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Description of marine copepods, *Centropages furcatus*, *Eucalanus monachus* and *Oncaea venusta*, in Mindanao waters, Southern Philippines

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Abstract. Morphological description on some marine pelagic Calanoida, viz. *Centropages furcatus* and *Eucalanus monachus* of the families Centropagidae and Eucalanidae, respectively, and Poecilostomatoida, viz. *Oncaea venusta*, of the family Oncaeida, was made. Taxonomic characters for identification of copepod species were based on the quantitative and qualitative characters. Differences between female and male were based on the antennules, morphology and structure of the fifth legs and the number of segments of the urosome. Female and male were described for each species. The detailed description together with the drawings and measurements are presented.
Key Words: Tropical marine pelagic copepods, Iligan and Sarangani Bays, Southern Philippines.

Introduction. Zooplankters are microscopic invertebrate organisms that are at the mercy of the current of the water and therefore tend to drift in the water. They usually range from one-tenth of a millimeter to four millimeters in size. Most often, these organisms have a herbivorous-detritivorous diet that used their feeding appendages to strain phytoplankton and other fine particles present in the water and hence, exerts a strong grazing impact on the phytoplankton biomass (Pont 1995). In turn, they constitute a source of food for organisms occupying the upper trophic levels such as the planktivorous fish and carnivorous invertebrates (Pinel-Alloul 1995). Because of this notable characteristics, zooplankton is an important intermediate component in food webs, acting as trophic link between small particles (detritus and microalgae) and planktivorous fishes (Morgan 1990; Boltovsky 1999).

Among these zooplankters, copepods are the most dominant and abundant component of the zooplankton community and are even considered to be the insects of the sea (Huys & Boxshall 1991). They have nominal size categories namely, micro- (primarily for eggs and nauplii), meso-and-macro (for copepodites and adults), ranging from 0.02 to 20 mm. Due to a wide variety of their feeding habits, copepods make up a trophic junction where the microbial food chain joins the grazing food chain. Their absolute abundance and trophic position secure a vital role in the marine ecosystem for copepods (Uye 2011). The classic food chain represented by phytoplankton–copepod–fish is certainly the main process leading to efficient and sustainable production of fish as human food (Ryther 1969 cf. Uye 2011). Despite the vital position these minute

creatures occupy in the pelagic food webs, *i.e.* being the major food items of small or young fishes (Robertson et al 1988; Chew et al 2007), shrimps (Chong & Sasekumar 1981), planktivorous fish and even jellyfish (Uye 2011), marine pelagic copepod taxonomy is still unpopular and uncommon in the Philippine Archipelago, with information limited only to the works of Wilson (1950), Walter (1984), Walter et al (2006) and Lacuna et al (2013ab). Hence, the purpose of this work is to offer additional information on other marine planktonic copepod forms as well as its geographical distribution in the waters of Mindanao.

Material and Method. Plankton samples were obtained from the offshore waters of the established stations in Iligan Bay (Figure 1). Iligan Bay is found at the northern part of Mindanao islands. It is separated in the south by Gingoog and Macajalar Bay from the coast of Northern Mindanao, and in north by the Mindanao Sea from Bohol. It is "U" shaped and is approximately 8°30'31" North Latitude, 123°43'15" East Longitude. It has a mouth of approximately 351 mi (560kms) and an area of about 2000 sq. km. (Camarao, 1983). The bay serves as a source of food, fish and other potential food resources such as shells and algae to the fisher folks in the nearby areas and has been identified by the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) as a major fishing ground for various sea products. Sarangani Bay is situated at 6º 07' North latitude and 125º 06' East longitude. The bay encloses an area of 449.22 km² from Tampuan Pt. in Maasim to Sumbang Pt. in Glan and opens into the Mindanao and Celebes Sea. The coastline length of Sarangani Bay from Glan extending to Maasim is about 79 km having an average depth of 350 m. It is recognized as the richest tuna fishing ground in the country and known for its abundant catch of tunas, scads and flying fishes including small fishes (frigate, mackerels, roundscads) and demersal fishes (snappers, breams, groupers and moonfishes) (Portugal 2000). The bay is fringed with mangrove and coral reefs that serves as shelter and refuge for resident and transient adult and juvenile fishes of commercial and recreational importance, invertebrates and various epiflora and epifauna (Portugal 2000). Within the bay, sampling was done by horizontal (towing of net for 5 minutes) and vertical (50m depth) tows and hauls, respectively, using a conical plankton net (length: 1.8 m; mouth diameter: 0.45 m; mesh size opening: 300 mm). All samples collected were preserved with 5% buffered formalin/seawater solution. Taxonomic characters for copepod identification were based on the body segmentation, number of segments, setae and spines on the antennule, antenna, maxilla, maxillipeds and paired legs. For each mounted part, the number of segments and setae were counted and the details of the urosome were noted. The number of spines of the caudal ramus was also recorded (Lacuna et al 2013ab). All copepod samples were identified to species by dissection and examination following the dissection procedures and techniques of Huys and Boxshall (1991). The dissected parts as well as the whole specimen were mounted on separate glass slides using Hoyer's medium as mountant and were examined and measured using a dissecting stereomicroscope. The parts projected from the microprojector were drawn in detailed. Lengths of prosome was taken dorsally starting from the anterior margin of the cephalon to the posterior tip of the last metasomal somite while urosome was made from the anterior margin of the genital somite to the posterior tip of the caudal rami not including the setae.

The specimens were identified using the descriptions and taxonomic keys of Farran (1936), Dakin and Colefax (1940), Wilson (1950), Kasturirangan (1963), Owre and Foyo (1967), Bradford-Grieve (1994, 1999), Mulyadi (2004) and Al-Yamani et al (2011).

Figure 1. Map of Mindanao Island showing the established stations in the two bays. Inset is the map of the Philippines with Mindanao Island enclosed in a square. Legend: ● Iligan Bay, ● Sarangani Bay.

Results and Discussion. Three marine pelagic copepod species, namely *Centopages furcatus*, *Eucalanus monachus* and *Oncaea venusta* under Families Centropagidae, Eucalanidae and Oncaeidae, respectively, were identified. Female and male were described for each species and the detailed description together with the drawings and measurements are presented below.

TAXONOMIC DESCRIPTION

Family CENTROPAGIDAE

Centropages furcatus Dana, 1849
Figures 2-7

Synonym: *Catopia furcata* Dana, 1849

Occurrence: Both sexes were commonly encounterd in the vertical and horizontal waters of Oroquieta, Lopez Jaena and Plaridel, Misamis Occidental in Iligan Bay. Females were quite numerous compared to the males.

Description of adult female and male: Body length: females 1.22 mm, males 1.31 mm. Both sexes have narrow elongate body and light-orange coloration in live specimens. The prosome of both sexes is comprised of a cephalosome and 5 metasomal segments or pedigerous somites (Figures 2a and 2b). Head with a truncate frontal portion. The posterolateral ends of metasome drawn out into strong spiniform projections, with two smaller spines placed dorsally in addition to the two large ones (Kasturirangan 1963). In female, the posterolateral ends of metasome 5 produced symmetrically into long spiniform processes with 1 accessory spine on the inner side (Figure 2a), while it is asymmetrical in male where the left side is more protruding then the right (Figure 2b) (Mulyadi 2004, Bradford-Grieve 1999).

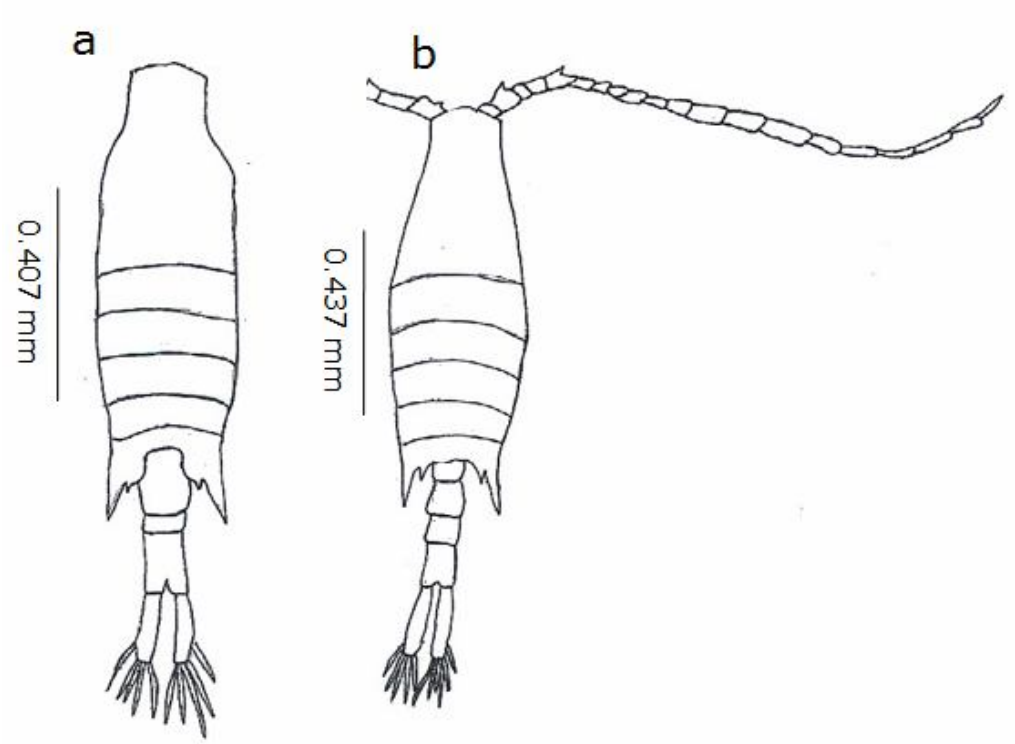

Figure 2. Dorsal view of (a) female and (b) male *C. furcatus* Dana.

The urosome in female (Figure 3a) is 3-segmented, with the genital complex without spines on the ventral surface (Bradford-Grieve 1999, Al-Yamani et al 2011), urosome 2 very short and urosome 3 or anal segment asymmetrical more than twice as long as urosome 2 (Bradford-Grieve 1999, Mulyadi 2004, Al-Yamani et al 2011). In male (Figure 3b), it is 4-segmented with urosome 3 much shorter than the other urosomal segments. The urosome measures 0.322 mm in female and 0.2875 mm in male. The caudal rami are slender for both sexes (Figures 3a and 3b).

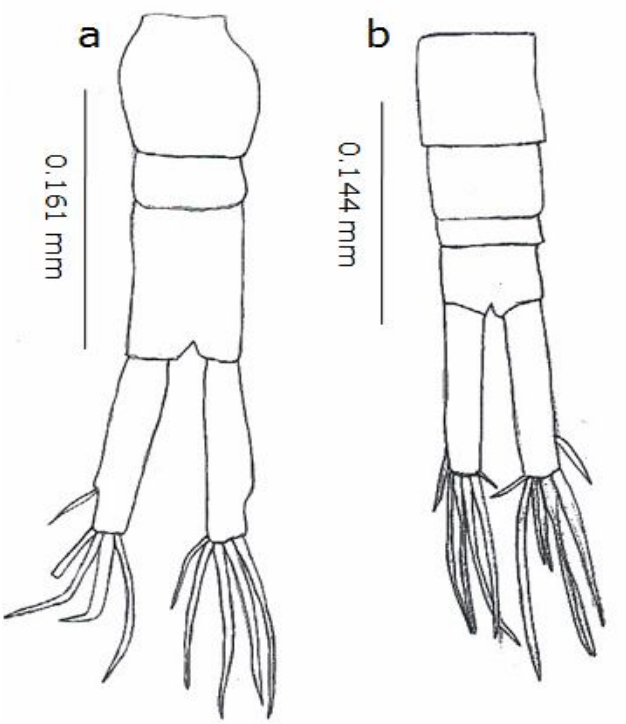

Figure 3. (a) Ventral view of female urosome and (b) dorsal view of male urosome of *C. furcatus* Dana.

The female left antennule is 23-segmented (Figure 4a) and measures 2.108 mm, while the right is 22-segmented (Figure 4b) and measures 1.5755 mm. Both antennules are symmetrical with the presence of spine on the anterior margin of segments 1,2 and 5 (Figures 4a and 4b as indicated by the red arrows). The male antennules are asymmetrical with the left antennule being 22-segmented (Figure 5a) and measures 1.4375 mm, while the right is 21-segmented (Figure 5b) and meaures 1.3685 mm. Geniculation occurs at the right antennule of segments 18 and 19 (Figure 5b).

Swimming legs 1 to 4 of both sexes (Figures 6 a-d and 7 a-d) are biramous with all of the legs having 3-segmented exopodites endopodites (Kasturirangan 1963). The swimming leg 5 of the female, which is also biramous and similar to legs 1 to 4, possess a prominent inwardly pointed spine on the middle of exopod segment (Figure 6e, red arrows pointed to the spines) (Kasturirangan 1963). For the male swimming leg 5, it is likewise biramous with the left leg having a 2-segmented exopod and 3-segmented endopod, while the right leg posseses 3-segmented exopod and endopod (Figure 7e). Asymmetrical was apparent on the right leg with an extension seen on exopod segment 2 having rounded protrusion on the proximal portion, while the claw-like structure in exopod segment 3 is stout with a spine on inner margin and 2 spines on outer margin (Bradford-Grieve 1999, Al-Yamani et al 2011). The left leg exopod segments 2 have spinal process at the apex and 2 spines near the distal end (Mulyadi 2004).

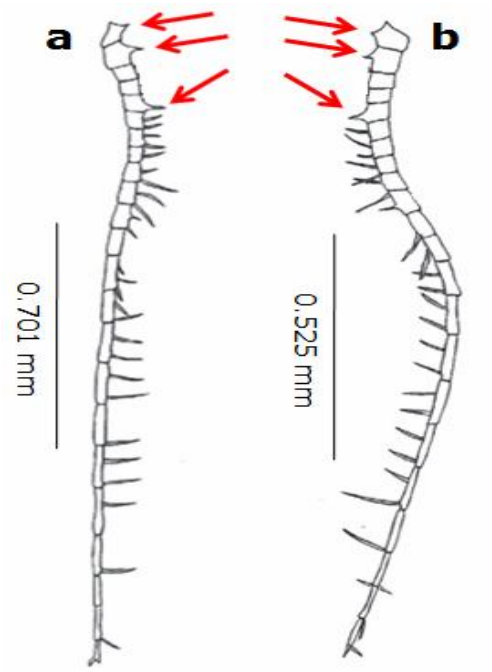

Figure 4. (a) left and (b) right antennule of female *C. furcatus* Dana. Red arrows indicate presence of spine on segments 1, 2 and 5.

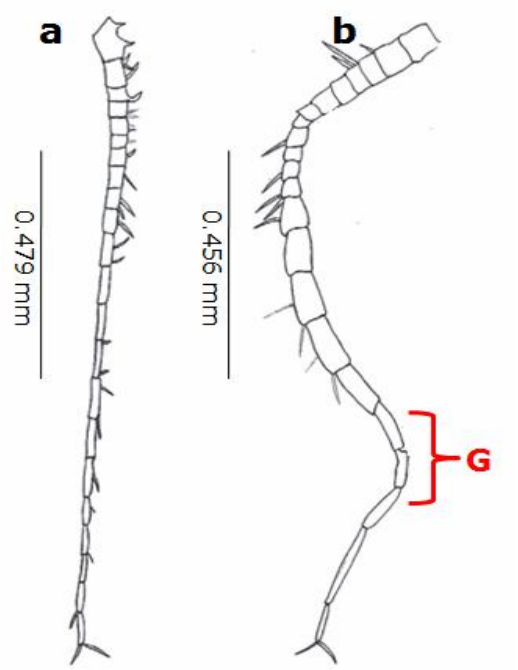

Figure 5. (a) left and (b) right antennule of male *C. furcatus* Dana. G: geniculation

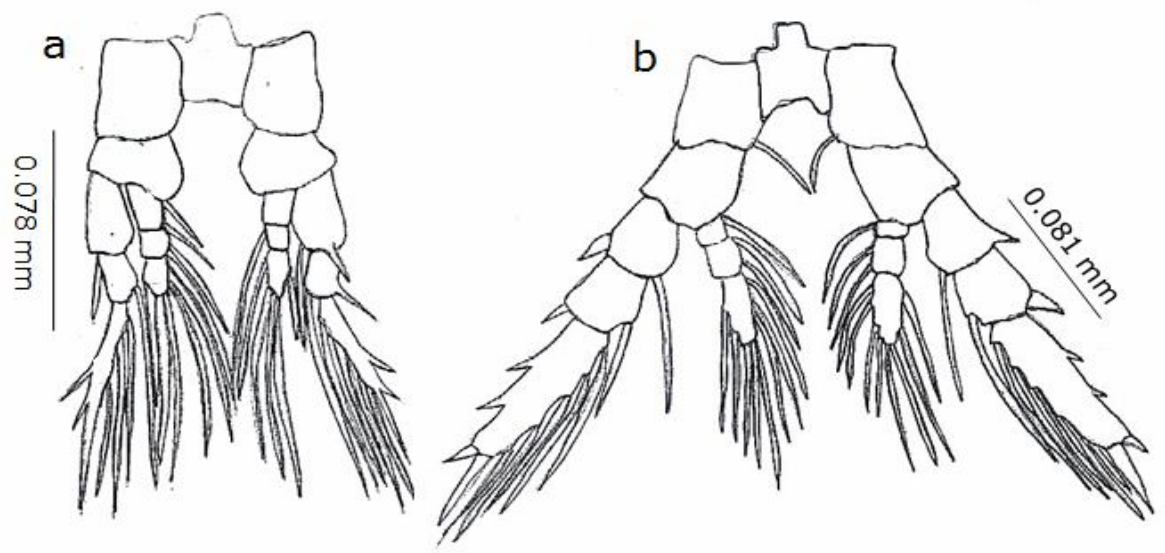

Figure 6. Female swimming (a) leg 1, (b) leg 2, (c) leg 3, (d) leg 4, and (e) leg 5 of *C. furcatus* Dana. Red arrow indicate pointed spine on middle exopod segment.

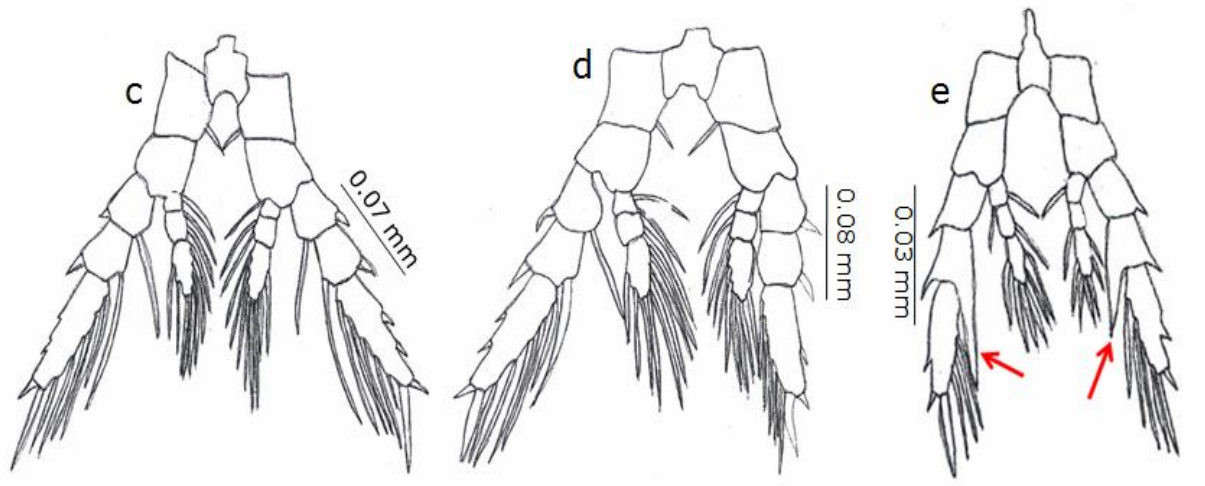

Figure 6. Female swimming (a) leg 1, (b) leg 2, (c) leg 3, (d) leg 4, and (e) leg 5 of *C. furcatus* Dana. Red arrow indicate pointed spine on middle exopod segment.

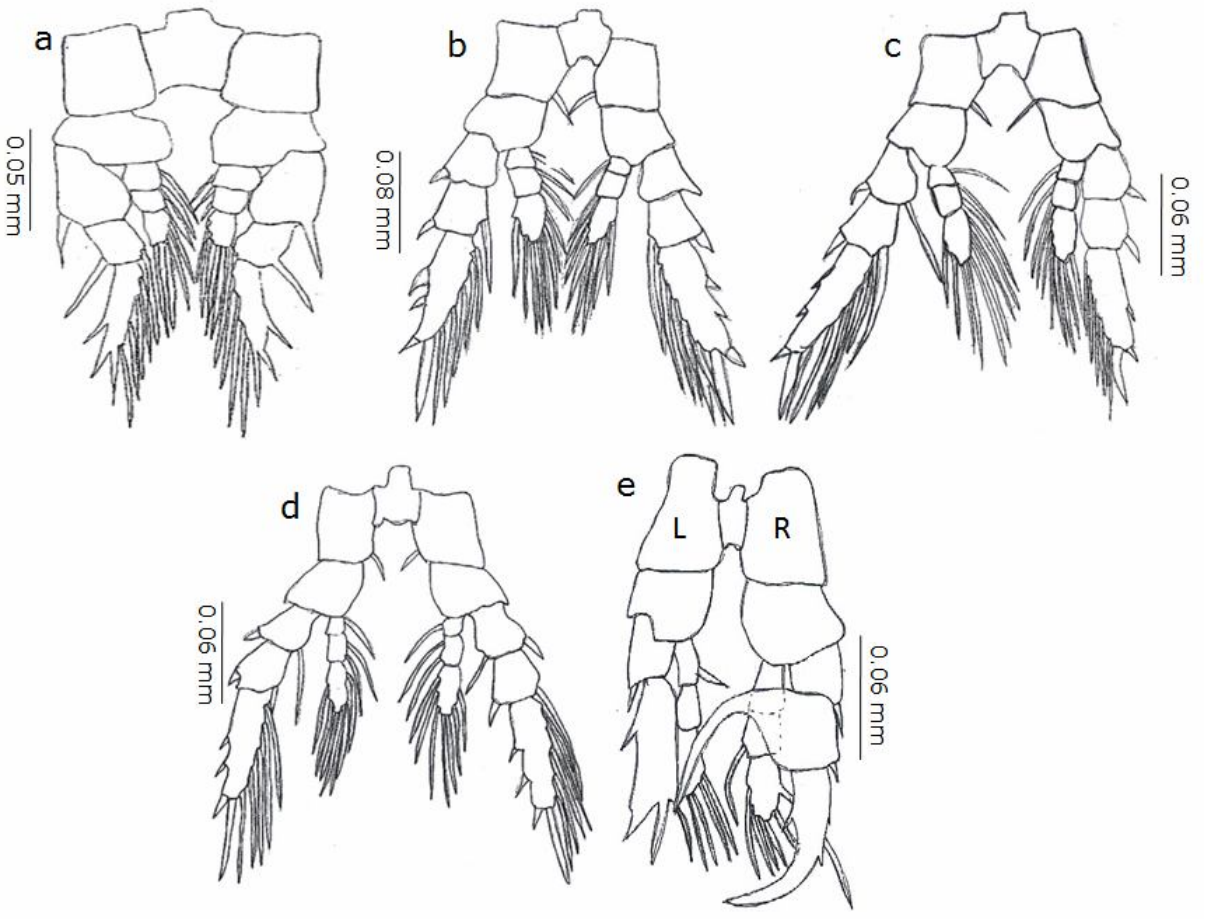

Figure 7. Male swimming (a) leg 1, (b) leg 2, (c) leg 3, and (d) leg 5 of *C. furcatus* Dana. L Left leg, R Right leg.

Present descriptions are similar with those described and figured by Giesbrecht (1892), Mori (1937), Kasturirangan (1963), Bradford-Grieve (1999), Mulyadi (2004), Phukham (2008) and Al-Yamani et al (2011).

Remarks: Wilson (1950) also reported this species in the following Philippine Islands: West Coast of Luzon, Ragay Gulf in Luzon, off Southern Luzon, Marinduque to Luzon, between Burias and Luzon, off Santa Cruz, off Eastern Mindoro, Mindoro Strait, South of Romblon, off Romblon, Palawan Passage, Malampaya Sound in Palawan, Eastern Palawan, Sabtan Island, Iloilo Straits, between Panay and Negros, East Coast of Negros, between Cebu and Bohol, off Northern Cebu, between Bohol and Leyte, off Western Samar, Jolo and Sulu Seas, near Basilan Island, Tawi-Tawi Group, Sulu Archipelago and Verde Island Passage.

Pacific Ocean Records: Mori (1937), Tanaka (1963), Chen and Zhang (1965), Mulyadi (2004), Phukham (2008).

Eucalanus monachus Giesbrecht, 1888
Figures 8-13

Synonym: *Eucalanus vadicola* F. Dahl, 1894; non *E. monachus* Dakin & Colefax, 1940

Occurrence: Both sexes were frequently encountered in Aloran, Lopez Jaena and Plaridel, Misamis Occidental for both horizontal and vertical waters. Female species were numerous in the plankton samples.

Description of adult female and male: Body length: females 5.88 mm, males 4.00 mm. Head end triangular for both sexes and body elongate (Kasturirangan 1963, Dakin and Colefax 1940). The prosome comprises of a cephalosome and metasome that have 3 thoracic somites for both female (Figure 8a) and male (Figure 8b). The cephalon is longer than the metasome with the posterior margin of the prosome being rounded (Kasturirangan 1963).

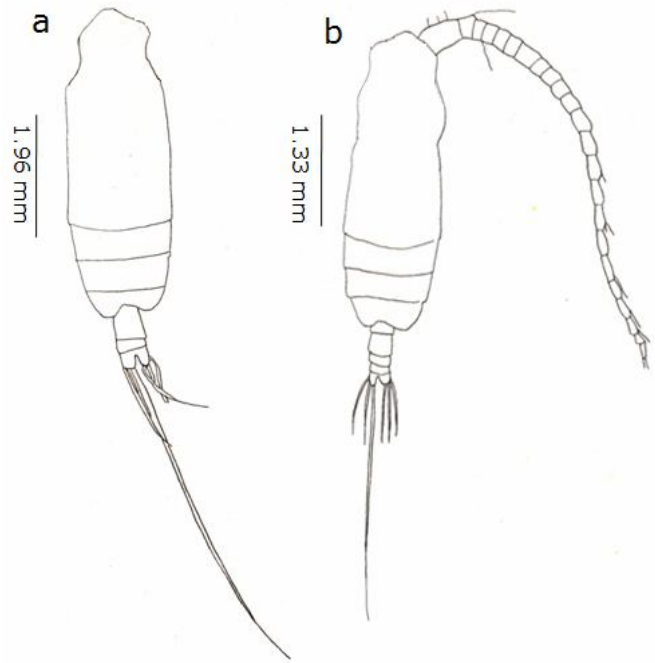

Figure 8. Dorsal view of (a) female and (b) male *E. monachus* Giesbrecht.

The female urosome is 3-segmented (Figure 9a), with the genital segment only a little broader than long and measures 0.33 mm. In male (Figure 9b), the urosome is 5-segmented and measures 0.465 mm. For both sexes, the caudal rami are fused to the anal segment being more conspicuous in the female. An enlarged and longer caudal seta is present on the left side of the caudal ramus (Kasturirangan 1963).

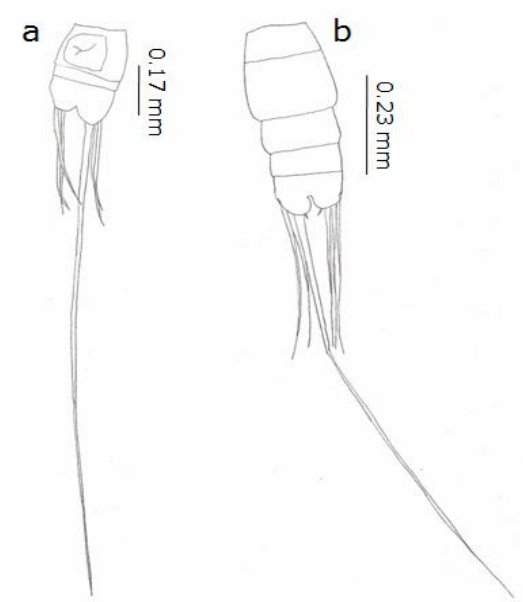

Figure 9. Ventral view of (a) female urosome and dorsal view of (b) male urosome *E. monachus* Giesbrecht.

Antennules of both sexes is 23-segmented and uniramous reaching beyond the caudal ramus (Figures 10 a-d). In female (Figure 10 a,b), the left antennule measures 3.270 mm while the right measures 3.015 mm. For the male (Figure 10 c,d), no geniculation was observed with the left and right antennules measuring 3.33 mm and 3.44 mm, respectively.

Swimming legs 1 to 4 of both sexes are biramous (Figures 12 a-d and 13 a-d) with legs 2 to 4 having 3-segmented exopodites and endopodites but leg 1 with 3-segmented exopodites and 2-segmented endopodites (Kasturirangan 1963). Outer margin of legs 1 to 4 bear a small tooth in both sexes being more apparent in males' leg 3 as indicated by a red arrow (Figure 13c). The swimming leg 5 for male is uniramous with the left leg being present only (Figure 13 e). Swimming leg 5 in female is absent.

The present records are similar with those described and figured by Kasturirangan (1963) and Dakin and Colefax (1940).

Remarks: Wilson (1950) also reported this species in the following Philippine Islands: South of Romblon, off Eastern Mindoro, Palawan Passage, Malampaya Sound in Palawan, between Samar and Masbate, Siquijor and Bohol, between Bohol and Leyte, Dupon Bay in Leyte, between Panay and Negros, Iloilo Straits, between Leyte and Mindanao, off Northern Mindanao, Jolo Sea, Sulu Sea off Mindanao

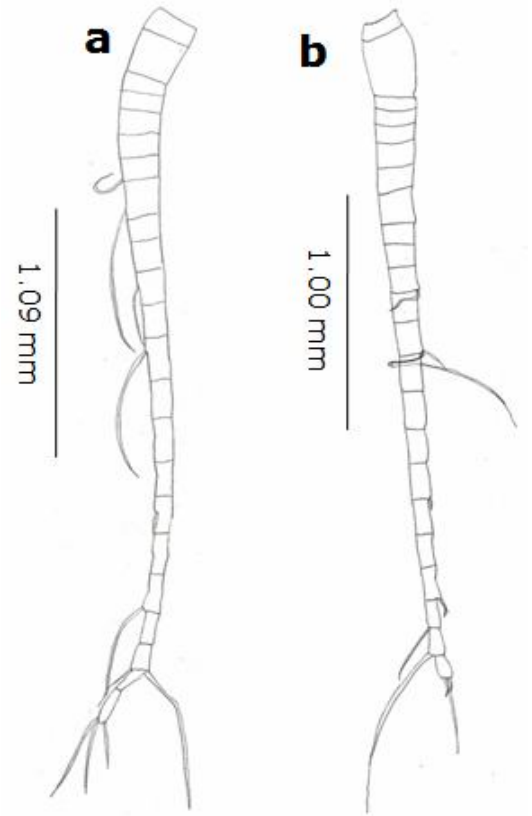

Figure 10. Female (a) right and (b) left antennules of *E. monachus* Giesbrecht.

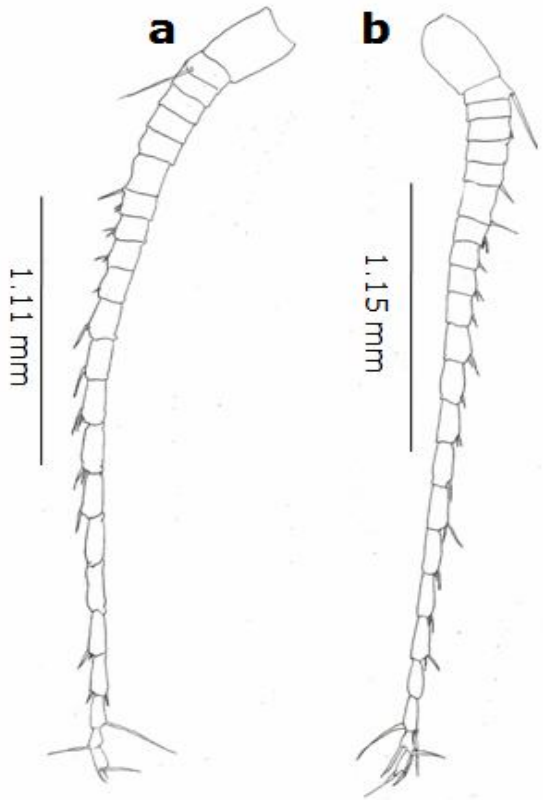

Figure 11. Male (a) left and (b) right antennules of *E. monachus* Giesbrecht.

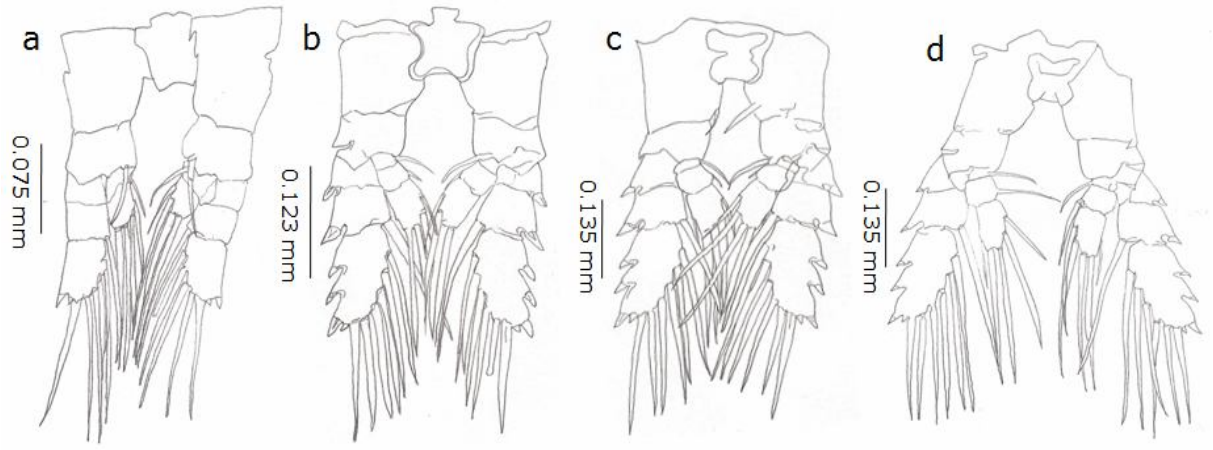

Figure 12. Female swimming (a) leg 1, (b) leg 2, (c) leg 3, (d) leg 4 of *E. monachus* Giesbrecht.

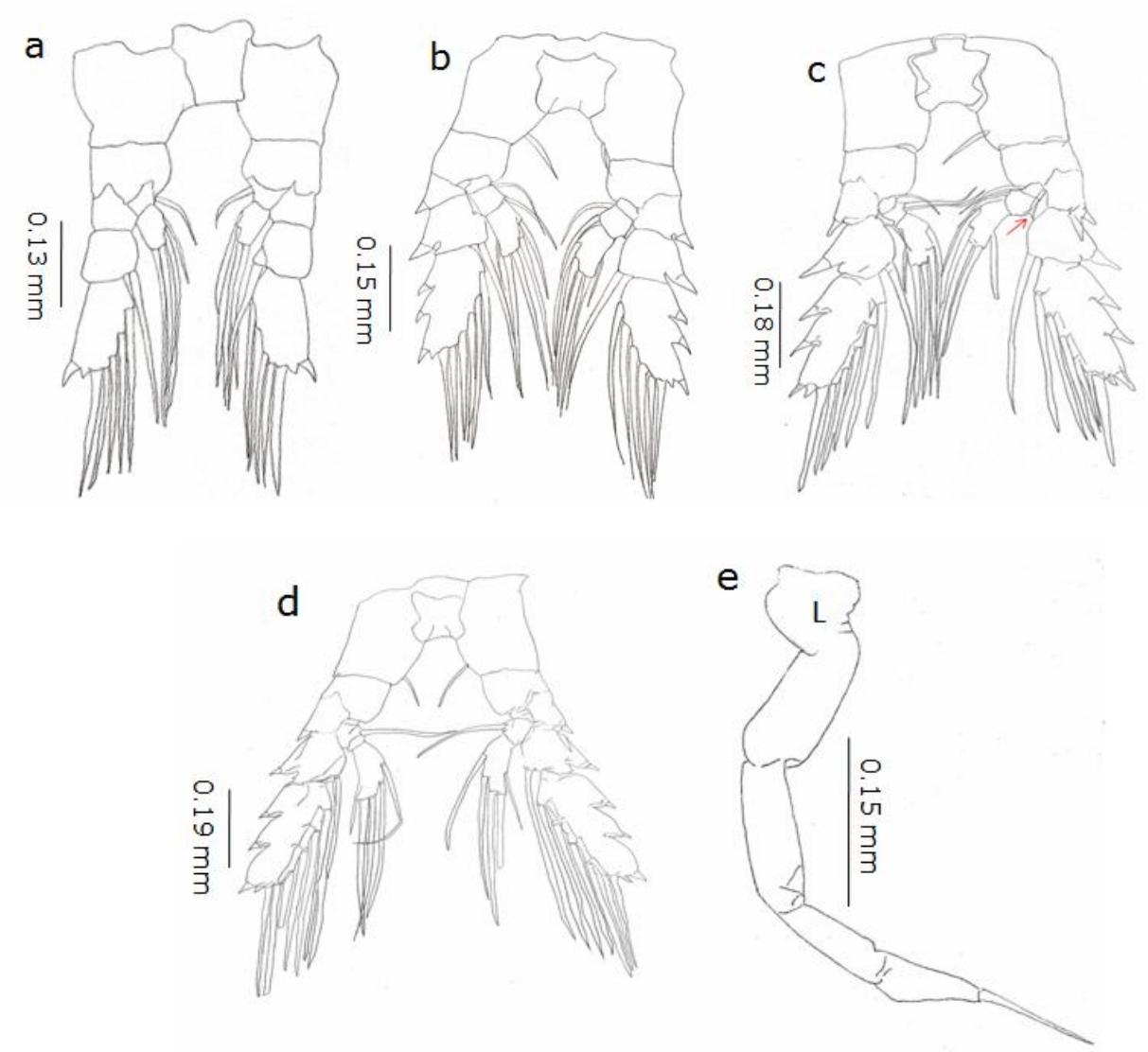

Figure 13. Male swimming (a) leg 1, (b) leg 2, (c) leg 3, (d) leg 4, and (e) leg 5 of *E. monachus* Giesbrecht.

Oncaea venusta Philippi, 1843
Figures 14-19

Synonym: *Antaria coerulescens* Claus, 1866; *Oncaea obtusa* Brady, 1883, Thompson, 1888; *Oncäa venusta* Giesbrecht, 1892, Razouls, 1972; *Oncaea praeclara* Humes, 1988, Suarez-Morales & Gasca, 1998.

Occurrence: The females were frequently encountered in all stations in Iligan and Sarangani Bays for both horizontal and vertical waters. Male species were not common in the plankton samples.

Description of adult female and male: Body length: females 1.29 mm, males 1.00 mm. Both sexes have elongate-oval body and light-orange coloration in live specimens. The body in female and male specimens have prosome comprising of cephalosome and 4

metasomal segments or free pedigerous somites (Figure 14 a,b). The anterior part of the body is obovate in both sexes, much wider in the female than the male. The prosome and urosome divisions are well defined.

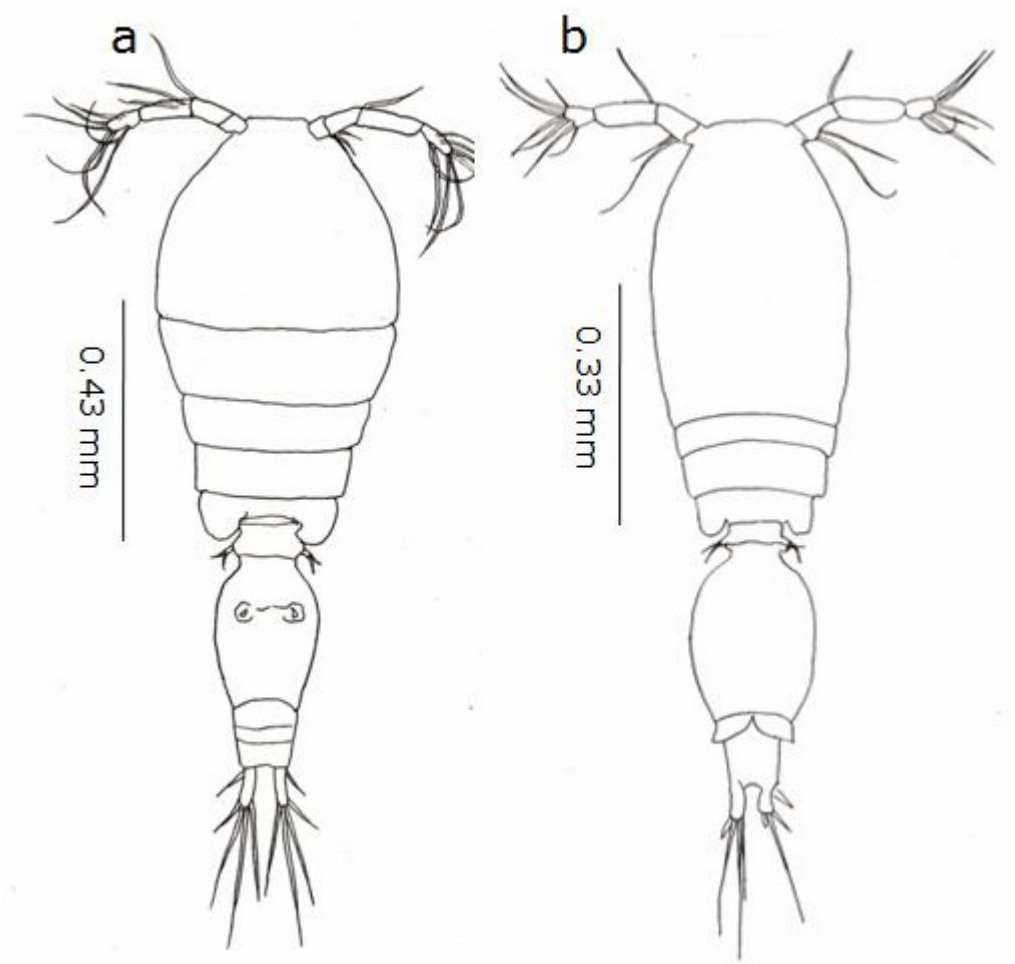

Figure 14. Dorsal view of (a) female and (b) male *O. venusta* Philippi.

The urosome in female (Figure 15a) is 4-segmented consisted of a genital somite and 3-segmented abdominal segments. The genital apertures are located dorsally on the genital segment. The genital segment is relatively larger as compared to the rest of the abdominal segments. In male, the urosome is 5-segmented (Figure 15b) and consisted of a genital segment and 4-segmented abdominal somites. The male genital segment is conspicuously enlarged than the female and has a floppy form which is not seen in female. The 2nd to 5th abdominal segments are closely telescoped with each other. Female genital apertures are located dorsally but ventrally in male. The anal segment or last abdominal segment of both sexes bears a pair of caudal rami, with each ramus having 1 seta located posteriorly plus 4 terminal setae of which terminal seta 1 is the smallest, seta 2 and 4 is almost equal in length while seta 3 is the longest. The length of the urosome including the caudal ramus is 0.510 mm for female and 0.450 mm for male.

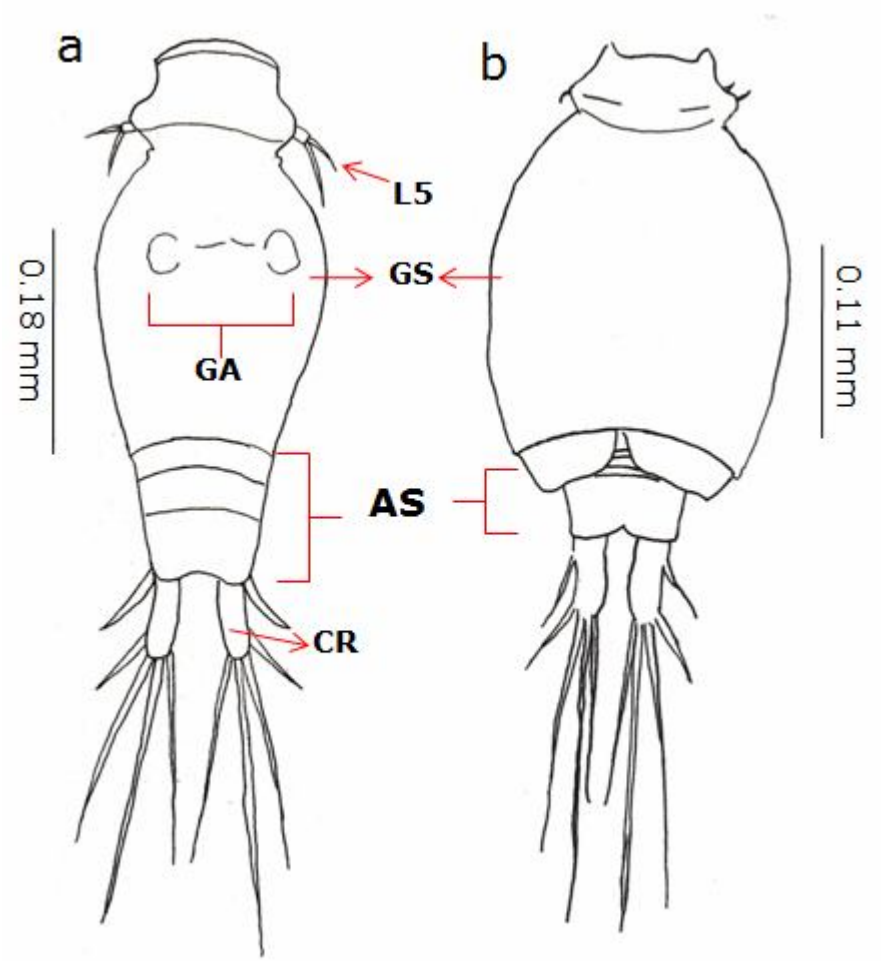

Figure 15. (a) Ventral view of female urosome and (b) dorsal view of male urosome of *O. venusta* Philippi. GA: Genital apertures, GA:Genital somite, AS:Abdominal segments, CR: Caudal rami, L5:Leg 5.

The antennules of both sexes are 4-segmented (Figures 16 a-b). In female, the left antennules (Figure 16a) bears 1, 2, 2 and 5 setae on segments 1, 2, 3 and terminal portion of segment 4, respectively. The right antennules (Figure 16b) bears 2, 3, 3 and 5 setae on segments 1, 2, 3 and terminal portion of segment 4, respectively. In male, the left antennule (Figure 17 a) bears 3, 3, 3 and 8 setae on segments 1, 2, 3 and majority on the terminal portion of the 4th segment, respectively. The right antennule (Figure 17b) bears 1, 4, and 9 setae on segments 1, 3 and 4, respectively.

The antenna in both sexes is 3-segmented (Figures 18 a-b). In female (Figure 18a), segment 3 bears 8 setae, 5 of which are located at the terminal end, while the other 3 setae are located on the middle portion of the segment. In male, segment 3 bears 9 setae (Figure 18b). Segments 1 and 2 are devoid of any seta for both sexes.

Maxilliped in both sexes is 4-segmented, with segment 2 being robust while segment 3 terminates into a long claw or hook which is devoid of any spines along the concave inner margin (Figures 19 a-b). In female (Figure 19a), segment 2 bears 2 spines on the inner surface, whereas a seta was present near the base of the long claw. In male (Figure 19b), anterior row of setules were conspicuous on segment 2.

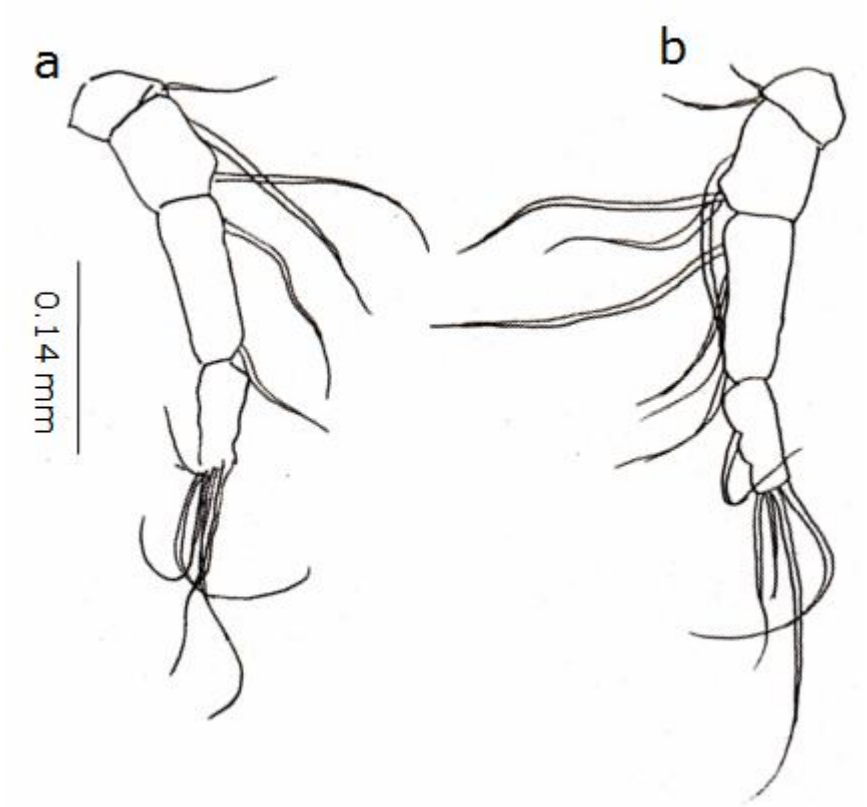

Figure 16. (a)Left and (b) right antennules of female *O. venusta* Philippi.

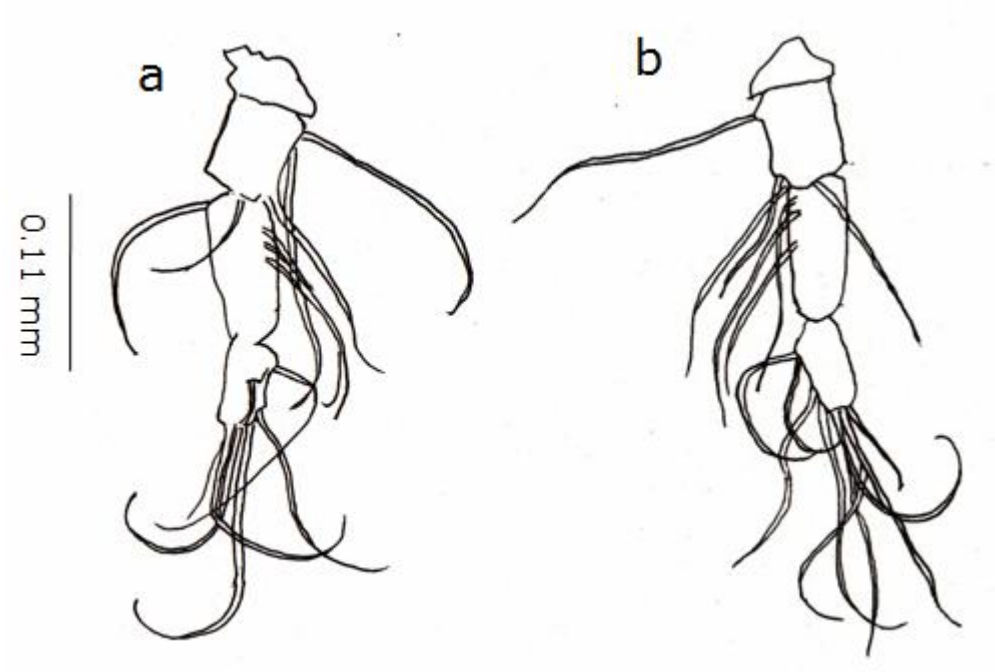

Figure 17. (a) Left and (b) right antennules of male *O. venusta* Philippi.

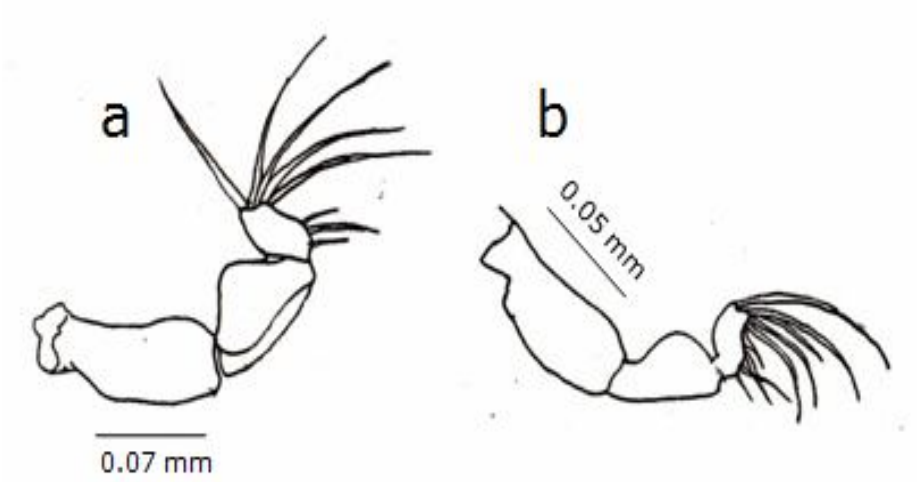

Figure 18. (a) Female and (b) male antenna of *O. venusta* Philippi.

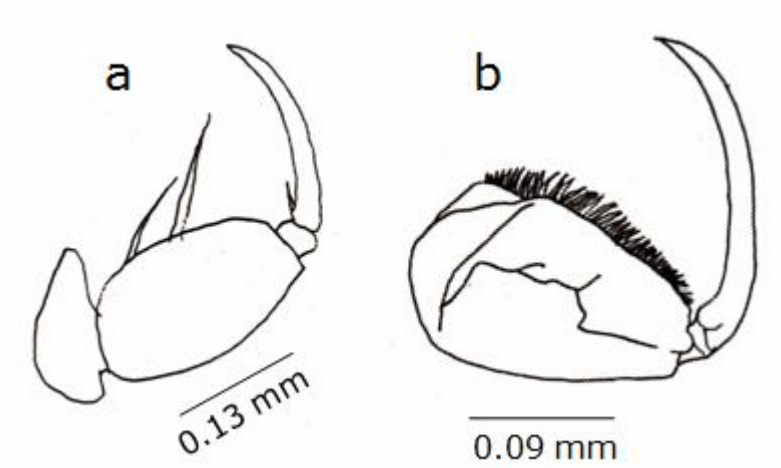

Figure 19. (a)Female and (b) male maxilliped of *O. venusta* Philippi.

Swimming legs 1 to 4 of both sexes are similar, biramous (Figures 20 a-d and 21 a-d) with all of the legs having 3-segmented exopodites and endopodites. Legs 2-4 with conical process between second and terminal spines (as indicated by a red arrow). Leg 5 (Figures 20e and 21e), which is located on the metasome segment 5, is a short free segment bearing 2 terminal setae, of which the inner seta is slightly longer (Heron and Bradford-Grieve 1995).

The above descriptions are similar with those described and figured by Dakin and Colefax (1940), Kasturirangan (1963), Razouls (1972), Chen and Zhang (1974), Boxshall (1977), Humes (1988), Heron and Bradford-Grieve (1995), Bottger-Schnack (2001) and Wi et al (2008).

Remarks: Wilson (1950) also reported this species in the following islands in the Philippine Archipelago: Sabtan Island, West coast of Luzon, Ragay Gulf Luzon, Santa Cruz Harbor, Eastern Palawan, off Palawan, Malampaya Sound Palawan, Palawan Passage, off Romblon Harbor, between Siquijor and Bohol, between Bohol and Leyte, between Cebu and Leyte, off western Samar, between Panay and Negros, East coast Negros, off Northern Mindanao, Eastern Mindanao, off Mindanao West, Sulu Sea, Tawi-Tawi and Jolo Sea in Mindanao.

Pacific Ocean Record: Chen and Zhang (1974).

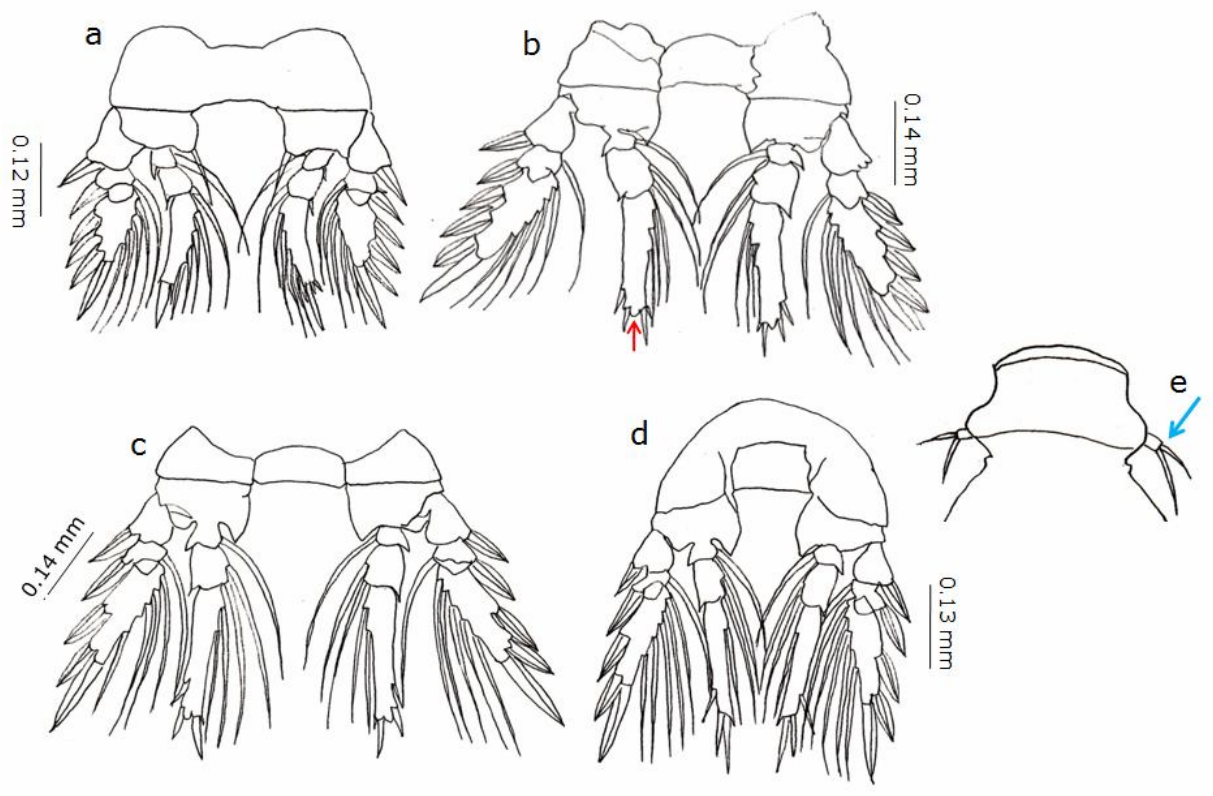

Figure 20. Female swimming (a) leg 1, (b) leg 2, (c) leg 3, (d) leg 4 and (e) leg 5 (pointed by a blue arrow) of *O. venusta* Philippi. Red arrow points to the conical process between second and terminal spines.

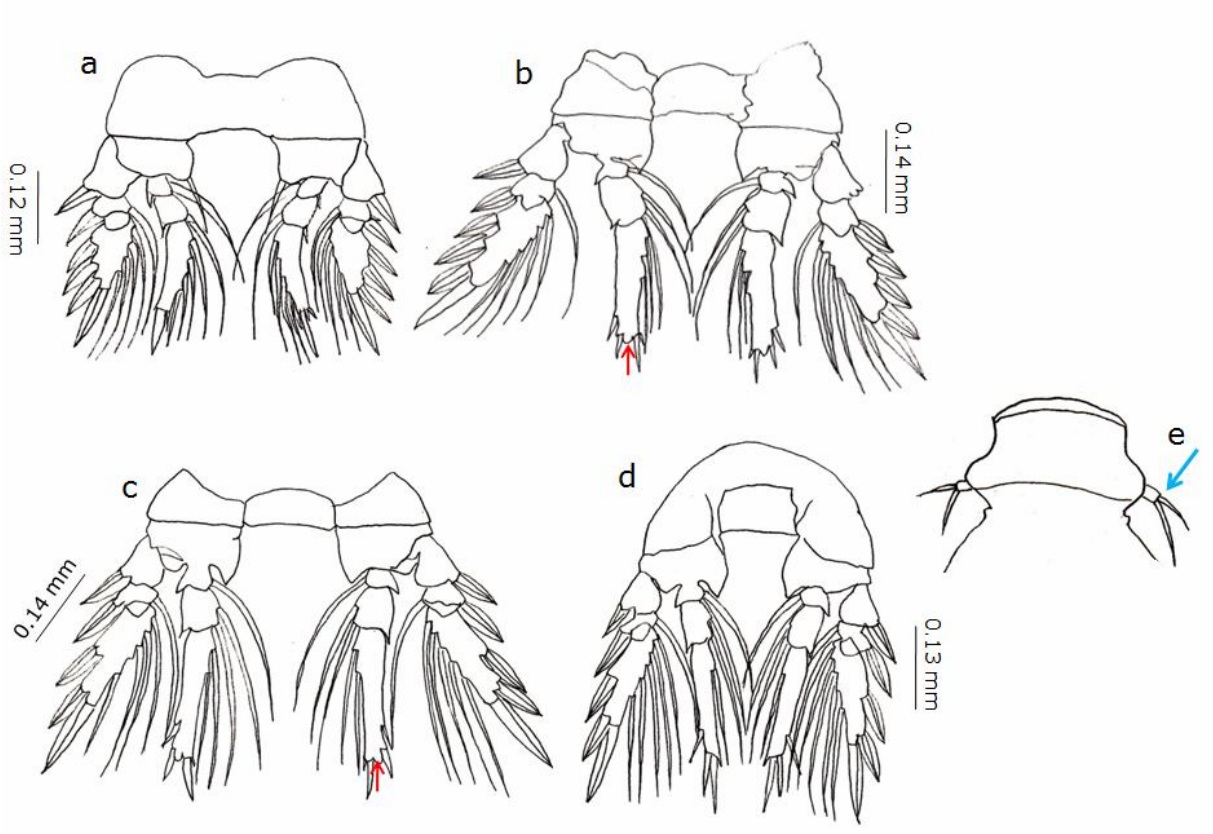

Figure 21. Male swimming (a) leg 1, (b) leg 2, (c) leg 3, (d) leg 4 and (e) leg 5 (pointed by a blue arrow) of *O. venusta* Philippi. Red arrow points to the conical process between second and terminal spines.

Conclusions. *Centropages furcatus, Eucalanus monachus* and *Oncaea venusta* female specimens are commonly seen in the offshore waters in Iligan and Sarangani Bays. Despite similarities among copepods, there is a tendency for the same identified species to vary morphologically depending on the place or area. In the case of *Oncaea venusta*, legs 2 and 3 of both sexes showed the presence of conical process between second and terminal spines, however these attributes were seen on the legs 2-4 of the same organism from the Australian waters.

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