

**STUDIES ON THE MORPHO TAXONOMIC VARIATIONS
OF FOUR CENTROPAGIDAE SPECIES (CRUSTACEA:
CALANOIDA) WITH NOTE ON THEIR ABUNDANCE
COLLECTED FROM SONMIANI BAY,
NORTHERN ARABIAN SEA**

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ABSTRACT: Centropagidae is comparatively a larger family to other families of order calanoida. The quantitative data revealed that the copepods of the genus *Centropages* are the dominant component in the zooplankton samples from the designated station in Sonmiani bay, a coastal lagoon at Balochistan coast, northern Arabian sea. Four epipelagic species of family Centropagidae, *Centropages* (*Centropages dorsispinatus* Thompson I.C. & Scott A., 1903, *Centropages tenuiremis* Thompson I.C. & Scott A., 1903, *Centropages furcatus* (Dana, 1849) and *Centropages orsinii* Giesbrecht, 1889) were identified. Male and female specimens were distinguished on their characteristic features of antennules, thoracic segments and fifth legs. Identified specimens were described briefly with their microscopic illustrations. *Centropages dorsispinatus* and *Centropages tenuiremis* were frequently found in zooplankton samples throughout the sampling season.

KEYWORDS: epipelagic copepods, Centropagidae, morphotaxonomy, relative abundance, Sonmiani bay

INTRODUCTION

Centropagidae calanoids are an important component of zooplankton community with wide temporal and spatial distribution (Carlotti and Harris, 2007; Calbet *et al.*, 2007). They feed on variety of organisms including diatoms, dinoflagellates, ciliates, appendicularia and sometimes planktonic larvae due to their flexible swimming capacity (Calbet *et al.*, 2007; Gaudy and Thibault-Botha, 2007; Benedetti *et al.*, 2016).

The Centropagidae is a comparatively larger family to other families of order calanoida. It consists of ~110 species in 13 genera (Bayly, 1992a, Boxshall and Halsey, 2004). The species of the genus *Centropages* are mostly pelagic and found in warm waters (Mulyadi, 2008). Globally, so far 47 species under the genus *Centropages* have been reported (WoRMS, 2023), and six (06) species have been recorded from Pakistan (Kazmi, 2004). Ahmed *et al.*, 1972; Haq and Fazal-ur-Rehman, 1973 and Ali-Khan, 1998 have examined the morphotaxonomic characters of species belonging to the family Centropagidae and their occurrence in coastal waters restricted to Karachi backwaters and off shore. Later on, Muniza and Kazmi, 2021 have described *Centropages furcatus* in the pelagic copepods collected during the northern Arabian sea (NASEER) Cruise I.

There is scarce literature available on the morphotaxonomic studies on copepods from Pakistan, and no published literature is available on the morphotaxonomic data of copepods from Sonmiani bay, Balochistan coast. The present study is based on the description of morphotaxonomic characters of four species; *Centropages dorsispinatus*, *Centropages tenuiremis*, *Centropages furcatus* and *Centropages orsinii* sorted out from zooplankton samples of Sonmian bay along with morphological comparison between them. The quantitative analysis of these species shows relative abundance within the family Centropagidae.

MATERIALS AND METHODS

Sonmiani bay or Miani hor ($25^{\circ} 45'33''16$ N- $66^{\circ}55'16'' 71$ E) a coastal lagoon at Balochistan coast, bordering northern Arabian sea, 95 km away in the west of Karachi. This 60 km long and 7 km wide tortuous bay have largest mangrove strand (42%) of the total mangroves in Balochistan. This mangrove forest provides shelter and food for a variety of marine organisms, including commercially important fish and shellfish. Zooplankton sampling was conducted during the high tide on seasonal intervals (Premonsoon, Southeast monsoon, Post monsoon and Northwest monsoon) in the mangrove areas from April 2018 to January 2020. Hydro-Bios zooplankton nets (500 μ m: L=254cm; D= 61 cm) were towed slowly against the water currents for 10 minutes. These plankton nets were equipped with a Hydro-Bios digital flowmeter fixed on its mouth opening to calculate the volume of water filtered through the net. Concentrated samples were preserved with 5% formalin on boat and kept in labeled plastic jars. Physicochemical parameters of water were taken simultaneously on the boat.

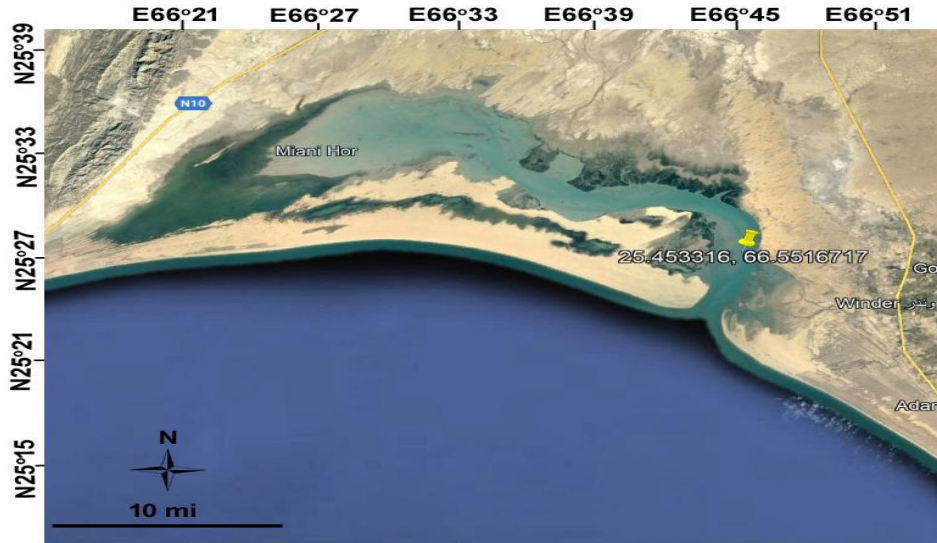


Fig. 1. Map of study area.

In laboratory, samples were split into aliquots (sub samples) through the splitter. The known volume from the aliquots was placed into the counting chamber. Copepods were sorted out from zooplankton samples with the help of a stereo-zoom microscope (Nikon SMZ 10). Number of specimens and percentage of each group also calculated. Copepods were identified to the possible taxon level with the help of published literatures. (Kasturirangan, 1963; Khan, S.A. 1998; Al-Yamani *et al.*, 2011).

RESULTS AND DISCUSSION

Four epipelagic copepods of family Centropagidae: *Centropages dorsispinatus*, *Centropages tenuiremis*, *Centropages furcatus* and *Centropages orsinii* were identified in the copepod samples of Sonmiani bay. Dissected parts were illustrated with the upright microscope (Nikon labophot 2) assorted with a drawing tube (Nikon drawing tube 1.25X). Taxonomic features for copepod identification were based on the body segmentation, antennae, presence/ absence of spine or setae on antennae, thoracic segments and paired swimming legs. Illustrations of all the dissected parts of each specimen were made and their temporary mounts are kept as record for future reference.

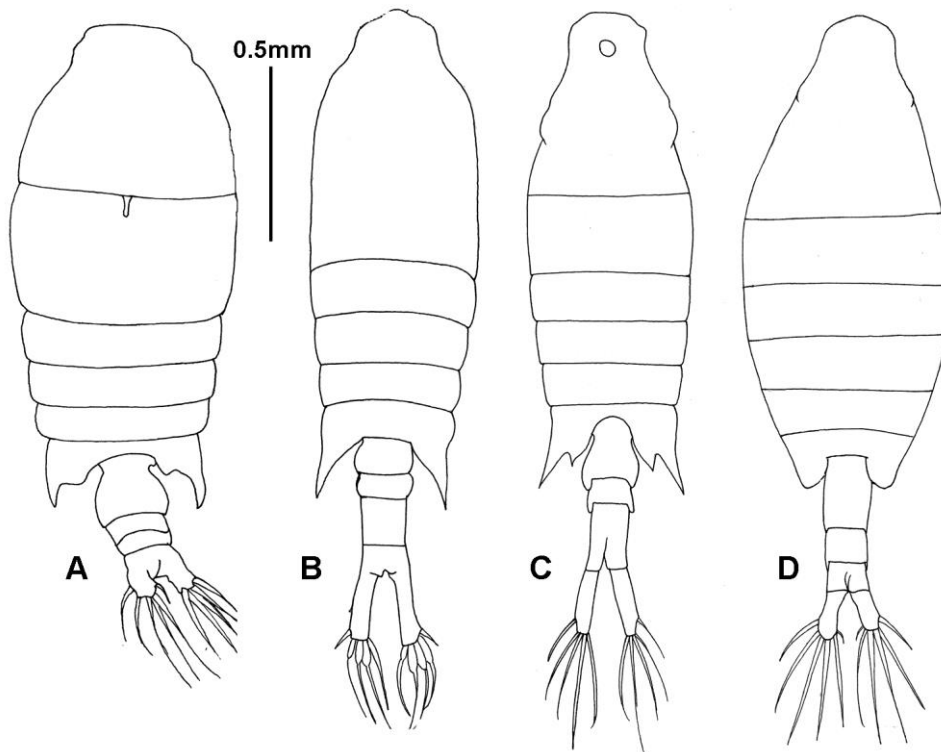


Fig. 2. Habitus of Female: A, *Centropages dorsispinatus*; B, *Centropages tenuiremis*; C, *Centropages furcatus*; D, *Centropages orsinii*.

Systematic account:

Order Calanoida

Family **Centropagidae** (Giesbrecht, 1893)Genus *Centropages* (Kroyer, 1848)**1: *Centropages dorsispinatus*** (Thompson & Scott, 1903). (Fig. 2A, 3A, 4A, 5A, 6A, 7A)

Description:

Size: 1.2mm-1.5mm.

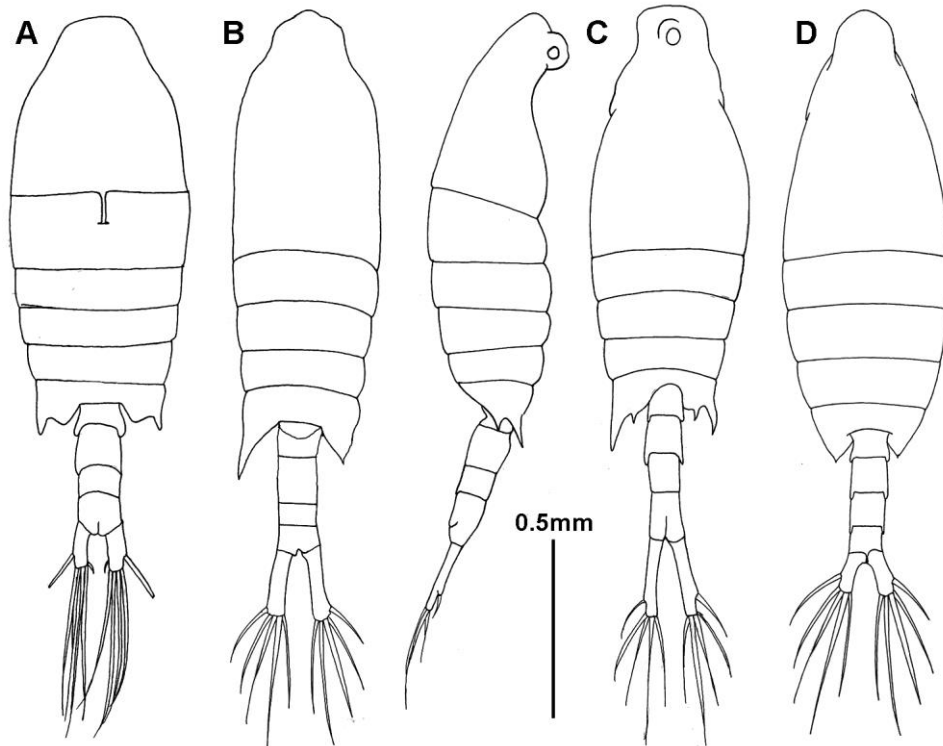


Fig. 3. Habitus of Male: A, *Centropages dorsispinatus*; B, *Centropages tenuiremis*; C, *Centropages furcatus*; D, *Centropages orsinii*.

Body is broad and somehow ovate. Antenna (A1) is with spines on segments 1,2 and 5. A prominent backwardly beaklike spine or hook is present in the mid dorsal line near the posterior margin of the cephalosome. Last thoracic segment is posteriorly drawn out into strong spiniform projections. In female, urosome have 3 segments. 5th swimming leg (P5) is symmetrical. Exopod 2 (Exp2) of 5th swimming leg extends into long plain spine like process with smooth outer edge. In male urosome have 5 segments. 5th swimming leg (P5) is assymetrical. Exopod 2 (Exp2) of P5 is extends into a rounded protrusion on

proximal portion, Exopod 3 (Exp3) claw stout with 1 spine on inner margin and 1 process on outer margin.

Habitat: Epipelagic.

Distribution: Indian Ocean, China seas.

2: *Centropages tenuiremis* (Thompson & Scott, 1903). (Fig. 2B,3B, 4B, 5B, 6B, 7B)

Description:

Size: 1.5mm-1.8mm.

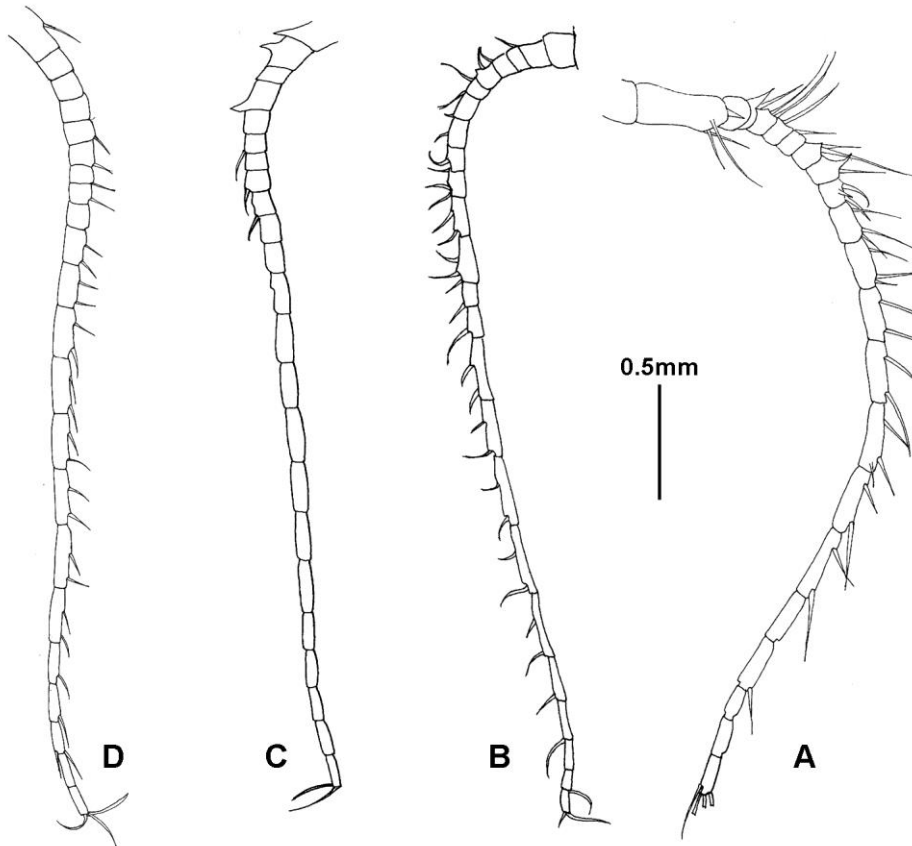


Fig. 4. Antenna (A1) of female: A, *Centropages dorsispinatus*; B, *Centropages tenuiremis*; C, *Centropages furcatus*; D, *Centropages orsinii*.

Body shape is slender. Antenna (A1) is without teeth on anterior margin. In females, last thoracic segment is posteriorly prolonged with symmetrical spines extend beyond distal borders of genital somite. Caudal rami setae are proximally swollen, 5th swimming leg (P5) is asymmetrical. Exopod 2 (Exp2) of right 5th swimming leg is curved into an internal spine with many spinules. The exopod 2 of left 5th leg also have an internal spine but without spinules. In males, grasping antenna (A1) has a spine on the 18th segment. Caudal rami slender. Exopod 2 (Exp2) of right 5th swimming leg (P5) is extends into a

rounded protrusion on proximal portion, with small tubercles along outer edge; Exopod 3 (Exp3) claw stout and with 1 spine on inner margin and 1 pointed process on outer margin.

Table 1. Morphotaxonomic variations among a) *Centropages dorsispinatus* b) *Centropages tenuiremis* c) *Centropages furcatus* d) *Centropages orsinii* found in Sonmiani Bay.

Characters	<i>C. dorsispinatus</i>	<i>C. tenuiremis</i>	<i>C. furcatus</i>	<i>C. orsinii</i>
Size	1.2mm-1.5mm	1.5mm-1.8mm	1.3mm-1.8mm	1.3mm- 1.6mm
Female:				
Antenna I	With spines on segments 1,2 and 5	Without spines on segments 1,2 and 5	With spines on segments 1,2 and 5	Without spines on segments 1,2 and 5
Projections of last thoracic segment	Spiniform projections	Long symmetrical spines	Pointed with an accessory spine on the interior border	Weakly pointed
P5	Symmetrical. Exp2 extends into spine like process with smooth edge	Asymmetrical. Right Exp2 with many spinules. Left Exp2 without spinules	Exp2 inner edge spine does not reach distal border of Exp3, being larger in right side	Asymmetrical on the basis of medial process of left and right Exp2
Male:				
Projections of last thoracic segment	Spiniform projections	Asymmetrical processes, left one larger than the right	Pointed with an accessory spine on the interior border	Triangular and pointed at the apex
Urosome	5 segmented	5 segmented	5 segmented	5 segmented
P5	Asymmetrical. Terminal claw stout with 1 inner marginal spine and 1 outer marginal process	Asymmetrical. Terminal claw stout with 1 inner marginal spinal and 1 outer marginal process	Asymmetrical. Terminal claw stout with 1 inner marginal spine and 2 outer marginal spines. Left Exp2+3 with long terminal fixed appendages	Asymmetrical. Terminal claw is slender. Left Exp2 is shaped into a long spine

Habitat: Epipelagic, Neritic, Estuarine.

Distribution: Indian Ocean, China sea, Black sea.

3: *Centropages furcatus* (Dana, 1849). (Fig. 2C, 3C, 4C, 5C, 6C, 7C)

Description:

Size: 1.3mm-1.8mm,

Body is long and slender, Antenna (A1) has spines on 1,2 and 5 segments anteriorly. This species have a ventral ball like eye on head region, both sexes have pointed prosome an accessory spine on the interior border. In females, Caudal rami relatively slender. Inner edge spine of exopod 2 (Exp2) of 5th swimming leg (P5) does not reach to the distal border of Exp3, being larger in right side. In males, Caudal rami slender. Exopod 2 (Exp2) of right 5th swimming leg (P5) is extends with rounded protrusion on proximal portion; Exopod 3 (Exp3) claw stout and with spine on inner margin and 2 spines on outer margin; Exopod 2+3 (Exp2+3) of left 5th swimming leg is with long terminal fixed appendages.

Habitat: Epipelagic.

Distribution: Indo-West Pacific and Western Central Atlantic.

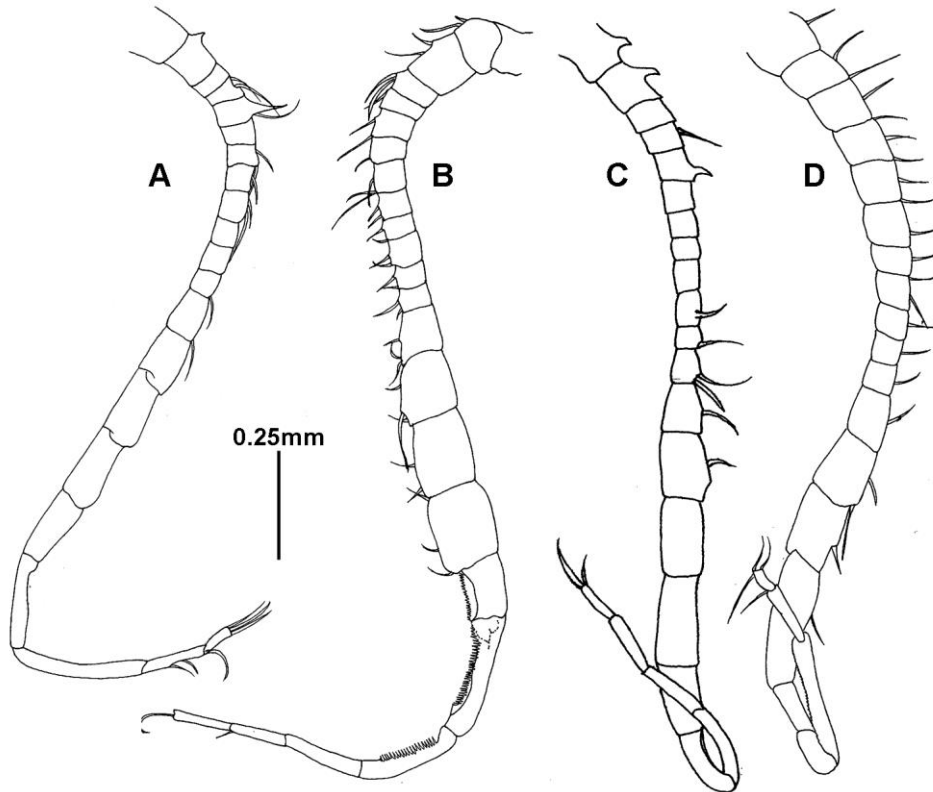


Fig. 5. Antenna (A1) of Male: A, *Centropages dorsispinatus*; B, *Centropages tenuiremis*; C, *Centropages furcatus*; D, *Centropages orsinii*.

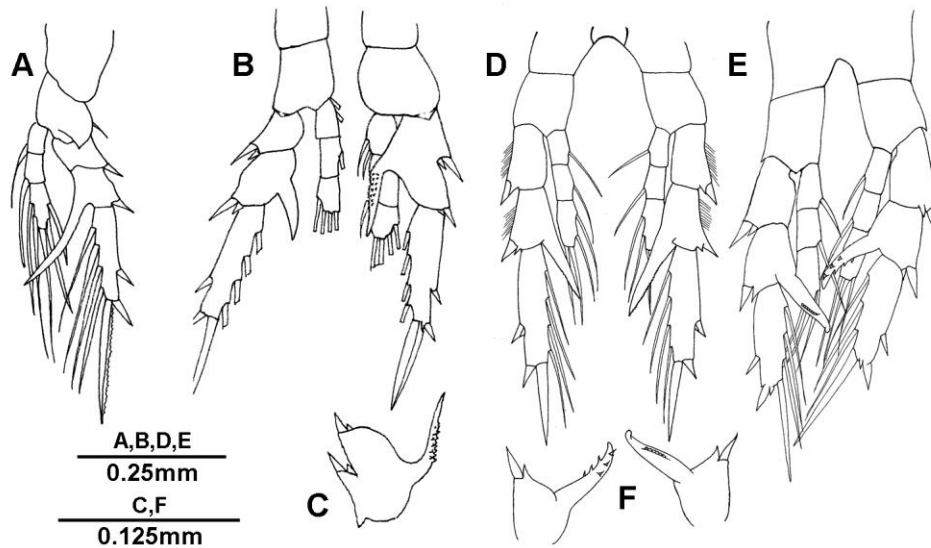


Fig. 6. 5th swimming leg (P5) of Female: A, *Centropages dorsispinatus*; B, *Centropages tenuiremis*; C, Enlarged Exp2 of *Centropages tenuiremis*; D, *Centropages furcatus*; E, *Centropages orsinii*; F, Enlarged Exp2 of *Centropages orsinii*. (Scale bar: A,B,D,E= 0.25 mm; C,F= 0.125 mm).

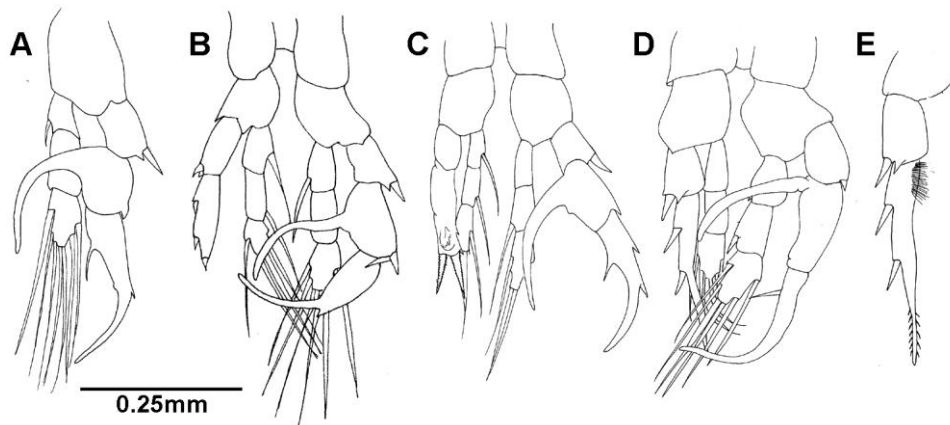


Fig. 7. 5th swimming leg (P5) of Male: A, *Centropages dorsispinatus*; B, *Centropages tenuiremis*; C, *Centropages furcatus*; D, *Centropages orsinii*; E, Left leg of *Centropages orsinii*.

4: *Centropages orsinii* (Giesbrecht, 1889). (Fig. 2D, 3D, 4D, 5D, 6D, 7D)

Description:

Size: 1.3mm- 1.6mm.

Table 2. Relative abundance (%) of *Centropages dorsispinatus*, *Centropages tenuiremis*, *Centropages furcatus*, *Centropages orsinii* with other Copepoda present in the zooplankton samples of Sonmiani Bay.

Seasons	Total number of copepods	Total numbers of family Centropagidae	<i>Centropages dorsispinatus</i>	<i>Centropages tenuiremis</i>	<i>Centropages furcatus</i>	<i>Centropages orsinii</i>	Other copepods
Premonsoon 2018	542	273	272 (50.18%)	01 (0.18%)	00 (0.00%)	00 (0.00%)	269 (49.63%)
Southwest monsoon 2018	1031	72	60 (5.81%)	11 (1.06%)	01 (0.09%)	00 (0.00%)	959 (93.01%)
Post monsoon 2018	698	12	12 (1.71%)	00 (0.00%)	00 (0.00%)	00 (0.00%)	686 (98.28%)
Northeast monsoon 2019	494	53	03 (0.60%)	36 (7.28%)	08 (1.61%)	06 (1.21%)	441 (88.46%)
Premonsoon 2019	1522	84	05 (0.32%)	79 (5.19%)	00 (0.00%)	00 (0.00%)	1438 (94.48%)
Southwest monsoon 2019	1770	53	09 (0.50%)	43 (2.42%)	01 (0.05%)	00 (0.00%)	1717 (97.00%)
Post monsoon 2019	8800	119	107 (1.21%)	12 (0.13%)	00 (0.00%)	00 (0.00%)	8681 (98.64%)
Northeast monsoon 2020	4900	53	50 (1.02%)	01 (0.02%)	01 (0.02%)	01 (0.02%)	4847 (98.93%)
Total	19,757	719	518	183	11	07	19038

Body shape is long and slender. Antenna (A1) is without spines on segments 1, 2, and 5. In females, Posterior border of prosome weakly pointed. 5th swimming leg (P5) is asymmetrical on the basis of Exopod 2 (Exp2) of left and right medial process. In male, lateral corner of the thoracic segment is triangular and pointed at the apex. Terminal claw of right 5th swimming leg (P5) is slender with 1 inner marginal spine and last segment is shaped into a long spine of the left 5th swimming leg (P5).

Habitat: Epipelagic.

Distribution: Indian Ocean.

Table 2. Relative abundance (%) of *Centropages dorsispinatus*, *Centropages tenuiremis*, *Centropages furcatus*, *Centropages orsinii* with other Copepoda present in the zooplankton samples of Sonmiani Bay.

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Total	19,757	719	518	183	11	07	19038

Relative abundance: Total copepods of (19,757) were sorted out from the zooplankton samples of Sonmiani bay during Premonsoon, Southeast monsoon, Post monsoon and Northwest monsoon of April 2018-January 2020. A total number of *Centropages dorsispinatus*(518) , *Centropages tenuiremis*(183), *Centropages furcatus*(11) and *Centropages orsinii*(07) were found. Table (2) shows the relative abundance (%) of *Centropages dorsispinatus* , *Centropages tenuiremis*, *Centropages furcatus*, *Centropages orsinii* with other Copepoda present in the zooplankton samples of Sonmiani bay. *Centropages dorsispinatus* shows the highest relative abundance (50.18%) in the copepod samples of post monsoon season of 2018 while the other copepod species shows the 49.63% and *Centropages tenuiremis* was only (0.18%) of the total copepods of Sonmiani bay. The other copepods were found in highest relative abundance as compared with the species of Centropagidae in other studied seasons. *Centropages tenuiremis* were found highest (7.28%) in Northeast monsoon of 2019 with the absence in post monsoon of 2018. *Centropages furcatus* were only found in southwest monsoon and northeast monsoon with highest relative abundance (1.61%) in northeast monsoon of 2019. *Centropages orsinii* was the lowest abundant specie only found in northeast monsoon season of Sonmiani bay. *Centropages tenuiremis*, *Centropages furcatus* and *Centropages orsinii* were found with lowest relative abundance (0.02%) in Northeast monsoon of 2020 as compared to *Centropages dorsispinatus* (1.02%).

DISCUSSION: The morphotaxonomic descriptions of *Centropages dorsispinatus*, *Centropages tenuiremis*, *Centropages furcatus* and *Centropages orsinii* of Sonmiani bay were found similar with the description and illustrations of Ahmed *et al.*, 1972; Ali Khan, 1998 and Muniza and Kazmi, 2021. The study is likely that specimens of family Centropagidae could be morphologically differentiated with projections of their last thoracic segments. Females of *Centropages dorsispinatus* and *Centropages furcatus* have similarity with the presence of spines on their 1,2 and 5 segments of antenna (A1). *Centropages dorsispinatus* could easily be distinguished by a spine present in the mid dorsal line near the posterior margin of the cephalosome whereas *Centropages furcatus* have ventral ball like eye on head region as its morphotaxonomic identification. Morphotaxonomic variations in 5th swimming leg (P5) could also be a distinguishing character of both male and female specimens of *Centropages dorsispinatus* and *Centropages furcatus*. *Centropages tenuiremis* and *Centropages orsinii* have antenna (A1) without spines on their 1, 2 and 5 segments. Females of both species could be morphologically differentiated with projections of their last thoracic segments and presence/absence of spinules on the 2nd exopod (Exp2) of 5th swimming leg (P5). Morphotaxonomic variations in male specimens of both species could be distinguished through the shape of terminal claw of right 5th swimming leg (P5).

It is further revealed that the copepods of the genus *Centropages* are the dominant component of the zooplankton in the Sonmiani bay. *Centropages dorsispinatus* and *Centropages tenuiremis* were frequently found in zooplankton samples. *Centropages furcatus* was observed in southwest and northeast monsoon. *Centropages orsinii* was reported rarely and only in northeast monsoon in Sonmiani bay. Naz *et al.*, 2012 evaluated relative abundance of copepods collected from mangrove areas of Phitti-Jhari creek, Indus delta along the Karachi coast in which *Centropages dorsispinatus*, *Centropages furcatus* and *Centropages orsinii* were found as dominant species. *Centropages dorsispinatus* were found in all monsoonal seasons of two year studies.

They were observed with highest (100%) relative abundance among Centropagidae family in Postmonsoon season 2018. Ramaiah and Nair, 1997 recorded this species in peak range during monsoon at Bombay Harbour-Thana Creek-Bassein creek from the west coast of India. *Centropages tenuiremis* is a second abundant species in Centropagidae family of Sonmiani bay. It is epipelagic, neritic or estuarine species. The temperature adaptations and flexible food choices under fluctuating coastal ecosystems may be the reason of their widely distribution along the coastal waters (Xu et al., 2020) The wide distribution pattern is quite noticeable in winter-spring seasons of Xiamen Harbor and Daya bay of China (Wang et al., 2005). *Centropages furcatus* is found in abundance in coastal water of subtropical regions (Lavaniegos & Gonzá-lez-Navarro, 1999). In our study case, *C. furcatus* were only collected in southwest monsoon and northeast monsoon of both years with percentage contribution from lowest(1.38%) in southwest monsoon 2018 to highest(15.09%) in northeast monsoon 2018 only. However, the same species were recorded as the abundant species during Oct 02 And Apr 02 samples collected from the port of Mumbai, India (Gaonkar et al., 2009). *Centropages orsinii* is neritic and oceanic epiplanktonic copepod. This species found in a temperature regime of 15 -27°C of Moreton Bay of Australia. Usually *Centropages orsinii* is rare and less abundant specie. Arshad *et al.*, 2013 also observed the rare abundance of *Centropages orsinii* from the coastal waters of Bintulu, Sarawak, Malaysia.

The present study is a humble effort to describe the morphotaxonomic variations of four species and understand the seasonal abundance of family centropagidae which may be influenced by biotic and abiotic characteristics of Sonmiani bay. Despite of a preliminary report, this study could serve as a baseline study for morphology of pelagic copepod of Sonmiani Bay.

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