pearl Banks by Thompson and Scott (1903), along the Chinese coast of Yellow Sea and Kwangyang, Anma Island Korea in summer (Kim, 1985), Port Dickson, Malaysia (unpublished data).

Centropages furcatus **(Dana, 1849)**

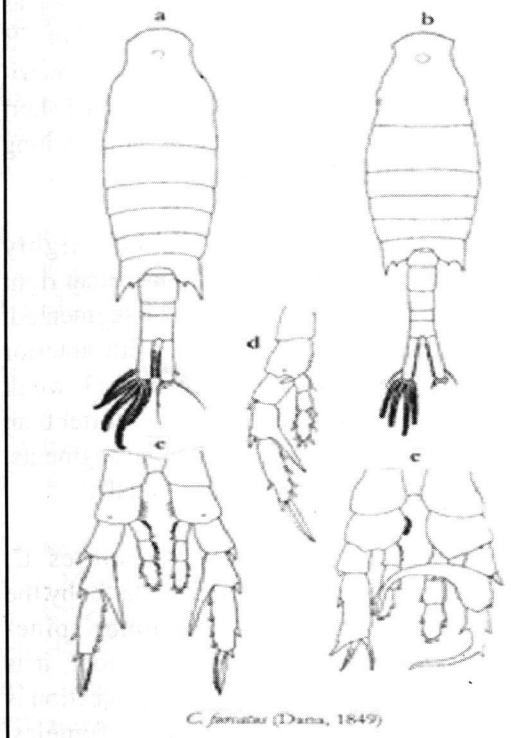
Catopia furcata Dana, 1849: 25; 1852: 1173–1174, pl. 79, fig. 1a–d.
Centropages furcatus (Dana), Cleve, 1900: 52; A. Scott, 1909: 113.
Centropages furcatus var. Carl, 1907: 8, 16, pl. 1, figs. 6–7.
Centropages furcatus var *carli* Fruchtl, 1923: 452; 1924: 45.

Material examined.- Ten females (1.62–1.70 mm), 10 males (1.55–1.65 mm) collected off Labuan, west Java by surface tow of 0.33 mm mesh plankton net at night on 18 June 1994.

Female.- Body narrowly elongated with truncate frontal portion. Posterolateral ends of Ms5 produced symmetrically into long spiniform process with 1 accessory spine on inner side. Genital complex produced into triangular lobes on either side and into a rounded ventral lobe on the right side; Ur2 very short; Ur3 asymmetrical, twice as long as Ur2. CR relatively slender, asymmetrical, right ramus slightly longer and wider than the left one. A1 24-segmented, reaching distal end of anal somite when folded backwards; anterior margin of segment 1, 2 and 5 produced into 1 sharp teeth. P1-P4 as in other species of the genus. P5, inner spine-like process of Re2 straight and stout, reaching middle of Re3.

Male.- Posterolateral ends of Ms5 asymmetrical, left side more protruded than right. Ur5 well developed, as long as UR3; CR 3 times as long as Ur5. Right A1 genicuilate, antarior margin of segments 15–16 with very small row of teeth. P4, Re2 with long outer spine. P5 asymmetrical, right leg, Re2 with spinal process as long as terminal claw; Re3 with 2 teeth on its proximal part. Left

CENTROPAGES FURCATUS GROUP



Characters	*C. furcatus*
Female	
Posterolateral ends of Ms5	symmetrical long spinal process with accessory inner process
Genital complex	symmetrical
Genital opening	not produced
CR	symmetrical with long rami
P5	Re2 with symmetrical long inner extention, reaching middle length of Re3
male	
P5	
Right leg	Re2 with long inner spinal process as long as Re3. Re3 with 2 Se and 1 Si
Left leg	apex with 2 spinal processes

Figure 3. *Centropages furcatus* group. *C. furcatus* (Dana, 1849). female. a, whole animal, dorsal view; c, 5th legs; d, 5th leg, other specimen; male. b, whole animal, dorsal view; e, 5th legs.

leg, Re2 with spinal process at apex and 2 spines near distal end.

Remarks.- *C. furcatus* is easily identifiable by the slender body, the spiniform prolongation of the posterolateral ends of Ms5, and the very short Ur2 in the female. The form of P5 of both sexes is also characteristic. A variety of the male was described by Carl (1907) from Ambon Bay, the Aru Islands (Carl, 1907) and the Indian Ocean.

Distribution.- It is the most widely distributed species of the genus, common in tropical and subtropical areas of the world oceans and often occurring in large numbers (Sewell, 1932; Tanaka, 1963; Gonzales and Bowman, 1965; Mori, 1937; Tanaka, 1963, and Wilson, 1950). Australian region: Great Barrier Reef waters (Farran, 1936), off the southern coast of Australia (Dakin and Colefax, 1933), Brisbane River mouth (Bayly, 1965), Moreton Bay (Greenwood, 1977). Indo-Malaysian region: frequently recorded throughout as noted by Cleve (1901), A. Scott (1909), Delsman (1939), and Wickstead (1961).

***Centropages gracilis* (Dana, 1849)**

Hemicalanus gracilis Dana, 1849: 1108, pl. 78.
Centropages gracilis (Dana), Giesbrecht, 1892: 305, pl. 17, figs. 31–32, 46; A. Scott, 1909: 114; Mori, 1937: 62, pl. 30, figs. 8–11; Tanaka, 1963; Zhang et al., 1989: 244.

Material examined.- Ten females (1.80–1.85 mm), 10 males (1.75–1.80 mm) collected from Derawan Strait, East Kalimantan by vertical haul of 0.33 mm mesh plankton net from 100 m to surface at night on 22 October 1994.

Female.- Posterolateral ends of Ms5 rounded. Right side of genital complex with spinules on lateral margin; Ur2 with distinct knob-like projection on lateral margins, surface of each knob covered with fine short spinules, ventral surface bearing a rounded process; CR symmetrical, about 3 times as long as wide. A1 reaching distal end of CR when folded backwards. P5 slightly asymmetrical, inner spine-like process of Re2 nearly straight, stout and almost as long as Re3, inner spine of Re2 of left leg slightly longer than right.

Male.- Posterolateral ends of Ms5 rounded. CR about 4 times as long as wide. Left A1 reaching distal end of CR by the last 3 segments when folded backwards, middle part of right A1 slender. P5, right leg with terminal claw longer than thumb, and with 1 triangular process on inner margin.

Remarks.- The female of *C. gracilis* is aesily identifiable by the lateral marginal spinules on Ur2, and the short inner spine of Re2 of left P5. The male is identifiable by the trianular process on the inner margin of the terminal claw of right P5, which is absent in other species of the genus.

***Centropages orsini* Giesbrecht, 1889**

Centropages orsini Giesbrecht, 1889: 305, pls. 17–18, 38; A. Scott, 1909: 115; Sewell, 1911: 315; Farran, 1936: 109; Mori, 1937: 60, pl. 29, figs.1–7; Tanaka, 1963: 9; Greenwood, 1977: 63, fig. 5c–d.

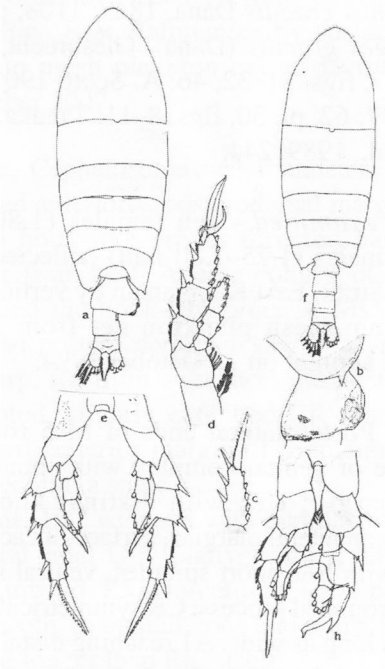
Material examined.- Ten females (1.40–1.60 mm), 10 males (1.25–1.30 mm) collected off Labuan, West Java by surface tow of 0.33 mm mesh plankton net at night on 18 June 1994.

Female.- Posterolateral ends of Ms5 pointed. Genital complex asymmetrical, right margin swollen, with 1 ventral spine; CR twice as long as wide. A1 24-segmented reaching distal end of CR when folded backwards. P5 slightly asymmetrical, left leg, inner spine-like process of Re2 short and stout, beset with small spinules, not reaching to distal end of Re3.

Male.- Posterolateral ends of Ms5 slighly asymmetrical, pointed, left side longer than right one. CR as in female. A1, left side 24-segmented, extends to middle CR; right side, with anterior margin of segments 15 and 16 with 1 weak process. P5, right leg, thumb of chela shorter than terminal claw; left leg with 2 exopodal segments, Re2 projecting into 1 long spine terminally.

Remarks.- *C. orsini* mostly resembles *C. kroyeri*, but is distinguished from the latter by the form of P5 of both sexes. The inner spine-like process of left Re2 is short and stout, it is beset with spinules. In *C. kroyeri* the projection is comparatively slender and its is without spinules. The terminal claw of the male right P5 is longer

CENTROPAGES SINENSIS GROUP



C. sinensis Chen & Zhang, 1965

Characters	*C. sinensis*
Female	
Posterolateral ends of Ms5	asymmetrical short spine on right and rounded process on left side
Genital complex	extremely asymmetrical, bulbous, with denticles on right dorsal surface
Genital opening	not produced
CR	symmetrical with short rami
P5	Re2 with symmetrical long inner extention, reaching 2/3 length of Re3
Male	
Right leg	Re2 with short inner spinal process. Re3 curved out-wards distally with 1 minute and 1 strong Se
Left leg	St of Re2 very long

Figure 4. *Centropages sinensis* group. *C. sinensis* Chen and Zhang, 1965. female. a, whole animal, dorsal view; b, Ms5 and genital complex, lateral view; c, distal segment of 4th leg; d, right 4th leg; e, 5th legs; amel. f, whole animal, dorsal view; g, 5th legs.

than the thumb. In *C. kroyeri* the thumb is longer than the terminal claw.

Distribution.- Indo-West Pacific in warm waters; Gulf of Aden and Red Sea (Giesbrecht, 1892), Indian Ocean (Wolfenden, 1905; Sewell, 1947; Saraswathy, 1967; Brady, 1915), Pacific Ocean (Mori, 1937; Tanaka, 1963; A. Scott, 1909).

***Centropages sinensis* Chen and Zhang, 1965**

Centropages sinensis Chen and Zhang, 1965: 126–127, pl. 26, figs. 1–7; Zhang et al. 1989: 243.

Material examined.- Ten females (1.40–1.42 mm), 10 males (1.25–1.30 mm) collected off Tegal, Central Java by surface tow of 0.33 mm mesh plankton net at night on 3 June 1994.

Female.- Cephalosome robust. Cephalon and Ms1; Ms4 and Ms5 separated. Posterolateral ends of Ms5 asymmetrical, right side pointed, left side rounded. Rostral filaments slender. Urosome, Ur1 asymmetrical, broadest, right side swollen provided with numerous denticles, anal somite shortest. CR asymmetrical, left ramus slightly longer than right. A1 24-segmented, reaching distal end of Ms5 when folded backwards. P2-P4 similar to other species of the genus. P5 asymmetrical, distal 1/3rd of inner spine of Re2 denticulated on both margins, longer than Re1 and Re2 combined, but shorter than Re3.

Male.- Cephalosome similar to female, posterolateral ends of Ms5 small and almost symmetrical. Right A1 geniculate, anterior margin of segment 17 with rows of denticles from proximal to 1/3 from distal end; segment 18 with short row of denticles; distal segment armed with long, spur-like process. P1-P4 of left side longer than right side. Se2 of Re2 of right P4 longer than left; Se3 of right Re3 hook-like and curved outwards, outer marginal denticles of apical spine smaller than those of the left side. P5 asymmetrical, left leg with 2 Re, Re2 longer than Re1; right leg with 3 Re, Re2 broadest with inner spine on ventral margin, apical spine strong and smooth its distal portion curved outwards.

Remarks. So far *C. sinensis* was only known from the China Sea, commonly found in the coastal waters of the Gulf of Hangchow and in the Chou-San Archipelagoes during summer and autumn (Chen and Zhang, 1965), and off Tegal, Java Sea (present records).

***Centropges tenuiremis* Thompson and Scott, 1903**

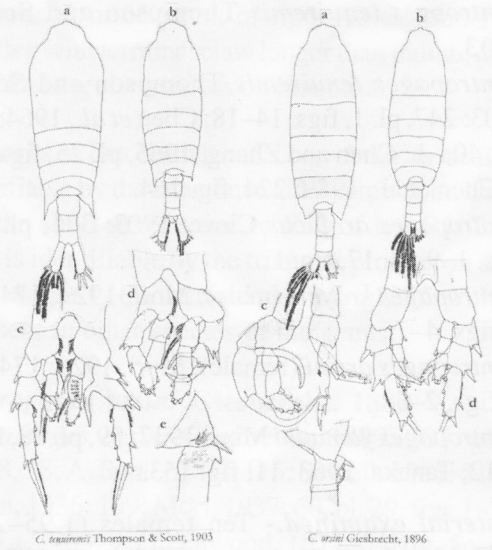
Centropages tenuiremis Thompson and Scott, 1903: 247, pl. 1, figs. 14–18; Chen *et al.*, 1964: 91, fig. 40a–h; Chen and Zhang, 1965, pl. 25, figs. 1–6; Chen et al., 1989: 224, fig. 164.
Centropages arabicus Cleve, 1903: 371, pl. 16, figs. 1–9, pl. 17, fig. 1.
Centropages kroyeri (male), Mori, 1929: 174, pl. 6, figs. 4–7.
Centropages orsini (female), Mori, 1929: 174, pl. 6, figs. 2–3.
Centropages yamadai Mori, 1937: 59, pl. 28, figs. 7–12; Tanaka, 1963: 11, fig. 153a–c.

Material examined.- Ten females (1.95–2.00 mm), 10 males (1.75–1.80 mm) collected off Tegal, Central Java by surface tow of 0.33 mm mesh plankton net at night on 3 June 1994.

Female.- Cephalon rather protruded. Posterolateral ends of Ms5 produced into symmetrical, long, spinal process. Urosome, Ur1 asymmetrical, left side with 2 swelling, separated by constriction, ventral surface with 1 hook-like process; Ur3 very short; CR 3 times as long as wide, outermost seta short and pointed, the outer 4 setae thickened proximally. A1 24-segmented, reaching distal end of CR by the last 2 segments when folded backwards. P1-P4 as in the genus. P5 asymmetrical, right leg with 2 Re and 3 Ri segments, inner margin of fused segments Re1-Re2 with 1 stout spinal process, extending backwards, and bearing fine teeth. Ri2 with hairs on posterior surface. Left leg with 3 Re and 3 Ri segments, inner spinal process on Re2 naked and shorter than the segment, posterior surface of Ri2 naked.

Male.- Posterolateral ends of Ms5 produced into short spinal processs. Urosome symmetrical, CR as in female. Right A1 geniculate, anterior margin of segment 18 with denticulated ridge. P1–P3 as in female. P4, right Re2 longer than the left one, Se3 of Re3 symmetrical. P5, right leg, Re 3-segmented, a spinal process stretching from middle part of inner margin of Re2 to form a chela with Re3, "thumb" of chela shorter than terminal claw (Re3).

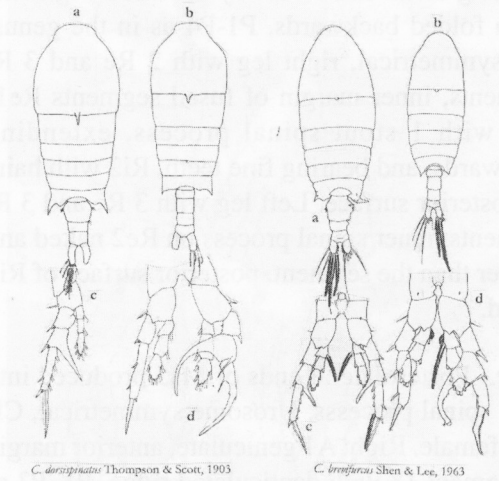
CENTROPAGES TENUIREMIS GROUP



Characters	*C. tenuiremis*
Female	
Posterolateral ends of Ms5	symmetrical spinal process
Genital complex	asymmetrical with 2 swelling on left side
Genital opening	with spiniform operculum
CR	symmetrical with long rami
P5	Re with asymmetrical short inner extention
Male	
P5	
Right leg	Inner spinal process of Re2 strectching from middle part, shorter than Re3. Re3 with 1 Si and 2 Se
Left leg	St very short

Figure 5. *Centropages tenuiremis* group. *C. tenuiremis* Thompson and Scott, 1903. female. a, whole animal, dorsal view; c, 5th legs; e, Ms5 and genital complex, lateral view; male. b, whole animal, dorsal view; d, 5th legs. *C. orsini* Giesbrecht, 1896. female. a, whole animal, dorsal view; c, 5th legs; e, Ms5 and genital complex, lateral view; male. b, whole animal, dorsal view; d, 5th legs.

CENTROPAGES TRISPINOSUS GROUP



Characters	*C. trispinosus*
Female	
Posterolateral ends of Ms5	asymmetrical with 3 pointed processes
Genital complex	asymmetrical, bulbous
Genital opening	not produced
CR	symmetrical with short rami
P5	Re2 with symmetrical short inner extention
Male	
P5	
Right leg	expansion of Re2 with recurved tip. Re3 S-shaped
Left leg	St of Re2 long

Figure 6. *Centropages trispinosus* group. *C. dorsispinatus* Thompson and Scott, 1903. female. a, whole animal, dorsal view; c, 5th leg; male. b, whole animal, dorsal view; d, 5th legs. *C. brevifurcus* Shen and Lee, 1963. female. a, whole animal, dorsal view; c, 5th legs; male. b, whole animal, dorsal view; d, 5th legs.

Remarks.- *C. tenuiremis* is an estuarine and coastal species, occurring in large numbers in epipelagic neritic waters of the Java Sea during the dry season, but it is rare in eastern Indonesian waters. This species described for the first time from Ceylon Pearl Banks (Thompson and Scott, 1903), China Sea (Chen *et al.*, 1964; Chen and Zhang, 1965; Zhang *et al.*, 1989), Korea (Kim, 1985), and warm waters of Japan (Mori, 1929; Tanaka, 1963).

GENERAL REMARKS

The genus *Centropages* Kroyer, 1848 consists of surface living forms, almost all of which are widely distributed in warm waters. Some of the species (*C. furcatus, C. sinensis*) are primarily neritic, while others (*C. calaninus, C. gracilis*) are oceanic.

Table 1. *Centropages* species-groups in Indonesian waters

Characters	*calaninus* (*gracilis*)	*furcatus* (no member)	*sinensis* (no member)	*tenuiremis* (*orsini*)	*trispinosus* (*brevifurcus*)
Female					
Posterolateral ends of Ms5	symmetrical rounded process	symmetrical long spinal process with accessory inner process	asymmetrical short spine on right and rounded process on left side	symmetrical long spinal process	asymmetrical with 3 pointed processes
Genital complex	symmetrical, bulbous	symmetrical,	extremely asymmetrical, bulbous, with denticles on right dorsal surface	asymmetrical with 2 swelling on left side	asymmetrical, bulbous
Genital opening	not produced	not produced	not produced	with spiniform operculum	not produced
CR	asymmetrical, right ramus longer and thicker	symmetrical with long rami	symmetrical with short rami	symmetrical with long rami	symmetrical with short rami
P5	Re2 with symmetrical long inner extention, reaching beyond distal end of Re3	Re2 with symmetrical long inner extention, reaching mid-dle length of Re3	Re2 with symmetrical long inner extention, reaching 2/3 length of Re3	Re with asymmetrical short inner extention	Re2 with symmetrical short inner extention
Male					
P5					
Right leg	Re2 with short inner spinal process, shorter than Re3. Re3 sharply bent inwards.	Re2 with long inner spinal process as long as Re3. Re3 with 2 Se and 1 Si	Re2 with short inner spinal process. Re3 curved outwards distally with 1 minute and 1 strong Se	Inner spinal process of Re2 strectching from middle part, shorter than Re3. Re3 with 1 Si and 2 Se	expansion of Re2 with recurved tip. Re3 S-shaped
Left leg	apex rounded with 2 unequal middle long processes	apex with 2 spinal processes	St of Re2 very long	St very short	St of Re2 long

All the species previously recorded from the area have been found in the present study. Besides four species, i.e., *C. brevifurcus*, *C. dorsispinatus*, *C. sinensis*, and *C. tenuiremis* have been newly recorded from Indonesian waters. *Centropages furcatus* and *C. orsini* occurring almost on all locations (Table 2). *C. furcatus* is known as a circumglobal species, commonly found in the Indian and Pacific Oceans, and extending into the tropical Atlantic Ocean, off Brazil. It was also found to be common in Indonesian waters and always co-occurred with *C. orsini*. *C. orsini* is apparently restricted to the Indian and Pacific Oceans.

Centropages calaninus and *C. gracilis* are frequent in oceanic waters of the Indo-Pacific, but are restricted in eastern Indonesian waters to limited numbers, whereas *C. brevifurcus* and *C. sinensis* appear to be neritic and endemic to the China Seas before this study. *C. sinensis* was only recorded inside the estuarine off Tegal, Central Java. *C. brevifurcus* known exclusively from Chinese estuaries and the Gulf of Thailand (Ohtsuka *et al*, 2003), and extend to Berau, East Kalimantan (St. 7), and Java Sea (Sts. 5 and 6). The species belongs to the *C. trispinosus* Sewell, 1914 group, which is restricted to the tropical Indo-Malayan region.

C. dorsispinatus considered to be endemic species to the Indian Ocean is also distributed along the Chinese coast of Yellow Sea, Kwangtung Bay and Anma Island, Korea in summer (Kim, 1985), Port Dickson, Malaysia (unpublished data), and Berau, East Kalimantan (new records).

Grouping of the Indonesian *Centropages*

The species of *Centropages* comprise somewhat heterogenous assemblage. So far no review of the group based on the study of all known species from the world has been made, and very little attempt has been made to separate groups of related species. It will be shown that there are several different groups of species with a number of important features in common, which tend to constitute morphologically and also zoogeographically distinct groups. In the genus *Centropages*, species and species-group can be distinguished by the structure of the last metasomal somite, the genital somite, caudal rami, and the fifth legs of both sexes.

Vervoort (1964) provisionally divided species of *Centropages* into five species groups: the *typicus, furcatus, hamatus, orsinii*, and *violaceus* species groups. Some new species have been added since then, and synonymies have been mostly clarified by Vervoort (1964), Razouls (1982), and McKinnon and Kimmerer (1988). Some of Vervoort's (1964) species groups are evidently heterogenous. *C. brevifurcus* was not included in any of Vervoort's (1964) groups, possibly because

Table 2. Species list of the genus *Centropages* recorded in the present study, their sampling sites and their previous records in indonesian waters, neigbouring areas and the major oceans. • = present records, ○ = previous records, nr = new records, A = Indonesian waters, B = Australian waters, C = China Seas, D = Japanese waters, I = Indian Ocean, P = Pacific Ocean, At = Atlantic Ocean.

Species	Sites											Indo-Australian				Oceans		
	1	2	3	4	5	6	7	8	9	10	11	A	B	C	D	I	P	At
C. brevifurcus					•	•	•					nr		○				
C. calaninus								•	•	•		○	○	○		○	○	
C. dorsispinatus							•					nr		○		○		
C. furcatus	•	•	•	•	•	•	•		•	•	•	○	○	○	○	○	○	○
C. gracilis								•		•		○	○	○	○	○	○	
C. orsini	•	•	•	•	•	•	•		•	•	•	○	○	○	○	○	○	
C. sinensis					•							nr		○				
C. tenuiremis								•		•		nr		○		○	○	

Notes: 1.Sempu Island; 2.Cilacap Bay; 3. Labuan, Sunda Strait; 4. Jakarta Bay; 5. Off Tegal, Central Java; 6. Off Surabaya, East Java; 7. Berau Bay, East Kalimantan; 8. Ombai Strait; 9. Ambon Bay; 10. Bitung, North Sulawesi, 11. Waigeo Island, Raja Ampat, Papua

Table 3. Sampling sites, dates and number of samples in Indonesian coastal waters.

No.	Sites	Position	Date	Depth of hauls	Number of samples
1.	Sempu Island	08º26'S 112º42'E	24-30 June 2006	20 m	30
2.	Cilacap Bay	07º44'S 109º00'E	20-22 March 2006	15 m	30
3.	Off Labuan	06º22'S 105º50'E	15-18 April 1998	15 m	30
4.	Jakarta Bay	06º00'S 106º48'E	4-8 June 2000	25 m	30
5.	Off Tegal	06º52'S 109º08'E	23-24 March 2006	10 m	30
6.	Off Surabaya	07º 10'S 112º42"E	14-16 June 1998	10 m	30
7.	Berau Bay	00º20'S 117º30'E	22-25 Sept. 2005	10 m	30
8.	Ombai Strait	08º24'S 125º01'E	29 Jun-3 July 2005	100 m	30
9.	Ambon Bay	03º40'S 128º10'E	14-17 May 1999	25 m	30
10.	Bitung Bay	01º23'N 125º01'E	18-31 March 2003	25 m	30
11.	Waigeo Island	00º15'S 130º48'E	27-30 June 2007	15 m	30

Table 4. Key to the species of *Centropages* in Indonesian waters

Sexes	Characters	Species
Female	**A. Posterolateral ends of Ms5 pointed**	
	1. Ms5 and anterior margin of segment 2 and 5 of A1 with accesssory	
	a. Ms5 with inner spine, cephalon naked	*C. furcatus*
	b. Ms5 with inner process, cephalon with dorsal spine	*C. dorsispinatus*
	2. Ms5 and anterior margin of A1 naked	
	a. Process of Re2 of P5 extending beyond distal end of Re3	*C. elongatus*
	b. Process of Re2 of P5 short	
	b.1. Ur1 with ventral spine-like process	*C. tenuiremis*
	b.2. Ur1 naked	
	b.2.1. Ms5 and Ur1 symmetrical	*C. orsini*
	b.2.2. Ms5 and Ur1 asymmetrical	
	- Ur1 and inner side of Ri1 of P5 with process	*C. brevifurcus*
	- Ur1 and inner side of Ri1 of P5 naked	*C. sinensis*
	B. Posterolateral ends of Ms5 rounded	
	1. Ur1 with lateral spinules, CR symmetrical	*C. gracilis*
	2. Ur1 naked, CR asymmetrical	*C. calaninus*
Male	**A. Posterolateral ends of Ms5 pointed**	
	1. Ms5 with accessory spines on inner side	*C. furcatus*
	2. Ms5 without accessory	
	2.1. Se of Re2 of P4 asymmetrical, right side longer	*C. tenuiremis*
	2.2. Se of Re2 of P4 symmetrical	
	- 3rd Se of Re3 of right P5 longer than thumb	*C. orsini*
	- 3rd Se of Re3 of right P5 shorter than thumb	*C. brevifurcus*
	- 3rd Se of P4 asymmetrical, right side hook-like	*C. sinensis*
	B. Posterolateral ends of M5 rounded	
	1. Se of Re3 of right P5 sharply bent	*C. calaninus*
	2. Se of Re of P5 smoothly curved	
	2.1. That part with an inner triangular process	*C. gracilis*
	2.2. That part naked	*C. elongatus*

he might have been unaware of the original description by Shen and Lee (1963).

A distinct species group comprised of *C. brevifurcus* and *C. trispinosus* may be defined as follows: posterolateral ends of Ms5 of both sexes bearing 3 pairs of pointed processes; P5 of both sexes with expansion at inner distal corner of Ri1; female prosome asymmetrical posteriorly, each side with 3 acute processes increasing posteriorly in size; female genital complex bulbous; female P5 with relatively short inner extention on Re2; male urosome 4-segmented; male right P5 bearing Re with recurved tip on expansion of 2nd segment and with S-shaped 3rd segment; male left P5 with distal exopodal segment bearing 2 leateral and 2 terminal short spines. In addition, asymmetry in the outer distal spines on the Re3 of male P4 may be shared between these species. This species group is restricted to the tropical Indo-Malayan region. Although Vervoort (1964) assigned *C. trispinosus* to his *hamatus* group, this latter species group should be revised on the basis of morphology and zoogeography.

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