Species of Copepods (Crustacea: Copepoda) from Northern Mindanao Nearshore Waters

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Abstract

Copepods are small shrimp-like crustaceans that usually form the bulk of zooplankton samples. Since copepods directly graze on phytoplankton, and themselves are eaten by many fish and invertebrate larvae, they primarily function as an indispensable food web link between phytoplanktonic primary production and fish production in oceans and other aquatic bodies. They are recently recognized as an important aquaculture live food organisms because of their high nutritional value to early developmental stages of commercially important shellfish and finfish species. Scattered published studies point to a fact that the Philippine waters are inhabited by a high diversity of copepod species, but there is no available single publication that embodies all Philippine species. Added to this dilemma is the lack of reference specimens that match descriptions and images that appear in various publications. Hence, diversity in terms of species richness was determined in copepods from selected sampling sites of northern Mindanao coastal waters. A total of 63 most common species were identified and documented in this study. It is hoped that in the long term more species from other Philippine waters will be collected, described, photographed and preserved reference specimens archived in Philippine museums so that future researchers can append the database to this initial study.

Keywords: Copepoda, species diversity, northern Mindanao, the Philippines

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INTRODUCTION

Copepods are small shrimp-like animals usually between 0.2-12mm in length (Bradford-Grieve et al. 1999). Most species are marine, abundant and freely swimming in oceans and seas, but some are found in lakes and other standing waters including those in bromeliads (Mauchline 1999). Marine copepods may be categorized as pelagic (inhabiting the water column), benthopelagic or hyperbenthic (living in the near-bottom layer), benthic (living on the bottom or in the sediment) or in association with other animals, and are widely distributed from the surface layers to abyssal depths in all the biogeographical zones of the world ocean in neritic to oceanic waters (Bradford-Grieve et al. 1999). Regarded the most numerous group of marine organisms, they may sometimes form up to 90-97% of the biomass of marine zooplankton (Mauchline 1999). Thus, copepods are extremely important in aquatic environments.

Milne-Edwards (1840 cited in Bradford-Grieve et al. 1999) established the Copepoda as a separate taxon. Up to now 10 copepod orders are recognized: Platycopioida, Calanoida, Misophrioida, Harpacticoida, Monstrilloida, Mormonilloida, Gelyelloida, Cyclopoida, Siphonostomatoida, and Poicilostomatoida (Huys and Boxhall 1991). A total of about 11,500 species have been identified worldwide rendering copepods more speciose than insects on land (Ianora, 2005).

The taxonomy and ecology of several temperate copepods have been well studied, but not so with tropical copepods (Mauchline 1999). Studies on systematics emphasize the immense diversity of copepod in the tropics (e.g. Wilson 1942, Huys and Boxhall 1991, Mulyadi 2004). Apart from the substantial work on freshwater species (Mamaril and Fernando 1980; Mamaril 1986, 2001), the estuarine and marine copepod species in the Philippine waters are poorly and scarcely studied. The diversity in form and function of the various copepod species in Philippine marine and estuarine waters remains unappreciated. There are about 500 copepod species in Philippine marine waters, but studies on their taxonomy and biology are very few (Razouls et al. 2011). Until thoroughly studied, the biology of this group of organisms and

their role in Philippine aquatic ecosystems and in the environmental health, aquaculture and fisheries sectors remain underestimated.

Copepods mainly serve as food to newly hatched fish and other larval stages of aquatic organisms (Ikeda 1973; Mauchline 1999; van der Meeren and Naas 1997). Copepods are primarily responsible for feeding on microscopic plants called phytoplankton which are also suspended in the surface waters of oceans and freshwater bodies. Thus, copepods are very basic component of food webs in aquatic environments. Some temperate and subtropical species have been reared for the aquaculture live feed industry because they contain high levels of docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), and arachidonic acid (ARA) polyunsaturated fatty acids (PUFA) or omega-3, ideal for the increased survival of fish larvae (Bell 1998; McKinnon et al. 2003; Morehead et al. 2005; Shields et al. 2005; Cheng et al. 2007; Chang et al. 2008). Except for the work of Toledo et al. (2005), the potential of marine copepods as aquaculture live feed has not been thoroughly explored in Philippine copepods. This could be partly attributed to a lack of accurate taxonomic studies.

In general, this study was envisioned to make an important contribution to the fundamental aim of understanding the role of copepod biodiversity in aquatic ecosystems. A separate study devoted to taxonomy is needed considering the immense diversity of copepods in the Philippine waters. This endeavor would lend more support to the recent recognition of the Philippines as the center of the global center of marine biodiversity (Carpenter and Springer 2005). The search for new and indigenous copepod species and establishing their importance in the aquaculture industry (O'Bryen and Lee 2005) and environmental science (Chang et al. 2009) remain a productive undertaking. Hence, a similar research study in the Philippine setting is expected to generate results that would contribute to the development of the aquaculture and other related industries in the country, as well as to the enrichment and understanding of basic taxonomy and systematics of copepods. The specific objectives of this study are to collect and identify copepod species from selected sites of northern Mindanao coastal waters,

and initiate the formal documentation and collection of reference species of Philippine marine copepods.

MATERIALS AND METHODS

Collection of samples

Copepods were collected from coastal marine waters of the southwestern Mindanao Sea (or Bohol Sea) (Figure 1), using a 279-µm mesh General Oceanics (California, USA) conical plankton net with a mouth diameter of 0.32 m and a closed cod-end which minimizes damage to the animals (Omori and Ikeda 1984; Sameoto et al. 2000). Specific selected sampling sites include central Panguil Bay; Southern Iligan Bay (Kauswagan, Lanao del Norte); and western Macajalar Bay (off Tubajon, Laguindingan, Misamis Oriental) (Figure 1). Zooplankton samples were collected through vertical towing from 15m deep to the surface and horizontal towing for 3 minutes at the lowest running speed of a motorized banca. Plankton samples were immediately fixed in 10% borax-buffered formalin in seawater, and stored in tightly covered jars. Samples for taxonomic study were preserved permanently in 10% formaldehyde in filtered seawater.

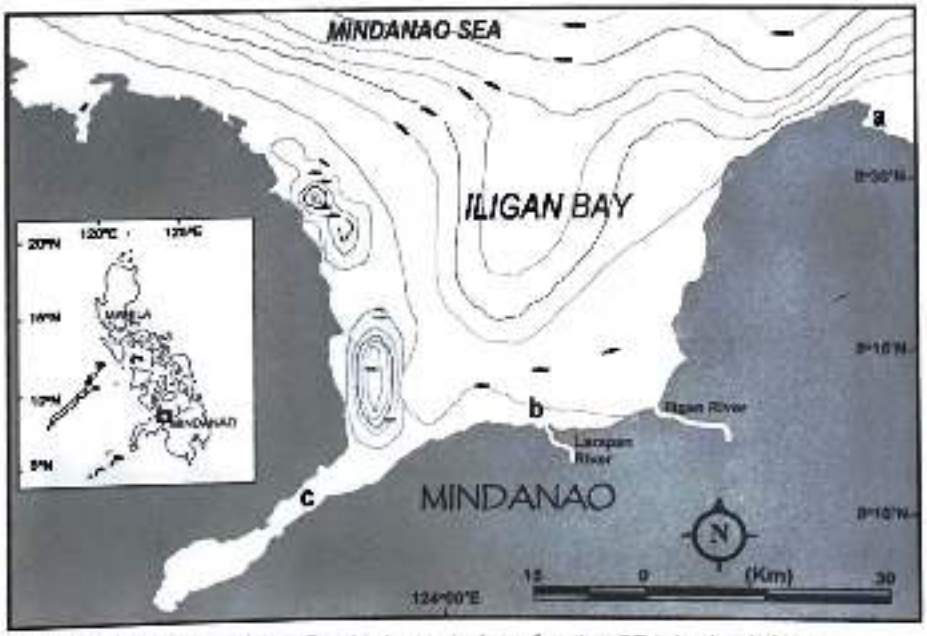

Figure 1. Bathymetric map of Iligan Bay showing copepod sampling sites off Tubajon, Laguindingan (Northwestern Macajalar Bay) (a) and Kauswagan (b), and central Panguil Bay (c). Inset is a map showing the location of Iligan Bay and part of Macajalar Bay (enclosed in a square) in Mindanao, Philippines.

Analysis of species richness

Copepods were sorted out from the samples under a Zeiss Stemi 2000 stereomicroscope, and placed in properly-labeled vials containing 10% borax-buffered formalin in seawater. In order to identify species, entire individual copepod species were photographed using Olympus stereophotomicrography attached with a Sony digital camera capable of producing 10.1 megapixels photographs. Taxonomically informative body parts from males and females such as the fifth swimming legs (5th pleopods or P5), the urosome, the first, second, and fourth pleopods, and the first and second antennae were dissected out under a dissecting stereomicroscope using Dumont (Switzerland) micro-dissecting forceps. Body parts were placed onto a glass slide with a drop of glycerol, covered with a cover slip, and examined under an Olympus compound microscope using both low and high power magnifications. Highly magnified structures were photographed using a 10.1 megapixel Sony digital camera attached on the microscope. The general body shape and the features of the different appendages were then matched to photographs, descriptions and taxonomic keys of Brady (1883), Scott (1909), Dahl (1912), Wilson (1942, 1950), Grice (1962), Tanaka (1969), Huys and Boxhall (1991), Ueda and Mulyadi (1996), Mulyadi (1997, 2003, 2004), Ohtsuka and Reid (1998), and Razouls et al. (2011). A catalogue comprising digital photographs of whole animals and body parts and taxonomic drawings from the different taxonomic references was then created. Identification of copepod species were confirmed by world copepod taxonomists including Prof. Dr. Shuhei Nishida, Atmosphere and Ocean Research Institute of the University of Tokyo; Prof. Dr. Susumo Ohtsuka, Hiroshima University; Dr. Mulyadi, Indonesia Oceanographic Institute; Dr. T. Chad Walter of the Invertebrate Zoology Section, Smithsonian Institution, Washington D.C., USA; and Prof. Khwanruan Pinkaew, Burapha University, Thailand. Preserved specimens of confirmed species were stored in small screw-capped vials which were then archived in the Ecology Research Laboratory of the Department of Biological Sciences, Mindanao State University-Iligan Institute of Technology.

RESULTS

Species Richness

A total of 63 common copepod species have been identified: 45 belong to the Order Calanoida, four (4) to the Order Cyclopoida, ten (10) to the Order Poicilostomatoida, and four (4) to the Order Harpacticoida.

The calanoid copepod species include:

Order Calanoida

Family Calanidae

(1) *Canthocalanus pauper* Geisbrecht 1888 (Figure 2)
(2) *Cosmocalanus darwini* Lubbock 1860 (Figure 3)
(3) *Undinula vulgaris* Dana 1849 (Figure 4)
(4) *Neocalanus gracilis* Dana 1849 (Figure 5)
(5) *Rhincalanus nasutus* Mori 1937 (Figure 6)

Family Euchaetidae

(6) *Euchaeta rimana* Bradford 1974 (Figure 7)
(7) *Euchaeta media* Giesbrecht 1888 (Figure 8)

Family Candaciidae

(8) *Candacia catula* Giesbrecht 1889 (Figure 9)
(9) *Candacia curta* Dana 1849 (Figure 10)
(10) *Candacia discaudata* A. Scott 1909 (Figure 11)
(11) *Paracandacia truncata* Dana 1849 (Figure 12)

Family Eucalanidae

(12) *Subeucalanus subcrassus* Giesbrecht 1888 (Figure 13)
(13) *Subeucalanus dentatus* A. Scott 1909 (Figure 14)

Family Centropagidae

(14) *Centropages furcatus* Dana 1849 (Figure 15)
(15) *Centropages gracilis* Dana 1849 (Figure 16)
(16) *Centropages calaninus* Dana 1849 (Figure 17)

Family Acartiidae
(17) *Acartia (Odontacartia) erythraea* Giesbrecht 1849 (Figure 18)
(18) *Acartia (Acartia) negligens* Dana 1849 (Figure 19)
(19) *Acartia (Odontacartia) bispinosa* Carl 1907 (Figure 20)
(20) *Acartia (Odontacartia) pacifica* Steuer 1915 (Figure 21)
(21) *Acartia (Acanthacartia) sinjiensis* Mori 1940 (Figure 22)
(22) *Acartia* sp. (Figure 23)

Family Pseudodiaptomidae
(23) *Pseudodiaptomus philippinensis* Walter 1986 (Figure 24)
(24) *Pseudodiaptomus diadelus* Walter 1986 (Figure 25)
(25) *Pseudodiaptomus anandalei* Sewell 1918 (Figure 26)

Family Tortanidae
(26) *Tortanus (Tortanus) gracilis* Brady 1883 (Figure 27)
(27) *Tortanus manadoensis* (Figure 28)

Family Paracalanidae
(28) *Paracalanus aculeatus* Giesbrecht 1888 (Figure 29)
(29) *Parvocalanus crassirostris* F. Dahl 1894 (Figure 30)
(30) *Acrocalanus gibber* Giesbrecht 1888 (Figure 31)
(31) *Acrocalanus gracilis* Giebrecht 1888 (Figure 32)

Family Calocalanidae
(32) *Calocalanus pavo* Dana 1849 (Figure 33)

Family Pontellidae
(33) *Pontella alata* A. Scott 1909 (Figure 34)
(34) *Pontellina plumata* Dana 1849 (Figure 35)
(35) *Calanopia thompsoni* A. Scott 1909 (Figure 36)
(36) *Calanopia australica* Bayly & Greenwood 1966 (Figure 37)
(37) *Labidocera acuta* Dana 1849 (Figure 38)
(38) *Labidocera bataviae* A. Scott 1909 (Figure 39)
(39) *Labidocera detruncata* Dana 1849 (Figure 40)

(40) *Labidocera minuta* Giesbrecht 1889 (Figure 41)

Family Temoridae
(41) *Temora turbinata* Dana 1849 (Figure 42)
(42) *Temora discaudata* Giesbrecht 1889 (Figure 43)
(43) *Temora stylifera* Dana 1849 (Figure 44)

Family Lucicutiidae
(44) *Lucicutia flavicornis* Claus 1863 (Figure 45)
(45) *Lucicutia curta* Farran 1905 (Figure 46)

The cyclopoid copepod species are:

Order Cyclopoida
Family Oithonidae
(46) *Oithona oculata* Farran 1913 (Figure 47)
(47) *Oithona plumifera* Baird 1843 (Figure 48)
(48) *Oithona tenuis* Rosendorn 1917 (Figure 49)
(49) *Oithona setigera* Dana 1849 (Figure 50)

The poecilostomatoid copepod species identified are:

Order Poicilostomatoida
Family Corycaeidae
(50) *Farranula gibbula* Giesbrecth 1891 (Figure 51)
(51) *Corycaeus (Ditrichocorycaeus) asiaticus* F. Dahl 1849 (Figure 52)
(52) *Corycaeus (Corycaeus) speciosus* Dana 1849 (Figure 53)
(53) *Corycaeus (Urocorycaeus) longistylis* Dana 1849 (Figure 54)
(54) *Corycaeus (Corycaeus) crassiusculus* Dana 1849 (Figure 55)

Family Oncaeidae
(55) *Oncaea venusta* Philippi 1843 (Figure 56)
(56) *Oncaea media* Giesbrecht 1891 (Figure 57)

Family Sapphirinidae
(57) *Sapphirina metallina* Dana 1849 (Figure 58)
(58) *Sapphirina senuicauda* Brady 1883 (Figure 59)
(59) *Copilia mirabilis* Dana 1849 (Figure 60)

The three harpacticoid copepod species identified include:

Order Harpacticoida
Family Euterpinidae
(60) *Euterpina acutifrons* Dana 1848 (Figure 61)
Family Miraciidae
(61) *Setella gracilis* Dana 1848 (Figure 62)

Family Etinosomatidae
(62) *Microsetella norvegica* Boeck 1864 (Figure 63)

Family Clytemnestridae
(63) *Clytemnestra scutellata* Dana 1848 (Figure 64)

Species Occurrence

The type localities of the different species collected in this study are shown in Table 1. This database of copepod species distribution has been submitted to the Census of Marine Zooplankton (CMARZ)-Asia (www.cmarz-asia.org/db).

Table 1. Species list of copepods collected from selected nearshore sites in Northern Mindanao.

SPECIES	LATITUDE	LONGITUDE	REGION	DENSITY (m^{-3})	STATION
Canthocalanus pauper	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	22	Kauswagan
Cosmocalanus darwini	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	7	Kauswagan
Undinula vulgaris	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	4	Kauswagan
Neocalanus gracilis	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	1	Kauswagan

Table 1. (cont.)

Euchaeta rimana	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	7	Kauswagan
Euchaeta media	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	4	Kauswagan
Candacia curta	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	1	Kauswagan
Candacia catula	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	1	Kauswagan
Candacia discaudata	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	0.5	Kauswagan
Paracandacia truncata	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	0.5	Kauswagan
Subeucalanus subcrassus	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	10	Kauswagan
Subeucalanus crassus	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	3	Kauswagan
Subeucalanus dentatus	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	1	Kauswagan
Rhincalanus nasutus	8° 11' 58" N	124° 6' 20" E	West Macajalar Bay	5	Tubajon
Centropages calaninus	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	2	Kauswagan
Centropages furcatus	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	2	Kauswagan
Centropages gracilis	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	5	Kauswagan
Acartia negligens	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	9	Kauswagan
Acartia erythraea	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	11	Kauswagan
Acartia bispinosa	8° 36.30' N	124° 36.30' E	West Macajalar Bay	1	Tubajon
Acartia pacifica	8° 36.30' N	124° 36.30' E	West Macajalar Bay	2	Tubajon
Acartia sinjiensis	8° 02' 52"N	123°45'18E	Central Panguil Bay	18.7	Tanggub
Pseudodiaptomus philippinensis	8° 02' 52"N	123°45'18E	Central Panguil Bay	7.457	Tanggub
Pseudodiaptomus diadelus	8° 36.30' N	124° 36.30' E	West Macajalar Bay	4.333	Tubajon
Pseudodiaptomus annandalei	8° 02' 52"N	123°45'18E	Central Panguil Bay	0.5	Tanggub
Tortanus gracilis	8° 11' 58" N	124° 6' 20" E	Central Panguil Bay	7	Tanggub
Tortanus manadoensis	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	0.5	Kauswagan
Paracalanus aculeatus	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	17	Kauswagan
Parvocalanus crassirostris	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	22	Kauswagan
Acrocalanus gibber	8° 11' 58" N	124° 6' 20" E	Central Panguil Bay	22	Tanggub
Acrocalanus gracilis	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	5	Kauswagan
Calocalanus pavo	8° 11' 58" N	124° 6' 20" E	West Macajalar Bay	4	Tubajon
Pontella elata	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	2	Kauswagan
Pontellina plumata	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	2	Kauswagan
Calanopia thompsoni	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	5	Kauswagan
Calanopia australica	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	4	Kauswagan
Labidocera acuta	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	2	Kauswagan
Labidocera detruncata	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	1	Kauswagan
Labidocera batavlae	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	1	Kauswagan
Labidocera minuta	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	3	Kauswagan
Temora discaudata	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	13	Kauswagan
Temora turbinata	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	18	Kauswagan
Temora stylifera	8° 11' 58" N	124° 6' 20" E	West Macajalar Bay	2	Tubajon
Lucicutia flavicornis	8° 36.30' N	124° 6' 20" E	Southern Iligan Bay	4	Kauswagan
Lucicutia curta	8° 36.30' N	124° 36.30' E	West Macajalar Bay	0.5	Tubajon
Oithona oculata	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	1	Kauswagan
Oithona plumifera	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	3	Kauswagan
Oithona tenuis	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	7	Kauswagan

Table 1. (cont.)

Oithona setigera	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	7	Kauswagan
Farranula gibbula	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	13	Kauswagan
Corycaeus asiaticus	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	14	Kauswagan
Corycaeus speciosus	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	5	Kauswagan
Corycaeus longistylis	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	7	Kauswagan
Corycaeus crassiusculus	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	4	Kauswagan
Oncaea venusta	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	21.6	Kauswagan
Oncaea media	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	14.4	Kauswagan
Sapphirina metallina	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	2	Kauswagan
Sapphirina sinuicauda	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	0.5	Kauswagan
Copilia mirabilis	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	2	Kauswagan
Euterpina acutifrons	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	8	Kauswagan
Setella gracilis	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	6	Kauswagan
Microsetella norvegica	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	0.11	Kauswagan
Clytemnestra scutellata	8° 11' 58" N	124° 6' 20" E	Southern Iligan Bay	0.1	Kauswagan

DISCUSSION

The 63 identified copepod species are first records in northern Mindanao coastal waters, Southern Philippines. The most common species in all samples were *Canthocalanus pauper*, *Acrocalanus gibber*, *Parvocalanus crassirostris*, and *Oncaea venusta*. Nearly all 63 species have been reported to be most common in the tropical waters of South East Asia as reported many years ago (e.g., Brady 1883; Scott 1909; Dahl 1912; Wilson 1950, 1952; Tanaka 1960, 1962; Grice 1962) and in more recent literature (e.g., McManus et al. 1991; Mulyadi 2004; Razouls 2011).

A few published studies have emphasized high diversity of Philippine species belonging to Families Candaciidae (Grice 1963), Pontellidae (Mulyadi 2002), and Pseudodiaptomidae (Walter et al. 2006). For instance, Family Candaciidae has 27 recognized species worldwide, and is divided into two genera, *Paracandacia* (three species) and *Candacia* (Grice 1963). The four species reported in this study are well known species that are distributed in Atlantic,

Pacific, and Indian Oceans (Grice 1963). These four species are also found in Indonesian waters (Mulyadi 2004).

The Philippine waters are endowed with demersal species belonging to the Genus *Pseudodiaptomus*. Walter et al. (2006) reported 14 species from many type localities in Luzon and Visayas (mainly off Panay Island), and three of these species (*P. philippinensis, P. diadelus, P. annandalei*) are first reported in this study. More species are expected to be added as more areas around Mindanao will be sampled. I suspect that the recently described *P. sulawesiensis* (Nishida and Rumengan 2005) from the Celebes Sea would also be found in southern waters of Mindanao and nearby islands as it is closely related with *P. philippinensis*. The 14 species include: *P. clevei, P. aurivilli, P. trihamatus, P. bispinosus, P. ornatus, P. trispinosus, P. caritus, P. philippinensis, P. diadelus, P. galleti, P. brehmi, P. terazakii, P. smithi, P. annandalei*. Walter et al. (2006) noted 77 total number of species in the Genus that belong to 7 species groups (Americanus, Burckhardt, Hyalinus, Improcerus, Lobus, Ramosus, and Nudus). The earliest studies that reported Philippine pseudodiaptomids were those by Wright (1937) who described *P. trihamatus* and *P. aurivilli* from Philippine islands, and Kiefer (1938) who identified *P. brehmi* from Mindoro Island waters. Walter (1984) described *P. bispinosus* and *P. sewelli*, and two years later Walter (1986) described four new species: *P. philippinensis* from Calatagan, Batangas; and *P. trispinosus, P. caritus*, and *P. diadelus* from Padre Burgos, Quezon Province. Walter in 1987 made a review on the taxonomy and distribution of Indo-West Pacific species of *Pseudodiaptomus*, and emphasized the region as the center of diversification. The species *P. annandalei* is currently mass cultured in Taiwan as live feed to larvae of high value fish species (Cheng et al. 2007; Chang et al. 2008).

The highest number of species (= 8) in this study was represented by Family Pontellidae. A total of 140 species are recognized worldwide (Silas and Pillai 1973 as cited in Mulyadi 2002). A recent account of pontellids in Philippine waters is that of Mulyadi (2002) where he listed 12 species: *Labidocera acuta* Dana 1849, *L. kroyeri* Brady 1883 (NE Sulu Sea and off northern Palawan, *L. minuta* Giesbrecht 1889, *L. pavo* Giesbrecht 1889,

Pontella diagonalis Wilson 1950, *P. forcicula* Scott 1909, *P. spinipes* Giesbrecht 1889, *P. surrecta* Wilson 1950, *Pontellopsis armata* Giesbrecht 1889, *P. yamadae* Mori 1937, *P. villosa* Brady 1883, and *Pontellina plumata* Dana 1849. Thus, the five species (*Pontella alata, Calanopia thompsoni, C. australica, Labidocera detruncata, L. bataviae*) in this study are new records, and three (*Labidocera acuta, L. minuta and Pontellina plumata*) are already known. The 12 species listed by Mulyadi (2002) could be an underestimate as past references have described other species not in Mulyadi's (2002) list. The oldest species record for the Family Pontellidae was that of Pesta (1933) who described *Pontella kieferi* from Malampaya Sound in Palawan, western Philippines. Smith (1941) described the blue copepod *Labidocera glauca* from Puerto Galera Bay, Mindoro in central Philippines, including some notes on the ecology and behaviour of the species. Pillai (1977) described six *Pontellopsis* species (*Pontellopsis armata* – Panay, Negros, Romblon, Bohol, Leyte, Malampaya, Palawan; Ragay Gulf, Luzon; *P. brevis* – Palawan Passage; *P. laminata* – Palawan; *P. strenua* – Sulu Archipelago, Palawan, Philippines; and *P. villosa* – Romblon) from Philippine waters. The species *Pontellina plumata* has circumglobal distribution particularly in the tropical belt region (Fleminger and Hulsemann 1974).

I believe that the 63 species reported in this work is only a scratch on the surface if we take into account all species inhabiting Philippine waters which, according to the list of Razouls et al. (2011), could reach up to 500 species. The present listing is provisional, and definitely more species would be discovered, many would be new to science, as more collections are done both in nearshore and offshore habitats of the Philippine territory.

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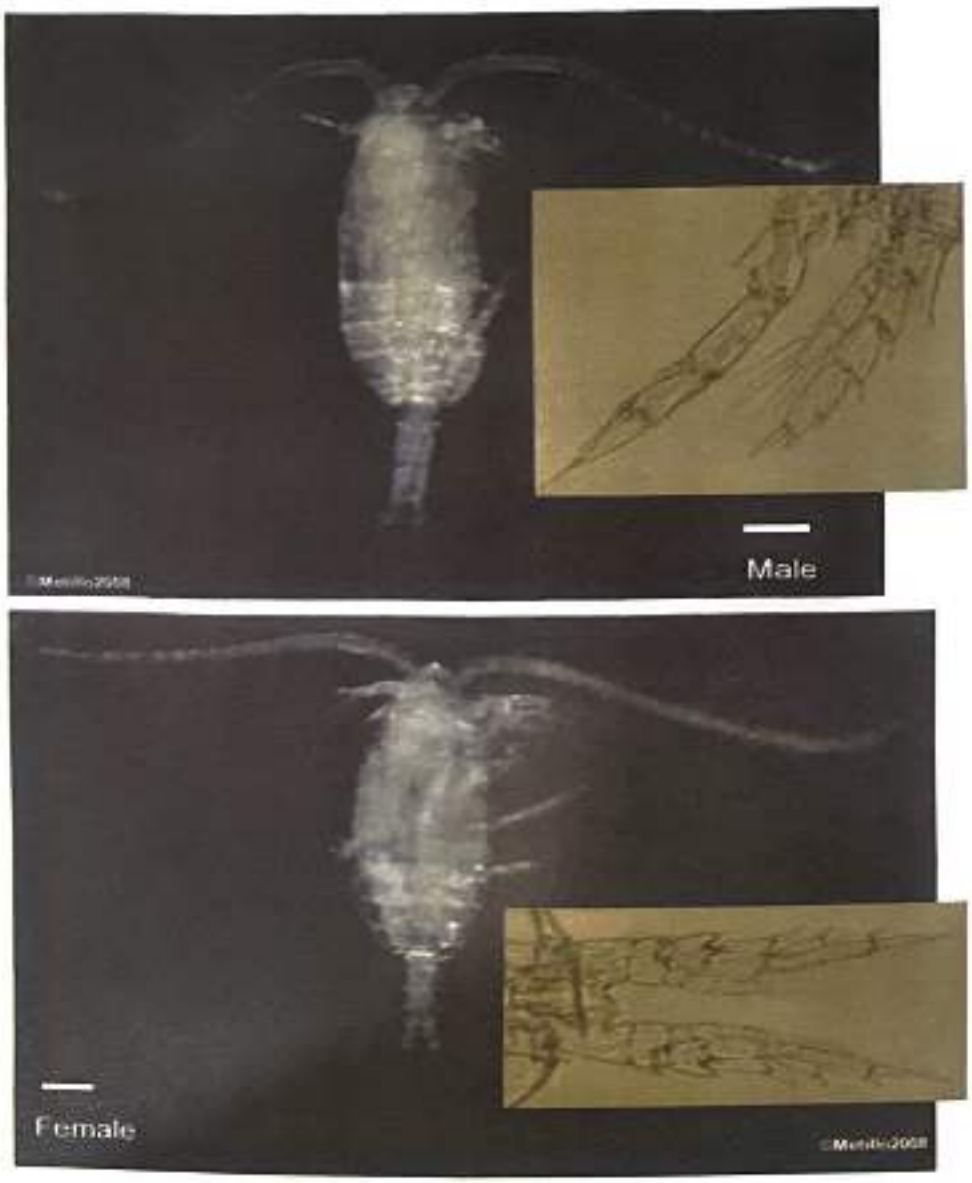

Figure 2. *Canthocalanus pauper*. Adult male and female and fifth legs. Bar = 0.04 mm

Figure 3. *Cosmocalanus darwini.* Adult male and female and fifth legs. Bar = 0.4 mm

Figure 4. *Undinula vulgaris*. Adult male and female and fifth (P5) legs. Bar = 0.04 mm

Figure 5. *Neocalanus gracilis*. Adult female. Bar = 0.04 mm

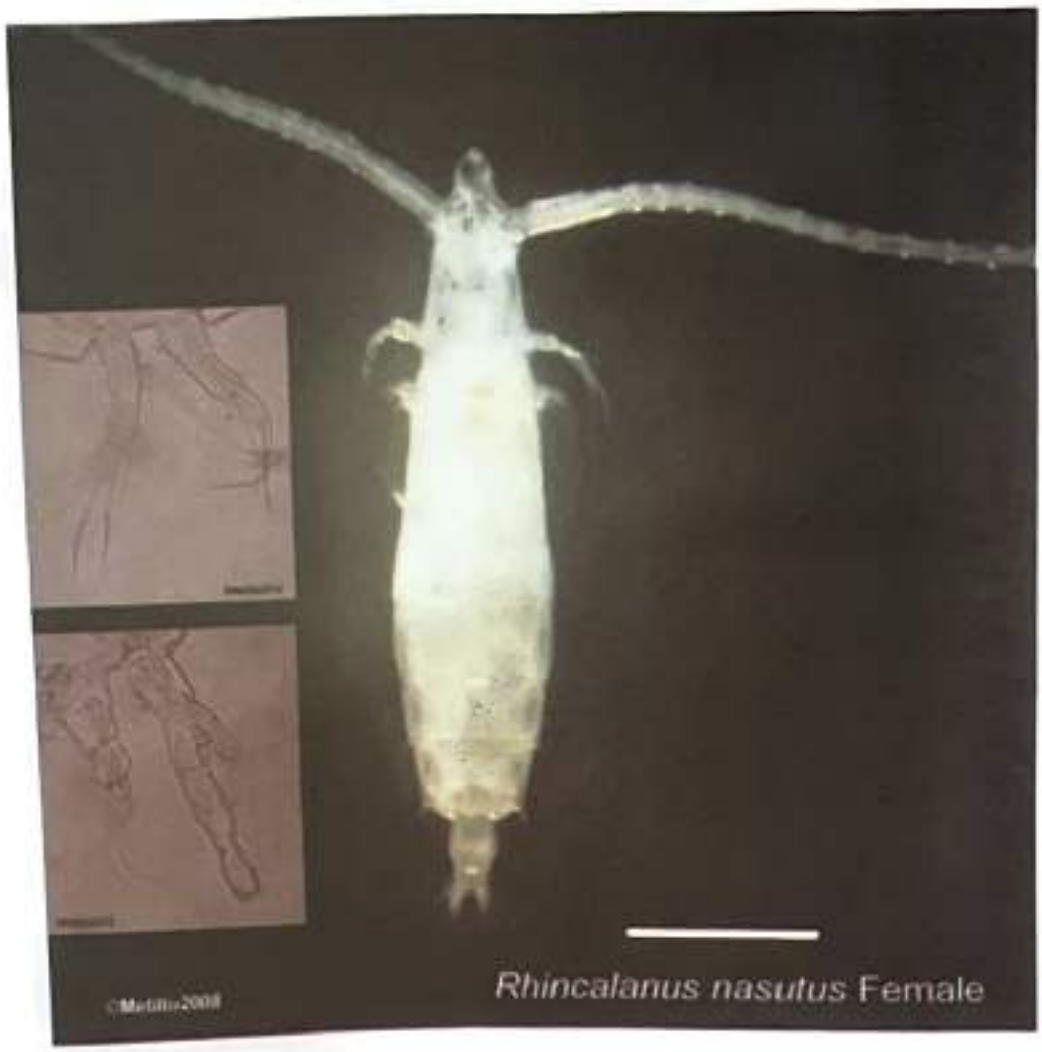

Figure 6. *Rhincalanus nasutus*. Adult female. Bar = 1.25 mm

Figure 7. *Euchaeta marina*. Adult male and female. Bar = 0.04 mm

Figure 8. *Euchaeta media*. Adult male and female. Bar = 0.04 mm

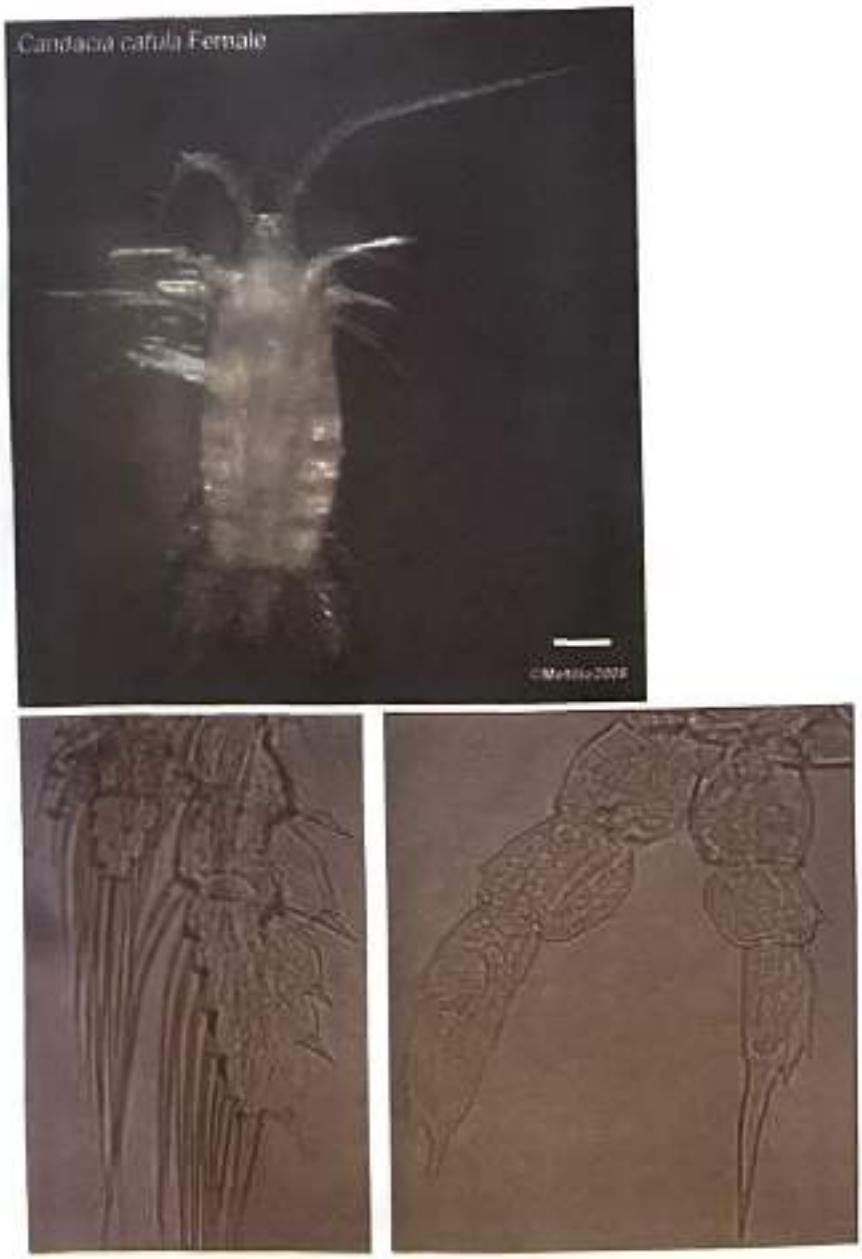

Figure 9. *Candacia catula.* Adult female and fifth legs. Bar = 0.04 mm

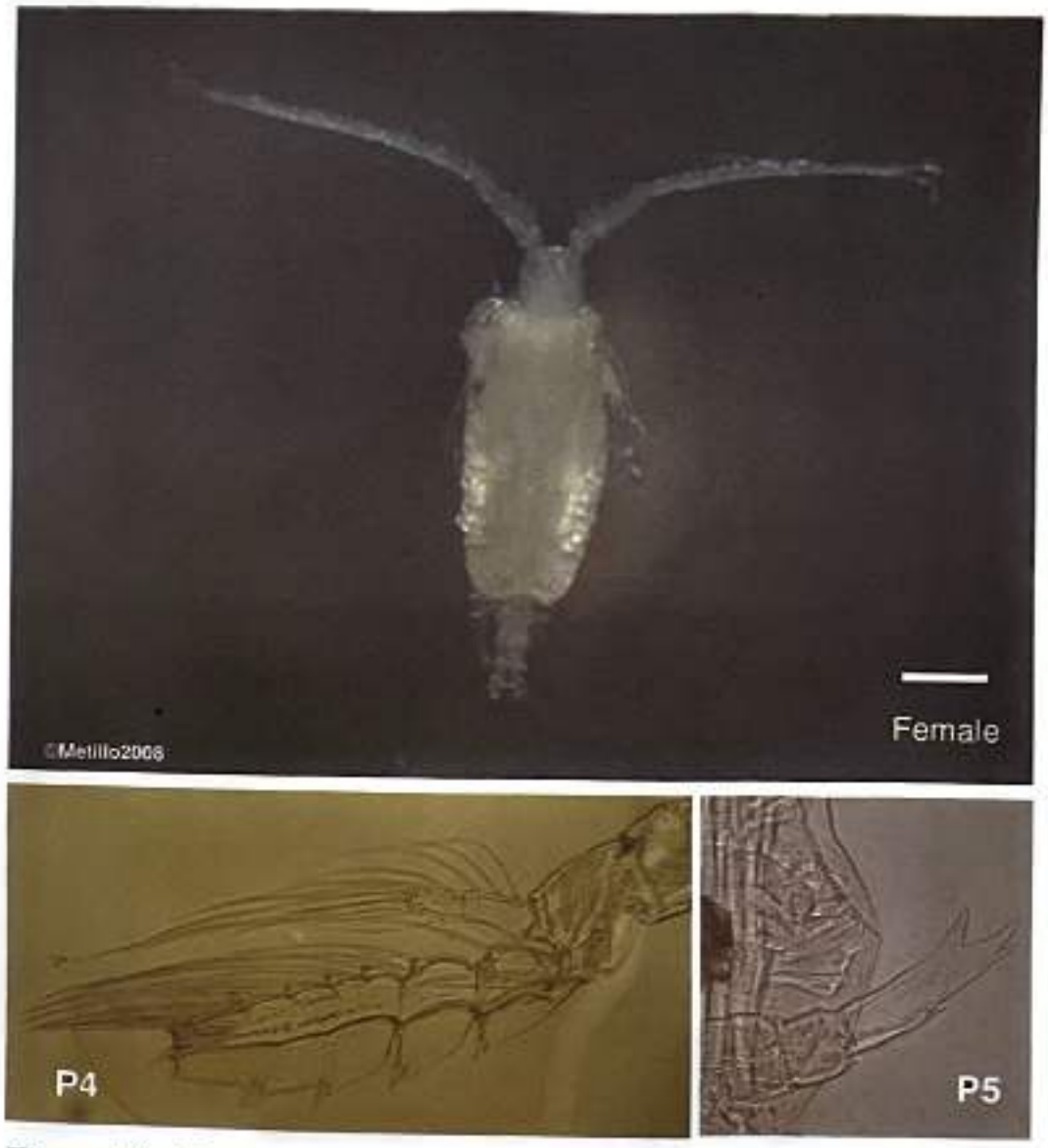

Figure 10. *Candacia curta*. Adult female; fourth (P4) and fifth (P5) legs. Bar = 0.04 mm

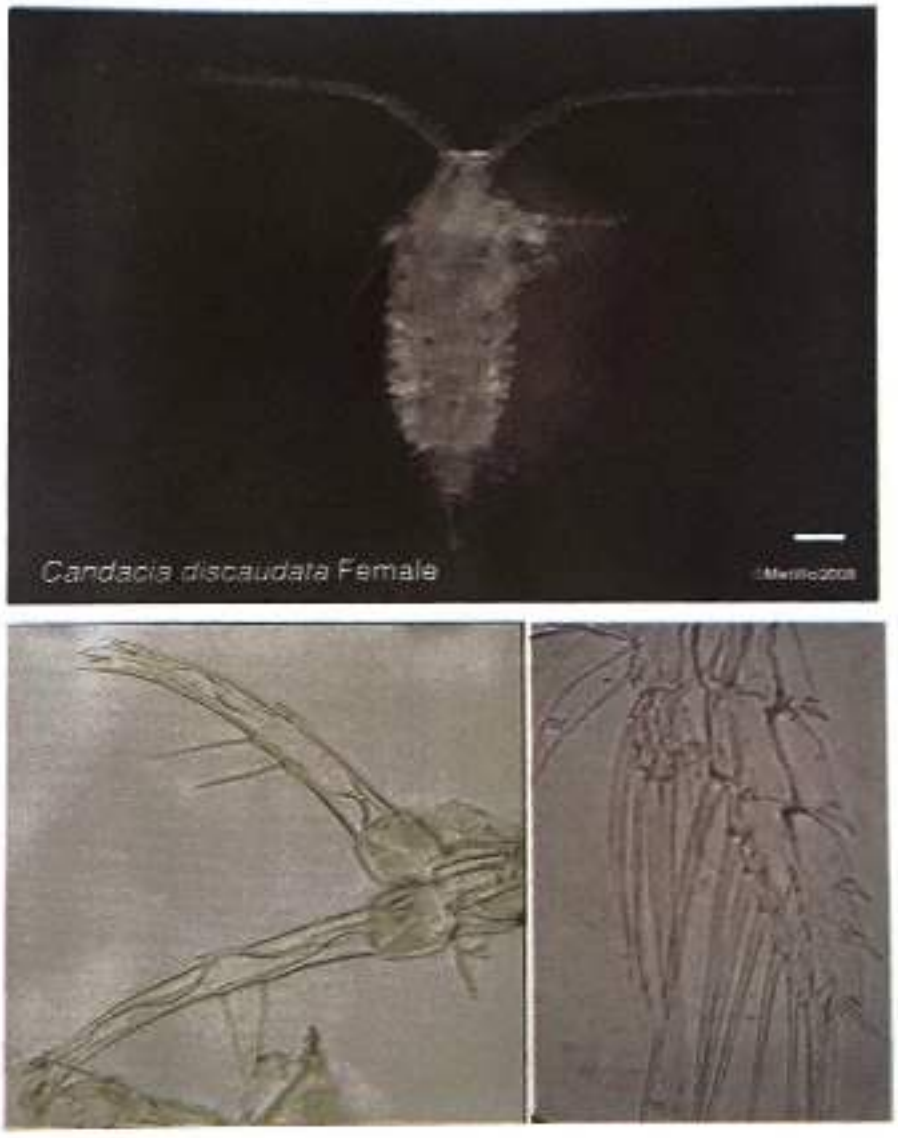

Figure 11. *Candacia discaudata.* Adult female and fifth legs. Bar = 0.04 mm

Figure 12. *Paracandacia truncata*. Adult male. Bar = 0.04 mm

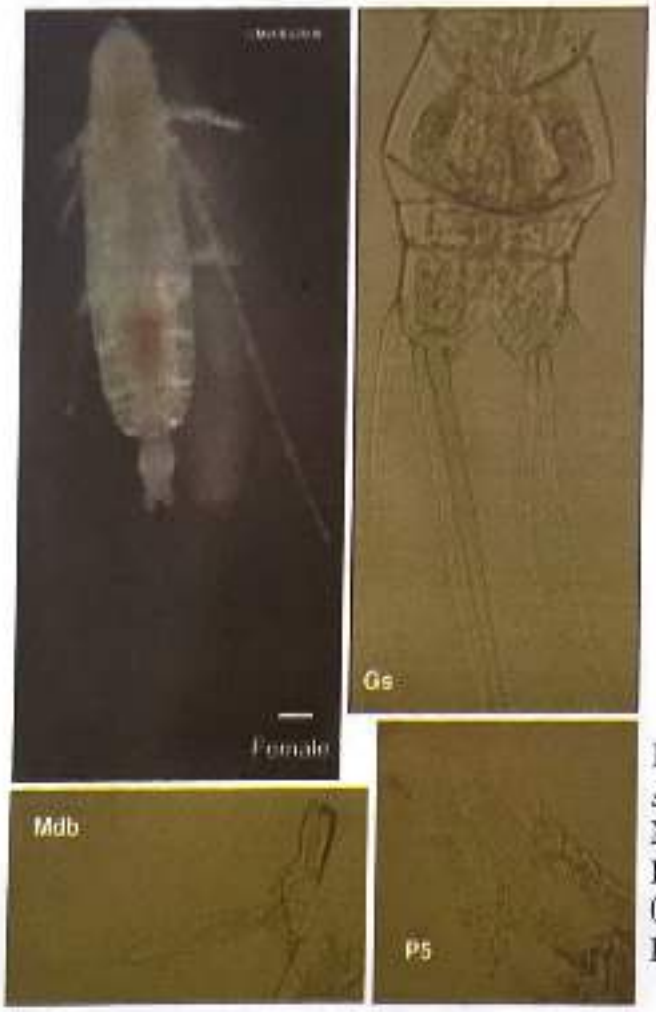

Figure 13. *Subcucalanus subcrassus*. Adult female. Mandible and mandibular Palp (Mdb), gonadal segment (Gs), and fifth (P5) legs. Bar = 0.04 mm

Figure 14. *Subeucalanus dentatus*. Adult female. Bar = 0.04 mm

Figure 15. *Centropages furcatus*. Adult female. Bar = 0.04 mm

Figure 16. *Centropages gracilis*. Adult female and male and fifth legs. Bar = 0.04 mm

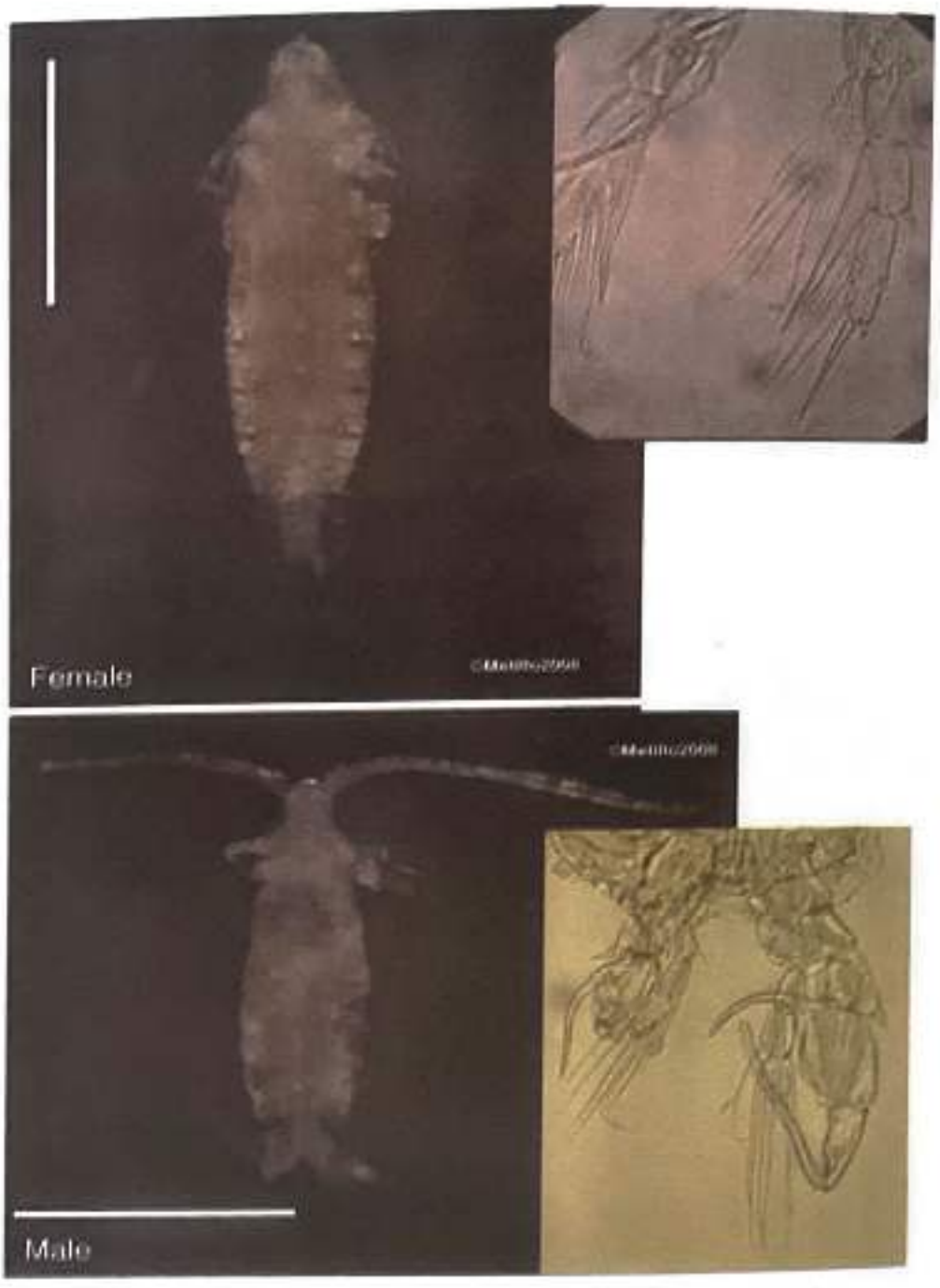

Figure 17. *Centropages calaninus*. Adult female and fifth legs, and adult male and fifth legs. Bar = 0.4 mm

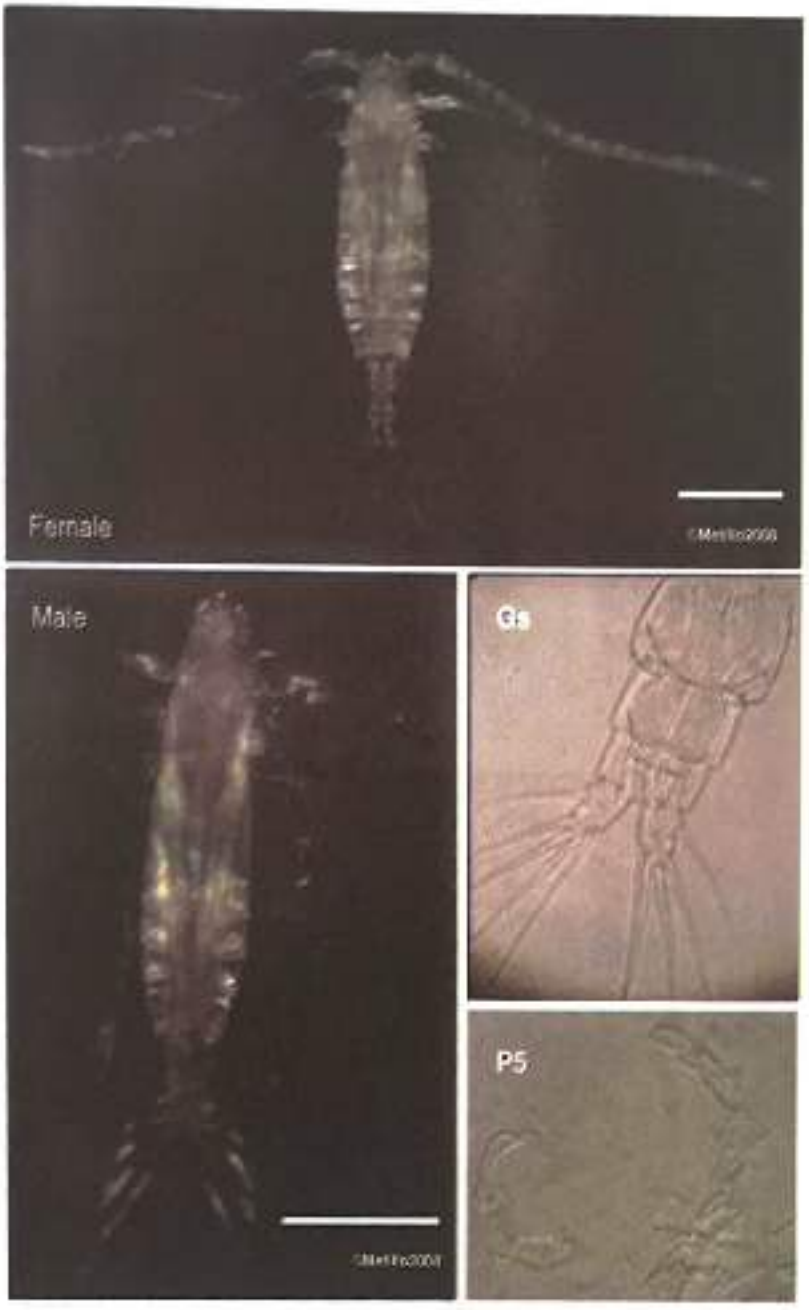

Figure 18. *Acartia erythraea*. Adult female and gonadal segment (Gs) and fifth (P5) legs. Adult male. Bar = 0.04 mm

Figure 19. *Acartia negligens*. Adult female. Bar = 0.04 mm

Figure 20. *Acartia bispinosa*. Adult male. Bar = 0.04 mm

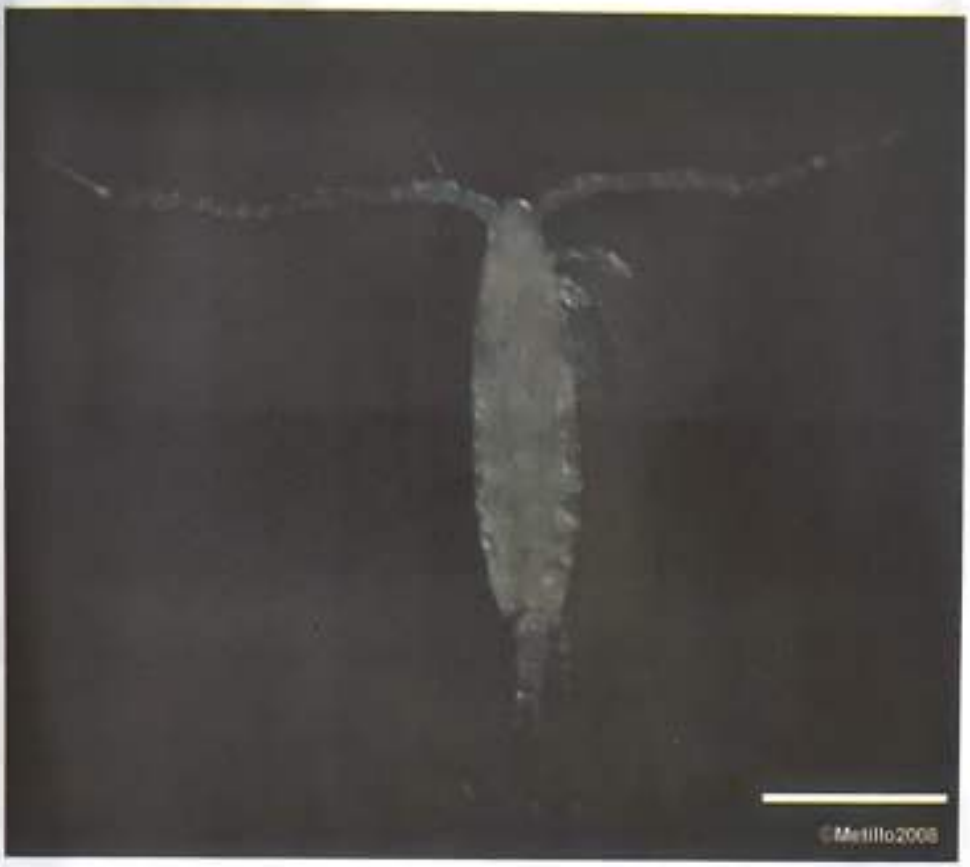

Figure 21. *Acartia pacifica.* Adult female. Bar = 0.04 mm

Figure 22. *Acartia sinjiensis*. Adult female and fifth (P5) legs. Male fifth legs. Bar = 0.04 mm

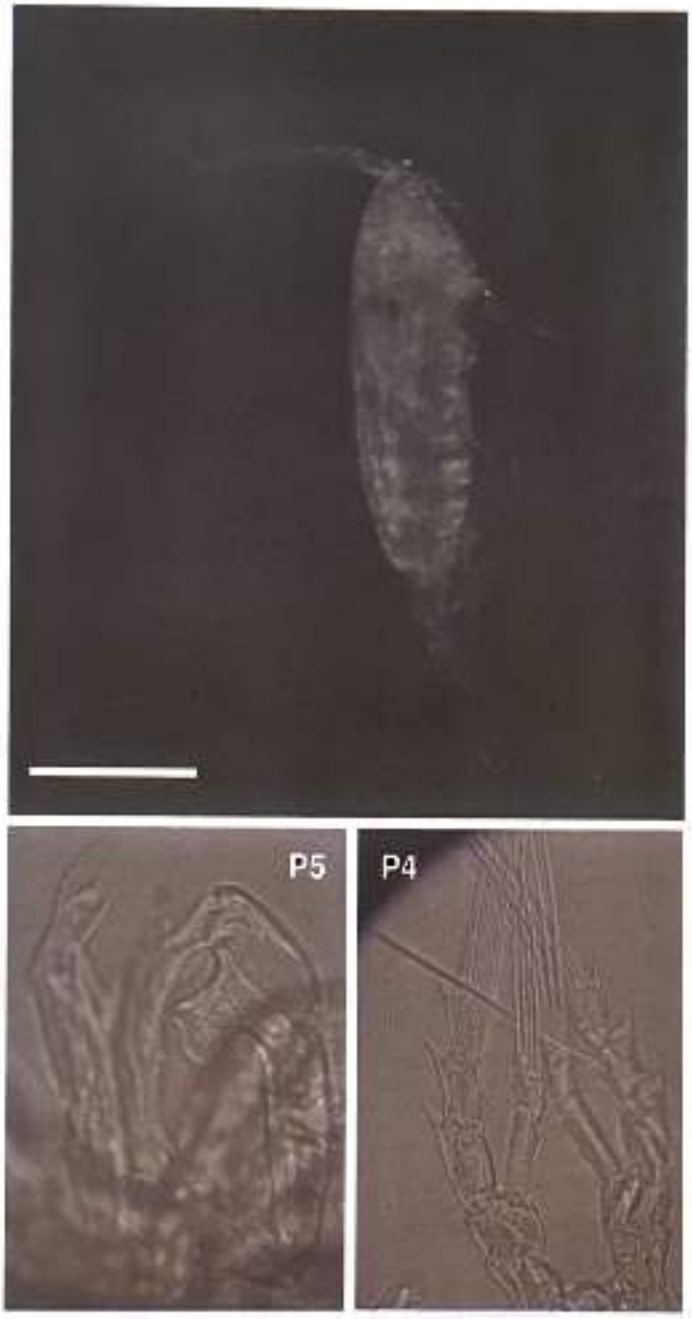

Figure 23. *Acartia* sp. Adult male, male fifth (P5) legs and fourth (P4) legs. Bar = 0.04 mm

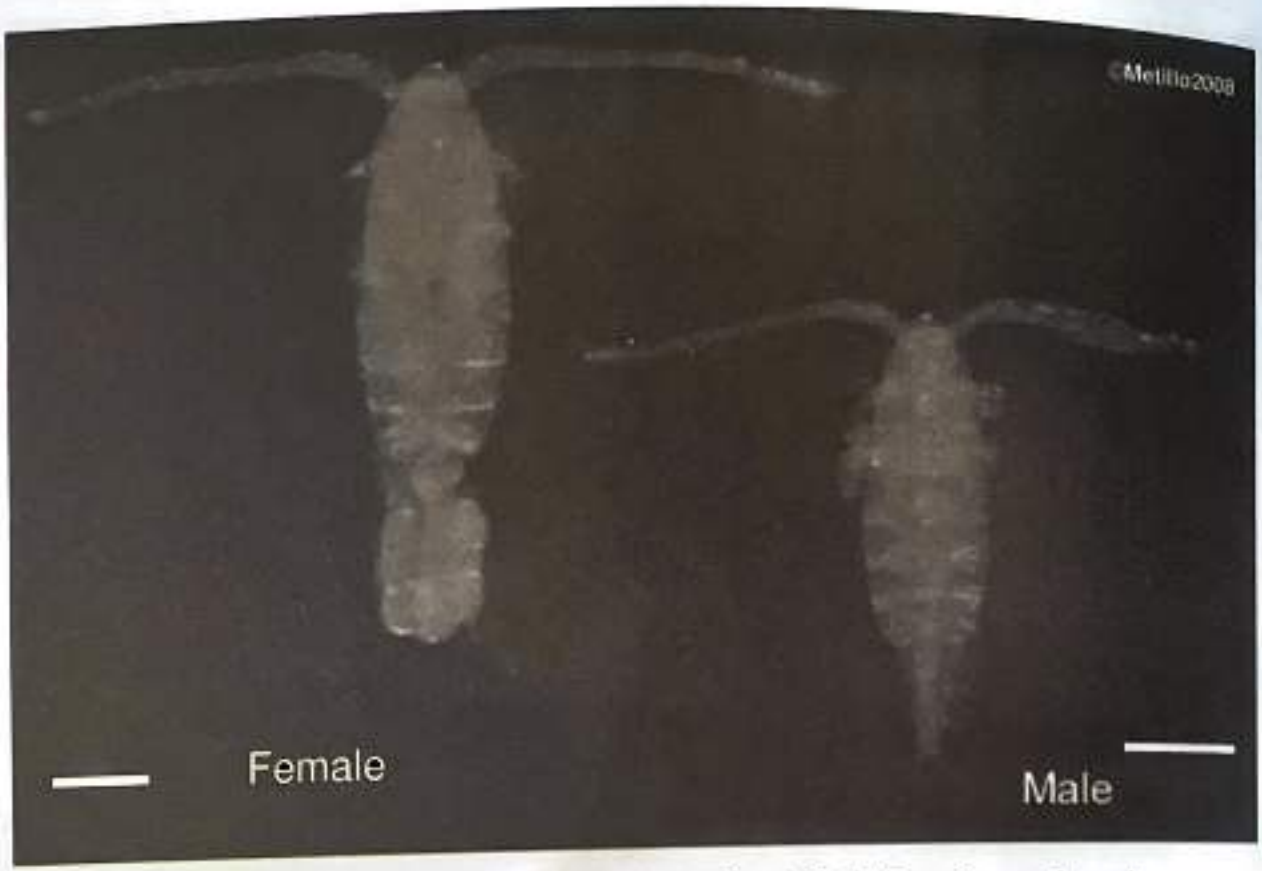

Figure 24. *Pseudodiaptomus philippinensis*. Adult female and male. Bar = 0.04 mm

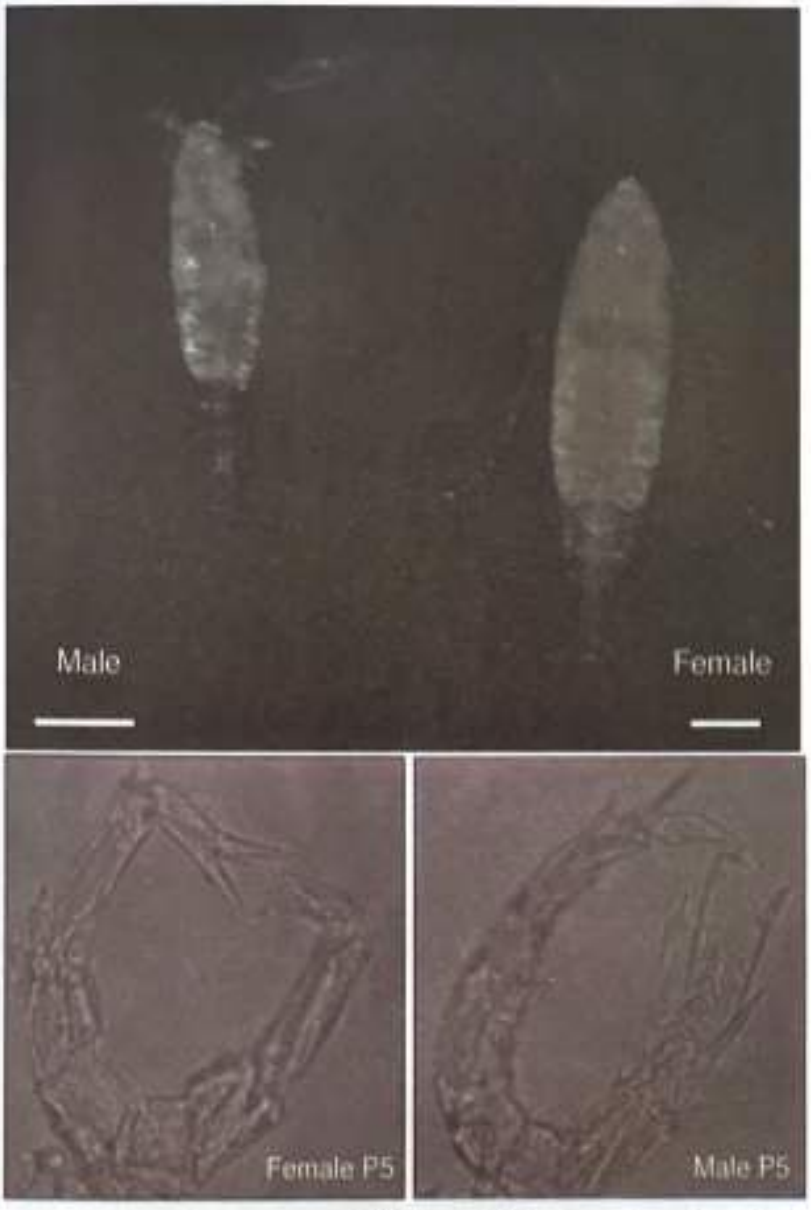

Figure 25. *Pseudodiaptomus diadelus.* Adult female and male. Male and female fifth (P5) legs. Bar = 0.04 mm

Figure 26. *Pseudodiaptomus annandalei*. Adult female. Bar = 0.04 mm

Figure 27. *Tortanus gracilis*. Adult female. Bar = 0.04 mm

Figure 28. *Tortanus mamadoensis*. Adult male. Bar = 0.04 mm

Figure 29. *Parvocalanus aculeatus*. Adult female. Bar = 0.04 mm

Figure 30. *Parvocalanus crassirostris.* Adult female individuals. Bar = 0.04 mm

Figure 31. *Acrocalanus gibber*. Adult female and fifth legs. Bar = 0.04 mm

Figure 32. *Acrocalanus gracilis*. Adult female. Bar = 0.04 mm

Figure 33. *Calocalanus pavo*. Adult female. Bar = 0.04 mm

Figure 34. *Pontella alata*. Adult male and female. Bar = 0.75 mm

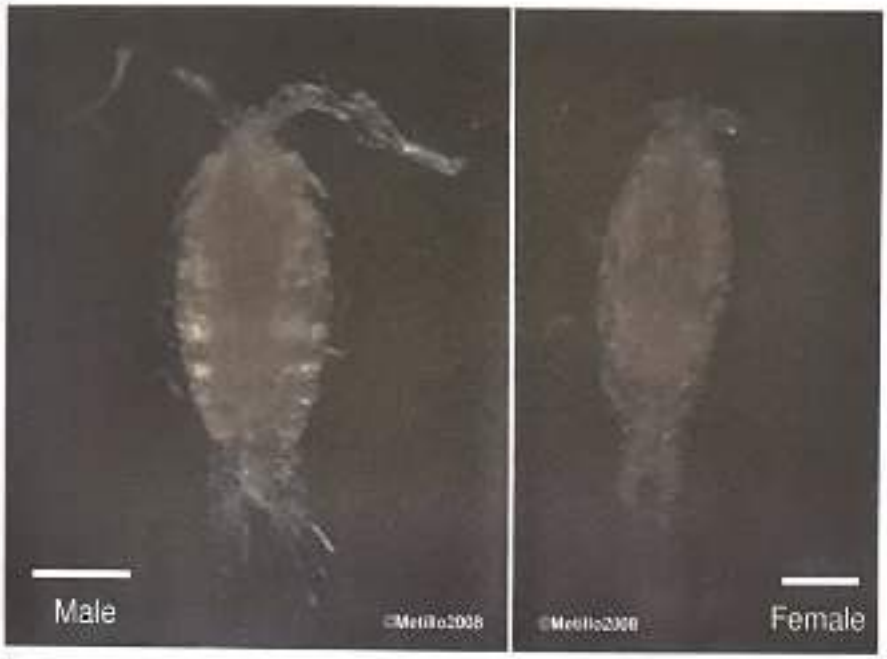

Figure 35. *Pontellina plumata*. Adult male and female. Bar = 0.04 mm

Figure 36. *Calanopia thompsoni*. Adult female. Bar = 0.25 mm

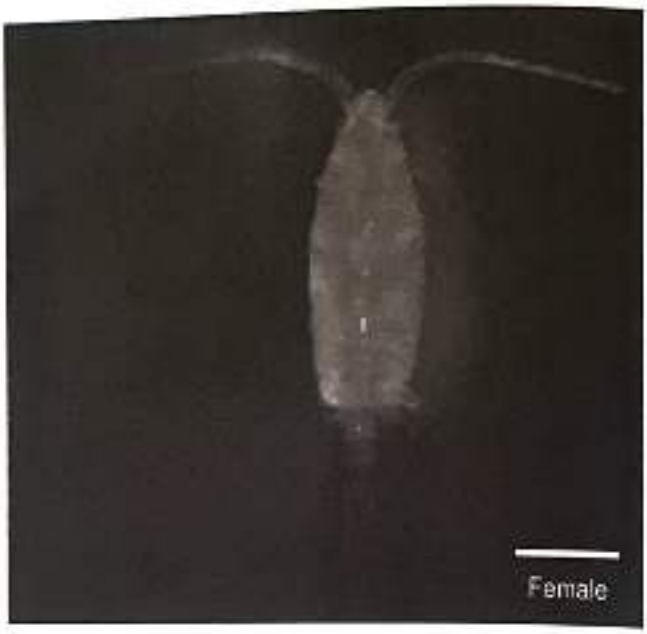

Figure 37. *Calanopia australica*. Adult female. Bar = 0.05 mm

Figure 38. *Labidocera acuta*. Adult female. Bar = 0.04 mm

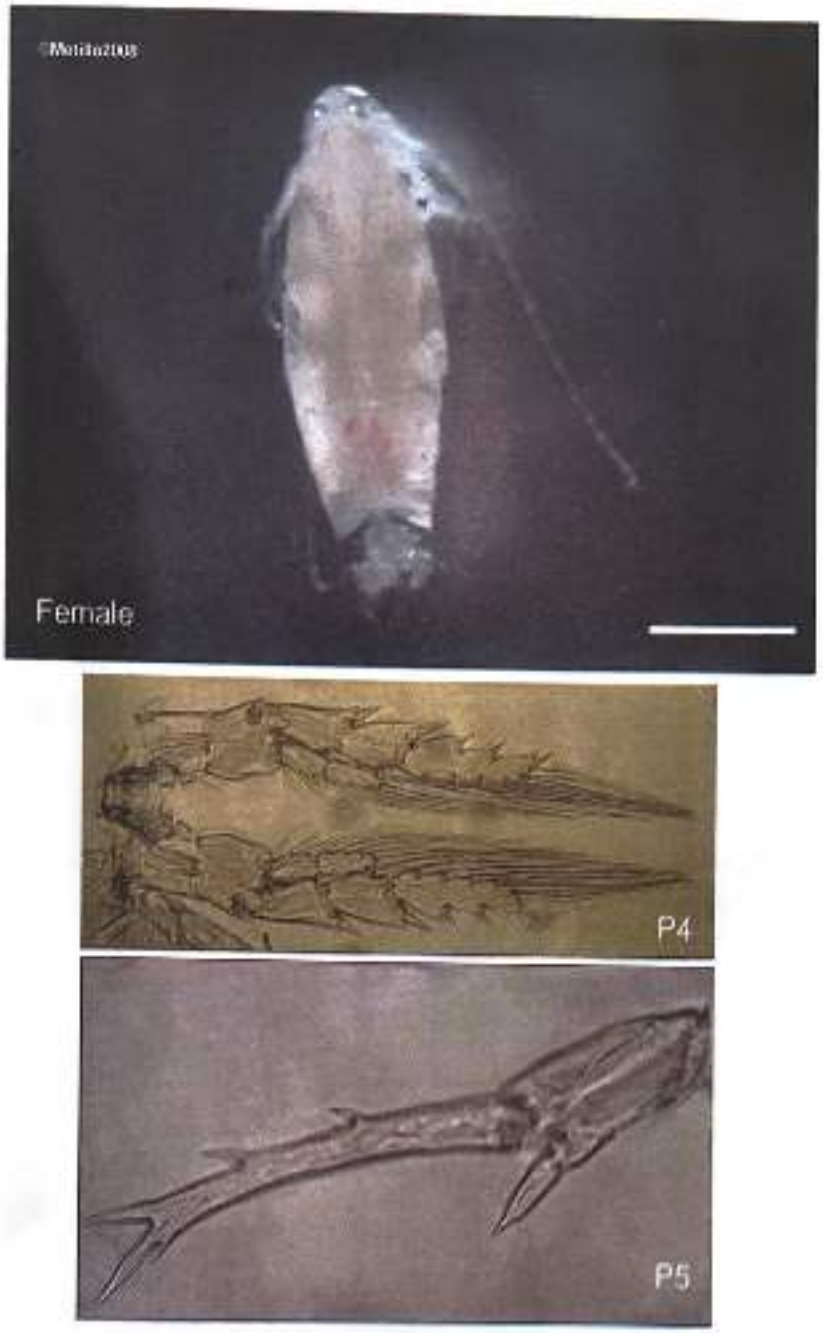

Figure 39. *Labidocera bataviae*. Adult female, female fourth (P4) legs, and fifth (P5) leg. Bar = 0.04 mm

Figure 40. *Labidocera detruncata*. Adult female individuals. Bar = 0.25 mm

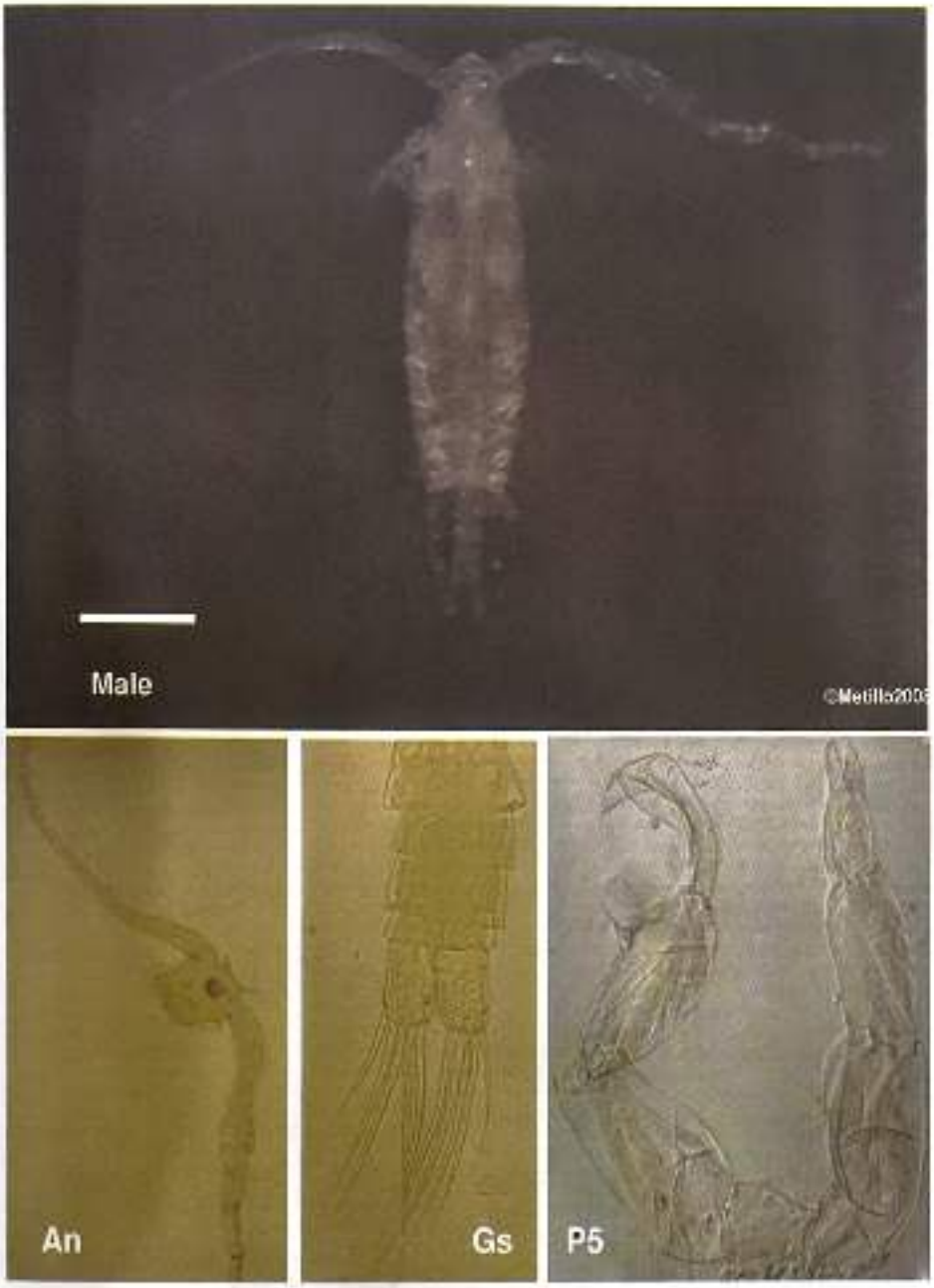

Figure 41. *Lebidocera minuta*. Adult male. Male antennules (An), gonadal segment (Gs), and fifth (P5) legs. Bar = 0.04 mm

Figure 42. *Temora turbinata*. Adult female. Bar = 0.04 mm

Figure 43. *Temora discaudata*. Adult female. Bar = 0.04 mm

Figure 44. *Temora stylifera*. Adult female individuals. Bar = 0.04 mm

Figure 45. *Lucicutia flavicornis*. Adult female. Bar = 0.04 mm

Figure 46. *Lucicutia curta*. Adult female. Bar = 0.04 mm

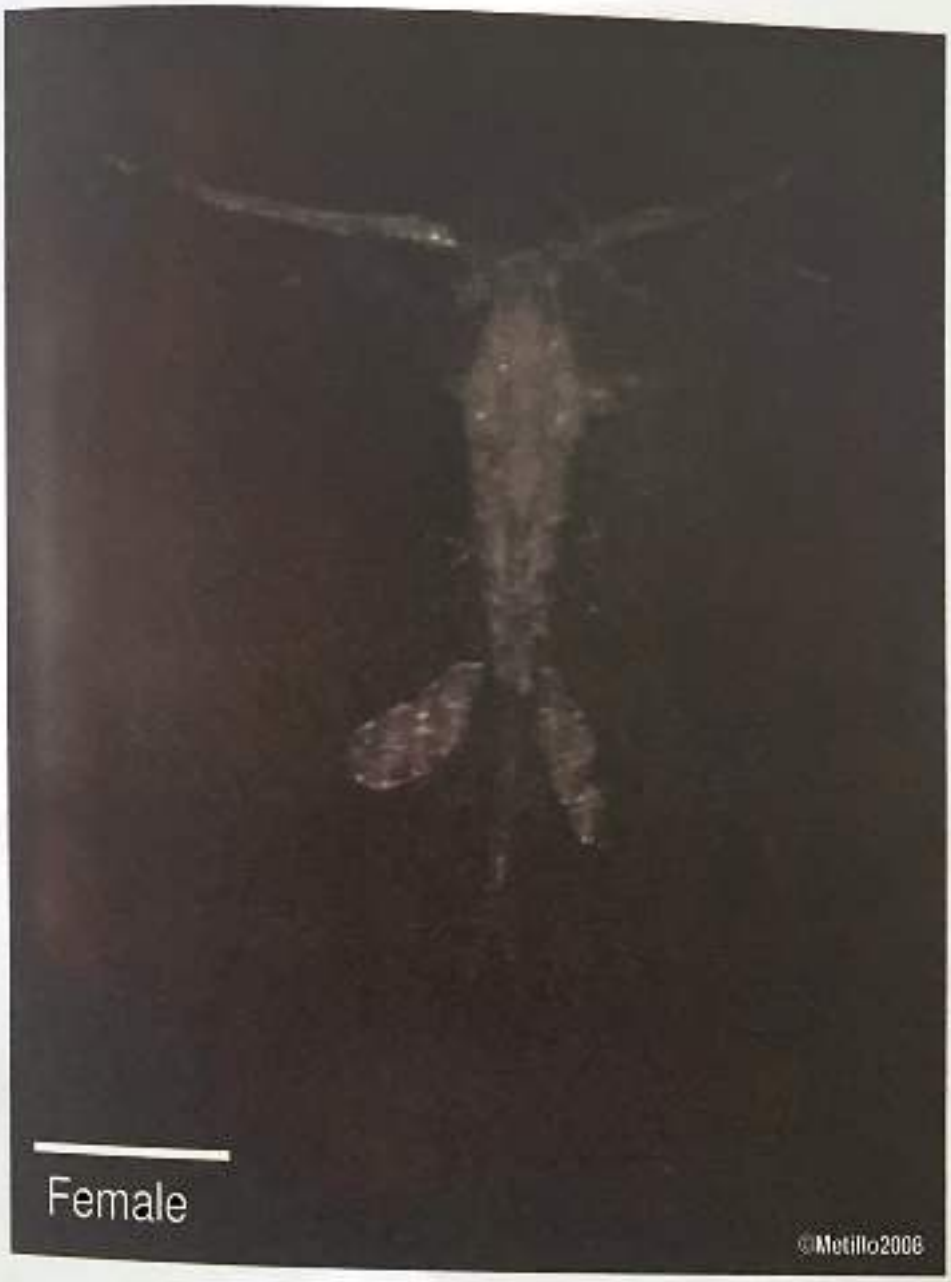

Figure 47. *Oithona oculata*. Adult female. Bar = 0.0 2 mm

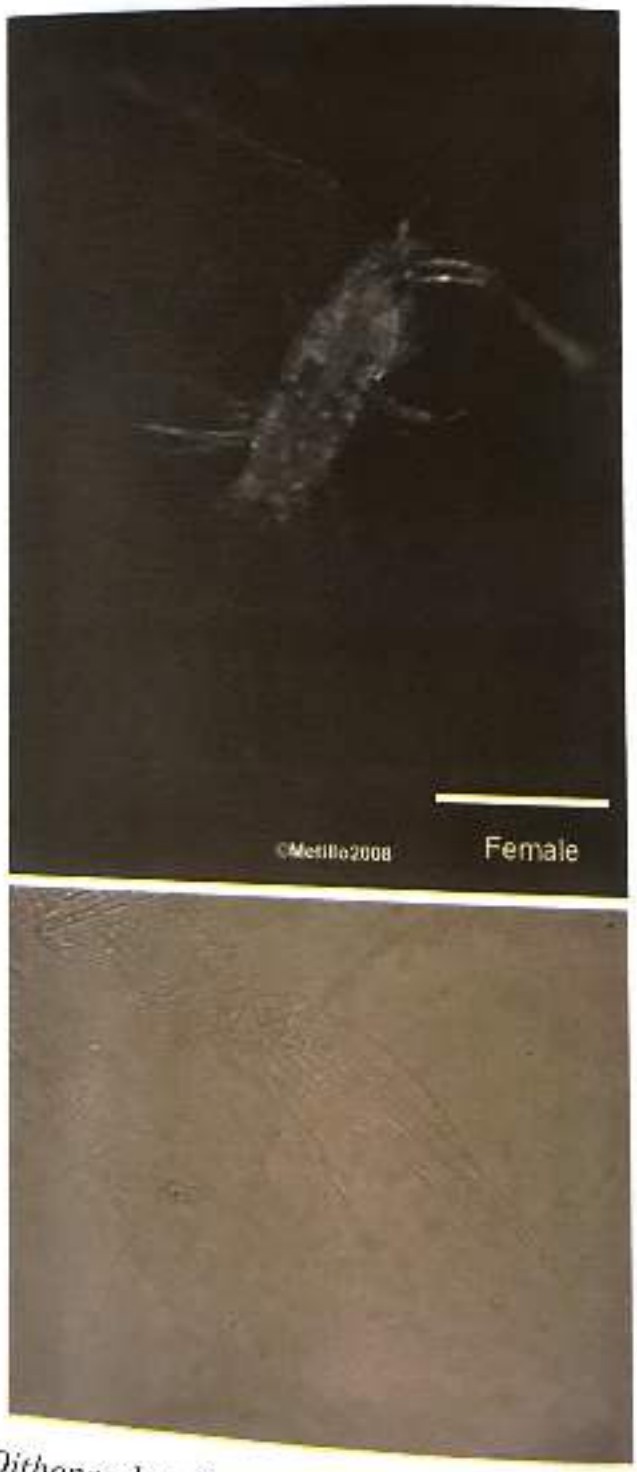

Figure 48. *Oithona plumifera*. Adult female, and fifth legs. Bar = 0.04 mm

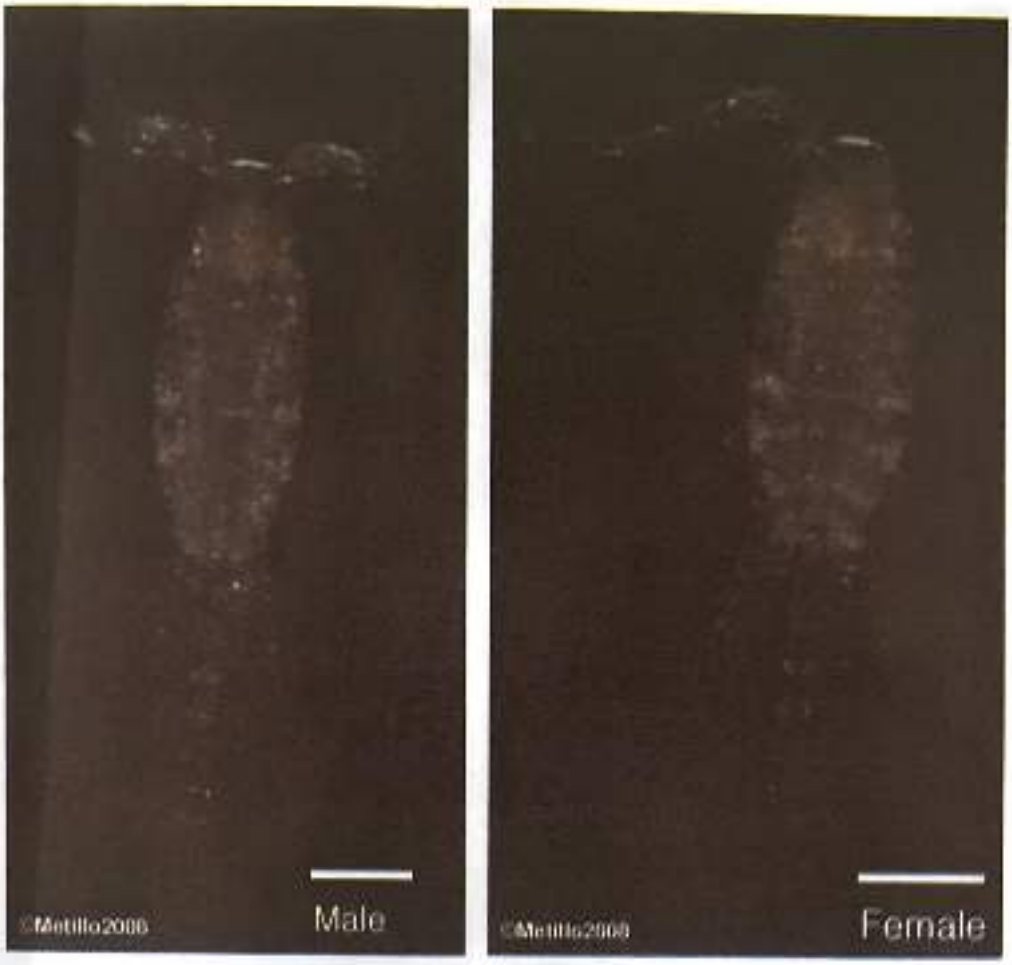

Figure 49. *Oithona tenuis*. Adult female and male. Bar = 0.04 mm

Figure 50. *Oithona setigera.* Adult female. Bar = 0.04 mm

Figure 51. *Farranula gibbula.* Adult female. Bar = 0.04 mm

Figure 52. *Corycaeus asiaticus*. Adult female. Bar = 0.04 mm

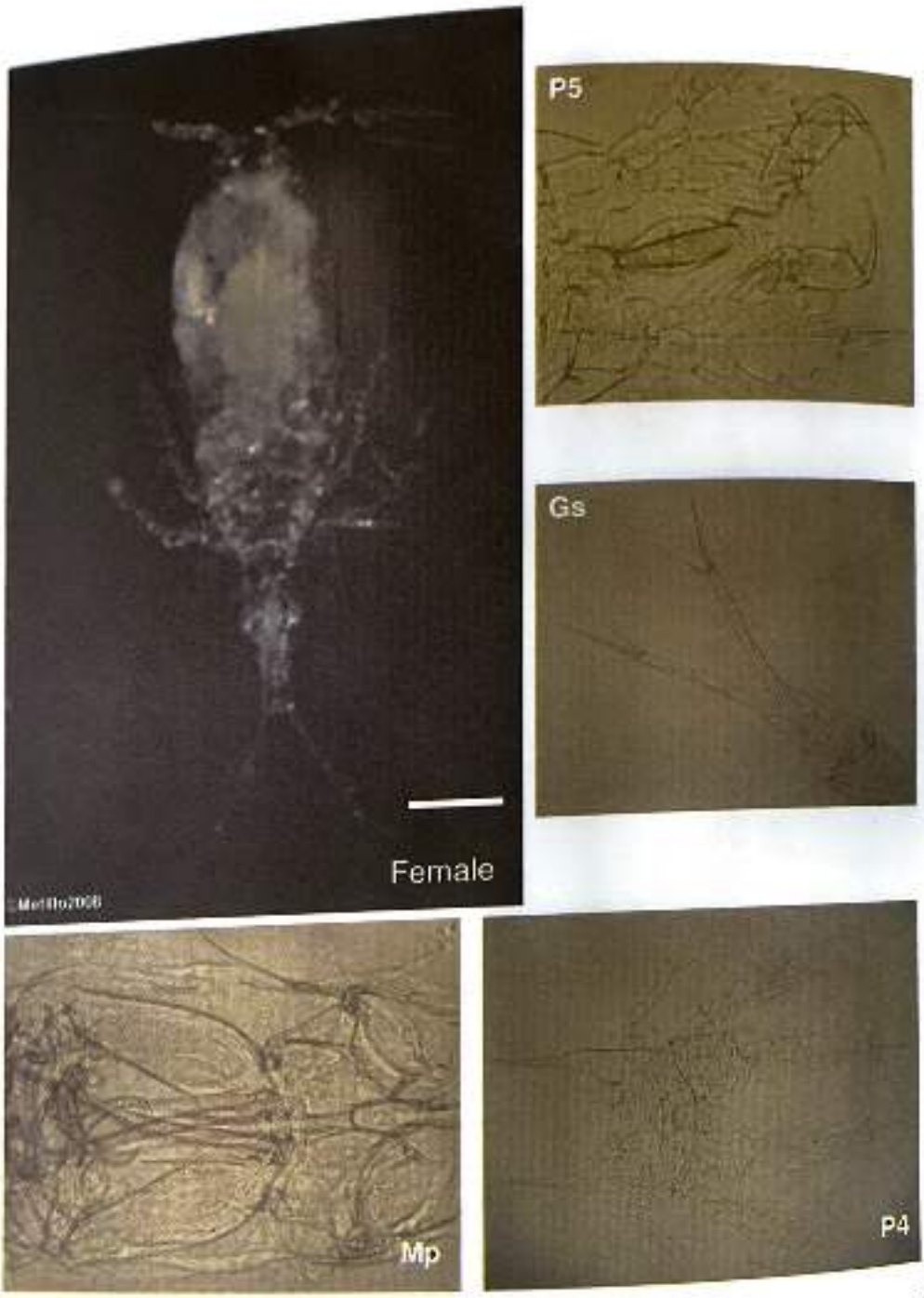

Figure 53. *Corycaeus speciosus.* Adult female. Fifth (P5) legs, gonadal segment (Gs), fourth (P4) egs, mouthparts (Mp). Bar = 0.04 mm

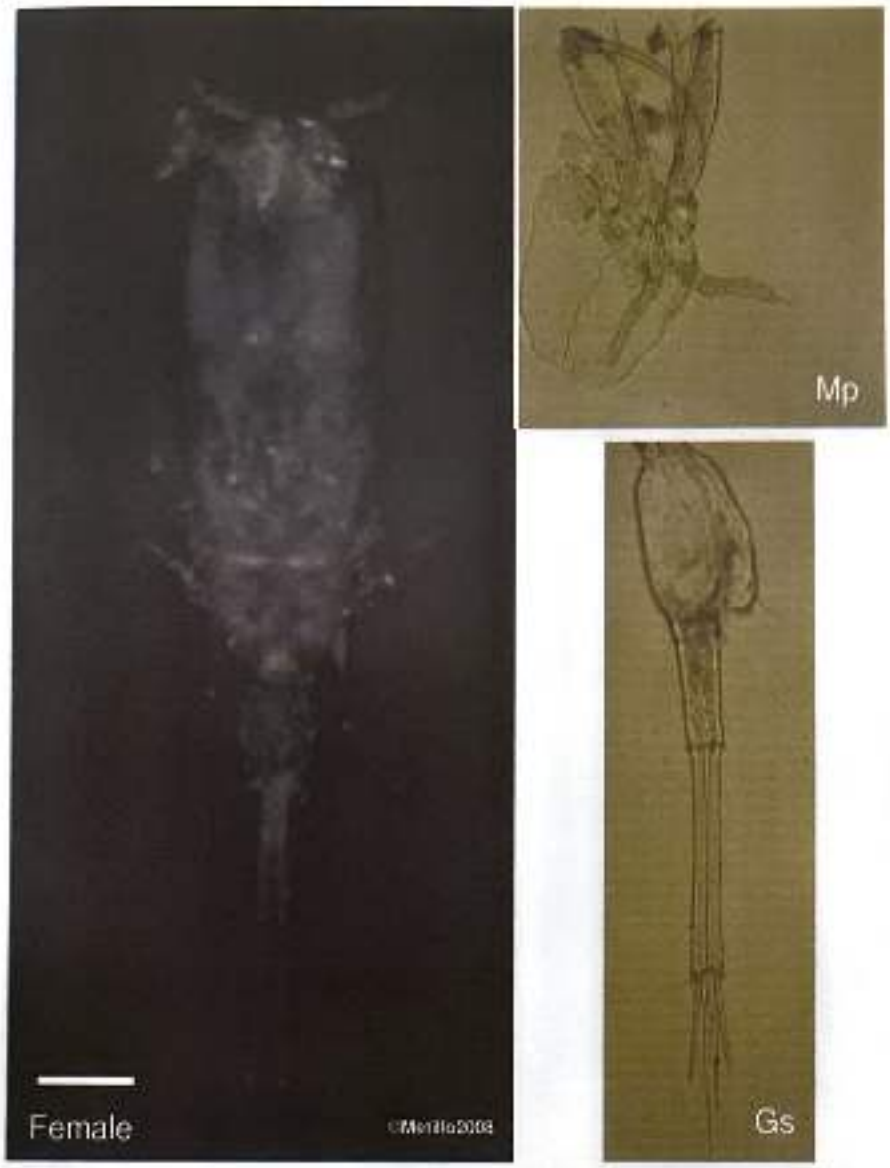

Figure 54. *Corycaeus longistylis*. Adult female, mouthparts (Mp), and gonadal segment (Gs). Bar = 0.04 mm

Figure 55. *Corycaeus crassiusculus*. Adult females. Bar = 0.04 mm

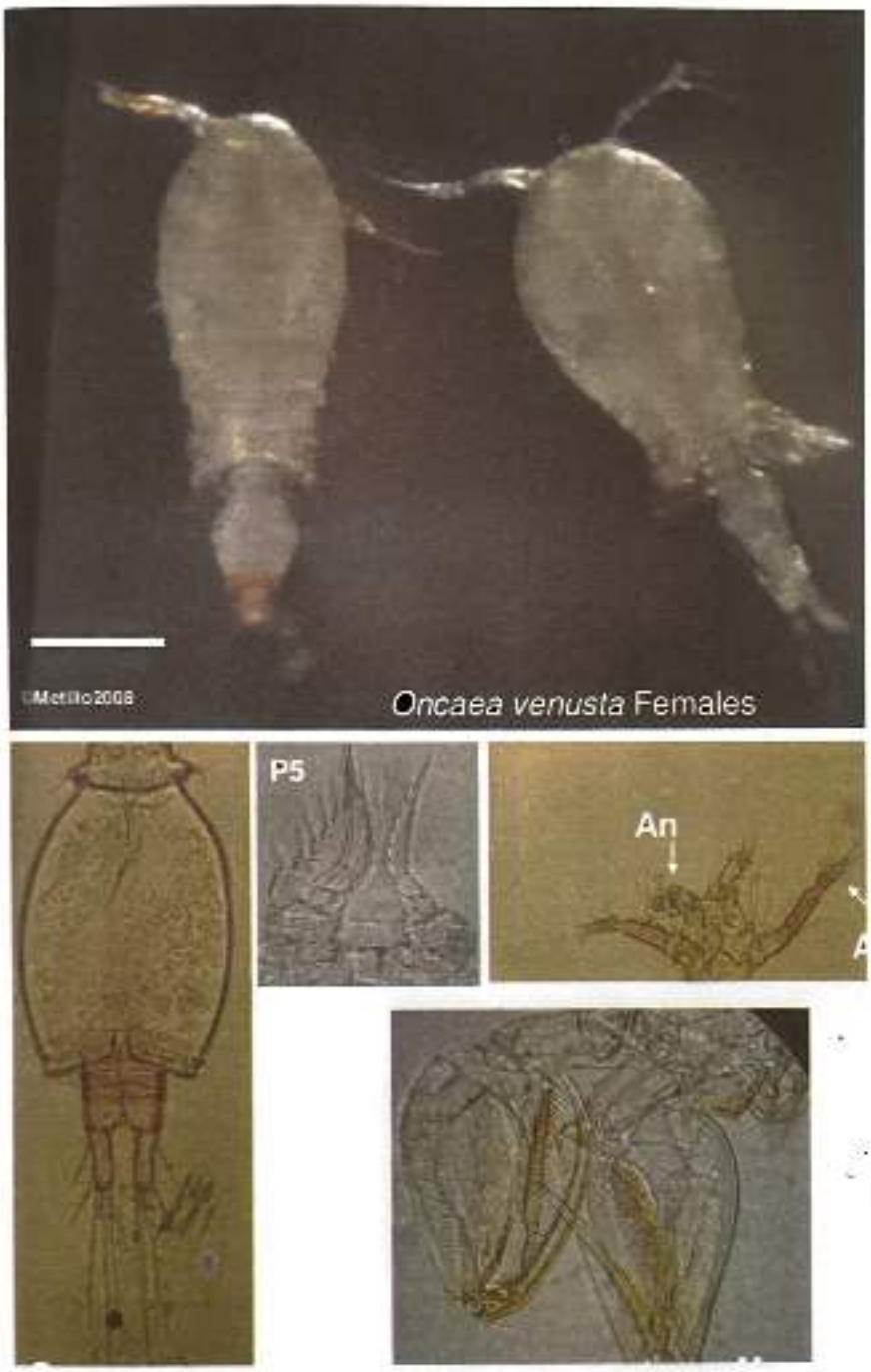

Figure 56. *Oncaea venusta*. Adult females, gonadal segment (Gs), antennules (An) and antennae (Ant), fifth legs (P5), and mouthparts (Mp). Bar = 0.04 mm

Figure 57. *Oncaea media*. Adult female. Bar = 0.04 mm

Figure 58. *Sapphirina metallina*. Adult female. Bar = 0.15 mm

Figure 59. *Sapphirina senuicauda.* Adult female. Bar = 0.15 mm

Figure 60. *Copilia mirabilis.* Adult female. Bar = 0.15 mm

Figure 61. *Euterpina acutifrons*. Adult female and male individuals. Bar = 0.04 mm

Figure 62. *Setella gracilis*. Adult female. Bar = 0.04 mm

Figure 63. *Microsetella norvegica*. Adult female. Bar = 0.04 mm

Figure 64. *Clymenestra scutellata*. Bar = 0.04 mm