UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO
POSGRADO EN CIENCIAS DEL MAR Y LIMNOLOGÍA

TAXONOMÍA, DIVERSIDAD Y DISTRIBUCIÓN DE LOS COPÉPODOS PELÁGICOS (CRUSTACEA, COPEPODA) DEL PACÍFICO MEXICANO

TESIS
QUE PARA OPTAR POR EL GRADO ACADÉMICO DE:
DOCTOR EN CIENCIAS
(BIOLOGÍA MARINA)

PRESENTA:
KARL EDWARD VELÁZQUEZ ORNELAS

TUTOR(A) O TUTORES PRINCIPALES:
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MAZATLÁN, SINALOA, JUNIO, 2024

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Taxonomía, diversidad y distribución de los copépodos pelágicos (Crustacea, Copepoda) del Pacífico mexicano

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Karl Edward Velázquez Ornelas
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ÍNDICE GENERAL

RESUMEN

Los copépodos son el grupo más abundante y diverso en sistemas pelágicos, y desempeñan un papel importante en el flujo de energía de las redes tróficas y el ciclo biogeoquímico de nutrientes. Se han registrado más de 200 especies de copépodos en el Pacífico mexicano, que puede dividirse en cuatro ecorregiones dentro de la zona económica exclusiva: el Pacífico Sur Californiano, el golfo de California, el Pacífico Transicional Mexicano y el Pacífico Medio Americano. El primer capítulo de este trabajo examina la variación latitudinal y estacional de los copépodos en el golfo de California, centrándose en la composición, abundancia, diversidad y longitud de las especies. Se encontró que el golfo de California se puede dividir en tres zonas según la variación latitudinal de los copépodos: norte, centro y entrada del golfo de California. Se observó una disminución de la diversidad hacia la entrada del golfo, donde predominan especies relativamente pequeñas y con hábitos depredadores, lo cual se relacionó principalmente con la estructura y abundancia del fitoplancton, influenciado a su vez por la salinidad. Aunque la composición fue similar entre ambas estaciones (cálida y fría), se registraron diferencias claras en las abundancias de la mayoría de las especies. En el segundo capítulo se describe la composición de especies a partir de muestras recolectadas en aguas profundas del golfo de California y el Pacífico Transicional Mexicano. Se planteó la hipótesis de que las capas inferiores a la zona de mínimo de oxígeno presentan una composición muy diferente a la zona epipelágica, debido a que la ZMO actúa como una barrera oceanográfica. Se identificaron un total de 36 especies características de ambientes batipelágicos o abisopelágicos, 25 de las cuales representan nuevos registros para el Pacífico mexicano. Se analizó también la variación espacial de estas comunidades: se encontraron diferencias entre las comunidades del golfo de California y del Pacífico Transicional Mexicano, mientras que la entrada del golfo fue una zona de transición entre ambas. Finalmente, el tercer capítulo actualiza la lista de copépodos pelágicos del Pacífico mexicano, considerando registros desde la actualización de 1998. En conjunto, los datos obtenidos en este estudio y en la literatura resultan en un total de 380 especies reportadas para el área de estudio, casi el doble del número reportado en 1998. Se determinó que, a nivel de especies, el golfo de California es similar al Pacífico Sur Californiano, aunque aún presenta suficientes diferencias para considerarse una ecorregión independiente. El Pacífico Medio Americano fue la ecorregión más distinta del resto del Pacífico mexicano, probablemente debido a su reducida superficie y la escasez de estudios realizados en ella.

ABSTRACT

The copepods constitute the most abundant and diverse group in pelagic systems, besides contributing significantly to the energy flow of food webs and the biogeochemical cycle of nutrients. More than 200 species of copepods have been recorded in the Mexican Pacific, which can be subdivided into four ecoregions within the exclusive economic zone: Southern Californian Pacific, Gulf of California, Mexican Pacific Transition, and Middle American Pacific. The first chapter addresses the latitudinal and seasonal variation of copepods in the Gulf of California, based on species composition, abundance, diversity, and length. It was determined that the Gulf of California can be subdivided into three zones according to the latitudinal variation of copepods: north, center, and entrance of the Gulf of California. It was observed that diversity decreases towards the entrance of the gulf, where relatively small species with predatory habits are found; this was mainly related to the structure and abundance of phytoplankton, influenced in turn by salinity. Although the composition was similar between both seasons (warm and cold), clear differences were observed in the abundances of most species. In the second chapter, the species composition is described based on material collected in deep waters of the Gulf of California and the Mexican Pacific Transition. It was hypothesized that layers below the oxygen minimum zone present a composition very different from that of the epipelagic zone, as the OMZ acts as an oceanographic barrier. A total of 36 species were determined to be characteristic of bathypelagic or abyssopelagic environments. Of these, 25 represent new records for the Mexican Pacific. The spatial variation of these communities was also analyzed, identifying differences between the communities of the Gulf of California and the Mexican Pacific Transition, with the gulf entrance being a transition zone between both. Finally, the third chapter is an update of the list of pelagic copepods of the Mexican Pacific, considering records made since the 1998 updated checklist. Together, the data obtained in this study and those obtained from the literature result in a total of 380 species reported for the study area. This number is almost twice as high as that reported in 1998. It was determined that, at the species level, the Gulf of California is similar to the Southern Californian Pacific, although it still presents enough differences to be considered as an independent ecoregion. The Middle American Pacific was the most distinct ecoregion from the rest of the Mexican Pacific, probably due to its reduced surface area and the few studies that have been conducted in there.

I. INTRODUCCION

Los copépodos son crustáceos relativamente pequeños, cuya longitud (en formas de vida libre) va, generalmente, de 0.5 a 3.0 mm. Conforman uno de los grupos biológicos más importantes por su contribución a la biomasa del zooplancton, su papel en la red trófica de ecosistemas marinos y limnéticos y su actividad en el ciclo del carbono a nivel global (Reid y Williamnson 2010; Jónasdóttir et al. 2015). La subclase Copepoda Edwards, 1840, junto con los Thecostraca Gruvel, 1905 (tecostráceos: percebes y bellotas de mar) y Tantulocarida Boxshall y Lincoln, 1987 (tantulocáridos: pequeños parásitos de otros crustáceos) conforman la clase Hexanauplia Oakley, Wolfe, Lindgren y Zaharoff, 2013. Se reconocen actualmente 10 órdenes (Khodami et al. 2017), de los cuales los más comunes y diversos en ambientes pelágicos son Calanoida Sars, 1903, Cyclopoida Burmeister, 1834 y Harpacticoida Sars, 1903. Otros grupos como los Siphonostomatoida Burmeister, 1835 o los Monstrilloida Sars, 1901 son predominantemente ecto o endoparásitos de otros organismos (Morales-Serna et al. 2012).

La riqueza de la subclase Copepoda está constituida por alrededor de 14,000 especies descritas, de las que la mayor parte (≈ 80%) habitan ecosistemas marinos (Boxshall y Defaye 2008; Reid y Williamnson 2010). Por la gran diversidad de formas y hábitos que presentan (Benedetti et al. 2016), los copépodos han colonizado prácticamente todo tipo de ecosistemas acuáticos, incluyendo los océanos polares (Palomares-García et al. 1998). Su distribución incluye además hábitats relativamente inaccesibles, como los cuerpos de agua hipogeos, charcos de alta montaña o la fitotelmata (conjunto de pequeños cuerpos de agua en plantas epífitas o cavidades en troncos) (Reid y Williamson 2010). En las masas de agua oceánicas, los copépodos comprenden hasta el 80% de la biomasa del mesozooplancton (Chen 1986; Buitenhuis 2006).

Los copépodos calanoides (Calanoida) componen la mayor parte del mesozooplancton (organismos cuyas tallas van de 0.2 a 2.0 mm) y tienen un papel ecológico fundamental como vínculo en el transporte energético dentro de la red trófica y en el depósito de materia orgánica sobre el fondo oceánico mediante la excreción de material fecal ("fecal pellets") (Yamaguchi et al. 2015). Este es el grupo de copépodos planctónicos más diverso, tanto a nivel de familia como a nivel de género, con 26 familias y 78 géneros registrados en aguas mexicanas (Suárez-Morales y Gasca 1998). En la región del Pacífico Norte, los copépodos omnívoros de talla grande dominan la estructura de las comunidades, tales como las especies de los géneros *Neocalanus* Sars, 1925, *Eucalanus* Dana, 1852 y *Metridia* Boeck, 1865

(Kobari et al. 2003). Cerca del 68% (325) de las 478 especies de copépodos registradas en aguas mexicanas (en las costas del Pacífico y el golfo de México) pertenecen al orden Calanoida, representado principalmente por las familias Acartiidae Sars, 1903, Aetideidae Giesbretch, 1892, Calanidae Dana, 1849, Centropagidae Giesbretch, 1893, Euchaetidae Giesbretch, 1893 y Pontellidae Dana, 1852 (Suárez-Morales y Gasca 1998). Géneros como *Acartia* Dana, 1846, *Centropages* Kroyer, 1849 o *Nannocalanus* Sars, 1925 suelen conformar una gran proporción de las comunidades de copépodos pelágicos en aguas del Pacífico mexicano (Jiménez-Pérez 2016).

Los ciclopoides (Cyclopoida), aunque menos abundantes y diversos en aguas marinas, también pueden representar una gran proporción del zooplancton marino, esto en particular por la presencia de algunos géneros como *Oithona* Baird, 1843, *Oncaea* Philippi, 1843 y *Corycaeus* Dana, 1845 (Paffenhöfer 1993; Nielsen y Sabatini 1996). Sin embargo, debido a que los copépodos ciclopoides suelen presentar tamaños más reducidos que los calanoides (menos de 1.0 mm de longitud total, y de 0.2 a 0.3 mm de ancho), es común que en las muestras disponibles se subestimen la abundancia y la riqueza real de este grupo, pues se suelen utilizar redes con aperturas de malla mayores que 200 µm (Nielsen y Sabatini 1996). En México, el grupo Cyclopoida está representado por alrededor de 100 especies en aguas marinas mexicanas, siendo *Oithona* el género mejor representado (Suárez-Morales y Gasca 1998). Este número incluye a las especies del orden Poecilostomatoida Thorell, 1859, que actualmente es considerado como un taxón dentro del orden Cyclopoida (Khodami et al. 2017).

Los harpacticoides (Harpacticoida) presentan también una riqueza elevada, incluso más que la de los calanoides. Sin embargo, debido a que son predominantemente de hábitat bentónico, no suelen estar bien representados en muestreos basados en arrastres pelágicos. Suárez-Morales y Gasca (1998) mencionan que hay registradas al menos 36 especies en aguas mexicanas, aunque este número debería ser más alto. Por ejemplo, en aguas del Caribe y de América Central, Reid (1990) registró hasta 211 especies de este grupo. En el trabajo de Hernández-Trujillo et al. (2004) se registraron, solo en la bahía de Magdalena, seis especies pelágicas. De estas, mencionan que *Euterpina acutifrons* Dana, 1847 fue la más abundante y frecuente. De acuerdo con el catálogo de Palomares-García et al. (1998), las familias de harpacticoides pelágicos registradas en el Pacífico mexicano son Ectinosomatidae Sars, 1903, Miraciidae Dana, 1846 y Peltidiidae Claus, 1860. Además, se han realizado trabajos sobre la riqueza del grupo en sistemas batipelágicos, como los de Gómez (2018a) y Gómez (2018b).

Otro grupo que puede encontrarse en la zona pelágica son los monstriloides (Monstrilloida), copépodos endoparásitos en etapas juveniles que presentan etapas adultas de vida libre (Suárez-Morales 2011). Es posible obtener representantes de este grupo en muestras de zooplancton. Entre los trabajos publicados para el Pacífico oriental sobre los monstriloides está el de Suárez-Morales y Palomares-García (1995), en el cual se describe a *Monstrilla gibbosa* Suárez-Morales y Palomares-García, 1995, recolectada en una laguna costera en la parte media del golfo de California. El número de especies de monstriloides registradas en el Pacífico mexicano es de aproximadamente 12, es decir, 10% de las más de 160 especies descritas actualmente de este grupo a nivel mundial (Suárez-Morales y Gasca 1998; Suárez-Morales 2011; Walter y Boxshall 2024). Es muy probable que la riqueza real de especies de monstriloides sea mucho más alta, debido a que los métodos de muestreo para especies pelágicas no consideran, por ejemplo, formas de vida parasíticas.

La diversidad de copépodos pelágicos en el Pacífico mexicano ha sido bien estudiada. Se han efectuado numerosos trabajos sobre la composición de especies, incluyendo descripciones, redescripciones, claves y diagnosis ilustradas que, al ser resultado de un trabajo de varios años, han logrado representar de manera adecuada la diversidad que posee este grupo biológico. Sin embargo, el material que se ha trabajado generalmente ha sido obtenido de profundidades menores a 500 m, por lo que una parte considerable de la fauna de copépodos a profundidades mayores es desconocida. La variación en la distribución vertical de estos organismos es bastante notable debido a fuertes gradientes en incidencia de luz, temperatura, oxígeno disuelto y salinidad, entre otras variables, y se han observado patrones marcados de distribución de acuerdo con el ciclo día-noche y la estratificación de los niveles de oxígeno del agua (Loeb y Nichols 1984; Longhurst 1985; Saltzman y Wishner 1997). Entre los principales factores que determinan la distribución vertical de las comunidades de copépodos se incluyen la disponibilidad de alimento y la depredación (Liu 2003). También hay una influencia de la temperatura y de la disponibilidad de alimento sobre el tamaño medio de los copépodos en su fase adulta (Brun et al. 2016).

Las aglomeraciones más densas de copépodos han sido reportadas en la zona superficial de la columna de agua, aunque a ciertas profundidades pueden observarse incrementos después de pasar el límite de la Zona del Mínimo de Oxígeno (ZMO), por ejemplo, después de 800 m de profundidad (Dias et al. 2018). Ciertas especies de copépodos funcionan como indicadores biológicos de las condiciones de las masas de agua, aunque en otros casos, debido a la capacidad que tienen estos organismos para desplazarse verticalmente, no es fácil asociar la presencia/ausencia de especies a determinadas variables ambientales. Algunas especies de copépodos pelágicos se asocian a condiciones particulares del ambiente y se sabe que muchas especies zooplanctónicas pueden permanecer en un área específica de acuerdo a las condiciones de la misma (Björberg 1981; Palomares-García et al. 1998). Los copépodos pelágicos pueden clasificarse en dos grupos de acuerdo con sus hábitos de movilidad: 1) especies con migraciones verticales bajas o moderadas y 2) especies con migraciones verticales amplias, muy notorias (Morales-Ramírez y Suárez-Morales 2009).

El Pacífico Este es la región marina donde la ZMO es la más amplia y la más intensa a nivel mundial. En el caso del Pacífico mexicano, grandes extensiones (i.e., el golfo de California central y sur; la parte sur de la costa oeste de la península de Baja California; el SW de México) presentan condiciones de hipoxia severa o -incluso- de anoxia, entre 50-150 m (límite superior de la ZMO) y 800-1200 m de profundidad (límite inferior de la ZMO) (Hendrickx y Serrano 2010; Papiol et al. 2016). Debido a este fenómeno natural y a la particularidad de las masas de agua del Pacífico mexicano, la ZMO representa un ambiente hostil para muchas especies pelágicas y bentónicas (Hendrickx y Serrano 2014). Por lo anterior, en las áreas donde ocupa parte de las franjas epi-mesopelágicas, la ZMO puede ser un factor determinante sobre la composición de las comunidades planctónicas y nectónicas (Hendrickx 2015, 2016). Hidalgo et al. (2005) proponen que el permanecer en la ZMO supone una ventaja para ciertas especies debido a un menor consumo energético bajo condiciones de bajo oxígeno y una menor probabilidad de depredación. En este mismo trabajo observaron que *Eucalanus inermis* Giesbrecht 1893 se asocia con la ZMO de forma que puede realizar migraciones verticales rápidas hacia aguas más oxigenadas. De acuerdo con Escribano et al. (2009) se ha observado que, por ejemplo, *Subeucalanus mucronatus* Giesbrecht, 1888 se adaptó para cambiar su metabolismo a anaerobio bajo condiciones de hipoxia, a diferencia de especies como *Calanus chilensis* Brodsky, 1959, que posee una limitada capacidad de utilizar energía en estas condiciones. La ZMO representa una barrera oceanográfica importante e, incluso, se ha observado que en especies como *Calanus helgolandicus* Claus, 1863 se presenta un aislamiento genético evidente entre poblaciones que se encuentran en aguas someras y profundas (Figueroa et al. 2019). En ese mismo trabajo observaron que los copepoditos V (5° estadio) de *C. helgolandicus* son el componente dominante del zooplancton, lo cual sugiere una probable adaptación ontogénica en respuesta a las variables ambientales. Al ser la ZMO tan amplia en las aguas del Pacífico mexicano, es probable que la distribución vertical de muchas especies presente una clara restricción con respecto a esta, o, dicho de otra forma, es muy probable que el incremento del esfuerzo de muestreo en zonas profundas del Pacífico mexicano resulte en la observación de taxones que no habían sido registrados previamente en aguas Mexicanas, como ha sido el caso con algunas especies de Mysida y algunos grupos de camarones pelágicos (Hendrickx 2015; Hendrickx y Hernández-Payan 2020).

Entre los métodos que actualmente permiten comprender e interpretar mejor la variación espacio-temporal de estas comunidades están los análisis de datos que consideran como variables la biomasa, los intervalos de talla, la diversidad funcional y ecológica o bien, aspectos genéticos y moleculares de las poblaciones o comunidades (Knutsen et al. 2001; Rombouts et al. 2009; Benedetti et al. 2016; Brun et al. 2016; Kozak et al. 2020). Si los datos lo permiten, en función del diseño del muestreo, es posible evaluar el impacto que tiene este grupo biológico sobre otros taxones dentro de las comunidades naturales, así como medir el impacto del ambiente o de las actividades humanas sobre sus poblaciones. En contraste, la mayoría de los trabajos sobre copépodos en el Pacífico se han realizado con datos de biomasa, dada la relativa facilidad para la obtención de muestras, pero en pocos se ha logrado determinar a los organismos a nivel de especie, por lo que se conoce poco sobre la composición de las comunidades de copépodos pelágicos en esta área (Yamaguchi et al. 2015).

Una amplia proporción de los trabajos realizados en territorio mexicano representan superficies marinas relativamente pequeñas (e.g., Jiménez-Pérez 1992; Álvarez-Silva et al. 2003; Kozak et al. 2014b; Franco-Gordo et al. 2015; Kozak et al. 2020), por lo que la distribución de muchas especies de copépodos en aguas mexicanas es todavía imprecisa. Hasta 1990 se tenía el registro de 167 especies de copépodos en aguas mexicanas (Pacífico y golfo de México) (Reid 1990). Gracias a los estudios realizados en las provincias golfo de California (GC), Pacífico sudcaliforniano (PSC) y Pacífico transicional mexicano (PTM), se han registrado aproximadamente 300 especies, que representan poco menos del 4% de la riqueza conocida de copépodos (Palomares-García et al. 1998; Suárez-Morales y Gasca 1998; Palomares-García et al. 2018). De acuerdo con Suárez-Morales y Gasca (1998), la comunidad de copépodos pelágicos del golfo de California incluyó, hasta ese momento, 154 especies. No se ha establecido de manera clara si hay un patrón en la distribución de los copépodos en relación a las provincias zoogeográficas reconocidas para el área de estudio, y es probable que este sea ligeramente distinto al que presentan otros grupos biológicos. Por ejemplo, en el caso de los peces, con los que se han elaborado algunas propuestas de cómo se subdivide el Pacífico mexicano, por ejemplo, las propuestas de Robertson y Cramer (2009) y Briggs y Bowen (2012) sobre la base de la distribución de peces en el Pacífico este tropical y a nivel mundial, respectivamente.

Debido a lo mencionado anteriormente, el presente trabajo tiene como objetivo analizar la variación espacial y temporal de la comunidad de copépodos pelágicos del Pacífico mexicano sobre la base de los datos relacionados con su composición, su abundancia y su diversidad, obtenidos por medio de arrastres con redes de zooplancton y micronecton efectuados en las campañas oceanográficas CORTES 1, 2 y 3, SIPCO I, II, y III, GEOBALIN, CEEMEX-P4, CEEMEX-P5. Este material es representativo de la fauna planctónica de las provincias zoogeográficas Californiana, Cortesiana, Mexicana y Panámica (México). Además, se cuenta con una amplia colección de muestras obtenidas de aguas profundas que han sido recolectadas en los últimos 30 años en el golfo de California y a lo largo del Pacífico mexicano (campañas TALUD I-XVI). Con ello, se pretende contribuir de manera significativa al conocimiento de este grupo en el Pacífico mexicano y permitir comparar la variación espacial y temporal de los copépodos pelágicos observada en este trabajo con lo reportado en estudios realizados en contextos espaciales y temporales distintos. Este trabajo también supone una base sólida para estudiar el cambio de la comunidad de copépodos en años futuros y así determinar los efectos del cambio climático sobre el grupo.

II. ANTECEDENTES

En el Pacífico Este se han llevado a cabo numerosos trabajos para determinar la riqueza de copépodos de esta región. Por ejemplo, hay una serie de trabajos pioneros realizados por Esterly (1905, 1906, 1911, 1912, 1913, 1924) sobre aspectos relacionados con la composición, la distribución y la taxonomía de los copépodos pelágicos en el área de San Diego, California. Posteriormente, se hicieron varios trabajos importantes en el contexto regional. Heinrich (1960), Grice (1961) y Fleminger (1964, 1967) trataron la distribución y la diversidad del grupo desde la zona tropical-ecuatorial hasta la zona donde se origina la corriente de California. Bowman y Johnson (1973) analizaron la distribución de los calanoides en la región de la corriente de California. Zamora-Sánchez (1974) fue pionera en la descripción de especies de copépodos en el golfo de California, con el género *Acartia*. Fleminger (1975) logró diferenciar a los pontélidos del golfo de California y los de la corriente de California a través de divergencias morfológicas.

Peterson et al. (1979) fueron pioneros en el estudio del grupo en zonas altamente dinámicas, tales como las zonas de surgencias, así como en el estudio de los mecanismos de adaptación que les permiten mantenerse como población. Por su parte, Alameda (1980) publicó un registro taxonómico de los copépodos pelágicos del Pacífico mexicano, con énfasis en el golfo de Tehuantepec. En el mismo año, McGowan y Miller (1980) llevaron a cabo un estudio sobre la ecología de la comunidad de copépodos y otros grupos, incluyendo larvas de peces pelágicos, empleando datos de la organización CalCOFI. Loeb et al. (1983) abordaron el estudio del patrón de abundancia de algunas especies de copépodos en la región de la corriente de California. Hernández-Trujillo (1984) llevó a cabo un estudio sobre la riqueza y la distribución de copépodos pelágicos frente a bahía Magdalena, en la cosa oeste de Baja California Sur. Chen (1986) analizó la estructura en la distribución vertical de los copépodos en el Pacífico Este Tropical y encontró 140 especies de calanoides.

Fleminger (1983) publicó la descripción de *Isaacsicalanus paucisetus* Fleminger, 1983, descubierta en material recolectado en las cercanías de las ventilas hidrotermales frente a Cabo Corrientes, Jalisco. Por otra parte, Zamora-Sánchez y Gómez-Aguirre (1985) describieron una especie nueva del subgénero *Acartia* (*Acanthacartia*) Steuer, 1915, *A.* (*A.*) *bacorehuiensis* Zamora-Sánchez y Gómez-Aguirre, 1985, recolectada en la laguna de Agiabampo, Sonora. Cervantes-Duarte y Hernández-Trujillo (1989) analizaron la relación entre las características hidrográficas y la comunidad de copépodos en la costa occidental de Baja California. En la misma zona (costa occidental de Baja California), Hernández-Trujillo

(1989a, 1989b) realizó trabajos donde enlistó las especies presentes en la zona y las relaciones interespecíficas y del grupo con las condiciones ambientales locales. Por su parte, Walter (1989) introdujo nuevos criterios para la identificación de especies de copépodos calanoides, especialmente de *Pseudodiaptomus*, que permitieron reajustar las listas taxonómicas locales.

Con material recolectado por el CICIMAR (1991), se llevó a cabo un estudio extensivo sobre el plancton en la zona económica exclusiva (ZEE) mexicana, frente a Baja California Sur, donde se recapitula parcialmente listas taxonómicas de las especies presentes, su distribución y su abundancia. Farfán y Álvarez-Borrego (1992) reportaron que el grupo más abundante en las aguas del golfo de California durante ese ciclo anual fueron los copépodos calanoides. Jiménez-Pérez (1992) determinó que, en la costa occidental de Baja California, la estructura termohalina vertical es un factor importante en la distribución de la comunidad de copépodos. Cervantes-Duarte et al. (1993) relacionaron las condiciones de surgencia en esa zona con la estructura de la comunidad de copépodos y su distribución espacial.

En la bahía Magdalena, en la costa oeste de Baja California, Hernández-Trujillo et al. (2004) registraron 152 especies de copépodos, de las que un 67% corresponde al orden Calanoida, un 26.3% a Cyclopoida y Poecilostomatoida, un 3.9% a Harpacticoida, un 2% a Monstrilloida y un 0.7 a Siphonostomatoida. Palomares-García et al. (2013) describieron el cambio temporal en la variación vertical de los copépodos pelágicos del golfo de California, trabajo en el que identificaron un total de 52 especies, distribuidas principalmente en los primeros 50 m de profundidad. Para las costas de Jalisco y Colima, Kozak et al. (2014a) analizaron la variación estacional e interanual de la comunidad de copépodos en la costa de Jalisco, donde observaron además el efecto del fenómeno ENSO (El Niño/Southern Oscillation) sobre la diversidad y la abundancia de estos organismos. Kozak et al. (2014b) registraron 82 taxones de copépodos, los que representan cerca del 17% del total de las especies conocidas en el Pacífico mexicano. Palomares-García et al. (2018) reportaron 146 especies para la bahía de la Paz, lo que representó un incremento del 52% con respecto a las especies inventariadas hasta ese momento para este ecosistema. Coria-Monter et al. (2020) evaluaron el efecto de la variación ambiental de la bahía de La Paz sobre distintos grupos de zooplancton, de los que los copépodos fueron los más abundantes. En el trabajo de Gómez-Gutiérrez et al. (2014) se aborda el estudio de cómo influyen ciertos mecanismos oceanográficos (i.e., surgencias, descargas de ríos, turbulencia) sobre las principales comunidades del zooplancton en el archipiélago de las islas Marías, frente a la costa de Nayarit.

En el resto de los mares del Pacífico de América se han realizado muchos estudios sobre la diversidad de los copépodos pelágicos. En las costas de Chile, por ejemplo, se consideraron la composición y la estructura de las comunidades (Hidalgo et al. 2010), el impacto de la ZMO del Pacífico Sureste sobre estas (Escribano et al. 2009) y la distribución vertical de ciertas especies relacionada con aspectos ambientales e intrínsecos de los copépodos (Castro et al. 2007). También se ha estudiado la diversidad de copépodos en las costas de Costa Rica (e.g., Morales-Ramírez y Vargas, 1995; Morales-Ramírez et al. 2014) y en Colombia (costa del Caribe) (e.g., Medellín-Mora y Nava 2010; Medellín-Mora et al. 2018; Gaviria et al. 2019), así como en la costa del Pacífico colombiano, donde Jerez-Guerrero et al. (2017) analizaron la composición y la variación espacio-temporal de la comunidad de copépodos. Fernández-Álamo y Färber-Lorda (2006) realizaron una recopilación de los principales avances en la investigación del zooplancton en el Pacífico este tropical, desde la costa sur de Baja California hasta el norte de Perú, donde presentan los patrones generales de distribución vertical y horizontal de los copépodos de acuerdo con diversos autores, información sobre la diversidad conocida y aspectos ecológicos del grupo. Jerez-Guerrero et al. (2020) identificaron un total de 73 especies de copépodos en la isla Gorgona, Colombia, donde, además, determinaron que la contribución de solo 6 especies alcanzó el 70% de la abundancia de copépodos.

A nivel mundial existe una gran cantidad de avances a nivel taxonómico y sistemático, como son la determinación de taxones crípticos y complejos de especies (e.g., Cornils y Held 2014; Kasapidis et al. 2018) o el análisis filogenético de distintos grupos e identificación de especies basados, incluso, en marcadores moleculares (e.g., Bradford-Grieve et al. 2010; Raupach et al. 2015; Radhika et al. 2016; Di Capua et al. 2017), en el análisis de diversidad ecológica (e.g., Spinelli et al. 2016; Kavitha et al. 2018; Dias et al. 2019), en el conocimiento de nuevos registros o descripciones de copépodos (e.g., Suárez-Morales y Fuentes-Reinés 2015; Sepahvand et al. 2017; Varela et al. 2017; Conradi et al. 2018; Korzhavina et al. 2019;), así como en la distribución y biogeografía de copépodos pelágicos (e.g., Jackson y Smith 2016; Sasaki et al. 2016; Prowe et al. 2018). Las tendencias actuales en el estudio de los copépodos incluyen el uso de tecnologías nuevas para la obtención de material: e.g., CPR, Continuous Plankton Recorder, distribución y biogeografía de distintos grupos, estudio del impacto de especies invasoras, copépodos como bioindicadores, estudios sobre la biología de la mielina en los copépodos y sus implicaciones y aspectos relacionados con la quimio recepción de estos organismos, entre otros temas (Uttieri 2018).

III. OBJETIVOS

3.1. Objetivo general

Realizar un trabajo integrativo sobre la composición, la diversidad y la distribución de los copépodos pelágicos del Pacífico mexicano.

3.2. Objetivos particulares

1. Evaluar la variación latitudinal y estacional de la comunidad de copépodos epipelágicos del golfo de California, así como su relación con la variación ambiental sobre la base de los datos recolectados durante las campañas CORTES.
2. Evaluar la composición de copépodos pelágicos del Pacífico mexicano, sus patrones de distribución y describir los principales caracteres morfológicos de aquellas especies que representan nuevos registros para el golfo de California o el Pacífico mexicano sobre la base del material recolectado durante las campañas TALUD.
3. Actualizar el estado del conocimiento de los copépodos pelágicos del Pacífico mexicano a partir del material recolectado durante las campañas CORTES, SIPCO, CEEMEX, TALUD y de la literatura publicada que incluya listas o incidencia de especies.

IV. ÁREA DE ESTUDIO

El Pacífico mexicano se extiende desde los 32°27’ N hasta los 14°32’ N y comprende una extensión litoral de aproximadamente 8,000 km (68% del litoral mexicano). El Pacífico mexicano abarca la totalidad o parte de 4 de las 10 provincias zoogeográficas del Pacífico este tropical: la provincia Californiana, la provincia de Cortés, la provincia Mexicana y la provincia Panámica, las cuales se han definido a partir de la distribución de otros invertebrados tales como los isópodos, los poríferos y los moluscos (véase Brusca y Wallerstein 1979; Lancellotti y Vásquez 1999; Espinosa-Pérez y Hendrickx 2006). La provincia Californiana se extiende desde punta Concepción, en el sur de California, E.U.A., hasta la zona de bahía Magdalena, México, y comprende una porción de la ecorregión Pacífico transicional de Monterey, definida en el trabajo de Spalding et al. (2007). La provincia de Cortés (golfo de California) es independiente de la provincia Mexicana de acuerdo con Briggs (1974) debido a su alto grado de endemismo (Hendrickx 1992; Correa-Sandoval y Rodríguez-Cortés 1998), y su extensión litoral incluye una pequeña porción de la costa oeste de Baja California Sur, las costas este de Baja California y Baja California Sur, así como las costas de Sonora, Sinaloa y Nayarit, hasta punta Banderas, Jalisco (Hendrickx et al. 2005). La provincia Mexicana se extiende desde punta Banderas hasta Tangola-Tangola, Oaxaca y comprende la ecorregión Pacífico transicional mexicano. Finalmente, la porción mexicana de la provincia Panámica se extiende en parte de Oaxaca y Chiapas (hasta la frontera sur de México), y forma parte de la ecorregión Pacífico centroamericano (Figura 1) (Espinosa y Hendrickx 2006; Wilkinson et al. 2009; Spalding et al. 2007).

La provincia Californiana se caracteriza por una productividad moderadamente alta, debido a surgencias ocasionales, y es afectada por varias corrientes cuya intensidad y extensión varían a lo largo del año, principalmente por la corriente de California, que va en sentido de norte a sur y acarrea aguas templadas (< 18 °C) y con salinidad menor a 34.5 ppm. (Wilkinson et al. 2009). Esta provincia presenta una compleja topografía del piso marino, que es resultado de los procesos tectónicos ocurridos desde los últimos 220 millones de años (Zárate-Vidal 1991; Ledesma-Vázquez y Johnson 2001).

El golfo de California es un mar semi-cerrado, exclusivamente mexicano, y conocido por su alta biodiversidad y altas tasas de productividad primaria debido a su topografía y a constantes surgencias (Wilkinson et al. 2009; Lavaniegos et al. 2012). Presenta una profundidad máxima variable, que va de entre 50 y 200 m en la parte noroeste hasta 3,600 m en la boca (Tovilla-Hernández 1991). Se caracteriza por una alta salinidad (< 36 partes por mil en la superficie) debida a que la precipitación anual es menor a la evaporación (Botello et al., 2000; Castro et al. 2000). Este mar presenta condiciones oceanográficas muy particulares, como es la dirección del giro de los vientos superficiales según la época del año (Wyrtki 1965; Brinton y Towsend 1980) y el patrón estacional del movimiento de las masas de agua del Pacífico este tropical hacia adentro del golfo (Álvarez-Borrego y Schwartzlose, 1979).

La provincia Mexicana, que va desde Cabo San Lucas y punta Banderas hasta Oaxaca, es una ecorregión muy compleja, con numerosos cañones de hasta 5,000 m de profundidad y una gran profundidad muy cerca de la costa por un fuerte desnivel de la plataforma y de la parte más somera del talud. La plataforma continental es muy reducida, con un ancho que va de 10 a 15 km. En mar abierto rapidamente se alcanzan profundidades de 2,500 a 3,000 m. Además, la región es caracterizada por muchas colinas y montes submarinos, que incluye un sistema de fisuras y conos volcánicos. Temporalmente, se ve ligeramente afectada por la influencia invernal de la corriente de California, mientras que en verano es principalmente afectada por la corriente costera de Costa Rica (Wilkinson et al. 2009).

En la provincia Panámica no hay influencia invernal significativa de la corriente de California; principalmente es influenciada por las corrientes de Costa Rica y Ecuatorial del Norte (Lemaitre y Alvarez-León 1992). Esta provincia se caracteriza por una alta variabilidad estacional debido a surgencias y es fuertemente afectada por la descarga de agua dulce de los sistemas lagunares y ríos de Chiapas (Wilkinson et al. 2009). En esta porción del país, la plataforma continental es más amplia y posee un talud continental con pendientes de distintos grados que van de suaves a empinadas. Presenta una profundidad máxima de 6,721 m en la trinchera mesoamericana de Tehuantepec; en la porción este de Guatemala alcanza profundidades de entre 4,600 y 4,900 m (Wilkinson et al. 2009; CONANP 2012).

Un caso particular es aquel de las islas oceánicas de la ZEE (archipiélago de las Revillagigedo), cuya fauna posee una componente endémica y otra con afinidad al océano Pacífico central/oeste (Brattstrom 1990; Hastings 2000), pero cuya afinidad a nivel del zooplancton es aún mal definida. Aunque muchas especies de copépodos se consideran cosmopolitas, algunas presentan restricciones de hábitat, como es el caso de *Acartia tonsa* Lonsdale y Coull 1977, que es abundante solo en zonas cercanas al litoral (Paffenhöfer y Stearns 1988). Debido a que las islas oceánicas presentan escenarios particulares para la especiación (Whittaker 2008), es probable que la diversidad de especies de copépodos pelágicos cerca de las islas Revillagigedo sea afín al resto del Pacífico mexicano, pero suficientemente distinta para ser clasificada como un punto independiente.

El Pacífico mexicano es fuertemente influenciado por el fenómeno ENSO, y se ha documentado su efecto sobre la variación de las comunidades de copépodos en el área. Este evento puede influir de distintas maneras sobre los copépodos. Por ejemplo, puede presentarse una disminución en su abundancia con poca modificación en la composición o, de manera inversa, un cambio drástico en la composición sin variar apenas la abundancia (Hidalgo y Escribano 2001; Peterson y Keister 2002). Esta variación se da principalmente por el cambio en la temperatura y la salinidad, dadas en condiciones de surgencia, lo que favorece la dominancia de ciertas especies (Kozak et al. 2014a).

El material que se utilizó para este proyecto se encuentra depositado en la colección de muestras del Laboratorio de Invertebrados Bentónicos, Instituto de Ciencias del Mar y Limnología (ICML), Unidad Académica Mazatlán, UNAM. Este material (~100 lotes) se recolectó durante las campañas CORTES 1 (1982), CORTES 2 (1985), CORTES 3 (1985), SIPCO I (1981), SIPCO II (1981), SIPCO III (1982), CEEMEX-P4 (1991), CEEMEX-P5 (1991), TALUD I, III, IV, V, VI, VII, X, XI, XII, XVIII, XIV y XV (1989-2014) (Figura 1). El golfo de California es la provincia zoogeográfica mejor representada tanto espacial como temporalmente, ya que de esta se cuenta con material recolectado en las campañas CORTES (1, 2 y 3), SIPCO (1, 2 y 3) y TALUD (I, III, IV, V, VI, VII, VIII, IX, X y XIV), lo que permitió un análisis más preciso de la variación de las comunidades de copépodos en esta zona.

V. LIMITACIONES TÉCNICAS Y FUENTES DE INCERTIDUMBRE

Es necesario considerar que el diseño de muestreo empleado para la obtención de las muestras que se usaron para este trabajo no permite analizar de manera sistemática el cómo se distribuyen temporal y espacialmente las comunidades de copépodos a lo largo de todo el Pacífico mexicano. Esto es debido a que los muestreos fueron realizados en épocas distintas y a distintos horizontes batimétricos, además de que el número de estaciones es muy distinto para cada provincia. Estos problemas metodológicos responden principalmente a la dificultad que conlleva realizar la recolecta de material a ciertas profundidades y al costo económico inherente a cada crucero.

El segundo punto de importancia es la disparidad en los equipos utilizados para realizar los arrastres. Indudablemente, el uso de distintos diámetros de red, diferencias en la luz de malla y el volumen de agua filtrada dificultan enormemente el analizar de manera unificada las características de las comunidades de copépodos a lo largo de toda el área de estudio. Indudablemente, representa un reto el tratar de establecer una metodología experimental que permita comparar resultados entre zonas de estudio para las que no se utilizaron metodologías idénticas. Otra limitante que respecta a este mismo punto es el diámetro de luz de malla de las redes utilizadas en los arrastres de micronecton. El utilizar redes con luz de malla de hasta 2 mm excluye de manera casi segura a especies con tamaños menores que podrían haberse encontrado a lo largo de todo un arrastre, por lo que resulta imposible comparar directamente la diversidad de dos zonas de estudio si entre estas se utilizaron distintos tamaños de luz de malla.

El tercer punto es la dificultad inherente al trabajo taxonómico con los copépodos, ya que, para la determinación confiable de las especies, es necesario el conocimiento y experiencia de un especialista en cada grupo (i.e., Calanoida, Cyclopoida, Harpacticoida). Si bien, se cuenta con las herramientas para ello, el determinar a cada una de las especies conlleva la probabilidad de cometer errores taxonómicos, los cuales son bastante comunes aún en trabajos publicados por especialistas. Elías-Gutiérrez (2021, com. pers.) ha mencionado que el número de trabajos con identificaciones incorrectas podría superar el 20%, lo cual es evidenciado cuando se hacen, de manera complementaria, análisis genéticos y ecológicos para discriminar especies.

Finalmente, el análisis de la distribución vertical de los copépodos en este trabajo resulta sumamente complicado, debido a que en ningún caso se utilizaron muestras discretas (i.e., muestreo estratificado con redes de apertura/cierre). Sin embargo, existen maneras de determinar los intervalos verticales de distribución más probables a través de la comparación entre las comunidades de profundidades que no sobrepasan la ZMO con las de las capas batipelágicas inferiores a la misma (más de 1000 m de profundidad). Si bien no es posible afirmar si el hábitat de estas especies se encuentra dentro de la ZMO, se puede especificar, sobre la base de la composición registrada de los arrastres que se realizaron entre 0 y 200 m de profundidad, cuales especies podrían pertenecer a profundidades mayores. Los intervalos de distribución vertical de las especies no reportadas para el área de estudio pueden consultarse en trabajos previos (véase citas pertinentes más adelante en el texto), en los que se han realizado arrastres a profundidades mayores que 200 m. La incidencia de especies que no se habían registrado en trabajos cuyo material fue obtenido por arrastres tomados a menos de 300 m de profundidad representa una muy alta probabilidad de que se trate de especies cuya distribución vertical se encuentra más allá de esta barrera oceanográfica.

Teniendo esto en cuenta, también es necesario precisar que el objetivo principal de estas campañas oceanográficas fue el aportar un panorama general de la composición de especies pelágicas y bentónicas a lo largo del área de estudio, por lo que no habría surgido en su momento la necesidad de un diseño de muestreo más robusto o más adecuado para realizar análisis estadísticos o biogeográficos que requieren de un diseño de muestreo distinto. A pesar de esto, es posible utilizar los datos obtenidos para describir de manera general el patrón de distribución de los copépodos pelágicos a lo largo del Pacífico mexicano.

VI. LATITUDINAL VARIATION OF THE COPEPODS (MULTICRUSTACEA; COPEPODA) IN THE GULF OF CALIFORNIA BASED IN THE CORTES CRUISES (1982 and 1985)

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6.1.1. *Abstract*

The Gulf of California is known for its high productivity, diversity and unique oceanography. Based on old and recent contributions, we estimate a richness of 160 copepod species in this province. This work seeks to identify latitudinal and seasonal patterns of the copepod composition, abundance and diversity in the Gulf of California during 1985. Differences among four zones (NGC, CGC, SGC, EGC) of the gulf and between the cold-warm seasons were hypothesized, based in taxonomical and ecological data. Samples were collected during the CORTES (2 and 3) cruises (1985), measuring salinity, temperature and dissolved oxygen in each station: we also compared these data with the obtained during may, 1982, when El Niño was still present. We analyzed the latitudinal and seasonal variation of the copepod community with multivariate analyses (NMDS-PCA) and correlated these with the environmental data (CCA). 82 copepod species were identified, averaging 265,649 and 98,885 ind. 1000m^{-3} in the cold and warm seasons, respectively. Only 53 of these occurred at both seasons, indicating seasonal change in species composition. The list for the CORTES 1 cruise included 43 species (three of these appeared only in these samples) and an average density of 45,441 ind. 1000m^{-3}. Composition, diversity and average body length varied latitudinally in the cold season ($P < 0.05$ in all comparisons but CGC vs. SGC), but not in the warm season (except NGC vs. the rest of the gulf). There was seasonal change in the composition, the abundance and the standard deviation of the body length ($P < 0.005$ cold vs. warm season). Richness, diversity and average body length were negatively correlated with the salinity (decreasing from the north of the gulf); abundance, composition and standard deviation of the body length were mainly affected by the shift in the temperature; smaller copepods (predatory species) for the warm season and for the southernmost stations, larger

copepods (filterer species) for the cold season and the northernmost stations. The general spatial pattern for the CORTES 1 copepod community was more similar to the observed during the cold season (CORTES 2), with differences between the EGC vs. the NGC and the CGC ($P < 0.05$). These patterns also match the phytoplankton abundance and size structure in the gulf, probably the main factor affecting the copepods distribution.

6.1.2. *Resumen extendido*

El golfo de California ha sido ampliamente estudiado debido a distintos factores, como son sus altos niveles de productividad en relación con algunas de las mayores pesquerías del país, sus múltiples casos de endemismo (desde invertebrados hasta grandes mamíferos) y sus condiciones oceanográficas únicas, de las que destacan los patrones estacionales de circulación superficial, su batimetría y las condiciones de evaporación-depósito de agua que ocurren de forma distinta a lo largo de todo el sistema. De acuerdo con distintos trabajos, hemos estimado que la lista de copépodos de vida libre del golfo de California comprende aproximadamente 160 especies, incluidos grupos que presentan formas parasíticas o epibióticas en algún momento de sus ciclos de vida. Estos estudios también proveen información acerca de los patrones de distribución vertical y horizontal en algunas áreas del golfo, aunque muchos de los trabajos publicados corresponden a zonas relativamente pequeñas y con ello dificultan comprender de manera integral como es la estructura de la comunidad de copépodos en una mayor escala. En este trabajo analizamos como fue la variación de la diversidad, la abundancia y la longitud tanto en una escala latitudinal (considerando cuatro zonas: norte, centro, sur y entrada del golfo) como en una escala temporal (considerando dos temporadas: fría-seca y cálida-húmeda) en el golfo de California. Se hipotetizó que existen diferencias significativas entre las 4 zonas del golfo tanto en la época cálida como en la época fría. El diseño de muestreo contempló 63 estaciones; en 21 de estas se recolectó zooplancton en ambas épocas. Las muestras fueron recolectadas durante las campañas CORTES 2 y 3, efectuadas en los meses de marzo (época fría) y agosto (época cálida) de 1985, respectivamente: los datos de composición y diversidad obtenidos de estas campañas fueron además comparados con los datos obtenidos en la época fría de mayo, 1982, en la campaña CORTES 1, cuando el fenómeno de El Niño 1982 aún estaba presente. En cada una de las 63 estaciones se registraron los valores de salinidad, temperatura y oxígeno disuelto en 3 niveles de profundidad: 5, 20 y 75 m. Los valores fueron medidos con métodos tradicionales (O_2,-Método Wilnkler, salinidad-salinómetro) y electrónicos (CTD-salinidad, temperatura, oxígeno disuelto y profundidad). Se analizó la variación latitudinal y estacional de la comunidad de copépodos con análisis multivariado, sobre la base de la composición, abundancia, riqueza, diversidad, longitud promedio de los copépodos y desviación estándar de la longitud de los copépodos (NMDS para los datos de composición, PCA para los datos de diversidad ecológica). Se determinó la correlación entre estas variables con los parámetros ambientales (CCA). Ochenta y dos especies de copépodos fueron identificadas sobre la base de caracteres morfológicos: 53 de estas ocurrieron en ambas temporadas, lo que indica cambio estacional en la composición de especies: tres de las especies se observaron solo en las muestras de la campaña CORTES 1. La familia con la mayor riqueza de especies, Pontellidae, fue más diversa, abundante y frecuente durante la época cálida; *Labidocera jollae* Esterly, 1906 fue la única especie del grupo que se registró únicamente durante la temporada fría (también en las muestras del CORTES 1). Tanto la riqueza como la diversidad tuvieron variación latitudinal significativa en ambas épocas, y los valores más bajos fueron obtenidos en las estaciones correspondientes al norte del golfo de California (NGC). En la campaña CORTES 1 se registraron 43 especies, con un patrón espacial similar. La diversidad, riqueza y longitud promedio de los copépodos presentó una estructura latitudinal marcada en la época fría ($P < 0.05$ entre todas las comparaciones, excepto CGC vs. SGC y SGC vs. EGC), pero no en la época cálida ($P < 0.05$ únicamente entre NGC vs SGC y EGC). La abundancia, la composición y la desviación estándar de la longitud de los copépodos presentaron variación estacional significativa ($P < 0.05$), la abundancia fue más alta durante la época fría. La zona EGC fue distinta a las zonas NGC y CGC en mayo de 1982 ($P < 0.05$). Se observó que las especies conformaron dos grandes grupos en función de la temperatura. De acuerdo con los resultados del CCA, la variación latitudinal en la comunidad de copépodos se asoció principalmente al gradiente de la salinidad, la cual decrece consistentemente desde la zona norte hacia la entrada del golfo. Por otra parte, la variación estacional se asoció principalmente con el cambio en la temperatura, más alta durante la época fría en los primeros 20 m de profundidad. Estos resultados coinciden con las diferencias de longitud de los copépodos entre ambas temporadas y entre las zonas NGC y CGC con respecto a las de las zonas SGC y EGC ($P < 0.05$) durante la época fría. La mayoría de las especies dominantes se asociaron con valores relativamente altos de salinidad y bajos de temperatura; muchas de estas se consideran como especies herbívoras de tamaño grande, asociadas con concentraciones altas de fitoplancton. En cambio, las especies asociadas con valores bajos de salinidad, pero altos de temperatura fueron, en su mayoría, especies de tamaño pequeño y con una tendencia hacia la carnivoría o la omnivoría. Esto coincide además con el patrón de distribución del fitoplancton, en cual presenta valores de abundancia más altos en la zona norte del Golfo, donde las especies dominantes fueron principalmente filtradoras, tal como *Rhincalanus nasutus*, *Calanus pacificus* o *Aetideus armatus*, mientras que las especies dominantes en el sur y la entrada del Golfo fueron más bien especies omnívoras o depredadoras, como *Labidocera acuta*, *Temora discaudata* o *Corycaeus catus*. La riqueza observada durante este trabajo fue relativamente alta al compararla con distintos trabajos taxonómicos y ecológicos en el golfo de California, aunque la abundancia fue más bien baja. Esto podría deberse a que las comunidades de copépodos aún no se recuperaban del impacto en el cambio de la composición provocado por el fenómeno de El Niño de 1982, el cual parece haber modificado considerablemente la dinámica poblacional de los copépodos, lo cual es notorio a observar la baja riqueza y abundancia de copépodos de la campaña CORTES 1.

6.2. *Introduction*

The Gulf of California is the only enclosed sea of the eastern subtropical Pacific and the only large evaporation basin in the Pacific Ocean, subjected to an intense mixing process near the coast due to the action of the daily tides (Argote et al. 1995; Lavín et al. 1997; Castro et al. 2000). The biological diversity of this sea has been widely studied because of its high level of endemism and particular oceanographic conditions (Hendrickx et al. 2007; Hastings et al. 2010; Angulo-Campillo et al. 2011; Lavaniegos et al. 2012; González-Acosta et al. 2021). The tropical-subtropical Gulf of California is known for its moderate to high biological productivity, comparable to what has been reported in large upwelling zones, like the Bay of Bengal in the Indian Ocean or the west coast of the Baja California Peninsula (Zeitzschel 1969; Brusca et al. 2005). It is also the habitat of very diverse and abundant invertebrate and vertebrate communities supporting some of the most important fisheries in Mexico (Brusca et al. 2005; Páez-Osuna et al. 2017; Munguia et al. 2018).

The class Copepoda is one of the major groups of the zooplankton, both in abundance and richness. This group of crustaceans currently includes about 14,000 valid species, more than 80% occurring in the marine environment (Suárez-Morales et al. 2020; Walther and Boxshall 2022). More than 200 pelagic copepod species have been recorded in the Eastern Tropical Pacific (Chen 1986; Suárez-Morales and Gasca 1998; Palomares-García et al. 2018; Razouls et al. 2024). We estimate the pelagic copepod richness for the Gulf of California to be close to 160 species, based on old and recent contributions (Jiménez-Pérez and Lara Lara 1988; Lavaniegos-Espejo and Lara-Lara 1990; Palomares-García et al. 1998; Suárez-Morales and Gasca 1998; Palomares-García et al. 2013; 2018; Gómez-Gutiérrez et al. 2014; Álvarez-Tello et al. 2015; Jiménez-Pérez 2016; Cruz-Hernández et al. 2018; Palomares-García et al. 2018; Beltrán-Castro et al. 2020).

The copepod community of the Gulf of California has been studied under different approaches. For example, Palomares-García et al. (2013) and Cruz-Hernández et al. (2018; 2019) studied the composition and vertical abundance of copepods, and their relation to environmental variables. Other studies have described the species composition in selected areas (e.g., Fleminger 1975; Suárez-Morales and Gasca 1998; Palomares-García et al. 2018). Some contributions have focused on copepod species endemic to the Gulf of California (e.g., Wolfenden 1905; Fleminger 1983; Humes 1987). Based on all these publications we can conclude that there are only a few (around 10) species which comprise up to 85% of the entire copepod fauna, that most of the abundance remains in the first 75 m of the water column and that the expected richness during a single annual cycle should be around 50–60 species.

The copepod abundance and community composition in the Gulf of California is known to vary along seasonal (e.g., Palomares-García et al. 2013) and interannual (e.g., Beltrán-Castro et al. 2020) cycles, which limits the value of short-term studies in small areas. Ideally, it is therefore desirable to analyze the structure of the copepod communities over several years in large areas in order to maximize our knowledge of this group's distribution and its relationship to oceanographic conditions. However, in many cases the cost of long-term sampling operations and analyses of a large amount of samples is highly expensive. Therefore, it is relevant to take advantage of available historical sample collections to provide baseline information to compare with further oceanographic cruises. The large series of samples collected in the Gulf of California during the cold and warm seasons in 1985 (and the cold season of 1982) allows for analysis of the copepod community in early Mexican oceanography with the initiation of the R/V "El Puma" in 1980. These samples have been previously used to study the distribution and abundance of *Lucifer typus* H. Milne Edwards, 1837 (Hendrickx and Estrada-Navarrete 1994), of phylosoma larvae of spiny lobsters (García-Rodríguez et al. 2008) and of Brachyura (see Hendrickx 1987).

An oceanographic approach to conditions in the Gulf of California can help to better understand how and why the copepod community varies in this area. The Gulf of California is about 283,000 km2 with depths of up to 3,500 m at the mouth (Hamilton 1961). According to Brusca et al. (2005) and Hendrickx et al. (2007) it extends from the Colorado River Delta in the north to a line between San Lucas Cape (Baja California Sur) and Corrientes Cape (Jalisco) in the south. The gulf presents increasing depth from the northernmost zone to the entrance; the north zone is particularly shallow, with an average depth of less than 200 m (Lavín and Marinone 2003). The north zone of the gulf is also characterized by saltier waters due to long residence times (Lavín et al. 1995) caused by a circulation pattern dominated by an anticyclonic gyre (Lavín et al. 2014); and it presents a wide variation in water parameters because of its shallow depth (Álvarez-Borrego and Galindo 1974). The Gulf of California is known for its seasonally reversing winds (Wyrtki 1965; Brinton and Towsend 1980), which change the upwelling line position from the east coast during winter to the west coast during summer and cause a seasonally reversing flow pattern in the surface waters (Badan-Dangon et al. 1985; Álvarez-Borrego and Lara-Lara 1991; Lavín et al. 2014). There is also a seasonal pattern for the latitudinal movement of the water masses: the waters from the Eastern Tropical Pacific and the subtropical subsurface waters enter only at the mouth of the gulf during winter, while these invade the whole gulf during summer (Álvarez-Borrego and Schwartzlose 1979). The waters of the Gulf of California are usually warmer compared to other water masses in similar latitudes; and this Gulf of California Water (GCW) has a salinity of ≥ 35 in the upper layers (Castro et al. 2000; Lavin and Marinone 2003; Álvarez-Borrego and Lara-Lara 1991). The temperature flux has been observed to increase from the entrance to the north, gaining heat along its overall length with a maximum flux in June and mainly along the east coast closest to the Tropical Surface Water (TSW) (Portela et al. 2016). Salinity doesn’t show a clear seasonal pattern (Castro et al. 1994), but due to the entrance of the previously mentioned water masses it varies widely latitudinally. The interannual variability is related to atmospheric changes, associated with El Niño-Southern Oscillation (ENSO) events (Durazo et al. 2005). The 1982–1983 El Niño was one of the strongest recorded for this province, bringing fresher and warmer waters of tropical origin into the entrance of the gulf (Lavín et al. 2003). ENSO episodes tend to coincide with low productivity, due to the increase in surface temperatures above 28 °C (Santamaría-del-Angel et al. 1994), although Valdéz-Holguín and Lara-Lara (1987) reported higher productivity during the 1982–1983 ENSO event. In 1985 the oceanographic conditions were influenced by a weak La Niña event (Storlazzi and Griggs 1998), which diminished the surface temperature of the Gulf of California waters below the average from January to June (NOAA 2023). The primary productivity in the Gulf of California during 1985 was, according to Lara-Lara et al. (1993), returning to normal levels after the 1982 ENSO.

This study seeks to answer three main questions: 1. What was the epipelagic copepod community composition in the Gulf of California during March and July–August 1985 and how does it compare to other years? 2. What was the spatial and temporal variation of the composition, diversity and abundance of these copepods in 1985? 3. How do environmental variables (salinity, temperature and dissolved oxygen concentration) recorded during the cold and warm periods of this year influence the distribution patterns of abundance, composition, and diversity of the copepod community in the Gulf of California? In order to answer these questions about the distribution patterns of the copepods in the Gulf of California we have hypothesized that there are significant differences in the composition, abundance, and diversity of the copepods among the four defined zones of the Gulf of California and between the two seasons of 1985, caused by latitudinal and seasonal variation in the water masses of the gulf.

6.3. *Material and Methods*

6.3.1. *Fieldwork*

In order to perform a spatial analysis of the copepod communities in the Gulf, we have considered four different zones based on several criteria, including its bathymetry (Merrifield and Winant 1989), its hydrography (Álvarez-Borrego 1983; Álvarez-Borrego and Lara-Lara 1991) and the biogeographic distribution of different groups, including benthonic species (Brinton and Towsend 1980; Brinton et al. 1986; Brusca et al. 2005; Hendrickx et al. 2007; Ulate et al. 2016) or phytoplankton (in terms of taxonomy and abundance) (Gilbert and Allen 1943; Santamaria-del-Angel and Alvarez-Borrego 1994; Mercado-Santana et al. 2017; Robles-Tamayo et al. 2020).

The gulf was divided in four zones according to these works: the Northern Gulf of California (NGC), which extends from the Colorado River Delta to a line between San Francisquito Bay, Baja California and Kino Bay, Sonora; the Central Gulf of California (CGC), limited by a line extending between Bahía Agua Verde, Baja California Sur and Bahía de Agiabampo, Sinaloa; the Southern Gulf of California (SGC), extending from the limits marked by Cabo San Lucas, Baja California Sur and Ponce, Sinaloa and, finally, the entrance of the Gulf of California (EGC), which extends up to the limits of the Gulf, marked by Cabo San Lucas, Baja California Sur and Cabo Corrientes, Jalisco (Fig. 1).

The oceanographic cruises CORTES 2, referred herein as the "cold season" (March 1985), and CORTES 3, the "warm season" (July-August 1985) covered the entire Gulf of California with almost the same positions for the stations. The oceanographic cruise was performed during may, 1982, but since it’s a totally different scenario it was only included as an additional source of data, not directly compared to the 1985 cruises. The sampling grid included 63 sampling stations in each cruise: Zooplankton samples were collected in 21 stations of this sapling grid (Fig. 1). For each zooplankton tow, a non-closing Bongo structure with a mouth diameter of 60 cm equipped with two 333/505 µm mesh size nets was deployed. Oblique tows went from a maximum depth of 220 m to the surface, and the sampled volume of water went from 98 to 432 m^3. Samples were fixed with a 4% formaldehyde solution, later washed with tap water and then preserved in 70% ethanol. Salinity, temperature and dissolved oxygen concentration were measured at the 63 stations and at three levels of depth: 5 m, 20 m and 75 m. Water was collected with Niskin bottles to measure salinity (conductivity meter) and dissolved oxygen (Winkler method). Temperature was measured in situ with reversal thermometers. A General Oceanics® flow meter was used to estimate the distance (d) covered by the net. Filtered volume was obtained by using standard methods (Smith and Richardson 1977). Densities of copepods are herein expressed as the number or organisms in 1,000 cubic meters (ind. $1000m^{-3}$).

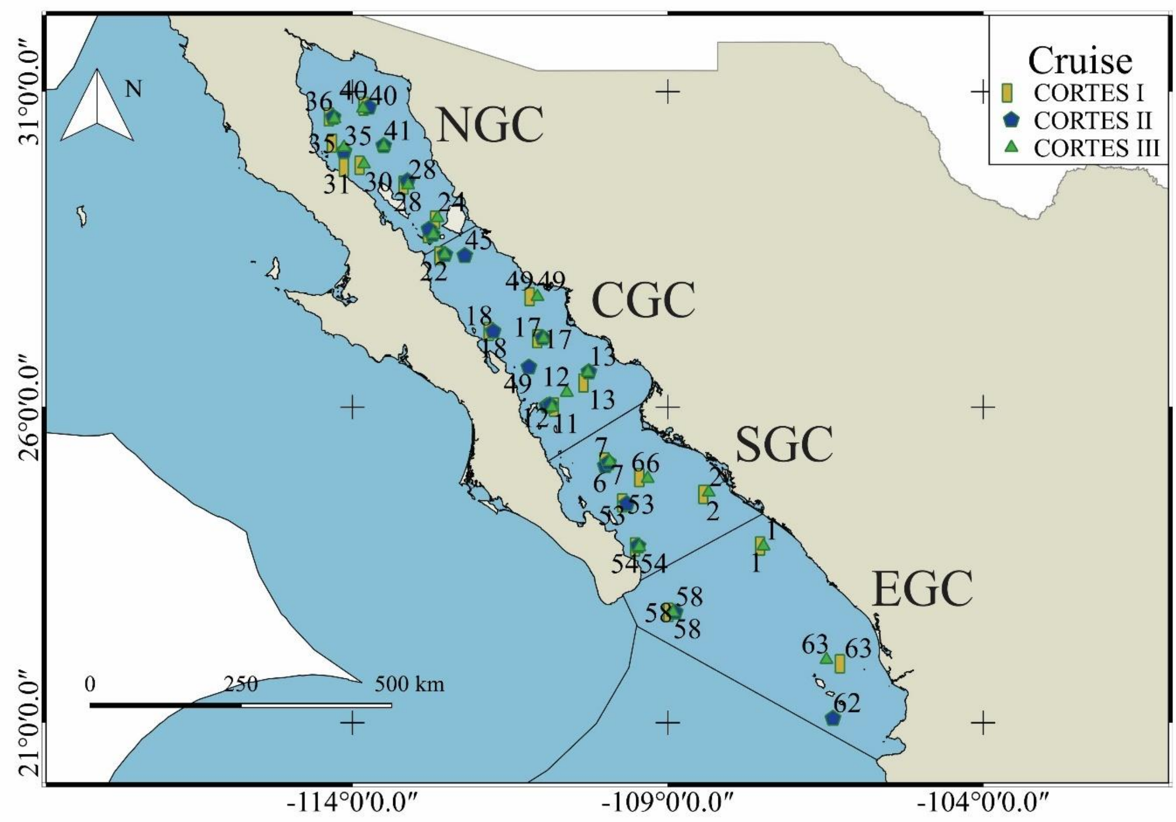

Figure 1. Zooplankton sampling stations in the Gulf of California during the CORTES cruises 2 and 3, in 1985, and during the CORTES 1, in 1982. The four zones of the gulf are, as following: NGC, Northern Gulf of California, CGC, Central Gulf of California, SGC, Southern Gulf of California, and EGC, Entrance of the Gulf of California.

6.3.2. *Taxonomical and ecological data collection*

Species were identified based on the morphological characters of each morphospecies and based mainly on the work of Palomares-García et al. (1998). When needed, specimens were dissected in order to reduce the taxonomical uncertainty to a minimum. The number of specimens of each species per sample was estimated by counting individuals in the entire sample or in fraction aliquots (Folsom splitter/Stempel pipette), depending upon the abundance of specimens in each sample (1/2 – 1/8 of the original sample). Counting of specimens in samples or subsamples was performed using a Bogorov chamber. The body length (from the anterior cephalic margin to the caudal margin of the caudal rami) of 50 different randomly selected specimens per sample was measured in order to estimate the average copepod body length at each station (N of 1050 specimens for each season).

6.3.3. *Data analysis*

The spatial (i.e., NGC, CGC, SGC and EGC) and temporal (i.e., cold and warm seasons) variation of the copepod composition was analyzed with a Non-metric Multidimensional Scaling analysis (NMDS) for each cruise (and combined), previous square root transformation of the data to reduce the distance between samples. Vectors for the species were added to illustrate the Pearson correlations of their abundance in relation to the sampling stations. A SIMPER analysis was performed to identify the species with the highest contribution to the dissimilitude between the two seasons and among the four zones. NMDS and SIMPER analyses were performed in the PRIMER-e 6.0 software. The spatial and temporal variation patterns for abundance, richness and the diversity (Shannon-Wiener diversity index) were analyzed with a Principal Component Analysis (PCA) for each cruise (and combined), previous normalization of the data in PRIMER-e 6.0. We tested the significance of the differences in composition and diversity between the two seasons and among the four zones with permutational MANOVAs, using independent one-way models for the spatial variation at each season in the PRIMER-e 6.0 program.

To test for statistical differences of the body length between the two cruises, a Mann-Whitney U test was performed. We've also tested for differences among zones with a Kruskal Wallis test, followed by Dunn's pairwise comparisons to determine which zones had, in average, larger or smaller copepods. To illustrate the variation in the body length frequencies between the two seasons, a histogram for each was performed. The statistical tests and the histogram were performed with the SigmaPlot 11.0 program.

The environmental data was plotted in maps in order to analyze its latitudinal variation, while boxplot graphics were used to analyze its vertical variation. Maps were done using the QGIS 3.14.0 program, and boxplot graphics (95% confidence interval) were done in SigmaPlot 11.0. To correlate the environmental variation with the biological variables (composition, abundance and diversity), we performed a Canonical Correlation Analysis (CCA) for each depth level, previous normalization of the environmental data and square root transformation of the biological data in the Canoco 4.5 software. The significance of the first four axes was tested with Monte-Carlo permutation tests in the same program, and the levels of correlation of each variable with the first two axes are displayed. Data for chlorophyll concentration (mg m^{-3}) for both cold and warm seasons is shown as maps. Data obtained from NASA Ocean Color, special thanks to Erika Chamorro for the elaboration of the maps.

6.4. *Results*

6.4.1. *Composition and abundance*

Abundance estimations were significantly different for each season. For the cold season, the average value for the abundance was of 265,649 ind. 1000m^{-3}, with a lowest density of 26,395 ind. 1000m^{-3} and a highest of 1,021,076 ind. 1000m^{-3}. For the warm season, the average observed abundance was much lower (98,885 ind. 1000m^{-3}), with low and high densities of 7,748 and 388,715 ind. 1000m^{-3}, respectively. The abundance was lower during 1982 compared to the cold and warm seasons, averaging 45,441 ind. 1000m^{-3}, a highest density of 114,113 ind. 1000m^{-3}and a lowest of 33 ind. 1000m^{-3}. In total, 82 species were recorded: 64 collected in the cold season and 66 in the warm season, plus 3 additional species that were recorded only in the CORTES 1 samples (Table 1). For both the cold and warm seasons, the most diverse order was clearly the Calanoida (cold season, 43 species; warm season, 48 species), followed by the Cyclopoida (cold season, 16 species; warm season, 14 species), and the Harpacticoida (cold season, 3 species; warm season, 2 species). A similar pattern in the richness was observed in 1982, with 35 calanoid species, 8 cyclopoid and 1 harpacticoid species. Rarefaction curves based in the CORTES 2 and 3 cruises provided an estimated of nearly 90 species expected for the highest estimations (Jackknife 1 and 2); Jackknife 2 and Chao 2 estimators reached the asymptote (Fig. 2). Overall, the richness observed in the cold and warm seasons was very similar, with only 26 species not shared between the two cruises. The lowest shared richness was observed for the Pontellidae family: 4 species in the cold season vs. 10 in the warm season (Table 1). Pontellids were also much less abundant in the cold season (0.72% of the abundance) than in the warm season (3.45%); *Labidocera jollae* appeared uniquely in the cold season and also appeared in the cold season of 1982 (CORTES 1). The rest of the families maintained a similar composition between both seasons (Table 1).

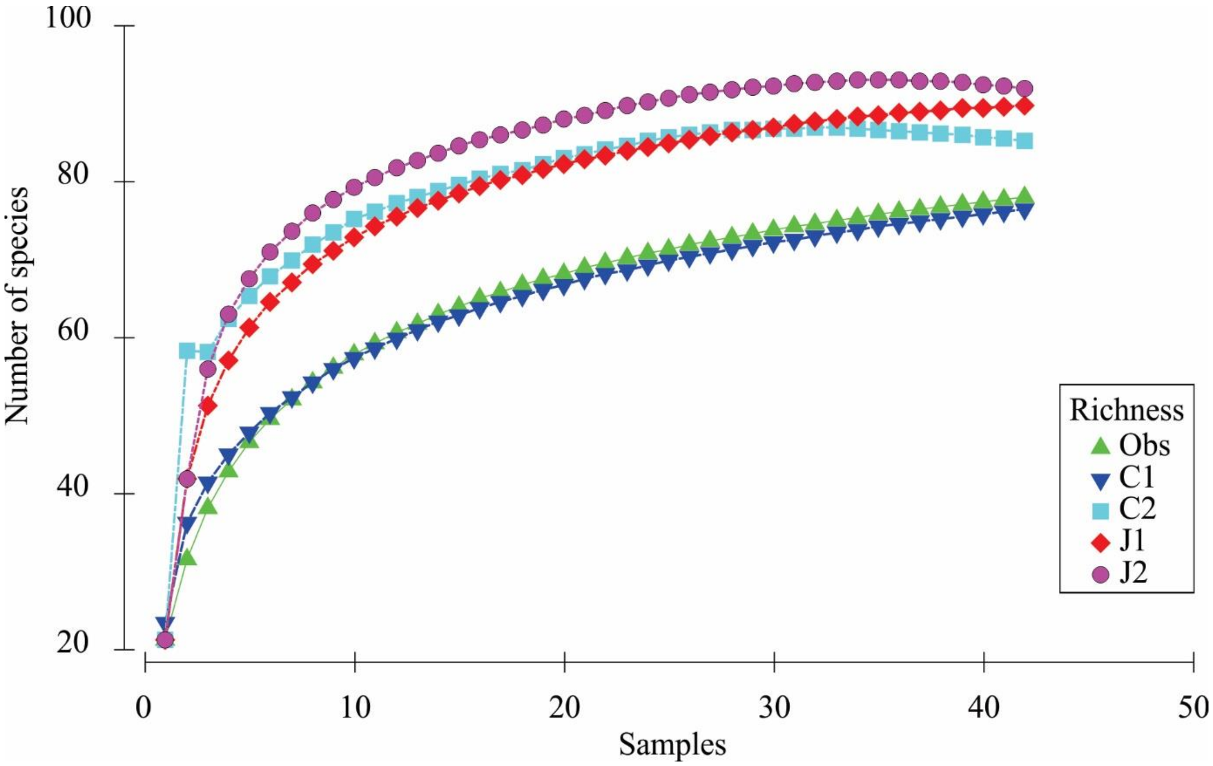

Figure 2. Estimation of the expected copepod richness for the Gulf of California in 1985. Rarefaction curves are based on the sampled stations of the CORTES 2 and 3 cruises. Curves corresponds to the observed number of species (Obs) and to the non-parametrical indicators: Chao 1 (C1), Chao 2 (C2), Jackknife 1 (J1) and Jackknife 2 (J2).

For the cold season, the most abundant and frequent species were *Calanus pacificus*, *Rhincalanus nasutus*, *Pleuromamma gracilis*, *Clausocalanus jobei* and *Aetideus armatus*. Together, these five species represented over 62% of the total copepod abundance and they were also the most frequent ones. As for the warm season, the most abundant and frequent species were instead *Nannocalanus minor*, *R. nasutus*, *P. gracilis*, *Scolecithrix danae* and *Paracalanus aculeatus*. Together, these five species accounted for 60% of the total abundance of copepods. According to the SIMPER analysis, inter-zone dissimilarity was mainly influenced, for both seasons, by the abundances of *C. pacificus*, *N. minor*, *R. nasutus*, *S. danae*, *C. jobei* and *P. gracilis,* together accounting at least to a 20% of the contribution to the variation among zones.

The list of records for the CORTES 1 samples included 3 species that were not recorded in the other 2 cruises: *Centropages elongatus*, *Labidocera Johnsoni* and *Scolecithricopsis ctenopus*. The most abundant species were, in descendent order: *Calanus pacificus*, *Rhincalanus nasutus*, *Nannocalanus minor*, *Euchaeta marina*, *Pleuromamma* *gracilis* and *Paraeucalanus sewelli*. Together, these six species accounted for 69% of the total copepod abundance.

Table 1. Species list of copepods collected in the Gulf of California during the CORTES cruises in 1982 and 1985. The abbreviated names are used in the CCA analyses. The species occurrence in each cruise is indicated with an “x” (CORTES 2 and 3 columns). C1-CORTES 1, C2-CORTES 2, C3-CORTES 3.

Order	**Species**	**Abbreviated name**	**C1**	**C2**	**C3**
Calanoida	**Acartidae**				
	Acartia (*Odontacartia*) *lilljeborgii* Giesbrecht, 1889	*Acalil*	x	x	x
	Acartia (*Acanthartia*) *tonsa* Dana, 1849	*Acaton*	x	x	x
	Aetideidae				
	Aetideus armatus (Boeck, 1872)	*Aetarm*	x	x	x
	Euchirella bitumida With, 1915	*Eucbi*	x	x	x
	Euchirella rostrata (Claus, 1866)	*Eucro*	x	x	x
	Euchirella sp.	*Eucsp*			x
	Augaptilidae				
	Augaptilus megalurus Giesbrecht, 1889	*Augmeg*		x	x
	Euaugaptilus filigerus (Claus, 1863)	*Euafil*		x	
	Haloptilus ornatus (Giesbrecht, 1893)	*Halor*	x	x	x
	Calanidae				
	Calanus pacificus Brodsky, 1948	*Calpac*	x	x	x
	Cosmocalanus darwinii (Lubbock, 1860)	*Cosdar*		x	
	Nannocalanus minor (Claus, 1863)	*Nanmin*	x	x	x
	Undinula vulgaris (Dana, 1849)	*Undvul*		x	x
	Candacidae				
	Candacia curta (Dana, 1849)	*Cancur*	x	x	x
	Candacia simplex (Giesbrecht, 1889)	*Cansim*	x	x	x
	Centropagidae				
	Centropages elongatus Giesbrecht, 1896	*Cenelo*	x		
	Centropages furcatus (Dana, 1849)	*Cenfur*	x	x	x
	Clausocalanidae				
	Clausocalanus furcatus (Brady, 1883)	*Clafur*			x
	Clausocalanus jobei Frost and Fleminger, 1968	*Clajob*		x	x
	Cosmocalanidae				
	Eucalanidae				
	Eucalanus californicus Jhonson M.W., 1938	*Euccal*		x	x
	Eucalanus elongatus elongatus (Dana, 1848)	*Eucelo*		x	
	Eucalanus hyalinus (Claus, 1866)	*Euchya*	x	x	x

Pareucalanus sewelli (Fleminger, 1973)	*Parsew*	x	x	x
Rhincalanus nasutus Giesbrecht, 1888	*Rhinas*	x	x	x
Subeucalanus subcrassus (Giesbrecht, 1888)	*Subsub*	x	x	x
Subeucalanus subtenuis (Giesbrecht, 1888)	*Subsub*	x	x	x
Euchaetidae				
Euchaeta marina (Prestandrea, 1833)	*Eucmar*	x	x	x
Euchaeta plana Mori, 1937	*Eucpla*			x
Heterorhabdidae				
Heterorhabdus papilliger (Claus, 1863)	*Hetpap*	x	x	x
Heterorhabdus sp.	*Hetsp*		x	
Lucicutiidae				
Lucicutia flavicornis (Claus, 1863)	*Lucfla*	x	x	x
Lucicutia pacifica Brodsky, 1950	*Lucpac*		x	x
Metridinidae				
Metridia brevicauda Giesbrecht, 1889	*Metbre*		x	
Pleuromamma abdominalis abdominalis (Lubbock, 1856)	*Pleabd*	x	x	x
Pleuromamma borealis Dahl F., 1893	*Plebor*	x	x	x
Pleuromamma gracilis gracilis Claus, 1863	*Plegra*	x	x	x
Paracalanidae				
Paracalanus aculeatus Giesbrecht, 1888	*Paracu*			x
Paracalanus parvus parvus (Claus, 1863)	*Parpar*		x	
Phaennidae				
Phaenna spinifera Claus, 1863	*Phaspi*	x	x	x
Pontellidae				
Labidocera acuta (Dana, 1849)	*Labacu*	x	x	x
Labidocera acutifrons (Dana, 1849)	*Labacu*		x	x
Labidocera johnsonii Fleminger, 1964	*Labjoh*	x		
Labidocera jollae Esterly, 1906	*Labjol*	x	x	
Labidocera trispinosa Esterly, 1905	*Labtri*			x
Pontella agassizi Giesbrecht, 1895	*Ponaga*			x
Pontella danae Giesbrecht, 1889	*Pondan*			x
Pontellina plumata (Dana, 1849)	*Ponplu*	x		x
Pontellopsis armata (Giesbrecht, 1889)	*Ponarm*			x
Pontellopsis occidentalis Esterly, 1906	*Ponocc*	x	x	x
Pontellopsis regalis (Dana, 1859)	*Ponreg*			x
Pontellopsis yamadae Mori, 1937	*Ponyam*			x
Scolecithricidae				
Scaphocalanus affinis (Sars G.O., 1905)	*Scaaff*		x	x
Scolecithricella abyssalis (Giesbrecht, 1888)	*Scoaby*		x	x
Scolecithricella nicobarica (Sewell, 1929)	*Sconic*	x	x	x
Scolecithricopsis ctenopus (Giesbrecht, 1888)	*Scocte*	x		
Scolecithrix bradyi Giesbrecht, 1888	*Scobra*			x
Scolecithrix danae (Lubbock, 1856)	*Scodan*	x	x	x

	Temoridae				
	Temora discaudata Giesbrecht, 1889	*Temdis*	x	x	x
	Temoropia mayumbaensis Scott T., 1894	*Temmay*		x	x
Cyclopoida	**Clausidiidae**				
	Halicyclops sp.	*Halsp*		x	
	Corycaeidae				
	Onychocorycaeus catus (Dahl F., 1894)	*Onycat*	x	x	x
	Corycaeus crassiusculus, Dana 1849	*Corcra*		x	x
	Urocorycaeus lautus (Dana, 1849)	*Urolau*		x	
	Corycaeus speciosus Dana, 1849	*Corspe*	x	x	x
	Lubbockidae				
	Lubbockia squillimana Claus, 1863	*Lubsqu*		x	x
	Oithonidae				
	Oithona setigera setigera (Dana, 1849)	*Oitset*	x	x	x
	Oithona sp.	*Oitsp.*		x	
	Oncaeidae				
	Oncaea conifera Giesbrecht, 1891	*Onccon*		x	x
	Oncaea media Giesbrecht, 1891	*Oncmed*	x	x	x
	Oncaea venusta Philippi, 1843	*Oncven*	x	x	x
	Sapphirinidae				
	Copilia mirabilis Dana, 1852	*Copmir*	x	x	x
	Sapphirina darwinii Haeckel, 1864	*Sapdar*		x	x
	Sapphirina gastrica Giesbrecht, 1891	*Sapgas*		x	x
	Sapphirina gemma Danna 1852-1853	*Sapgem*	x	x	x
	Sapphirina metallina Dana, 1849	*Sapmet*		x	x
	Sapphirina opalina Dana, 1849	*Sapopa*	x	x	x
	Sapphirina stellata Brady, 1891	*Sapste*		x	
Harpacticoida	**Ectinosomatidae**				
	Microsetella rosea (Dana, 1847)	*Micros*	x	x	x
	Peltidiidae				
	Clytemnestra scutellata Dana, 1847	*Clyscu*		x	x
	Tachidiidae				
	Euterpina acutifrons (Dana, 1847)	*Eutacu*	x	x	
Siphonostomatoida	**Pontoeciellidae**				
	Pontoeciella abyssicola (Scott T., 1893)	*Ponaby*		x	x
	Rataniidae				
	Ratania flava Giesbrecht, 1893	*Ratfla*			x

6.4.2. *Latitudinal variation of the composition and the ecological indices*

The NMDS ordination gave a clear latitudinal pattern of the composition for the cold season, with increasing abundances of most of the species from the north to the entrance of the Gulf; there were not apparent differences between the SGC and the EGC (Fig. 3A). There was a much less clear latitudinal pattern in the warm season; the stations of the NGC and the CGC displayed a mixed arrangement, and the same occurred with the samples of the SGC and the EGC. However, the samples of the SGC-EGC zones conformed two different subgroups: one given by the stations 1, 2, 7 and 63 (closer to the east coast of the gulf) and another by the stations 6, 54 and 58 (closer to the west coast) (Fig. 3B). The majority of the species with high contribution to the latitudinal variation for both seasons were, according to the SIMPER tests, considered as dominant species. These results were supported by the PERMANOVAs, the paired comparisons results are displayed below (Table 2). The spatial pattern of the CORTES 1 composition data was more similar to the cold season (CORTES 2) data (Fig. 5A), with clear differences among zones, particularly between the NGC and CGC vs. the EGC; again, the majority of the species presented higher densities in the SGC and EGC zones (Table 2).

Table 2. Paired comparisons among the four zones of the Gulf of California based on the composition data. Results from the PERMANOVA paired tests, expressed as p-values. Significant values are marked in boldface.

Composition				
CORTES 1	NGC	CGC	SGC	EGC
NGC	-	-	-	-
CGC	P > 0.05	-	-	-
SGC	P > 0.05	P > 0.05	-	-
EGC	**P < 0.05**	**P < 0.05**	P > 0.05	-
CORTES 2	NGC	CGC	SGC	EGC
NGC	-	-	-	-
CGC	**P < 0.01***	-	-	-
SGC	**P < 0.01***	P > 0.05	-	-
EGC	**P < 0.05***	**P < 0.05***	P > 0.05	-
CORTES 3	NGC	CGC	SGC	EGC
NGC	-	-	-	-
CGC	P > 0.05	-	-	-
SGC	**P < 0.01***	P > 0.05	-	-
EGC	**P < 0.05***	P > 0.05	P > 0.05	-

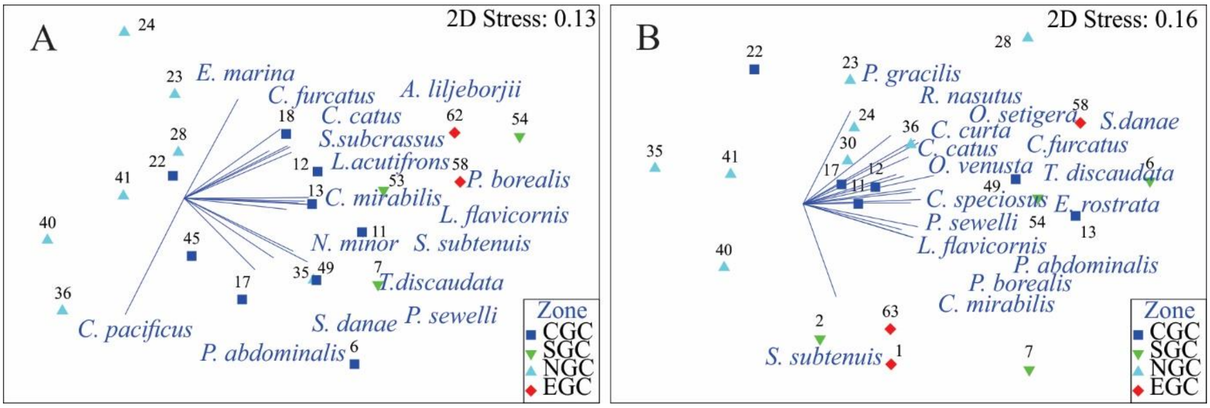

Figure 3. Latitudinal pattern of the copepod composition for the Gulf of California in 1985. NMDS ordination of the sampling stations of the CORTES 2 and 3 cruises: the cold (A) and the warm seasons (B). Vectors indicate the Pearson correlations between the dominant species abundance and the sampling stations. NGC, northern Gulf of California, CGC, central Gulf of California, SGC, southern Gulf of California, EGC, entrance of the Gulf of California.

In regard to the ecological data, there was a clear latitudinal pattern for the cold season, with the four zones conforming distinct groups. The richness and the diversity strongly decreased from the north to the entrance of the Gulf (from 6 species at a single station in the NGC and up to 35 species in the SGC), while the abundance was higher in the CGC (319,340 ind. 1000 m^{-3} in average) and lower in the NGC (203,764 ind. 1000m $^{-3}$ in average); the highest values were observed at stations 18, 22 and 23 (closer to the west coast, CGC) (Fig. 4A). A similar richness-diversity latitudinal pattern was observed for the warm season, although the dissimilitude among the CGC, SGC and the EGC zones were much less evident. The richness went from 11 species at a single station in the NGC and up to 35 species in the CGC. The density presented, in average, lower values in the NGC (84,493 ind. 1000 m^{-3}), but the highest abundance was recorded in there, station 28 (closer to the west coast) (Fig. 4B). In average, the highest abundance was recorded in the EGC (143,074 ind. 1000 m^{-3}) during this season. The PERMANOVAs paired comparisons are presented below (Table 3). The latitudinal variation of the ecological data of the CORTES 1 samples was more similar to the observed for the cold season (CORTES 2), with a decreasing richness and diversity towards the NGC. The abundance was, again, relatively homogeneous among zones, with slightly higher abundances towards the SGC; the EGC presented lower values of richness and diversity than the SGC (Fig. 5). The highest abundance was recorded at the EGC (114,113 ind. $1000m^{-3}$), while the lowest was recorded also there (33 ind. $1000m^{-3}$). In average, the highest abundance was recorded in the EGC (60,743 ind. $1000m^{-3}$). There were not statistically significant differences in the diversity among zones during the 1982 cruise (Table 3).

Table 3. Paired comparisons among the four zones of the Gulf of California based in the ecological data. Results from the PERMANOVA paired tests, expressed as p-values. Significant values highlighted in boldface.

Diversity				
CORTES 1	NGC	CGC	SGC	EGC
NGC	-	-	-	-
CGC	P > 0.05	-	-	-
SGC	P > 0.05	P > 0.05	-	-
EGC	P > 0.05	P > 0.05	P > 0.05	-
CORTES 2	NGC	CGC	SGC	EGC
NGC	-	-	-	-
CGC	**P < 0.05***	-	-	-
SGC	**P < 0.01***	P > 0.05	-	-
EGC	**P < 0.05***	**P < 0.05***	P > 0.05	-
CORTES 3	NGC	CGC	SGC	EGC
NGC	-	-	-	-
CGC	P > 0.05	-	-	-
SGC	**P < 0.01***	P > 0.05	-	-
EGC	**P < 0.05***	P > 0.05	P > 0.05	-

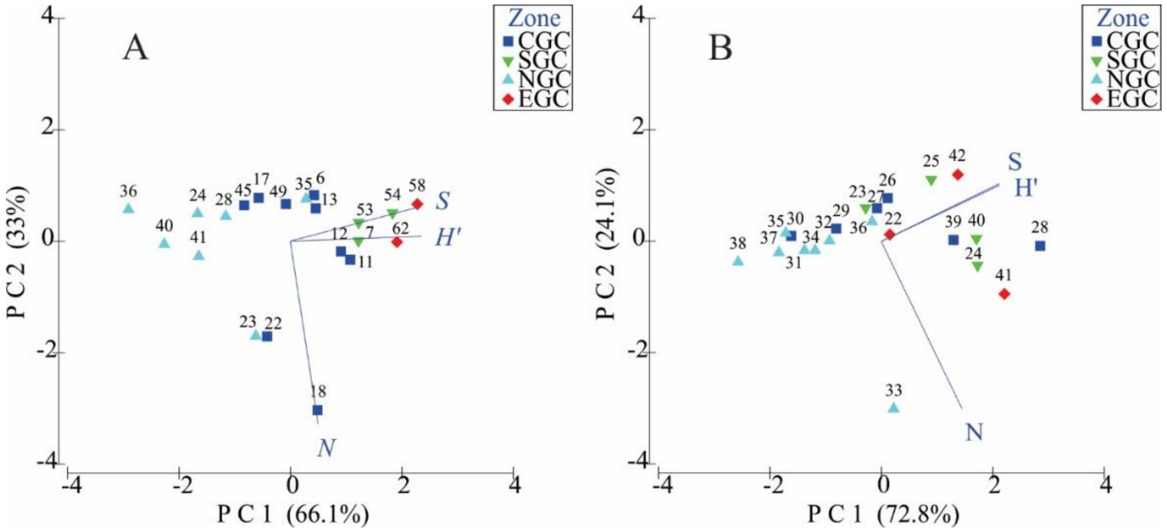

Figure 4. Latitudinal pattern of the copepod ecological indices in the Gulf of California in 1985. PCA ordination of the sampling stations of the CORTES 2 and 3 cruises: the cold (A) and the warm seasons (B). Vectors corresponds to the biological variables used in this study: S, richness, N, abundance, H’, diversity. NGC, northern Gulf of California, CGC, central Gulf of California, SGC, southern Gulf of California, EGC, entrance of the Gulf of California.

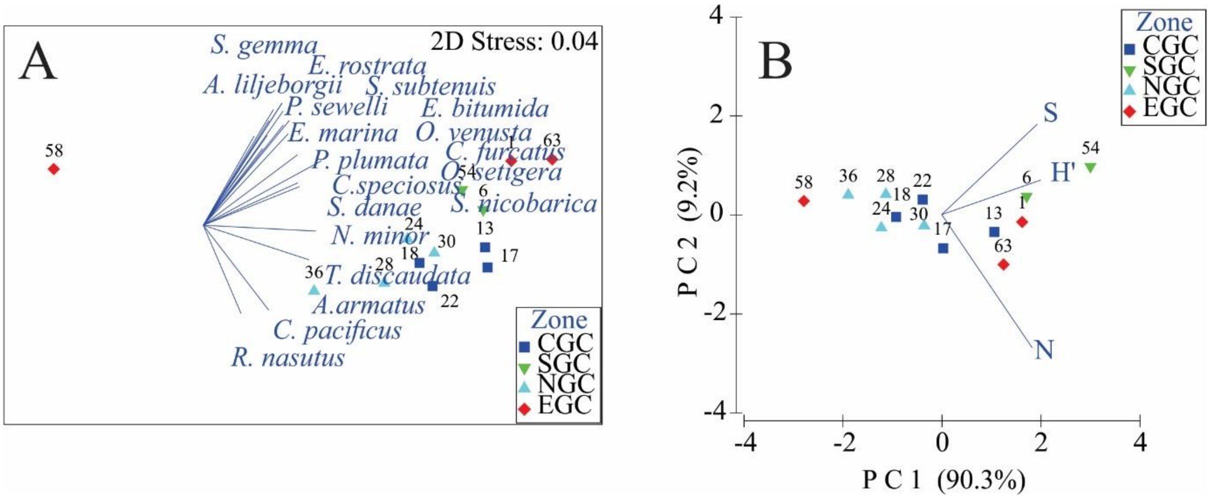

Figure 5. Latitudinal variation of the composition (NMDS) (A) and the ecological indices (PCA) (B) in the Gulf of California in 1982: ordination of the sampling stations of the CORTES 1 cruise. Vectors corresponds to the Pearson correlations between the dominant species abundance and stations (A) and to the correlations of the ecological variables (B): S, richness, N, abundance, H', diversity. NGC, Northern Gulf of California, CGC, Central Gulf of California, SGC, Southern Gulf of California, and EGC, Entrance of the Gulf of California.

6.4.3. *Seasonal variation of the composition and the ecological indices*

According to the SIMPER test, the species with the highest contribution to the differences between the two seasons were: *Calanus pacificus* (11.79%), *Rhincalanus nasutus* (9.04%), *Nannocalanus minor* (7.23%), *Aetideus armatus* (6.0%), *Pleuromamma gracilis* (5.16%) and *Clausocalanus jobei* (4.79%). These six species accounted for 44 % of the contribution. The NMDS results indicate that the abundances of these species were higher during the cold season; there were also more abundant towards the NGC zone (Fig. 6A). Finally, neither the diversity or the richness shown any seasonal pattern, but the abundance was, in general, higher for the cold season (Fig. 6B). The PERMANOVAs results indicated differences between the two seasons for the composition ($P < 0.005$), but not for the ecological data ($P > 0.05$), in despite of the seasonal change in the abundance.

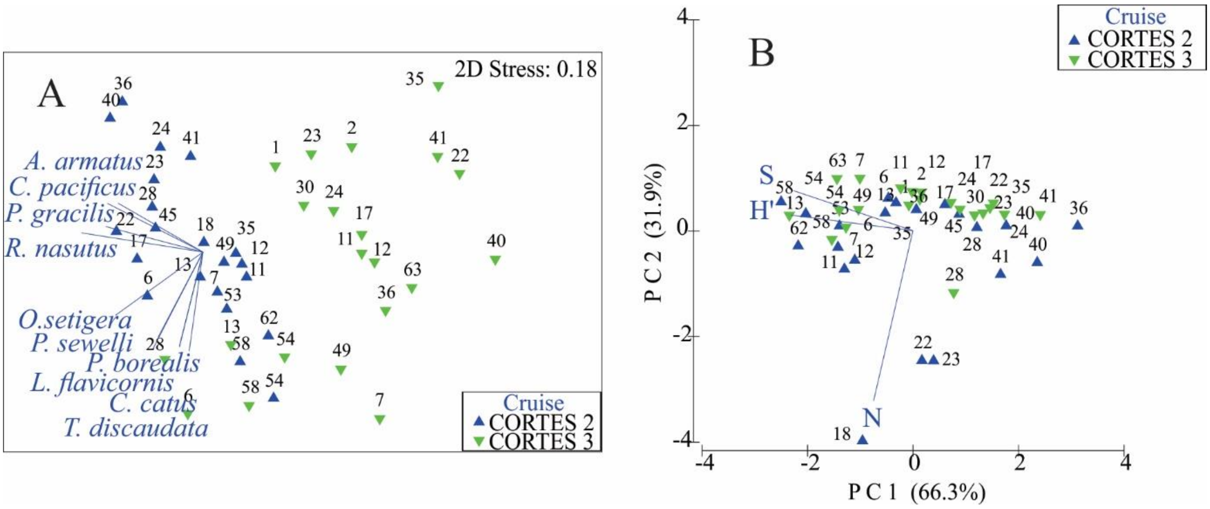

Figure 6. Seasonal variation of the composition (NMDS) (A) and the ecological indices (PCA) (B) in the Gulf of California in 1985: ordination of the sampling stations of the CORTES 2 and 3 cruises. Vectors corresponds to the Pearson correlations between the dominant species abundance and stations (A) and to the ecological variables correlations (B): S, richness, N, abundance, H', diversity.

6.4.4. *Latitudinal and seasonal variation of the copepod body size*

The observed body length distribution of the copepod community was statistically different between the two seasons ($P < 0.001$), although the species list was very similar for the two cruises. The main difference between the two cruises was the observed body length distribution, which consisted in a larger proportion of large copepods (3 to 5 mm) for the cold season, although the vast majority of the individuals ranged between 1 and 3 mm, particularly during the warm season. The Kruskal-Wallis tests also shown significant latitudinal variation among the four zones for the body length of the copepods for both the cold ($P < 0.001$) and the warm season ($P < 0.001$); the Dunn's pairwise comparisons pointed out a larger average size for the NGC and the CGC in relation to the observed at the SGC and the EGC ($P < 0.05$) for the cold season (Fig. 7A), and also a smaller average size of the NGC copepods in relation to the rest of the Gulf ($P < 0.05$) for the warm season data (Fig. 7B).

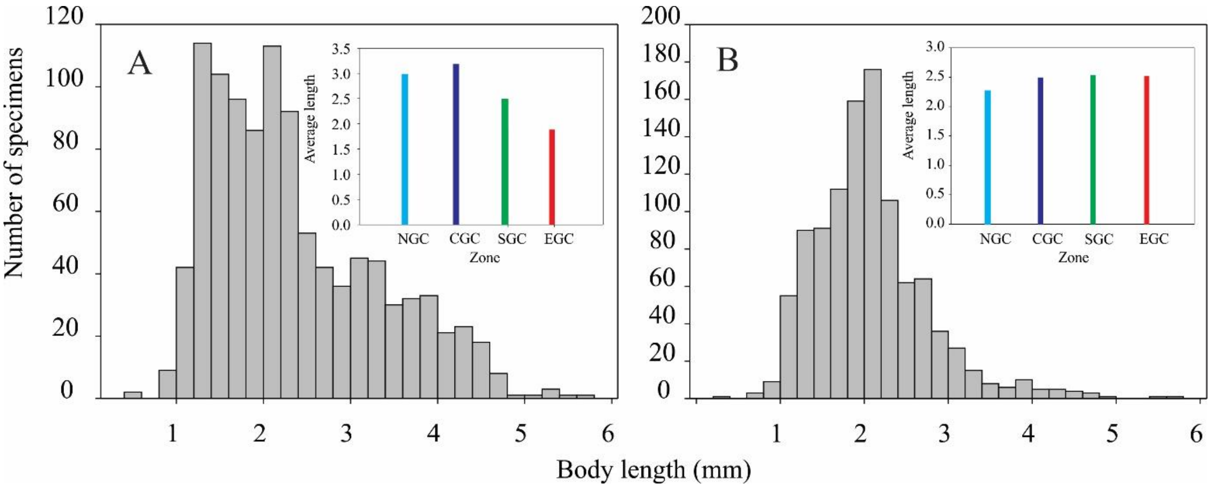

Figure 7. Histograms of the copepod body length frequencies registered for the cold (A) and warm (B) seasons. The number of specimens corresponds to the number of times that each value was observed. The total number of measured specimens is equal for both seasons. The small colored graphics represents the latitudinal variation of the average length per zone for each cruise. NGC, Northern Gulf of California, CGC, Central Gulf of California, SGC, Southern Gulf of California, and EGC, Entrance of the Gulf of California.

6.4.5. *Environmental variables in relation with the copepod distribution*

A strong latitudinal pattern was observed for the salinity in both seasons, gradually decreasing from the NGC towards the EGC. This pattern was stronger in the warm season, and the range of values was larger compared to the cold season; the CGC presented a higher average salinity during the cold season, similar to the recorded in the NGC (Figs. 8A, D). There was also strong latitudinal variation of the temperature, but only during the cold season, with colder waters at the NGC, gradually heating towards the EGC (Fig. 8B); there was not any clear latitudinal temperature pattern during the warm season (Fig. 8E). We observed a longitudinal pattern in the temperature for both seasons, with colder waters in the east coast for the cold season and colder waters in the west coast for the warm season (Figs. 8B, E). Finally, the dissolved oxygen spatial pattern was inverse to the temperature, especially in the 5m-depth layer (Figs. 8C, F).

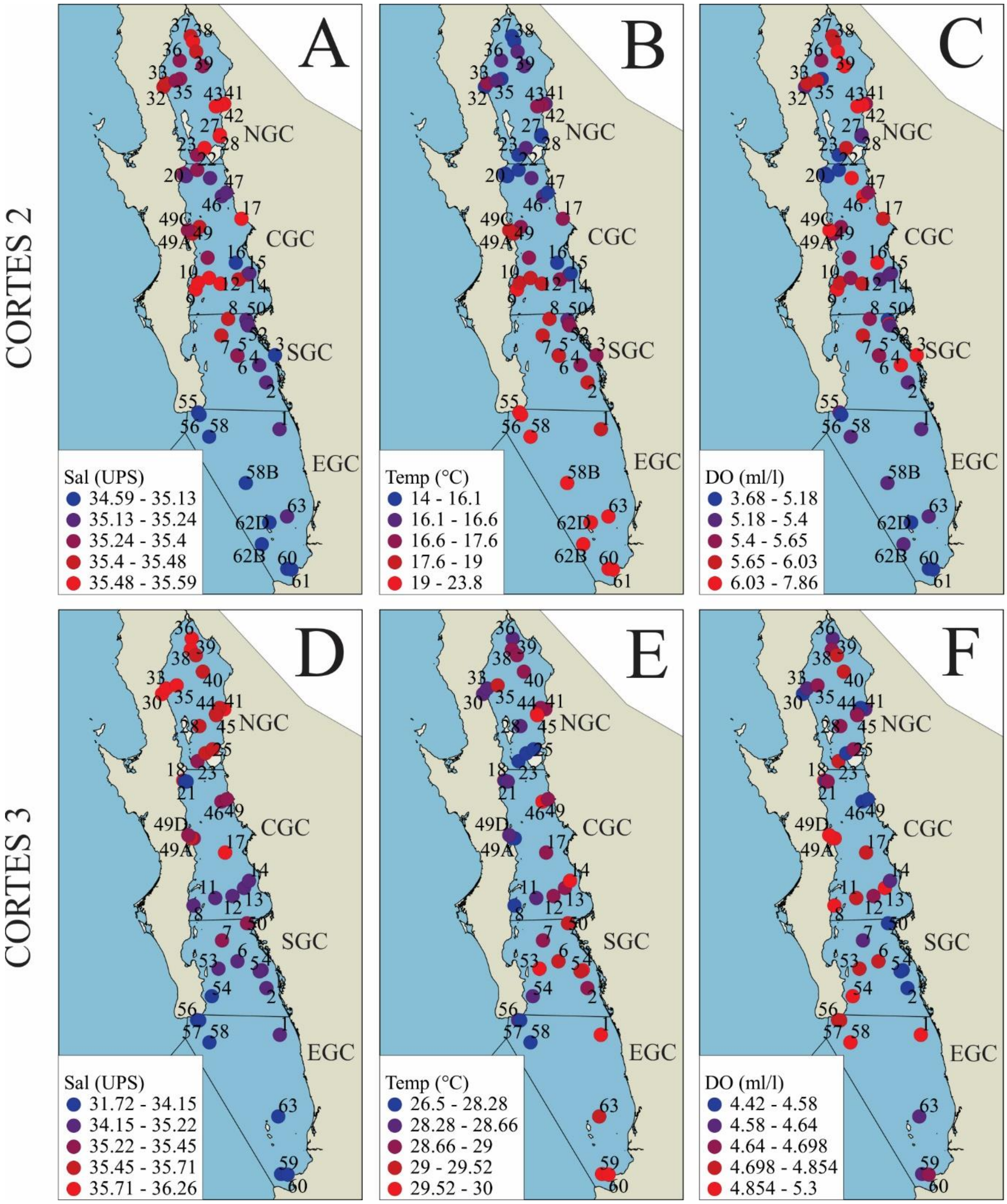

Figure 8. Maps showing the latitudinal variation of the environmental variables registered in the Gulf of California in 1985. Data were recorded during the CORTES 2 (cold season) (A, B, C) and the CORTES 3 (warm season) (D, E, F). The maps include the observed intervals of the salinity (Sal), temperature (Temp) and dissolved oxygen (DO) for the first 5 m of depth. NGC, Northern Gulf of California, CGC, Central Gulf of California, SGC, Southern Gulf of California, and EGC, Entrance of the Gulf of California.

We observed no vertical variation of the salinity for any of both seasons, but the range of the values was larger during the warm season (Fig. 9A). The strongest vertical (and seasonal) pattern was observed for the temperature, with warmer waters in the 5 and 20 m-depth layers, abruptly decreasing at the 75 m-depth layer. This vertical stratification of the temperature was weaker during the cold season, and its average temperatures in the first 20 meters were around 12 °C colder compared to the warm season temperatures (Fig. 9B). The dissolved oxygen shown less pronounced seasonal variation, but still it was significantly lower in the first two layers during the warm season compared to the cold season (Fig. 9C). The maximum, minimum and average values of each variable per depth level of both cruises are shown below (Table 4).

Table 4. Maximum (max.), minimum (min.) and average (avg.) values of the environmental variables for the CORTES 2 and 3 cruises. Temperature expressed as °C, dissolved oxygen expressed as ml/l.

CORTES 2		**Salinity**	**Temperature**	**Dissolved oxygen**
5 m	max.	35.59	23.8	7.86
	min.	34.59	14	3.68
	avg.	35.29	17.76	5.59
20 m	max.	35.56	24	6.7
	min.	34.02	13.7	1.02
	avg.	35.26	17.31	4.91
75 m	max.	35.48	20.2	5.9
	min.	34.19	13.2	0.21
	avg.	35.17	15.04	2.45
CORTES 3		“	“	“
5 m	max.	36.26	30	5.3
	min.	31.72	26.5	4.42
	avg.	34.89	28.78	4.70
20 m	max.	36.54	30	5.68
	min.	31.76	21.6	3.2
	avg.	35.01	27.30	4.72
75 m	max.	36.46	27.5	4.32
	min.	31.76	14.3	0.88
	avg.	34.98	20.04	2.67

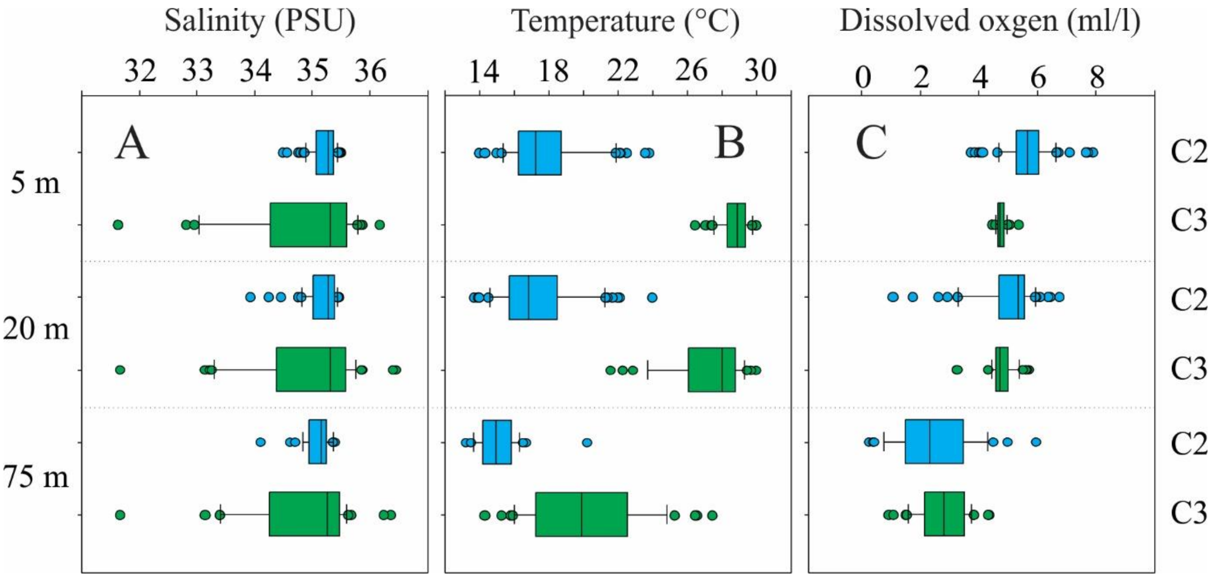

Figure 9. Vertical variation of the environmental variables registered in the Gulf of California in 1985: salinity (A), temperature (B) and dissolved oxygen (C) considering the records in the 5, 20 and 75 depth layers. The Boxplot graphics depict the observations in the cold (C2, blue) and the warm (C3, green) seasons.

As for the spatial pattern of the chlorophyll concentration, there was a considerable difference between the cold and the warm seasons, with values between 2 and 20 mg m^{-3} during the cold season and between 0.1 and 20 during the warm season. The NGC presented, in average, higher concentrations than the CGC, the SGC and particularly than the EGC during the cold season, while there was no a clear latitudinal pattern during the warm season. The higher chlorophyll concentrations were, for both seasons, located towards the eastern coastline of the Gulf.

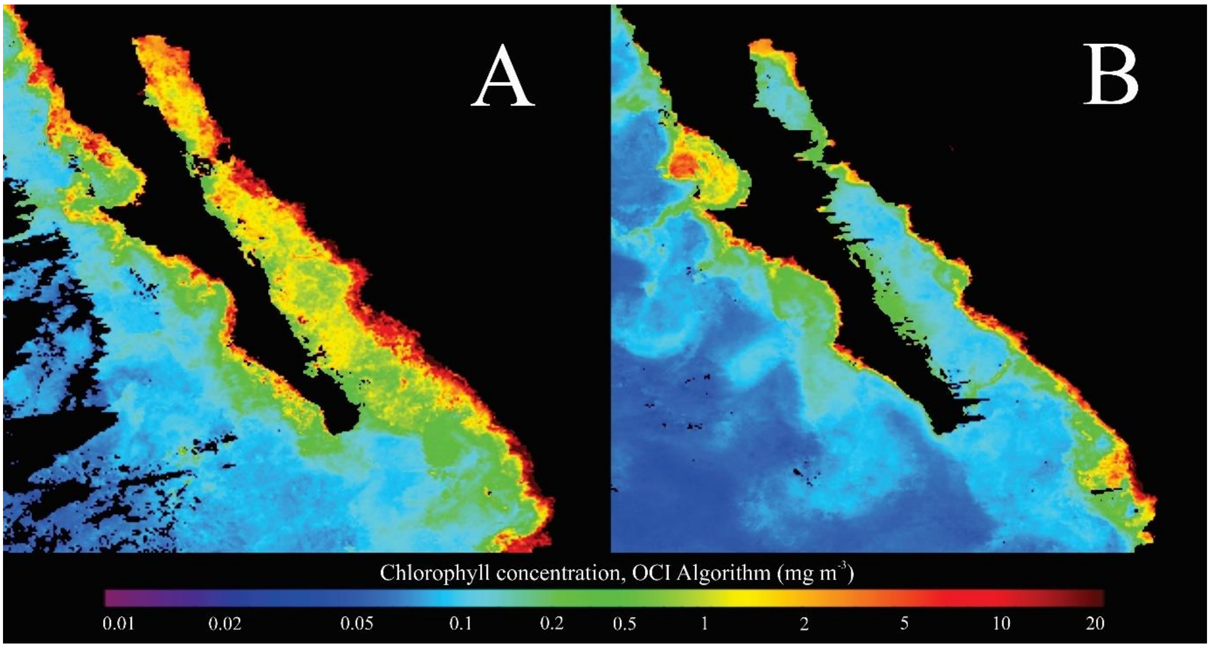

Figure 10. Spatial variation of the chlorophyll concentration in the Gulf of California during A) March, cold season, and B) August, warm season. Units expressed as mg m^{-3} of total chlorophyll.

CCA Analyses were statistically significant for the three depth layers ($P < 0.01$), and the variance inflation factor (VIF) values were maintained below 10 for all the variables, except for the richness (VIF = 12.31) and the diversity (VIF = 11.73) at 75 m depth, because of their strong correlation. The explanation (sum of the canonical eigenvalues over the inertia) of the first canonical eigenvalues was between 0.336 (for the 75 m-depth layer data) and 0.348 (for the 5 m-depth layer data). The main source of variation between the cold and warm seasons observed for the three bathymetric levels was the temperature, negatively correlated with the the dissolved oxygen, with the abundance and with the Blσ in the three analyses. Salinity contributed mostly to the latitudinal dissimilarity, and was negatively correlated with the richness and the diversity at both seasons and at the three bathymetric layers. Dissolved oxygen levels were positively correlated with the abundance at the three depths and with the richness and the diversity at 20 m.

For the 5 m-depth CCA, the relation between temperature and the dissolved oxygen was inversely proportional. Both seasons were well separated and the species conformed two well defined groups, each associated with a season. The cold season species group was composed by large species (high BL and Blσ), like *Aetideus armatus*, *Calanus pacificus*, *Heterorhabdus papilliger*, *Scolecithrix danae* and *Rhincalanus nasutus*, while the warm season group was composed by smaller species (low BL and Blσ), like *Nannocalanus minor*, *Clausocalanus furcatus*, *Lucicutia pacifica*, *Labidocera trispinosa* or *Pontella danae* (Fig. 11). The influence of the salinity was associated with larger copepods (high BL), inversely correlated with the richness and the diversity. The pattern was slightly different for the 20 m-depth CCA, where both the species and sampling stations groups were less defined; also, the relations of the temperature with the salinity and the dissolved oxygen were weaker; only the Blσ was inversely proportional to the temperature at this layer. The relation between the salinity and the BL was also stronger at this layer. (Fig. 12). Finally, for the 75 m-depth CCA, the temperature had stronger correlation with the abundance, but neither the seasons or the species groups were clearly conformed (Fig. 13). The correlations of each variable with the first two axes for the three levels of depth is presented below (Table 5).

Table 5. Correlation values for each environmental and ecological variable used in the CCA analyses. Each variable is correlated with the first two axes (AX1, AX2) of the three levels of depth (5, 20 and 75 m). S) richness, N) abundance, H') diversity, BL) average body length, Blσ) standard deviation of the body length, Sal) salinity, Temp) temperature in °C, DO) dissolved oxygen.

Variable	**AX1 (5 m)**	**AX2 (5 m)**	**AX1 (20 m)**	**AX2 (20 m)**	**AX1 (75 m)**	**AX2 (75 m)**
S	-0.7496	-0.5063	-0.7567	-0.5004	0.7837	-0.4493
N	0.1068	-0.1353	0.1126	-0.1849	-0.0979	-0.1208
H'	-0.6913	-0.5455	-0.6961	-0.5478	0.7265	-0.4698
BL	0.5865	0.1664	0.5774	0.2031	-0.5971	0.0665
Blσ	0.5124	-0.2509	0.5079	-0.211	-0.5162	-0.2858
Sal	0.4838	-0.0781	0.4814	0.1015	-0.6101	-0.0964
Temp	-0.7946	0.4869	-0.7836	0.4727	0.4438	0.471
DO	0.3879	-0.3041	0.0715	-0.4457	-0.3675	-0.2622

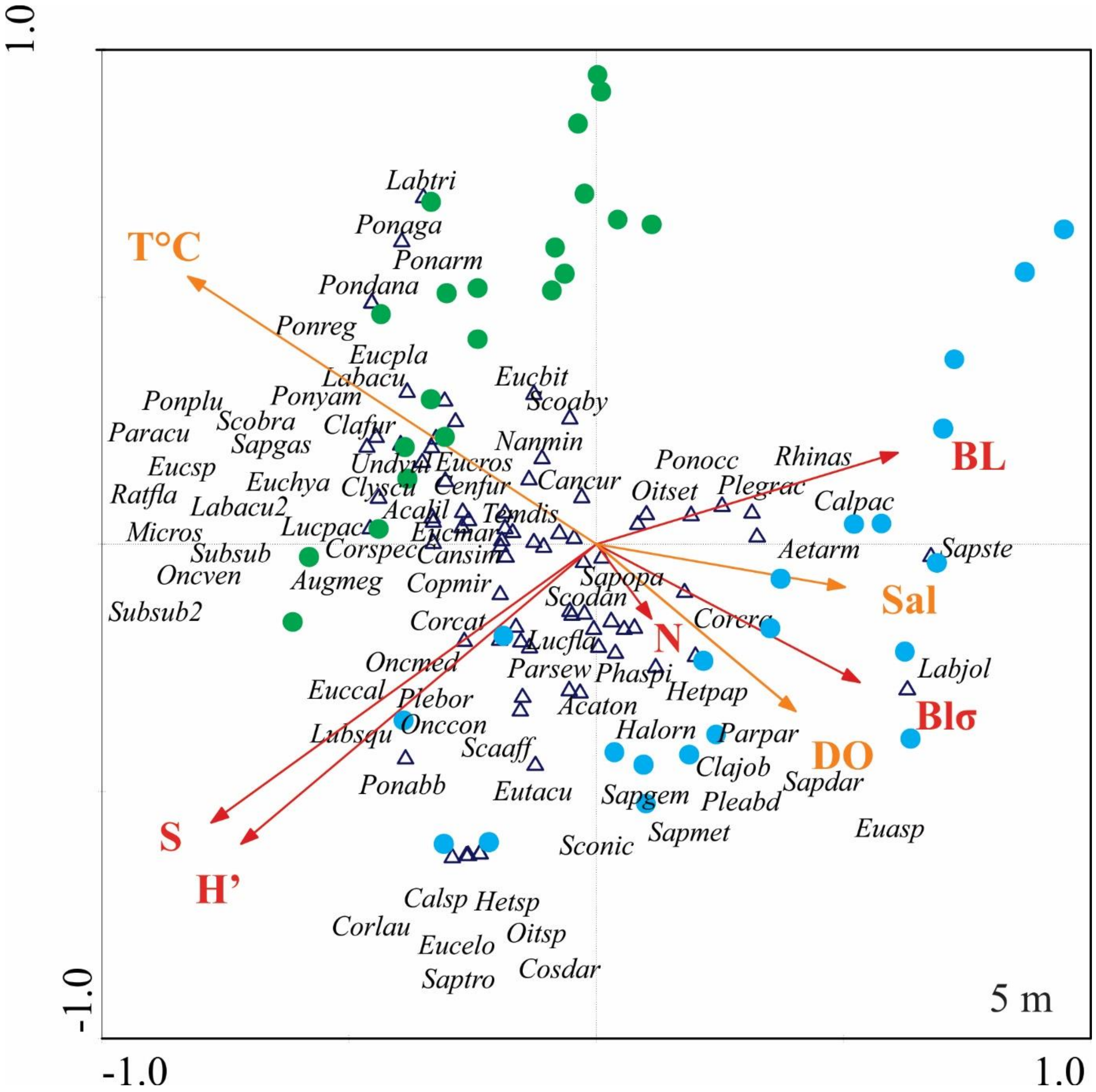

Figure 11. Influence of the environmental variables (orange vectors; T° C-temperature, Sal-salinity, DO-dissolved oxygen) over the ecological indices (red vectors; S-richness, H’-diversity, N-abundance, BL-average body length, Blσ-standard deviation of the body length) and the species composition (blue triangles) registered in the Gulf of California, in 1985. The CCA includes the stations of the cold (blue circles) and the warm (green circles) seasons. Results correspond to the environmental variables measured at a depth of 5 m.

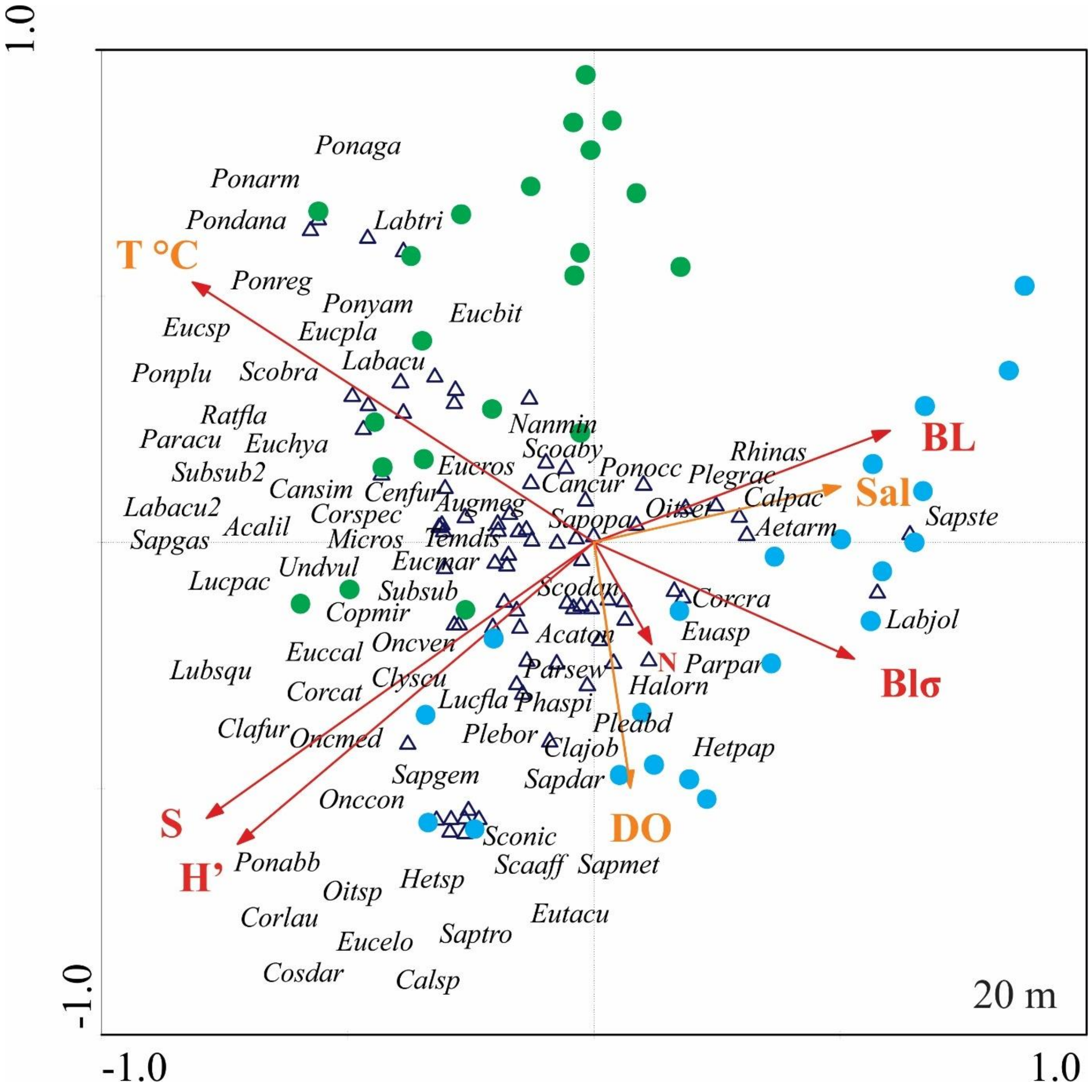

Figure 12. Influence of the environmental variables (orange vectors; T° C-temperature, Sal-salinity, DO-dissolved oxygen) over the ecological indices (red vectors; S-richness, H’-diversity, N-abundance, BL-average body length, Blσ-standard deviation of the body length) and the species composition (blue triangles) registered in the Gulf of California, in 1985. The CCA includes the stations of the cold (blue circles) and the warm (green circles) seasons. Results correspond to the environmental variables measured at a depth of 20 m.

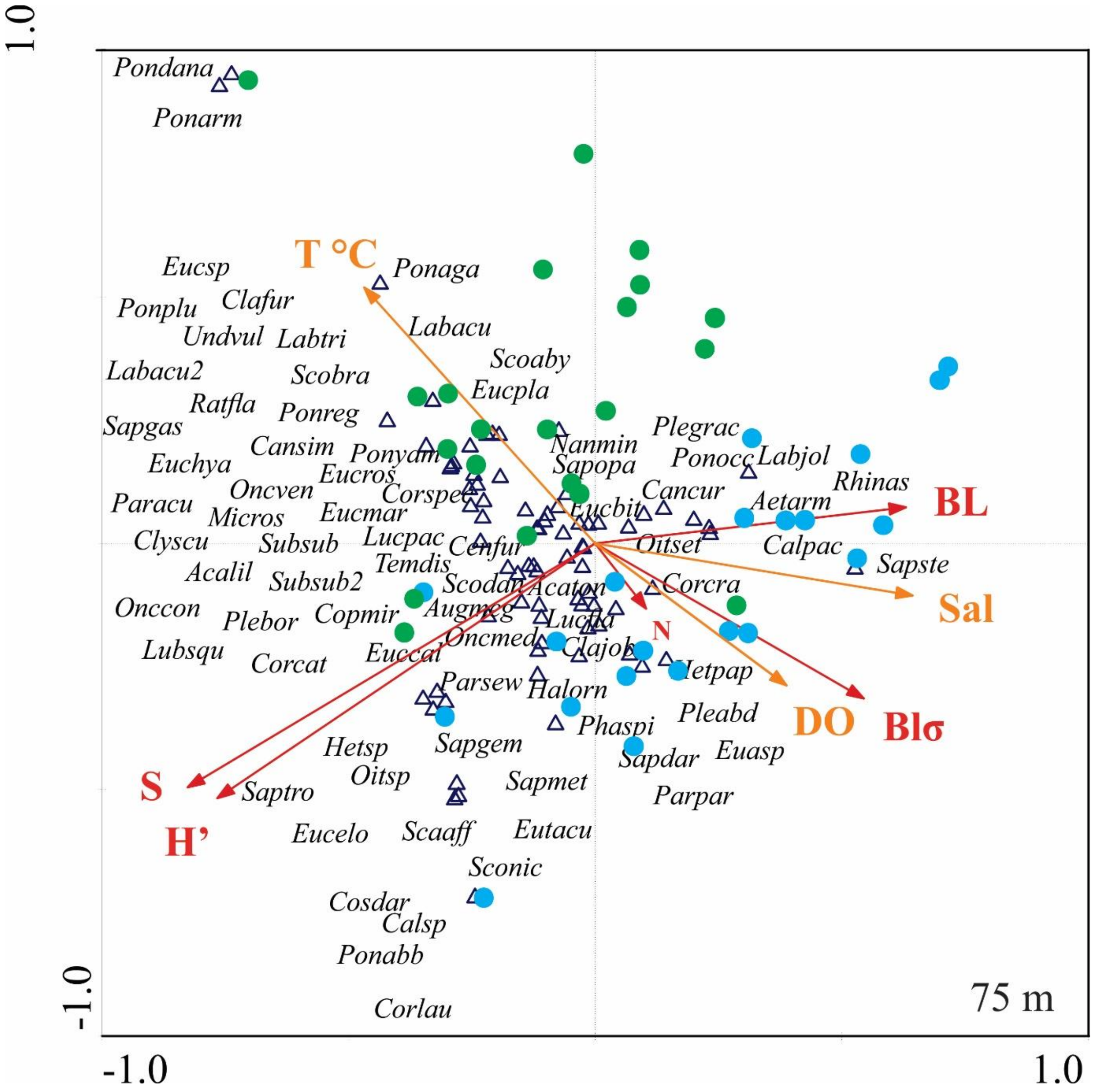

Figure 13. Influence of the environmental variables (orange vectors; T° C-temperature, Sal-salinity, DO-dissolved oxygen) over the ecological indices (red vectors; S-richness, H'-diversity, N-abundance, BL-average body length, Blσ-standard deviation of the body length) and the species composition (blue triangles) registered in the Gulf of California, in 1985. The CCA includes the stations of the cold (blue circles) and the warm (green circles) seasons. Results correspond to the environmental variables measured at a depth of 75 m.

6.5. *Discussion*

6.5.1. *Taxonomical composition, richness, abundance and diversity*

The observed copepod richness in this study was high, considering the short survey period. For the different studies in the Gulf of California, the focus, the sampling area, the sampling period or the number of samples was highly variable (Table 6). Lavaniegos et al.

(2012) analyzed a large proportion of the zooplankton taxa and reported 24 copepod species at the Bahía de los Ángeles, Baja California. Jiménez-Pérez and Lara-Lara (1988) found 76 copepod species in the samples collected during march 1983 along the central and southern regions of the Gulf of California, with an average abundance of around 340,000 ind. 1000m^{-3}. Later, Lavaniegos-Espejo and Lara-Lara (1990) quantified the copepod abundances in the Gulf of California after the 1982-1983 ENSO event and reported around 560,000 ind. 1000m^{-3}. A complete checklist for the entire gulf, based on historic records, published in 1998 by Suárez-Morales and Gasca (1998) included 154 species, but some of these correspond to parasitic or benthonic records. Gómez (2000, 2003, 2018a, 2018b, 2018c) have made several descriptions of coastal and marine benthic harpacticoids for the Gulf of California, although new pelagic copepod species are rarely described for this province. Palomares-García et al. (2013) reported a total of 52 species in a 2007 study of the central and northern Gulf of California and estimated their abundances to be between 100,000 and 500,000 ind. 1000m^{-3}. Álvarez-Tello et al. (2015) collected 33 species in a central Gulf of California embayment. Cruz-Hernández et al. (2018) reported 57 calanoid species in the central Gulf of California, and Beltrán-Castro et al. (2020) observed 49 copepod species for the Cabo Pulmo National Park, in the SW of the gulf, with a larger dominance of calanoids and an average abundance of 242,243 ind. 1000m^{-3}. Another review of historical records for the Bay of La Paz, in the SW gulf, indicated the presence of 146 species after a wide literature revision (Palomares-García et al. 2018). Based on these former works, we have estimated that the current number of pelagic species of copepods in the entire gulf is close to 160 species, although not all of these can be confirmed (Table 6). There is still a large unknown proportion of the gulf of California waters below the 200 m-depth, since most of the works for this area have only surveyed the epipelagic layers. There are only a few works that explored the deep waters of the gulf, as those of Wiebe et al. (2008) or Fleminger (1983), so there is a high chance that new records for this province can still be added.

Table 6. List of published copepod data in the Gulf of California. The most comparable aspects are included: Reference (Ref.), period of study (Per. st.), zone of the gulf (Zone), sampling method (Samp.), number of stations (N° st.), maximum sampled depth (Max. dpt.), average density expressed as ind. $1000m^{-3}$ (Avg. den.), richness (or descriptions/new records) (Rich.) and the three most abundant species (Dom. spec.). The most comparable contributions to this work are highlighted in boldface. ND: non defined by the author or data not found. Please note that some of the presented data were not directly given by the authors and were calculated, so there could be some discrepancies.

Ref.	**Per. st.**	**Zone**	**Samp.**	**N° st.**	**Max. dpt.**	**Avg. den.**	**Rich.**	**Dom. spec.**
Fleminger (1967)	apr 1956-sep 1963	NGC-SGC	Conical net (333 µm)	33	5	ND	2 spp. nov.	ND
Manrique (1977)	ND	ND	ND	ND	ND	ND	ND	*Calanus pacificus*, *Acartia tonsa*, *Acartia lilljeborgii*
Brinton et al. (1986)	ND	NGC-SGC	Literature revision	ND	ND	ND	132 spp.	ND
Jiménez-Pérez and Lara-Lara (1988)	**mar '83**	**CGC, SGC**	**Bongo nets (333 µm)**	**22**	**250 m**	**340,000**	**76 spp.**	***Pleuromamma gracilis*, *Eucalanus subtenuis*, *Eucalanus pileatus***
Wiebe et al. (1988)	jul-aug 1985	CGC	Opening-closing nets (333 µm)	1	1000 m	3705	67 spp.	*Gaidius minutus*, *Spinocalanus* sp., *Candacia magna*
Lavaniegos-Espejo and Lara-Lara (1990)	**mar-apr 1984**	**CGC-EGC**	**Bongo nets (333 µm)**	**26**	**200 m**	**560,000**	**ND**	**ND**
Palomares-García (1996)	1984	SGC (Bahía de la Paz)	Conical net (250 µm)	ND	Surface	ND	59 spp.	*Acartia clausii*, *Acartia lillljeborjii*, *Paracalanus parvus*
Lavaniegos-Espejo and López-Cortés (1997)	jan-nov 1994	SGC (Bahía de la Paz)	Conical net (333 µm)	1	30 m	672,000	20 spp.	*Acrocalanus longicornis*, *Centropages furcatus*, *Nannocalanus minor*
Suárez-Morales and Gasca (1998)	ND	Mexican Pacific and Atlantic	Literature revision	ND	ND	ND	154 spp.	ND
Lavaniegos-Espejo and González-Navarro (1999)	feb-aug 1990, may-nov 1992 and jan 1993	SGC	Bongo nets (300/500 µm)	1	60 m	62,077	93 spp.	*Temora discaudata*, *Nannocalanus minnor*, *Oithona plumata*
López-Cortés et al. (1999)	mar-apr 1995	CGC	ND	9	300 m	ND	3 spp.	*Calanus pacificus*, *Rhincalanus nasutus*
Suárez-Morales and Palomares-García (1999)	sep-96	SGC, Bahía de Madalena	Conical net (333 µm)	ND	ND	ND	1 sp. nov.	ND
Gómez (2000)	apr-june 1991	SGC (Pabellones)	Plastic corer	15	Surface (2 cm)	ND	3 spp.;1 sp. nov.	ND
Gómez (2003)	1991 and 2001	EGC (Pabellones, Urias)	Plastic corer	2	Surface (10 cm)	ND	3 sp. nov.	ND
Lavaniegos-Espejo et al. (2012)	may 2003-oct 2004	SGC (Bahía de los Ángeles)	Conical net (200 µm)	4	Surface	ND	24 spp.	*Paracalanus parvus*, *Acartia tonsa*, *Acartia clausii*

Ref.	Per. st.	Zone	Samp.	N° st.	Max. dpt.	Avg. den.	Rich.	Dom. spec.
Palomares-García et al. (2013)	**jan-aug 2007**	**NGC, CGC**	**Opening-closing conical nets (333 um)**	**34**	**200 m**	**100,000-500,000**	**52 spp.**	***Pleuromamma gracilis, Calanus pacificus, Rhincalanus nasutus***
Beltrán-Castro and Hernández-Trujillo (2016)	ND	ND	Conical net (300 µm)	ND	ND	ND	101 spp.	ND
Cruz-Hernández et al. (2018)	jul-aug 2011	CGC	Opening-closing conical net (505 µm)	21	200 m	46,647-72,471	57 spp.	*Nannocalanus minor, Scolecithrix danae, Temora discaudata*
Cruz-Hernández et al. (2019)	jun-jul 2010	EGC	Opening-closing conical net (505 µm)	17	200 m	62,161	78 spp.	*Nannocalanus minor, Rhincalanus nasutus, Subeucalanus subtenuis*
Gasca et al. (2015)	apr 2005 and mar 2015	CGC-SGC	Remotely operated submersible	ND	3000 m	ND	1 sp. (new record)	ND
Gómez (2018a)	aug 2000 and feb 2007	CGC, SGC	Sediment corer	ND	2120 m	ND	1 sp. nov.	ND
Gómez (2018b)	aug 2000	CGC	Sediment corer	30	2120 m	ND	2 spp. nov.	ND
Gómez (2018c)	feb-07	CGC	Sediment corer	26	1642 m	ND	2 spp. nov.	ND
Gómez-Gutiérrez and Hernández-Trujillo (1994)	aug 1988	EGC	Bongo nets (333/505 µm)	9	600 m	24,176.20	51 spp.	*Paracalanus parvus, Pleuromamma abdominalis, Euchaeta marrina*
Hernández-Nava and Álvarez-Borrego (2013)	sep-dec 2009	CGC	Conical net (150 µm)	12	Surface	10,000,000-50,000,000	24 spp.	*Acartia* sp., *Paracalanus* sp., *Oncaea* sp.
Gómez-Gutiérrez et al. (2014)	nov-10	EGC (Islas Marías)	Conical net (333 µm)	11	Surface	58,576.30	35 spp.	*Calanopia minor, Clausocalanus jobei, Acrocalanus gibber*
Palomares-García et al. (2018)	1980-2007	SGC (Bahía de la Paz)	Literature revision	39	400 m	1,000,000	146	*Temora discaudata, Centropages furcatus, Oithona plumata*
Beltrán-Castro et al. (2020)	jan 2014-dec 2015	EGC (Cabo Pulmo)	Conical net (300 µm)	81	5 m	242,243	49 spp.	*Oncaea venusta, Paracalanus parvus, Clausocalanus jobei*
Coria-Monter et al. (2020)	sep 2008-aug 2009	SGC (Bahía de la Paz)	Bongo nets (333 µm)	56	200 m	39,000-75,520	ND	ND
Rocha-Díaz et al. (2021)	feb-07	SGC	Bongo nets (333 µm)	13	200 m	1,480-15,020	ND	ND
Quiroz-Martínez et al. (2022)	mar-apr 1978	GC	Bongo nets (202 µm)	41	95 m	32,000-90,000	ND	ND
Gómez and Yanez-Rivera (2023)	aug 2000 and aug 2012	SGC	Multiple sediment corer	ND	2120 m	ND	1 sp. nov.	ND

Comparatively, the richness of epipelagic copepods along the west coast of the Baja California Peninsula, influenced by the California Current, is estimated to exceed 152 species (Hernández-Trujillo 2004; López-Ibarra and Palomares-García 2006). Information for the rest of western Mexico is scarce. Off the coast of Jalisco and Colima, around 82 species have been recorded (Kozak et al. 2014a, 2014b, 2018) while 72 species are known to occur off the coast of Oaxaca and Chiapas (Fernández-Álamo et al. 2000). Jiménez-Perez (2016) reported 57 copepod species in Bahía de Banderas, located between Jalisco and Nayarit. Chen (1986) identified 63 species of copepods and their abundance, including some records for the mouth of the gulf of California.

It is not easy to compare species lists of different works, especially if their focus is not taxonomical. There are usually some incorrectly identified species in almost every non-taxonomical work, and their records in different works could actually be assigned to other species, like for example the *Acrocalanus longicornis* Giesbrecht, 1888 and *A. gibber* Giesbrecht, 1888 records for the gulf (Lavaniegos-Espejo and López-Cortés 1997; Gómez-Gutiérrez et al. 2014) could actually correspond to species of the genus *Scolecithricella* Sars G.O., 1902. A similar problem occurs when only the genera are specified (e.g., Hernández-Nava and Álvarez-Borrego 2013). The list presented in the most comparable work (Jiménez-Pérez and Lara-Lara 1988) is actually very similar compared to our observations, except for some doubtful records, like *Spinocalanus* Giesbrecht, 1888 sp. or *Xanthocalanus* Giesbrecht, 1893 sp., probably corresponding to the *Lucicutiidae* Sars G.O., 1902 and *Scolecithricidae* Giesbrecht, 1893 families, based on our observations. The general composition of the copepods in the gulf seems to be, however, very stable along the years.

The average abundance values recorded for the warm season samples were low if compared to the most similar works (Jiménez-Pérez and Lara-Lara 1988; Lavaniegos-Espejo and Lara-Lara 1990; Palomares-García et al. 2013; Coria-Monter et al. 2020), but close to the expected according to the works of Chen (1986) and López-Ibarra et al. (2014) in the Eastern Tropical Pacific, and higher than the reported out of the gulf (e.g., Kozak et al. 2018). The average copepod abundance recorded for the cold season (265,649 ind. 1000m^{-3}) was significantly higher, and the highest recorded density (1,021,076 ind. 1000m^{-3}) was similar to the values that can be observed at temperate and cold waters (see Spinelli et al. 2016; Thompson et al., 2013). Usually, the productivity is expected to be lower during an El Niño event, since the high productivity tends to be associated with colder and saltier waters, as pointed by Santamaría-del-Angel et al. (1994), but the Gulf of California seems to behave inversely compared to other provinces in the ETP (Valdéz-Holguín and Lara-Lara 1987). During the 1982-1983 event, the phytoplankton productivity was actually increased and the zooplankton abundance didn’t significatively decreased, but there was a change in the copepod composition (Valdéz-Holguin and Lara-Lara 1987; Jiménez-Pérez and Lara-Lara 1988). Our lower observed abundances could then be related to the weak effect of La Niña in 1985, but also to the later consequences caused by the change in the copepod composition during El Niño 1982-1983.

6.5.2. *Latitudinal and seasonal copepod variation in the Gulf of California*

The spatial variation of the copepods was similar with the recognized distribution patterns for other pelagic groups (Brinton and Townsend 1980; Brinton et al. 1986; Urias-Leyva et al. 2018; Quiroz-Martínez et al. 2023) and copepods in other years (Jiménez-Pérez and Lara-Lara 1988; Lavaniegos-Espejo and Lara-Lara 1990; Palomares-García et al. 2013). This can be attributed to the oceanographic characteristics in the gulf and the general spatial distribution of the phytoplankton (Santamaría-del-Angel and Alvarez-Borrego 1994; Mercado-Santana et al. 2017; Robles-Tamayo et al. 2020). By these studies on the phytoplankton, we know that the largest abundance in the gulf is present in the NGC, and it gradually decreases towards the EGC, an inverse pattern to the copepod abundance here recorded. The diversity of copepods, at least in the Eastern Tropical Pacific, is usually higher in oligotrophic waters than in more productive waters (Fernández-Álamo and Färber-Lorda 2006), so the lower diversity observed at the NGC compared to the rest of the gulf is not unexpected. A parabolic pattern for the zooplankton richness of the Gulf of California was noticed by Quiroz-Martínez et al. (2023), describing a decrease in the richness both towards the NGC and the SGC. This was predicted by the mid-domain effect, produced when the species ranges of distribution overlaps in a geometrical middle, resulting in a unimodal curve for the richness (Colwell and Lees 2000).

Differences among the four zones were clear considering both the environmental and the ecological data only during the cold season, with statistically significant differences among all the zones ($P < 0.05$), except for the comparison between the CGC and the SGC. The NGC remained as a different zone in the gulf, considering both composition and ecologic data in the cold season ($P < 0.05$ vs. CGC, SGC, EGC), but it was similar to the CGC ($P > 0.05$) in the warm season, The lack of statistically significant differences between the CGC and the SGC in both seasons in terms of composition and ecology result unexpected compared to the work of Jiménez-Perez and Lara-Lara (1988); there was no difference between the ECC and the SGC in any season either, and the EGC was different compared to the CGC only in the cold season ($P < 0.05$), considering both composition and diversity. This lack of latitudinal structure pattern of the copepods in the Gulf of California during the summer is probably related with the seasonal change in the water masses inside the gulf, with a stronger inflow of warm tropical waters to the inner gulf (see Álvarez-Borrego and Schwartzlose 1979; Portela et al. 2016).

The east-west gradient pattern observed for the composition, the temperature, the dissolved oxygen and the chlorophyll concentration can be explained by two different scenarios: either the seasonally reversing winds and sea surface circulation cause this by upwelling events, or the inflow of TSW in the east coast and the outflow of GCW in the west coast (Portela et al. 2016) is the main cause of this effect. It is necessary to sample larger number of stations that allow to compare in a more efficient way how different really is the western copepod community compared to the eastern coast. This seasonal pattern can be compared to the observed in the gulf by Palomares-García et al. (2013): a seasonal shift of the composition, related with the functional structure of the phytoplankton. He also observed dominance of larger copepod species in winter, mostly herbivores, and of smaller, mostly carnivore species in summer, and also noticed the species composition gradient between the NGC and the CGC. These observations match with our observations of the differences in the body length and the standard deviation of the body length of the copepods for both seasonal and latitudinal factors. The larger copepods of the NGC and the CGC in relation to those of the SGC and the EGC during the cold season indicates a larger proportion of filterer species towards the north of the gulf, like *Rhincalanus nasutus*, which was more dominant in these zones. The larger proportion of large copepods during the cold season was also clear, which means that the main factor affecting the copepod community structure is seasonal.

6.5.3. *Environmental influence on the copepod richness, abundance and diversity*

Changes in the taxonomical groups reflect the large environmental variation in their ecosystems (Hernández-Trujillo et al. 2010). Copepods and other zooplanktonic groups are affected in different ways by seasonal changes. Dominance of certain copepod groups may vary from one season to another, sometimes being reduced enough to become rare, giving place to biological successions (Fulton 1984; Stevens and Campbell 2022). Seasonal and interannual abundance variation has been studied for some species like *Acartia clausi* Giesbrecht, 1889 and *Calanus finmarchicus* (Gunnerus, 1770) both showing marked temporal patterns in their distribution (Valdés et al. 2022). If we compare the composition observed in the present study with some of the most similar works for the Gulf of California (Table 6), the dominant species are usually the same in despite of the zone, the season or the survey period. The largest differences in the composition between zones, seasons and years are given by the infrequent or less abundant species, probably due to their higher sensibility to environmental changes.

Latitudinal patterns of copepod richness and diversity have been positively correlated with temperature variation and dissolved oxygen concentration (Rombouts et al. 2009; Ashlock et al. 2021) but, for this scale, we observed no correlation between the diversity and the temperature at any level of depth. Rombouts et al. (2009) described a positive latitudinal correlation between salinity and diversity, an inverse pattern to the observed at this province (Ulate et al. 2016. The salinity is probably not directly driving the latitudinal copepod variation in the Gulf of California, but the phytoplankton abundance and its size structure might be: the latitudinal and seasonal differences for the primary productivity in the gulf (decreasing from the NGC to the EGC, higher during the winter) (Santamaria-del-Angel and Alvarez-Borrego 1994; Mercado-Santana et al. 2017; Robles-Tamayo et al. 2020) concur with the copepod abundance and diversity spatial patterns, and the size of the phytoplankton cells (micro-phytoplankton dominance in the CGC, nano-phytoplankton dominance in the SGC) (Valdéz-Holguín and Lara-Lara 1987; Lara-Lara et al. 1997) seems to be linked to the copepod composition. The influence of the salinity on the phytoplankton has different effects, including changes in the nutrient availability (Sew and Todd 2020). The higher phytoplankton biomass towards the NGC also explains the higher abundance of large copepods in this zone, while the smaller (usually predatory) copepods preferred waters with low productivity. Our results for the chlorophyll concentration during both seasons match the spatial pattern described by Santamaria-del-Angel and Alvarez-Borrego (1994).

The seasonal temperature shift, together with the seasonal change of the productivity in the gulf, can explain the seasonal change in the composition, the abundance and the average body length of the copepod populations. The most abundant and frequent species herein registered in the cold season, with higher chlorophyll concentration in average, are considered to be large filterer herbivorous. *Rhincalanus nasutus* is a widespread distributed species with a wide depth range and also resistant to low oxygen concentrations and starvation (Schnack-Schiel et al. 2008). This species has been observed to be an actually cryptic species complex, with inter-populations differences that doesn’t match to their distribution (Goetze 2003). *Calanus pacificus* is considered to prefer tempered waters (López-Ibarra and Palomares-García 2006; Engström-Öst et al. 2019), although its abundance can also be associated with warmer waters (Fisher et al. 2020; Ashlock et al. 2021). This species is highly abundant and frequent in waters influenced by the California current (Hernández-Trujillo 1991) and is also a resistant species when the oxygen concentrations are low (Engström-Öst et al. 2018; Wyeth et al. 2022). *Pleuromamma gracilis* has shown a wide range of tolerance to dissolved oxygen values, and it has been observed to be a dominant species in relation to other *Pleuromamma* Giesbrecht in Giesbrecht and Schmeil, 1898 species (Jayalakshmy et al. 2008).

The warm season, with lower chlorophyll concentration in average, was characterized by smaller species, like the carnivore pontellids and corycaeids, or the small herbivore *Nannocalanus minor*, a dominant species in this season, which is a widespread distributed species that has been associated to large thermocline conditions, where its abundance can be considerably high (Cruz-Hernández et al. 2018). For the Gulf of Tehuantepec, pontellids have been described to be a very versatile group, easily adapting to changes in salinity and temperature (Álvarez-Silva et al. 2003). The relative higher diversity and abundance of pontellids observed for the warm season can be explained by their significant association with lower phytoplankton productivity, due to their diet type, mostly carnivore (Battuello et al. 2017). Corycaeids are well known as predators (e.g., Landry et al. 1985; Turner et al. 1984) and are considered to have great adaptative capacities against changing conditions (Bjönberg 1981; Suárez-Morales 1989). Spinelli et al. (2016) observed that at the higher radiation and temperature in the summer cause an increase in the carnivore species number, correlated with a decrease in the diatom abundance and an increase in the flagellate abundance, while the winter is characterized by the dominance of herbivore species. This aligns well with the findings of Palomares-García et al. (2013) concerning copepod composition of the Gulf of California.

Dissolved oxygen concentrations did also seem to have a noticeable relation with the variation of the composition at the three layers of depth; some species like *Haloptilus ornatus*, *Sapphirina gema*, *Oncaea conifera*, *Heterorhabdus papilliger* and *Pleuromamma borealis* exhibited a distribution related with higher dissolved oxygen concentrations, while other species like *Pontella agassizi*, *Pontellopsis armata*, *Pontellina plumata*, *Labidocera trispinosa* and *Euchaeta plana* showed higher affinity for lower dissolved oxygen concentrations. Most of the dominant species, like *Calanus pacificus*, *Rhincalanus nasutus*, *Aetideus armatus* and *Pleuromamma gracilis*, were associated with saltier and colder waters, with high concentrations of dissolved oxygen. Other dominant species, like *Nannocalanus minor* or *Centropages furcatus*, were associated with fresher and hotter waters, lower in dissolved oxygen concentrations.

6.6. *Conclusions*

The taxonomical composition was similar compared to other works for the Gulf of California, except for the differences in some infrequent species. There was a clear latitudinal pattern of the richness and the diversity for the cold season, but not for the warm season due to the seasonal changes in the water masses of the gulf; the NGC was the only zone that remained different than the rest of the gulf at both seasons. The CGC and the SGC were not different in terms of composition and diversity at any season, and the SGC was not different than the EGC either; the CGC was only different than the SGC in terms of the average body length of the copepods during the cold season. The east and west coasts of the SGC and the EGC were different in terms of composition because of the seasonal changes in the sea circulation, revealed by the spatial patterns of the temperature. The cold and the warm seasons were different in terms of composition and body length of the copepods, but similar in terms of diversity; the abundance was higher in the cold season. The salinity was strongly correlated with the latitudinal variation of the richness and the diversity, also associated with the latitudinal pattern of the phytoplankton abundance and the phytoplankton size structure. The temperature (inversely correlated with the dissolved oxygen) had a larger effect on the composition and the abundance between the two seasons, matching the seasonal change in the phytoplankton abundance. The herein observed richness was high, but the abundance was low if compared to the observed during the 1982-1983 El-Niño, probably because of the later effects of the change in the composition, caused by this event.

6.7. *References*

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VII. TAXONOMY AND DISTRIBUTION OF DEEP-WATER PELAGIC COPEPODA (MULTICRUSTACEA: COPEPODA) COLLECTED DURING THE TALUD PROJECT IN THE MEXICAN PACIFIC

VIIA. SPECIES COLLECTED IN THE GULF OF CALIFORNIA AND THE MEXICAN PACIFIC, TAXONOMY AND NEW RECORDS.

7a.1.1. *Abstract*

Due to its oceanographic and geological features, the Gulf of California is known to be one of the most diverse and productive marine zoogeographic provinces in the world. The copepod diversity has been well studied in the Mexican Pacific since the early 1900s, resulting in more than 330 species registered to date, nearly half of these occur in the Gulf of California. The vast majority of records in the Mexican Pacific, however, were obtained from the epipelagic layer, which implies unawareness of the deep-water copepod composition in this geographic area, particularly in the Gulf of California. The main purpose of this study was to identify the deep-water copepods in samples obtained from the surface to up to 1625 m in the Gulf of California and the Mexican Pacific Transition. Micro and macro morphological characters were used and line-drawings were made of the main morphological characters. Distributional patterns of the copepod community in the Mexican Pacific were analyzed with multivariate analyses. We analyzed zooplankton samples collected during 12 research cruises of the TALUD project (1989-2014). Mid-water tows were made between surface and to about 1625 m of depth, from the Gulf of California to off the coast of Guerrero, Mexico. Samples were fixed in situ with 4 % formaldehyde and later transfered to 70% ethanol for long term preservation. Eighty-five species of copepods were identified, belonging to 24 families. Thirty-six deep-water species were found; 27 of these species represent new records for the Gulf of California and 25 for the Mexican Pacific. The most diverse family was Augaptilidae (10 species in 5 genera), followed by Aetideidae (7 species in 4 genera). *Lucicutia hulsemannae* was the most abundant and frequent deep-water species, occurring in 67% of the samples. Spatial variation was observed: 2 main groups were conformed, the CGC-SGC zones were different than the EGC-MPT zones in terms of composition; *Rhincalanus nasutus* was more dominant in the Gulf of California, while *Eucalanus hyalinus* dominated in the MPT. This work increases by 8% the copepod list for the Mexican Pacific and provides information about the distribution of these deep-water species.

7a.1.2. *Resumen extendido*

El golfo de California es conocido por ser uno de los sistemas marinos más productivos y diversos en el mundo, debido a sus características oceanográficas y geológicas. La diversidad de copépodos en esta área ha sido ampliamente estudiada desde inicios del siglo 20, dando como resultado más de 330 especies registradas; cerca de la mitad de estas se encuentran en el golfo de California. Uno de los principales problemas acerca del estudio de los copépodos en el Pacífico mexicano es que la gran mayoría de los registros para esta región corresponden a muestras tomadas a profundidades relativamente bajas, en la zona epipelágica a menos de 200 m, lo que implica un profundo desconocimiento de la composición y la distribución de los copépodos, particularmente en el golfo de California. Por ello, este trabajo tiene como principal objetivo el determinar la composición taxonómica de la comunidad de copépodos de aguas profundas del golfo de California a través del uso de micro y macro caracteres morfológicos, así como identificar su patrón de distribución y la afinidad zoogeográfica de la comunidad de copépodos de esta provincia basada en el conocimiento de la distribución de estas especies a nivel mundial. Para ello, se analizaron muestras de zooplancton recolectadas con redes durante las campañas TALUD, realizadas en el Pacífico mexicano a profundidades de entre los 500 y los 1625 m, y para lo que se utilizaron redes de arrastre de micronecton de tipo Isaacs-Kidd de 0.8 m^2 de diámetro y con una luz de malla de 1 mm. Estas campañas fueron dirigidas por el instituto de Ciencias del Mar y Limnología de la Universidad Nacional Autónoma de México, en el periodo comprendido entre 1989 y 2014. Las muestras fueron fijadas in situ con formaldehido al 4% y posteriormente preservadas en etanol al 70%. Para la identificación taxonómica se realizaron disecciones completas de los apéndices cefálicos y torácicos de cada especie. Posteriormente se hicieron dibujos de los principales caracteres taxonómicos con una cámara lúcida y estos fueron comparados con distintos trabajos particulares para cada familia de copépodos. En total se identificaron 85 especies de copépodos, de las cuales 36 se consideran como especies de aguas profundas. En total, 27 especies suponen nuevos registros para el golfo, 25 de ellas también son nuevas para el Pacífico mexicano. La familia con el mayor número de especies fue Augaptilidae, con 10 especies en 5 géneros, seguida por Aetideidae, con 7 especies en 4 géneros. Las otras familias con representantes en aguas profundas fueron: Arietellidae, Bathypontidae, Candaciidae, Heterorhabdidae, Lucicutiidae, Megacalanidae, Nullosetigeridae, Phaenidae y Scolecithricidae. En general, las especies con mayor abundancia y frecuencia en estas muestras fueron: *Rhyncalanus nasutus*, *Eucalanus hyalinus* y *Paraeucalanus sewelli*,

especies de tamaño grande con un amplio intervalo de distribución vertical (0-1000 m). La especie de aguas profundas más frecuente y abundante fue *Lucicutia hulsemannae*, la cual apareció en el 67% de las muestras y contribuyó en promedio al 4% de la abundancia total de copépodos. Otras especies de aguas profundas ampliamente distribuidas en el golfo de California fueron: *Pseudhaloptilus pacificus Euaugaptilus angustus*, *Metridia princeps, Pseudochirella obtusa* y *Paraheterorhabdus compactus*, las cuales presentaron una frecuencia relativa de 21, 18, 15, 12 y 10%, respectivamente. Las especies consideradas como nuevos registros presentan, en su mayoría, una distribución más bien mundial, con algunas excepciones como *Nullosetigera auctiseta*, que únicamente se había registrado en el mar de Japón, *Lucicutia hulsemannae*, la cual solamente se había observado en una localidad al suroeste de Guerrero, México, *Centraugaptilus macrodus,* restringida a la corriente de California y *Augaptilus cornutus*, que es más bien una especie de distribución boreal. Algunas de estas especies pueden observarse en profundidades menores, como es el caso de *Euaugatilus nodifrons* (con un intervalo de distribución de 200 a 1000 m de profundidad) o *Pseudochirella obtusa*, que ha sido registrada en muestras de aguas superficiales. La ausencia de la mayoría de estas en muestras recolectadas a menos de 300 m se puede atribuir a la amplia zona de mínimo de oxígeno que se encuentra en prácticamente todo el Pacífico este tropical, que va desde los 50 hasta a más de 800 m en algunas áreas. Esta zona conforma una barrera física para muchas especies, debido al gasto energético que suponen las migraciones verticales a través de la misma. *Lucicutia hulsemannae* fue la especie meso-abisopelágica con distribución más amplia tanto en el golfo de California como en la zona MPT. Se observó variación espacial en la composición, con diferencias entre los dos grupos principales: las zonas CGC-SGC con respecto a las zonas EGC-MPT. En el primer grupo, la especie más dominante fue *Rhincalanus nasutus*, mientras que *Eucalanus hialinus* fue más dominante en las estaciones del segundo grupo. *Paraeucalanus sewelli*, otra especie con amplia distribución vertical, fue muy abundante en las muestras del golfo, más prácticamente inexistente en la zona MTP. Este trabajo incrementa en un 8% la riqueza de copépodos para el Golfo de California, e incrementa la disponibilidad de datos de la distribución geográfica de estas especies.

7a.2. *Introduction*

Pelagic copepods are considered to be one of the most abundant and diverse groups of zooplanktonic organisms. Recent estimations put the number of valid species at around 14,000 species (Suárez-Morales et al. 2020). The pelagic copepod fauna in the Mexican Pacific is rather reduced in number and to date only 300 species have been recorded (Chen 1986; Suárez-Morales and Gasca 1998; Palomares-García et al. 2018), mostly in the epipelagic fringe. When reviews performed in the 90s and recent contributions are considered, the list of copepods currently registered in the Gulf of California includes more than 160 species (Suárez-Morales and Gasca 1998, Palomares-García et al. 1998, Palomares-García et al. 2013, Álvarez-Tello et al. 2015, Jiménez-Pérez 2016, Palomares-García et al. 2018, Cruz-Hernández et al. 2018, Beltrán-Castro et al. 2020).

Traditionally, sampling for zooplankton in the Mexican Pacific has been essentially performed between surface and maximum depths of about 200 m, generally using plankton nets with mesh aperture of about 300 or 500 um (e.g., Brinton et al. 1986; Chen 1986; Jiménez-Pérez and Lara-Lara 1988; Lavaniegos-Espejo and Lara-Lara 1990; Ayala-Duval et al. 1996; Lavaniegos et al. 1998; Suárez-Morales et al. 2000; Franco-Gordo et al. 2001; Palomares-García et al. 2013; Beltrán-Castro et al. 2020; Velázquez-Ornelas and Hendrickx 2023). Some sampling has been performed in deeper waters (e.g., to 500 m), using MOCNESS multiple-net gear (e.g., Lorda and Data 2023), but copepods have not been properly studied. Some data were also collected in the Mexican Pacific related to the zooplankton communities living at or near hydrothermal vents (e.g., Berg and Van Dover 1987). Consequently, there is a significant lack of information on deep-water copepods (i.e., occurring below 200 m depth) in the Mexican Pacific and, particularly, in the Gulf of California.

There are clear differences in the copepod community's composition among the different vertical zones, and the bathymetric gradients are usually regulated by species-specific ecophysiological performance and also by biological interactions, although the specific mechanisms that drive these gradients are still poorly understood, particularly in the deep sea (Bode et al. 2018). The presence of Oxygen Minimum Zones (OMZ) is one of the main factors that can profoundly affect the vertical structure of the zooplankton communities, and these have received increasing attention due to their geographic and vertical expansion (Wishner et al. 2013; Teuber et al. 2019). Since zooplanktonic species tolerate specific oxygen levels according to their adaptations (Saltzman and Wishner 1997; Wishner et al. 2008), the copepod community of the epipelagic layer is quite different to that of the deeper strata, as noticed in several works (e.g., Maatsura et al. 2010; Bode et al. 2018; Stefanoudis et al. 2019; Hirai et al. 2020). The largest known OMZ occurs in the eastern tropical Pacific (ETP) and is known to be a physical barrier between the invertebrate communities inhabiting above and below the OMZ core (Hendrickx and Serrano 2014; Papiol et al. 2016).

Despite of the large proportion of seas and oceans with depths greater than 1000 m (Childress 1995), the knowledge of the deep-sea pelagic communities is relatively scarce. This is mainly a consequence of the inherent difficulties of sampling at these depths, making hard it hard to collect large amount of material (Ward and Shreeve 2001). The density and abundance of zooplanktonic species in deep waters is relatively low, thus requiring large nets and specialized equipment to ensure filtration of large volumes of water (Fernandez de Puelles et al. 2019). Copepods are a highly important component of the biological pump system for both minerals and organic matter, and they play a paramount role in the meso and bathypelagic trophic nets (Yamaguchi et al. 2015).

Some examples of calanoid genera associated with deep water environments (> 500 m depth) include *Alrhabdus* Grice, 1973, *Bradyidius* Giesbrecht, 1897, *Caudacalanus* Markhaseva and Schulz, 2008, *Euagaptilus* Sars G.O., 1920, *Foxtosognus* Markhaseva, 2008 or *Spinocalanus* Giesbrecht, 1888 (Harding 1974; Markhaseva and Schulz 2008; Markhaseva 2008; Bode et al. 2018; Hirai et al. 2020; Markhaseva and Renz 2021; Andronov and Kosovokova 2024). In the Mexican Pacific, few species considered meso or bathypelagic have been previously recorded: e.g., *Augaptilus megalurus* Giesbrecht, 1889, *Gaetanus brevicornis* Esterly, 1906, *Isaacsicalanus paucisetus* Fleminger, 1983, *Lucicutia bicornuta* Wolfenden, 1905, *Lucicutia hulsemannae* Markhaseva and Ferrari, 2005, *Metridia princeps* Giesbrecht, 1889, *Paraeuchaeta copleyae* Park, 1993, *Paraeuchaeta grandiremis* (Giesbrecht, 1888), *Racovitzanus pacificus* (Esterly, 1905), *Scaphocalanus echinatus* (Farran, 1905), *Spinocalanus abyssalis* Giesbrecht, 1888, or *Xanthocalanus pinguis* Farran, 1905 (Suárez-Morales and Gasca 1998; Razouls et al. 2024). Some species recorded in the Mexican Pacific, as *Eucalanus hyalinus* (Claus, 1866), *Paraeucalanus sewelli* (Fleminger, 1973), *Rhincalanus nasutus* Giesbrecht, 1888, or *Chiridius poppei* Giesbrecht, 1892 are considered as vertical migrators, with a wide distribution range (from surface to abyssopelagic habitats). There are very few reliable records of deep-water copepod species in the Gulf of California, most provided by Esterly's (1905, 1906, 1911, 1912, 1913, 1924) contributions. *L. bicornuta*, *M. princeps*, *P. copleyae* and *X. pinguis* are some deep-water species recorded also in the Gulf of California. Recent contributions by Jiménez-Pérez and Lara-Lara (1988) and Wiebe et al. (1988) includes the records of unidentified species of *Chiridius* Giesbrecht, 1893, *Gaetanus* Giesbrecht, 1888, *Spinocalanus* Giesbrecht, 1888 and *Xanthocalanus* Giesbrecht, 1893, but species level identification of these have not been provided in further taxonomic works. Consequently, the deep-water copepod community in the Gulf of California remains largely unknown.

The present work is aimed at identifying members of the copepod community inhabiting below 200 m depth collected during the TALUD cruises. Based on many new records, it analyzes the spatial distribution pattern of deep-water pelagic. We also describe the general spatial pattern of the copepod communities in the Gulf of California and the Mexican Pacific Transition.

7a.3. *Material and Methods*

7a.3.1. *Fieldwork*

The Mexican Pacific (MP) extends from 32°27’ N to 14°32’ N. It includes a large littoral region of about 8000 km long (68% of the Mexican littoral). The MP can be subdivided into five zoogeographic provinces (Hendrickx 1992; Espinosa-Pérez and Hendrickx 2006) or five ecoregions (Wilkinson et al. 2009, Spalding et al. 2007): the Panamic province (Middle American Pacific, MAP), the Mexican province (Mexican Pacific Transition, MPT), the Cortezian province (Gulf of California, GC), the Californian province (Southern Californian Pacific, SCP) and the Oregonian province (Montereyan Pacific Transition, MPT) (Wilkinson et al. 2009). These have been defined based on the known distribution of different taxa, e.g., isopods, mollusks and other invertebrates (e.g., Brusca and Wallerstein 1979; Lancellotti and Vásquez 1999). The Californian province (SCP) extends from Punta Concepción (South California, E.U.A.) to Bahía Magdalena (Baja California Sur, México). The Cortezian province (GC) is independent from the Californian province (Spalding et al. 2007; Espinosa & Hendrickx 2006), with a large portion of endemic species (Hendrickx 1992; Correa-Sandoval and Rodríguez-Cortés 1998), and a unique oceanography caused by the tidal regime combined with the wind circulation (Álvarez-Borrego and Schwartzlose 1979; Badan-Dangon et al., 1985; Lavín et al. 1995; Lavín et al. 2014). This province extends from the upper Gulf to Punta Banderas (Jalisco, Mexico) (Hendrickx et al.

2005). The Mexican province (MPT) extends from Punta Banderas to Tangola Tangola (Oaxaca, Mexico). The Panamic province (MAP) includes, in Mexico, the area corresponding to Oaxaca and Chiapas (see Espinosa and Hendrickx 2006; Spalding et al. 2007; Wilkinson et al. 2009). The portion of the Oregonian province is too small to be considered as an independent zone, thus it will be treated as part of the Californian province from here.

The biological material studied herein was collected with a Bongo net (BO; 0.505 mm mesh aperture) (TALUD I), an Isaacs-Kidd midwater trawl (IK) (TALUD III), or a 0.9 m x 0.9 m mouth aperture micronekton net (MN; 1 mm mesh aperture) (TALUD (IV to XII and XIV). Samples were collected between 1989 and 2014 onboard of the R/V "El Puma", Universidad Nacional Autónoma de México (UNAM). The area covered during the survey was from the northern Gulf of California (TALUD XIV) and throughout the Gulf to off Guerrero, Mexico (TALUD XI and XII) (Figure 1). All tows were taken obliquely from surface to depths of up to 1530 m, thus reaching deep water fringe below the OMZ core. The samples were fixed in situ with 4% formaldehyde and later preserved in 70% ethanol.

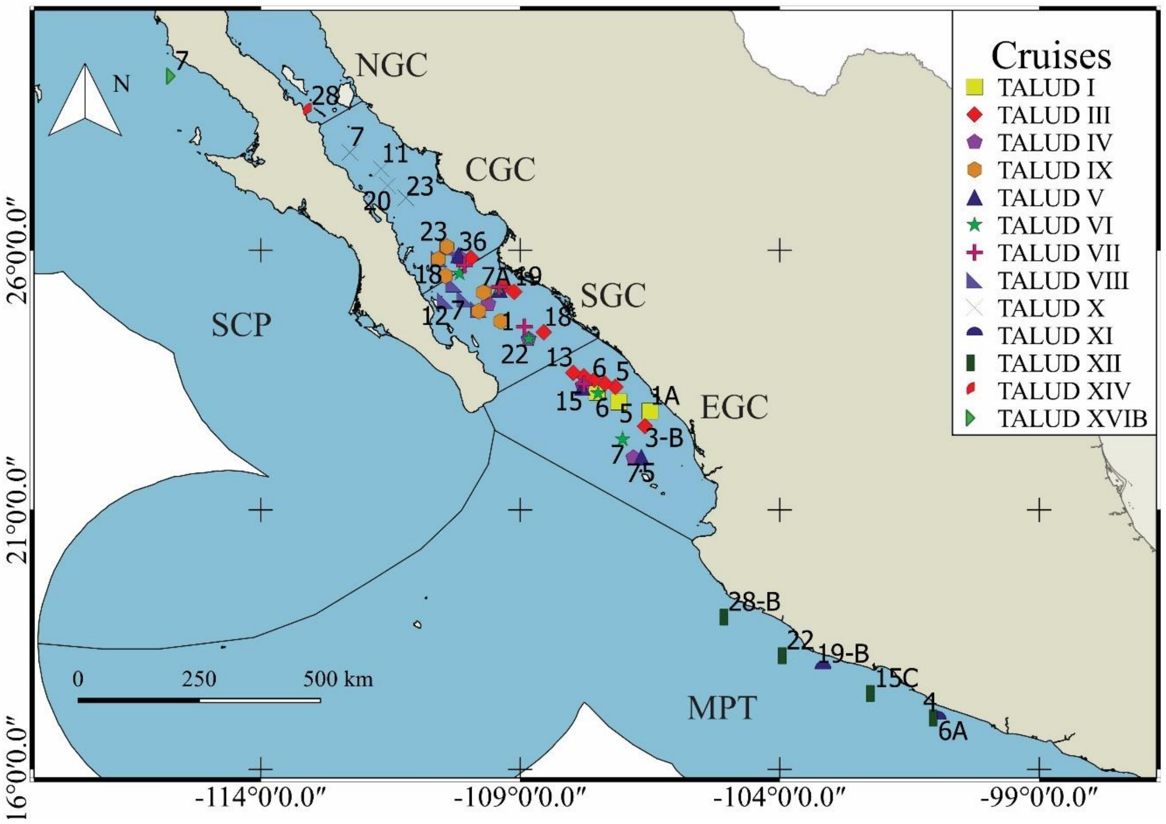

Figure 1. Map of the stations sampled during the TALUD I-XIV cruises in the Cortezian (GC) and the Mexican (MPT) provinces. NGC, Northern Gulf of California, CGC, Central Gulf of California, SGC, Southern Gulf of California, EGC, Entrance of the Gulf of California, MPT, Mexican Pacific Transition, SCP, Southern Californian Pacific.

7a.3.2. *Data collection and analyses*

The material was identified based on micro and macro morphological characters, making full dissections of all the cephalic and thoracic appendages. Permanent preparations were made with the dissected material using glass slides, glycerin as media, and xylol-based resin as sealant (see Suárez-Morales et al. 2020). Illustrations of the main taxonomic characters were drawn with the aid of a camera lucida, mounted in a Leica® DM LS2 compound microscope. Specialized literature and original species descriptions (see details in the systematics chapter) for families of Calanoida occurring worldwide were used (e.g., Tanaka 1961, Bradford et al. 1983; Markhaseva and Ferrari 2005, Mazzocchi et al. 1995; Markhaseva 1996; Soh et al. 1999, Prusova et al. 2012, Soh and Moon 2014; Bradford-Grieve et al. 2017).

To analyze the spatial variation of the composition at species and family level, non-parametric multidimensional scaling (NMDS) analyses were performed, previous square root data transformation of the data and then plotted as a Bray-Curtis similitude matrix. For the family level analysis, data were sum for factor and also square root transformed. On the same species-level matrix, a CLUSTER analysis was performed: 50% resemblance line is overlaid on the NMDS to circle the conformed subgroups. A principal components analysis (PCA) was also used to evaluate the variation of the diversity in relation with the depth, previous normalization of the data. Multivariate analyses were performed with the PRIMER E6 program. The sampling stations map was performed using the QGIS 3.14 program.

7a.4. *Results*

7a.4.1. *Species composition*

Considering all available samples, 85 species (Table 1) were identified (49 species known to be epipelagic), including 69 calanoids, 14 cyclopoids, and 2 monstrilloids. 36 calanoid species are considered to be distributed in meso or bathypelagic waters, between 500-2000 m depths (Tanaka 1961; Soh et al. 1999; Markhaseva and Ferrari 2005; Bradford-Grieve et al. 2017, Razouls et al. 2024). As many as 27 species had not been previously recorded in the Gulf of California, 25 in the case of the Mexican Pacific. *Lucicutia bicornuta* Wolfenden, 1905, *Metridia princeps* Giesbrecht, 1889 and *Paraeuchaeta copleyae* Park, 1993 are deep-water species previously recorded in the Gulf of California (Suárez-Morales and Gasca 1998). Most of these calanoids are large species, usually longer than 5 mm (not including the caudal setae), compared to the epipelagic taxa that rarely surpass 2-3 mm lengths. The 14 species of cyclopoids collected during this survey (Table 1) are considered to be epipelagic species and will not be treated in this contribution. No deep-water harpacticoid species were found. Two species of monstrilloid copepods are added: *Monstrilla leucopis* Sars G.O., 1921 and *Monstrilla* sp. nov., both recorded from deep-water samples (Table 1).

Among the 36 species of calanoids considered meso or bathypelagic, the best represented family was Augaptilidae (10 species in total), with 4 genera and 9 species associated with deep-water: *Augaptilus*, 2 species; *Centraugaptilus*; 2 species, *Euaugaptilus*, 4 species; *Pseudhaloptilus*, 1 species. The family Heterorhabdidae was the second largest in number of deep-water species: 5 in 4 genera (table 1). The other families were, in decreasing order of deep-water species richness: Aetideidae and Arietellidae (with 4 species each), Scolecithricidae (with 3 species), Lucicutiidae and Nullosetigeridae (with 2 species each) and Bathypontidae, Candacidae, Megacalanidae and Metridinidae (with one species each).

Table 1. List of species in samples collected during the TALUD cruises. Species considered as deep-water copepods (vertical distribution from 500 to 2000 m) are in boldface. Non-identified species are underlined. See text for more details.

Order	Family	Species
Calanoida	Acartidae	*Acartia (Acartiura) clausi* Giesbrecht, 1889
	Aetideidae	*Aetideus armatus* (Boeck, 1872)
		Euchirella bitumida With, 1915
		Euchirella rostrata (Claus, 1866)
		***Gaetanus kruppii* Giesbrecht, 1903**
		***Gaetanus miles* Giesbrecht, 1888**
		***Gaetanus pileatus* Farran, 1903**
		***Pseudochirella obesa* Sars G.O., 1920**
	Arietellidae	***Arietellus setosus* Giesbrecht, 1893**
		***Arietellus* Giesbrecht, 1893 sp.**
		***Sarsarietellus* Campaner, 1984 sp. 1**
		***Sarsarietellus* Campaner, 1984 sp. 2**
	Augaptilidae	***Augaptilus cornutus* Wolfenden, 1911**
		***Augaptilus megalurus* Giesbrecht, 1889**
		***Centraugaptilus horridus* Farran, 1908**
		***Centraugaptilus macrodus* (Esterly, 1911)**
		***Euaugaptilus angustus* (Sars G.O., 1905)**
		***Euaugaptilus longimanus* (Sars G.O., 1905)**
		***Euaugaptilus nodifrons* (Sars G.O., 1905)**
		***Euaugaptilus austrinus* Park, 1993**
		Haloptilus ornatus (Giesbrecht, 1893)
		***Pseudhaloptylus pacificus* (Jhonson, M.W., 1936)**
	Bathypontidae	***Temorites elongata* (Sars, G.O., 1905)**
	Calanidae	*Calanus pacificus* Brodsky, 1948
		Nannocalanus minor (Claus, 1863)
	Candaciidae	*Candacia curta* (Dana, 1849)
		***Candacia elongata* (Boeck, 1872)**
	Centropagidae	*Centropages elongatus* Giesbretch, 1896
		Centropages furcatus (Dana, 1849)
	Eucalanidae	*Eucalanus hyalinus* (Claus, 1866)
		Pareucalanus sewelli (Fleminger, 1973)
		Rhincalanus nasutus Giesbrecht, 1888
		Subeucalanus subtenuis (Giesbrecht, 1888)
	Euchaetidae	*Euchaeta acuta* Giesbrecht, 1893

		Euchaeta indica Wolfenden, 1906
		Euchaeta marina (Prestandrea, 1833)
		***Paraeuchaeta copleyae* Park, 1993**
		Euchaeta media Giesbretch, 1888
	Heterorhabdidae	***Disseta palumbii* Giesbrecht, 1889**
		***Disseta scopularis* (Brady, 1883)**
		Heterorhabdus papilliger (Claus, 1863)
		***Heterostylites major* (Dahl F., 1894)**
		***Mesorhabdus angustus* Sars G.O., 1907**
		***Paraheterorhabdus compactus* (Sars G.O., 1900)**
	Lucicutiidae	***Lucicutia bicornuta* Wolfenden, 1905**
		Lucicutia flavicornis (Claus, 1863)
		***Lucicutia hulsemannae* Markhaseva and Ferrari, 2005**
		Lucicutia pacifica Brodsky, 1950
	Megacalanidae	***Megacalanus frosti* Bradford-Grieve, Blanco-Bercial and Boxshall, 2017**
	Metridinidae	***Metridia princeps* Giesbrecht, 1889**
		Pleuromamma abdominalis abdominalis (Lubbock, 1856)
		Pleuromamma borealis Dahl F., 1893
		Pleuromamma gracilis gracilis Claus, 1863
	Nullosetigeridae	***Nullosetigera auctiseta* Soh, Ohtsuka, Imabayashi and Suh, 1999**
		***Nullosetigera mutica* (Sars G.O., 1907)**
	Phaennidae	***Cephalophanes* Sars G.O., 1907 sp.**
		Phaenna spinifera Claus, 1863
		***Xanthocalanus* sp.**
	Pontellidae	*Labidocera acuta* (Dana, 1849)
		Labidocera acutifrons (Dana, 1849)
		Pontella fera Dana, 1849
		Pontellina plumata (Dana, 1849)
		Pontellopsis armata (Giesbrecht, 1889)
	Scolecitrichidae	***Lophothrix frontalis* Giesbrecht, 1895**
		***Pseudoamallothrix inornata* (Esterly, 1906)**
		***Scaphocalanus affinis* (Sars G.O., 1905)**
		Scolecithrix danae (Lubbock, 1856)
	Incertae sedis	cf. Scolecithricidae sp.
	Temoridae	*Temora discaudata* Giesbrecht, 1889
Cyclopoida	Corycaeidae	*Corycaeus crassiusculus,* Dana 1849
		Corycaeus speciosus Dana, 1849
		Onychocorycaeus latus (Dana, 1849)
	Oithonidae	*Oithona robusta* Giesbrecht, 1891
		Oithona setigera setigera (Dana, 1849)
	Oncaeidae	*Oncaea venusta* Philippi, 1843
	Sapphirinidae	*Copilia mirabilis* Dana, 1852
		Copilia quadrata Dana, 1849
		Sapphirina angusta Dana, 1849

		Sapphirina darwinii Haeckel, 1864
		Sapphirina gastrica Giesbrecht, 1891
		Sapphirina iris Dana, 1849
		Sapphirina metallina Dana, 1849
	Incertae sedis	*Pachos punctatum* (Claus, 1863)
Monstrilloida	Monstrillidae	*Monstrilla leucopis* Sars G.O., 1921
		Monstrilla hendrickxi sp. nov

7a.4.2. *Systematic section. New records of deep-water pelagic copepods in the Gulf of California and the Mexican Pacific Transition*

A description of the main morphological characters of the new recorded species for the Gulf of California or the Mexican pacific is presented. Species considered as meso-abyssopelagic copepods, based in their morphological adaptations and their depth of collection are shown in boldface (Table 1). Morphological descriptions are based on the material examined during this study: drawn individuals are in boldface. Terminology for body and appendages (see Figures 3, 4; modified from Prusova et al. 2012) and abbreviations used for calanoids follow Dussart and Defaye (2001).

Abbreviations.

For systematics:

ae- Aesthetasc

asm- anal somite

A1- Antennule

A2- Antenna

bp- basipodite

Cr- Caudal rami

cx- coxopodite

Enp- Endopod

Exp- Exopod

F- Female

gb- Gnathobase

Gs- Genital double somite

ie- intercoxal esclerite

ied- internal endite

juv.- juvenile

M- Male

Md- Mandible

Mx1- Maxillule

Mx2- Maxilla

Mp- Maxilliped

pcx- praecoxa

P1 to P6- First to sixth thoracic appendages

Th1 to Th5- Thoracic somites

Ur1 to Ur5- Urosomal somites

For methods:

SPS- Mounted on semipermanent slide

UD- Undissected, in a vial with 70% ethanol

St.- Station

TD- Total depth at station

MN- Micronekton net, used for sampling

PS- Prime synonym

ETP- Eastern tropical pacific

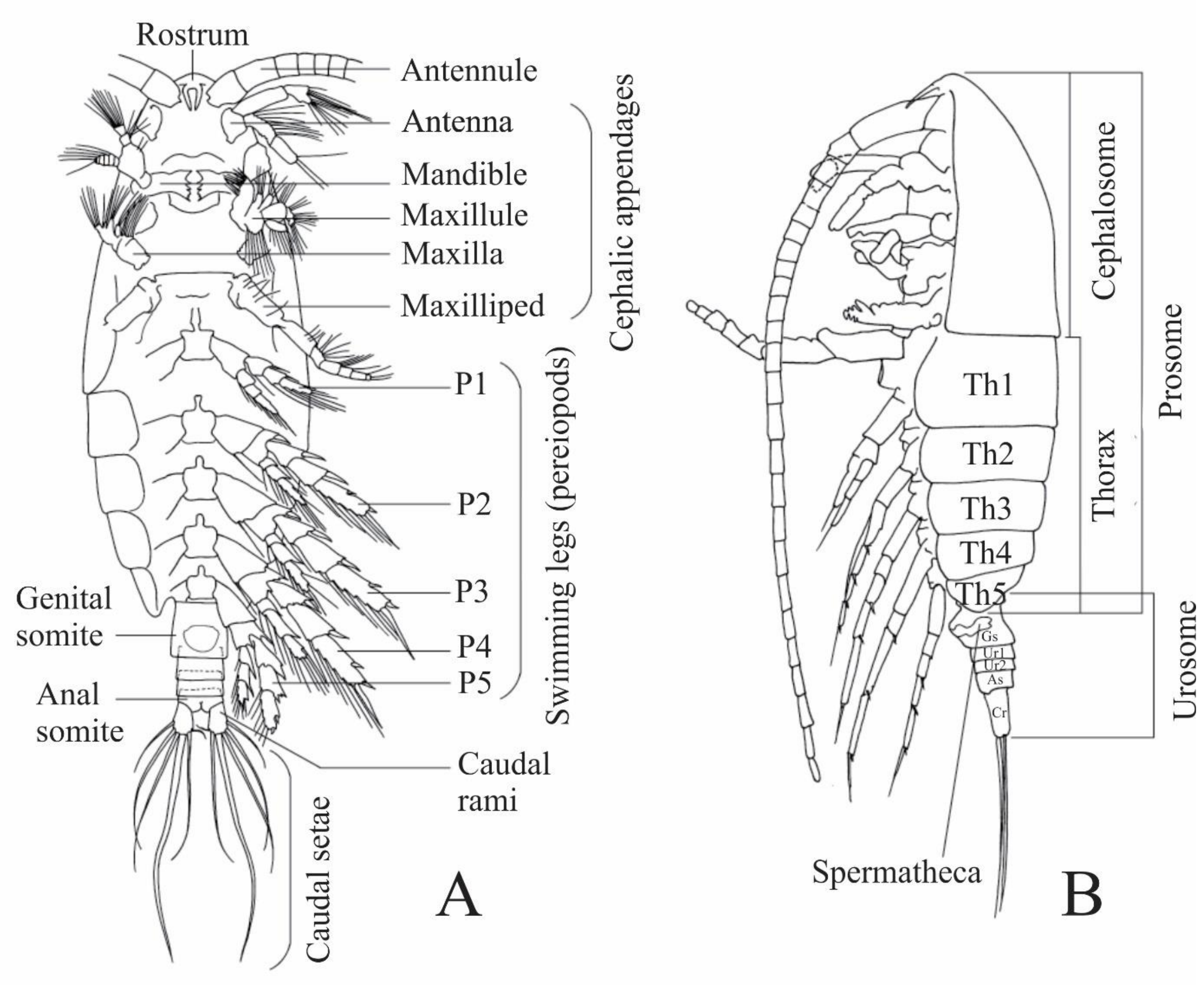

Figure 2. General anatomy of the body of a calanoid copepod in (A) ventral and (B) lateral view. Modified from Prusova et al. (2012).

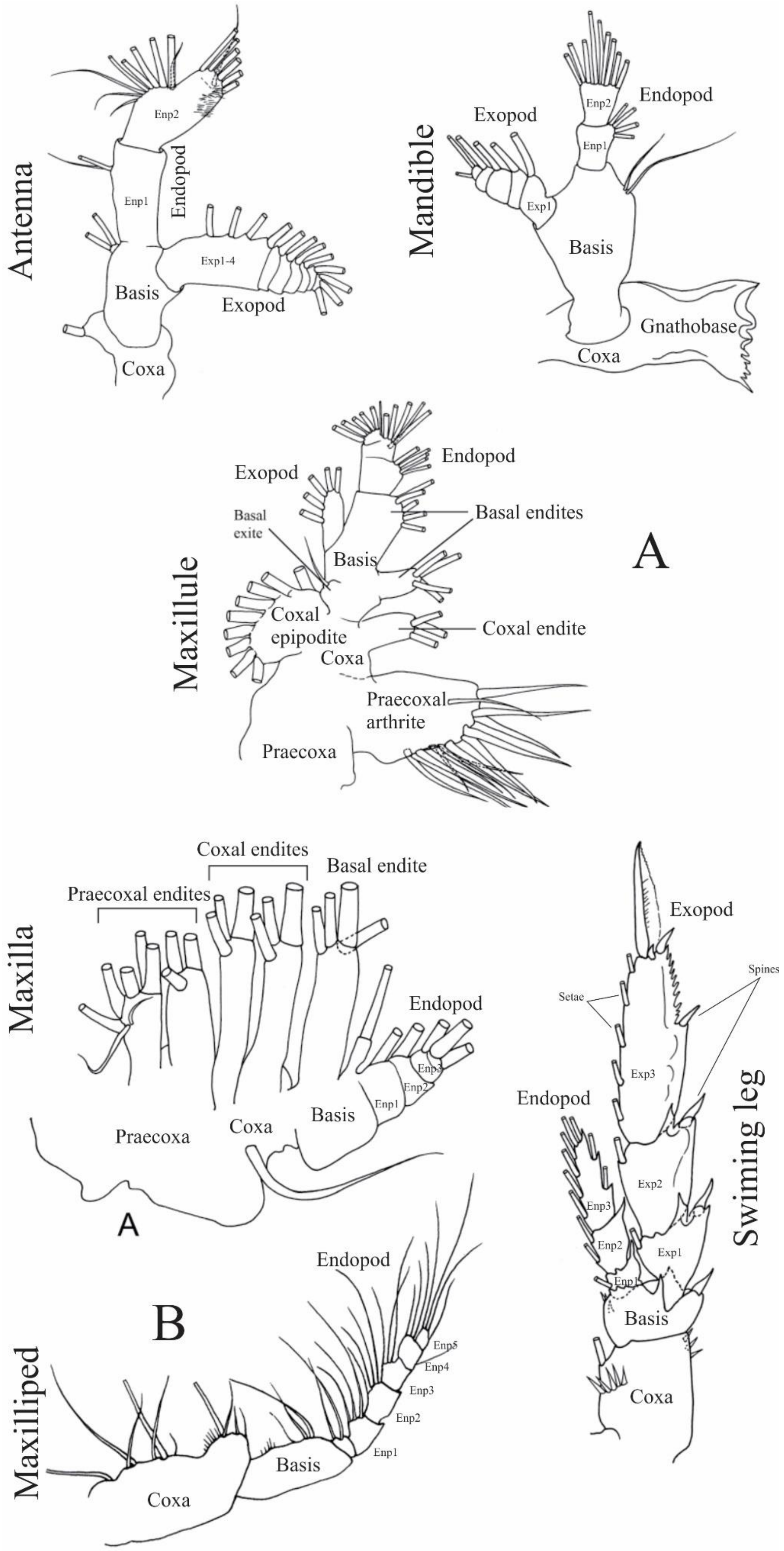

Figure 3. Anatomy of a calanoid copepod’s (A) cephalic and (B) natatory appendages. Modified from Prusova et al. (2012).

Order Calanoida Sars G.O., 1903

Family Aetideidae Giesbrecht, 1892

Genus *Gaetanus* Giesbrecht, 1888

***Gaetanus kruppii* Giesbrecht, 1903** (Figures 4-5)

Synonymized names. *Gaetanus kruppi* Giesbrecht, 1903 (PS); *Gaetanus major* Wolfenden 1903; *Gaetanus brevicaudatus* Wolfenden, 1911; *Gaetanus antarticus* Brady, 1918; *Gaetanus microcanthus* C.B. Wilson, 1950; *Gaetanus wolfendeni* Park, 1975.

Material examined. 1 F, TALUD IX, St. 6 (24°49’36"N, 109°47’59"W), MN, from surface to 1500 m depth (TD, 1650 m), November 12, 2005, (SPS; ICML-EMU-13820). 1 F, TALUD IV, St. 36 (25°51’59’’ N, 110°11’00’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (UD; ICML-EMU-13821A). 1 F, TALUD VII, St. 13B (23°30’18’’ N, 107°44’00’’ W), MN, from surface to 1450 m depth (TD, 1450 m), June 6, 2001 (UD; ICML-EMU-13821B). 1 F, TALUD IX, St. 9B (25°11’19’’ N, 109°42’45’’ W), MN, from surface to 850 m depth (TD, 2392 m), November 15, 2005 (UD; ICML-EMU-13821C). 1 F, TALUD XI, St. 6A (16’58’00’’ N, 100°57’00’’ W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (UD, ICML-EMU-13821D).

Female. Length measured from head anterior margin to posterior margin of Cr: 8.66 mm. General appearance of the cuticle very opaque, with spots in dorsal margin of cephalothorax disposed symmetrically on both sides. Rostrum anteriorly projected, enlarged, with spiniform shape. Cuticular lenses visible in dorsal view, 2 pairs, anterior pair rounded, posterior pair laterally enlarged (Fig. 4). Cephalothorax long, more than 0.5 length of body. Th5 with long projections, extended beyond Gs posterior margin. Ur robust, with 2 free somites + asm; Gs subsquared, similar in length to Ur1+ Ur2 length. Cr short, almost twice as wide as long. A1 23-segmented, extended up to Cr posterior margin, last 8 segments particularly longer. A2 Exp and Enp similar in length, cp with proximal seta, bp with 2 distal external, setae. Md with strong gb, distal margin straight, with 5 queratinized teeth (Fig. 5A). Mx1 well-developed, pcx endite with 11 spiniform setae. Mx2 reduced, 1 thick seta in second endite of basis, accompanied by 2 not-modified setae. Mp long, with 3 lobes over anterior margin of coxa, each lobe armed with 3 setae; ornamented projections over distal margin of basis (Fig. 5B). P1 with 1 outer spine in each Exp, 3-segmented Exp and 1-segmented Enp. (Fig. 5C). P2 with 3-segmented Exp and 2-segmented Enp; 1 outer spine in Exp1 and Exp2, 3 outer and 1 apical spine on Exp3. P3 and P4 with 3-segmented Enp, Exp with armature as in P2; P1-P3 with setules over inner margin of coxa. P4 with strong spinules near coxal seta of basis (Fig. 5D). Medial spine of Exp3 of P2-P4 with serrated external margin. P5 absent.

Male. Not collected.

Remarks. *Gaetanus kruppii* is one of the largest copepods found in the Gulf of California. It was not a very frequent or abundant species, appearing in only 9% of the samples. This species has been collected in hauls from depths of 600-8000 m (Farran, 1926; Park, 1975), and is considered a meso-bathypelagic species.

Figure 4. *Gaetanus kruppii* Giesbrecht, 1888. Habitus of the female, dorsal view.

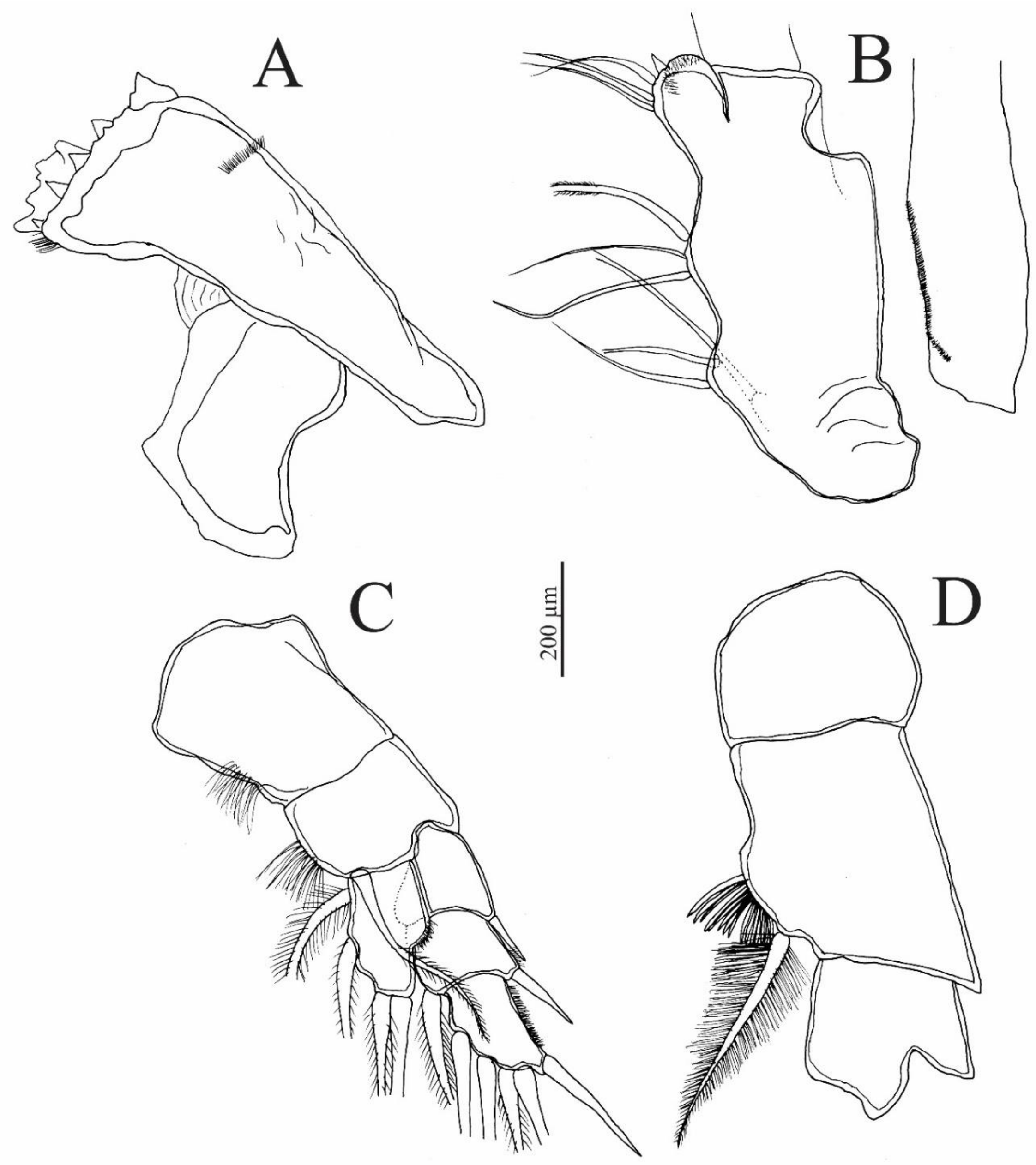

Figure 5. *Gaetanus kruppii* Giesbrecht, 1903. Female (ICML-EMU-13820). (A) Details of the mandibular gnathobase, (B) coxa and basis of the maxilliped, (C) left first leg, anterior view, (D) basal segments of the right fourth leg, anterior view.

***Gaetanus miles* Giesbrecht, 1888** (Figures 6-7)

Synonymized names. *Gaetanus ferox* With, 1915.

Material examined. 1 F, TALUD IX, St. 6 (24°49’36"N, 109°47’59"W), MN, from surface to 1500 m depth (TD, 1650 m), November 12, 2005, (SPS; ICML-EMU-13822). 1 F, TALUD XI, St. 6A (16’58’00’’ N, 100°57’00’’ W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (UD, ICML-EMU-13823).

Female. Length measured from head anterior margin to posterior margin of Cr: 3.55 mm. General appearance of the cuticle slightly opaque. Cephalothorax relatively long, almost twice the length of thorax + Ur length, with a constriction in the head, between at A2 and Md insertion level. Rostrum anteriorly projected, visible in dorsal view. Acute projections over posterior lateral margins of Th5 (Fig. 6). Ur relatively small, with 2 free somites + asm; Gs shorter than Ur length. Cr 1.2 times as long as asm. A1 23-segmented, particularly long, more than twice the length of the body; last 10 segments particularly large (Fig. 7A). Enp of A2 larger than Exp, 7 and 2-segmented, respectively. Md flat in distal margin of the gb, with squared and strong cuspidated teeth; external seta accompanied by 3 spiniform teeth (Fig. 7B). Mx1 with 2 ied, Enp bilobated; ied1 and internal lobe of Enp with strong spinules on its inner margin (Fig. 7C). Mx2 with strongly spinulated setae; seta of endite 4 well-developed, with spinules over posterior margin. Mp with 3 setae in last segment of Enp, apical seta is longer, not spinulated. P1 Exp 2-segmented, Enp 1-segmented; distal lateral spines on Exp1 and Exp2; anterior projection in Enp1. P2 with 3-segmented Exp and 1-segmented Enp; outer spine of Exp1 much shorter than outer spines on Exp2 and Exp3. Spiniform projections in both distal and proximal sides of base of lateral spines of Exp1-3. P3 and P4 with 3-segmented Exp and End, similar armature than P2. Apical spines on Exp3 of P2-P4 serrulated in outer margin. Coxa of P4 with short and thick spinules in inner margin, at level of inner seta (Fig. 7D). P5 absent.

Male. Not collected.

Remarks. *Gaetanus miles* can be easily identified by the length of its antennules in proportion to the body. This species was relatively rare, and it only appeared in 5% of the samples.

Figure 6. *Gaetanus miles* Giesbrecht, 1888. Habitus of the female, dorsal view.

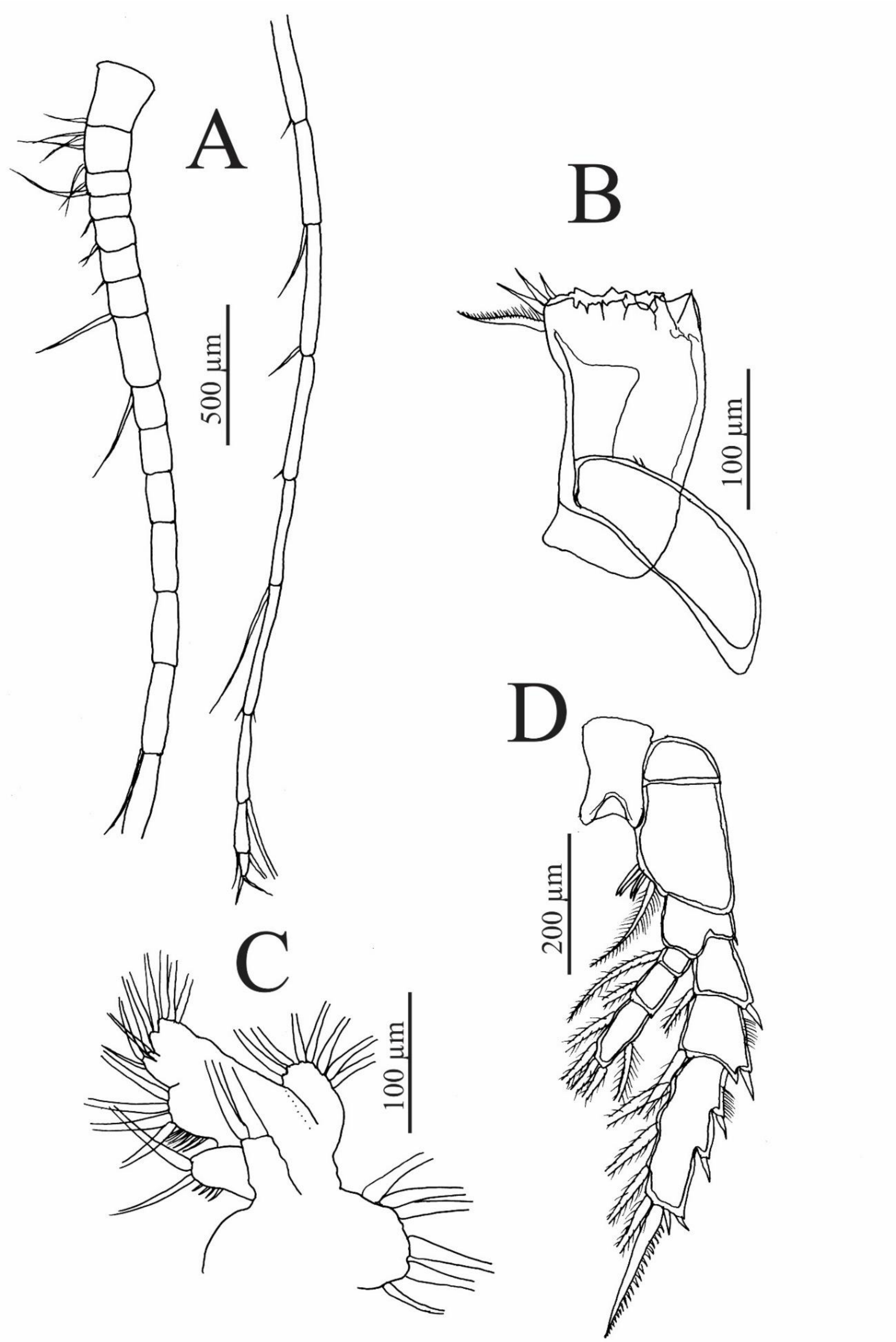

Figure 7. *Gaetanus miles* Giesbrecht, 1888. Female (ICML-EMU-13822). (A) Antennular segments, (B) detail of mandibular gnathobase, (C) maxillule, external view, (D) right fourth leg, anterior view.

Gaetanus pileatus **Farran, 1903** (Figure 8-9)

Synonymized names. *Gaetanus clarus* Esterly, 1903; *Gaetanus unicornis* Esterly, 1906; *Gaetanus recticornis* Wolfenden, 1911.

Material examined. 1 F, TALUD IX, St. 6 (24°49’38"N, 109°47’58"W), MN, from surface to 1500 m depth (TD, 1650 m), November 12, 2005 (SPS; ICML-EMU-13824).

Female. Length measured from head anterior margin to posterior margin of Cr: 3.26 mm. General appearance of the cuticle slightly opaque. Rostrum anteriorly projected, visible in dorsal view (Fig. 8). Cephalothorax is less than a half of prosome length, with no constrictions. Posterior acute projections in Th5, symmetrical; their length reaches posterior margin of the Gs. Ur relatively short, with 2 free somites + asm; Gs is almost as long as Ur length; asm is longer than Ur1 + Ur2; Cr short, same length than the asm. A1 with 26 segments that reaches the posterior margin of Cr: segments 18-26 particularly elongated. A2 Enp slightly larger than Exp, 7 and 2-segmented, respectively. Md with 5 large and quitinized teeth, internal-most tooth relatively large; with 2 patches of spinules near the base of outer seta and 1 more over internal margin (Fig. 9A). Mb palp smaller than gb. Mx1 with 2 ied, Enp bilobated; ied1 with 5 setae, ied2 with 4 setae. Mx2 relatively short, modified seta of the fourth endite is larger than Mx2; modified seta of fifth endite is much smaller than Mx2. Mp with a row of small spinules over internal margin of the first segment of Enp; 8 setae over external margin of coxa (Fig. 9B). P1 with long setules in inner margins of coxa and basis; Exp with 3 segments and 1-segmented Enp (Fig. 9C). Outer margin of the Exp3 bears small spinules; anterior ornamented projection of Enp is present. P2 with 2-segmented Enp and 3-segmented Exp, with inner setules in coxa but not in basis; Exp1 and Exp2 with 1 outer spine, Exp3 with 3 outer spines and 1 apical serrated spine, as long as Exp3. P3 and P4 with 3-segmented Exp and End, similar armature than P2; both with setules in the inner margin of coxa, spine-like modified on P4 coxa (Fig. 9D). P5 absent.

Male. Not collected.

Remarks. *Gaetanus pileatus* Farran, 1903 is one of the most widespread copepod species in the world (Razouls et al. 2024), but it was not previously recorded in the Gulf of California or the Mexican Pacific. It is known to occur from off California to off Chile in the eastern Pacific.

Figure 8. *Gaetanus pileatus* Farran, 1903. Habitus of the female, lateral view.

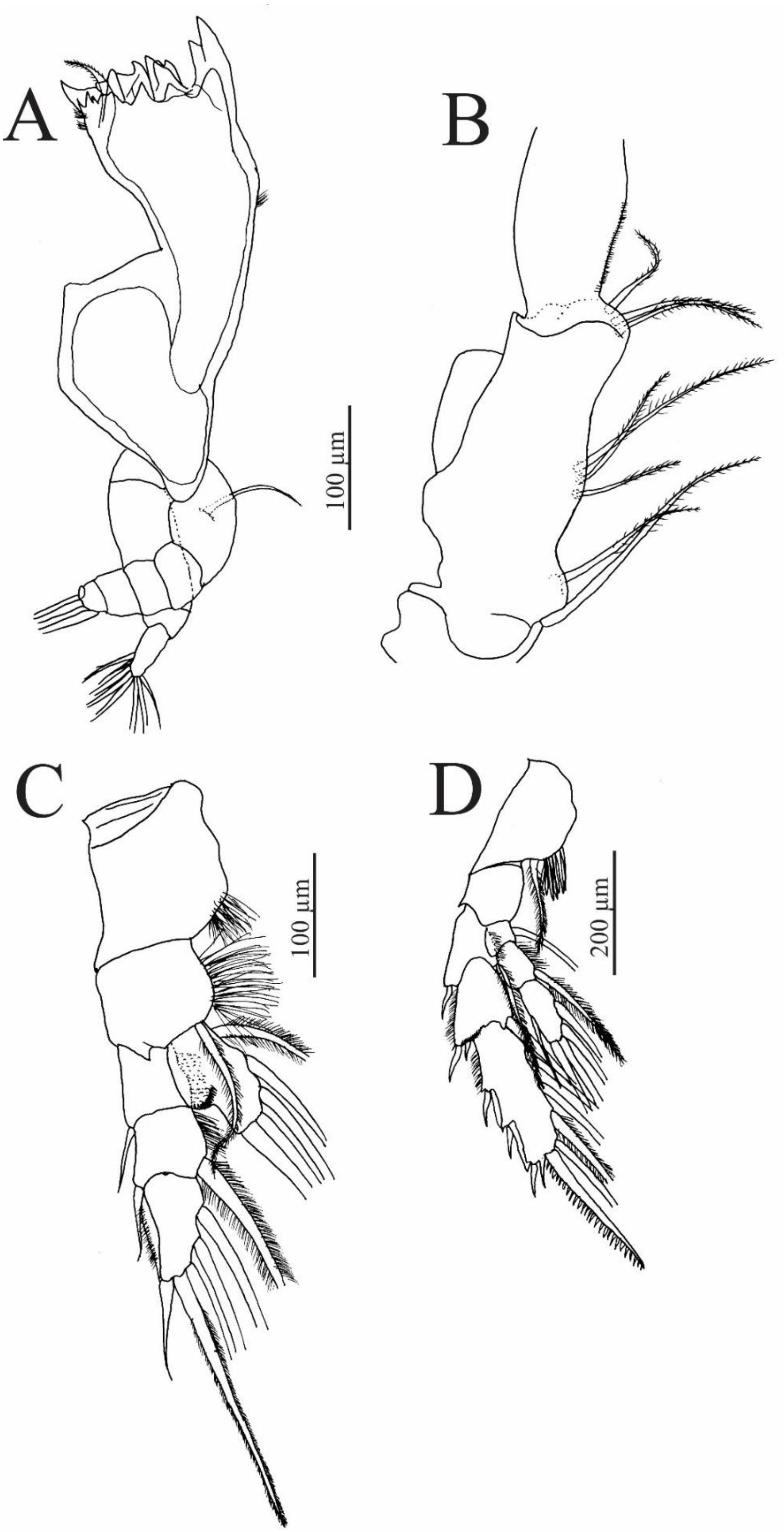

Figure 9. *Gaetanus pileatus* Farran, 1903. Female (ICML-EMU-13824). (A) Mandible, inner view, (B) coxa and basis of the maxilliped, (C) right first leg, anterior view and (D) right fourth leg, anterior view.

Genus *Pseudochirella* Sars G.O., 1920

***Pseudochirella obtusa* (Sars G.O., 1905)** (Figures 10-11)

Synonymized names. *Euchirella obtusa* (Sars G.O. 1905) (PS); *Euchirella dubia* Scott A., 1909; *Chirundina abyssalis* With, 1915; *Pseudochirella polyspina* Brodsky, 1950; *Pseudochirella spinifera* Brodsky, 1950.

Material examined. 1 F, TALUD IX, St. 6 (24°49’38"N, 109°47’58"W), MN, from surface to 1500 m depth (TD, 1650 m), November 12, 2005 (SPS; ICML-EMU-13825-A). 1 F, TALUD XII, St. 4 (16°59’39’’N, 100°58’07’’W), MN, from surface to 1200 m depth (TD, 1995 m), March 28, 2008 (SPS; ICML-EMU-13825-B). 2 M, TALUD VII, St. 22 (24°31’34’’ N, 108°55’10’’ W), MN, from surface to 1415 m (TD, 2000 m), June 7, 2001 (SPS; ICML-EMU-13825-C). 4 F, TALUD IV, St. 36 (25°51’59’’ N, 110°11’00’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (UD; ICML-EMU-13826).

Female. Length measured from head anterior margin to posterior margin of Cr: 5.6 mm. General appearance of the cuticle very opaque, with dense musculature, very robust (Fig. 10). Cephalothorax constricted at A2-Md insertion level and at Md-Mx2 insertion level. Thorax with Th4 and Th5 fused, rounded posterior margins. Ur relatively short, but thick, with 2 free somites + asm; Gs wider than long, much wider than Ur (almost twice); Gs with 4 distal and 1 proximal row of setules, Ur1 with 3 mid rows in ventral margin and Ur2 with 1 row of setules at each outer margin; asm longer than Cr, with hairy outer margins (Fig. 11C). Cr with a dense patch of long setules over inner margins, with 4 very thick distal setae and 1 thin dorsal seta. A1 relatively short, doesn’t reach posterior margin of Th5, last segment with 6 setae and 1 ae. A2 Enp larger than Exp, 7 and 2 segments, respectively; pcx with strong setules on proximal margin. Md very large, with 1 large inner cuspidated tooth, 3 queratinized acute smaller teeth and 3 very small outer teeth; with 2 outer setae (Fig. 11A). Md palp with 3 setae on exterior margin, proximal seta relatively large. Mx1 with 2 ied, Enp bilobated; ied1 with 5 setae and ied2 with 4 setae; Exp reduced. Mx2 with ied1-5 well-developed, ied6 reduced; ied2-5 with 1 small, very ornamented seta; external margin of coxal and basal endites with strong spinules. External distal margin of first 4 ied rounded, with short but strong spinules. Mp with 1 short row of setules over posterior margin of coxa, near base; basis long, with 3 setae and 3 rows of spinules along the anterior margin; apical seta of the Enp4 of the Mp with 1 row of short but thick spinules (Fig. 11B). P1 with 1-segmented Enp and 3-segmented Exp; Enp with an anterior ornamented projection; coxa and basis with long inner setules; 1 small spine on outer margin of basis. Enp1 and Exp3 of the P1 with short setules over inner and outer margins. Enp of the P2 1-segmented, with a distal patch of setules over anterior margin. P2-P4 with setules on the inner margin of coxa, setules of P4 modified as spinules (Fig. 11D; Exp with 3 segments, segments Exp1 and Exp2 with one outer spine, Exp3 with 3 outer and one apical spine; apical spines with dense outer ornamentation. P5 absent.

Male. Length from head anterior margin to posterior margin of Cr: 4.92 mm. Relatively large P5, right Exp3 with setules on distal, inner and basal margins, with 1 small apical spine. Left End with an apical aperture, ornamented with short spinules. Left Exp2 with a convex apical margin, ornamented with short setules. Md gb reduced, with only 1 weak tooth-like projection and 1 seta near the palp insertion; palp well developed, as in female.

Remarks. Remarks. *Pseudochirella obtusa* was a relatively frequent species. Many specimens were juveniles and not fully identified due to their similitude with other aetideid juveniles. *Pseudochirella obtusa* could be present in up to 30% of the samples if juveniles prove to belong to this species. Some micro and macrocharacters of the cephalic and natatory appendages showed variation among the examined specimens, i.e., small differences in the ornamentation of the maxilliped, the fourth pair of legs, and also differences in the genital field.

Figure 10. *Pseudochirella obtusa* (Sars G.O., 1905). Habitus of the female, dorsal view.

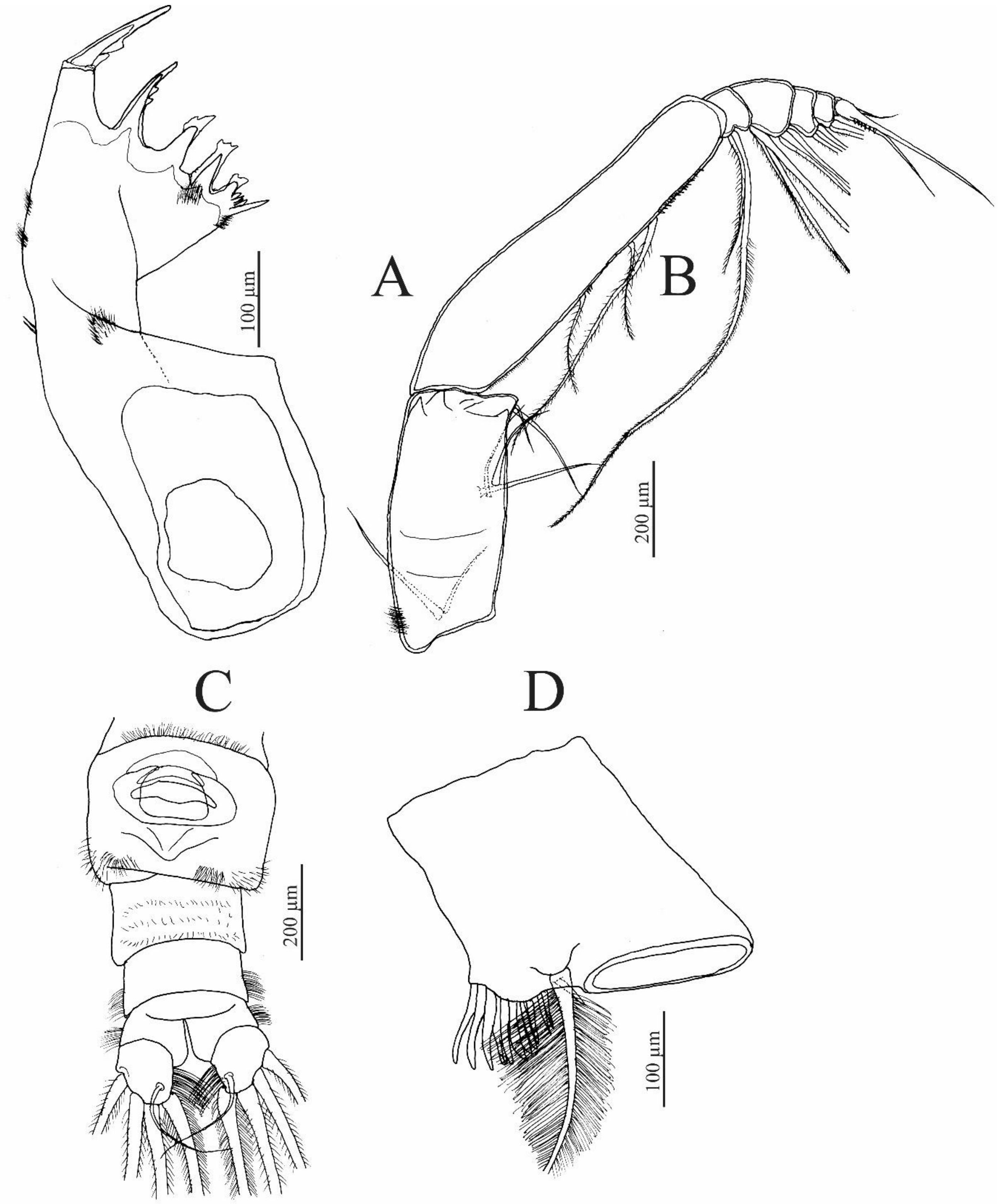

Figure 11. *Pseudochirella obtusa* (Sars G.O., 1905). Female (ICML-EMU-13825-A). (A) Details of mandibular gnathobase, (B) right maxilliped, internal view, (C) urosome, ventral view and (D) coxa of the right fourth leg, anterior view.

Family Arietellidae Sars, G.O., 1902

Genus *Arietellus* Giesbrecht, 1893

***Arietellus simplex* Sars G.O., 1905** (Figures 12-13)

Synonymized names. *Arietellus major* Esterly, 1906.

Material examined. 1 F, TALUD XI, St. 6A (16°57'59'' N, 100°56'59'' W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (SPS; ICML-EMU-13827).

Female. Length measured from head anterior margin to posterior margin of Cr: 4.93 mm. General appearance of the cuticle translucid, dense muscles (Fig. 12). Prosome anterior margin enlarged, narrowed, head thinner than the thorax, constricted at the Mx1 insertion; rostrum relatively short, with 2 filaments; Th5 posterior margins rounded. Ur with 2 free somites + asm, asm and Cr relatively long, each as long as Ur1 + Ur2 length; Gs short, 0.8 times as long as Ur1. Cr 0.8 times as long as asm. A1 reaches posterior margin of Th5, segment 1 relatively long, longer than distal segments; segments 2-11 constricted, segments 11-21 elongated. A2 with both rami elongated; 2-segmented Enp 1.7 times as long as 6-segmented Exp, with 1 seta on the distal margin of basis. Md palp 2 times larger than gb; gb with 4 strong, sclerotized denticles, outer seta not visible, gb with 2 setule patches, visible in external view (Fig. 13A). Mx1 Enp reduced, represented by a single seta on a protuberance; Exp relatively large, with 3 distal setae; ied 1 with a large naked, thick seta (Fig. 13B). Mx2 basis as long as pcx + coxa length, with 1 seta on pcx endite, 2 setae on coxa endites 1 and 2 and 1 thick spine-like seta on basis endite; Enp reduced, with 8 setae. Mp with 1 seta on of syncoxa distal margin, with 1 row of spinules on ied2 and 1 on distal endite, distal row composed by small and large spinules; basis with 1 anterior row of large setules and 1 external row of small spinules; setae of the Enp ornamented with thick spinules (Fig 13C). P1-P4 with both rami 2-segmented. P1 Exp1 with 1 outer spine, Exp3 with 2 outer and 1 distal spine. P2-P4 Exp1 with 1 outer spine, Exp2 with 1 outer spine (larger in P2), Exp3 with 3 outer and 1 apical spine, accompanied by a distal spiniform process. P5 modified, symmetrical, Enp 0.25 times as long as Exp, fused to the basis, with 2 distal setae; Exp 1-segmented, with 1 distal seta (Fig. 13D).

Male. Not collected.

Remarks. Although there are not visible setae on the female P5 basis, these should be present in this species, as seen in *Arietellus* sp. 2. These setae probably fell off, but there are no visible insertion marks.

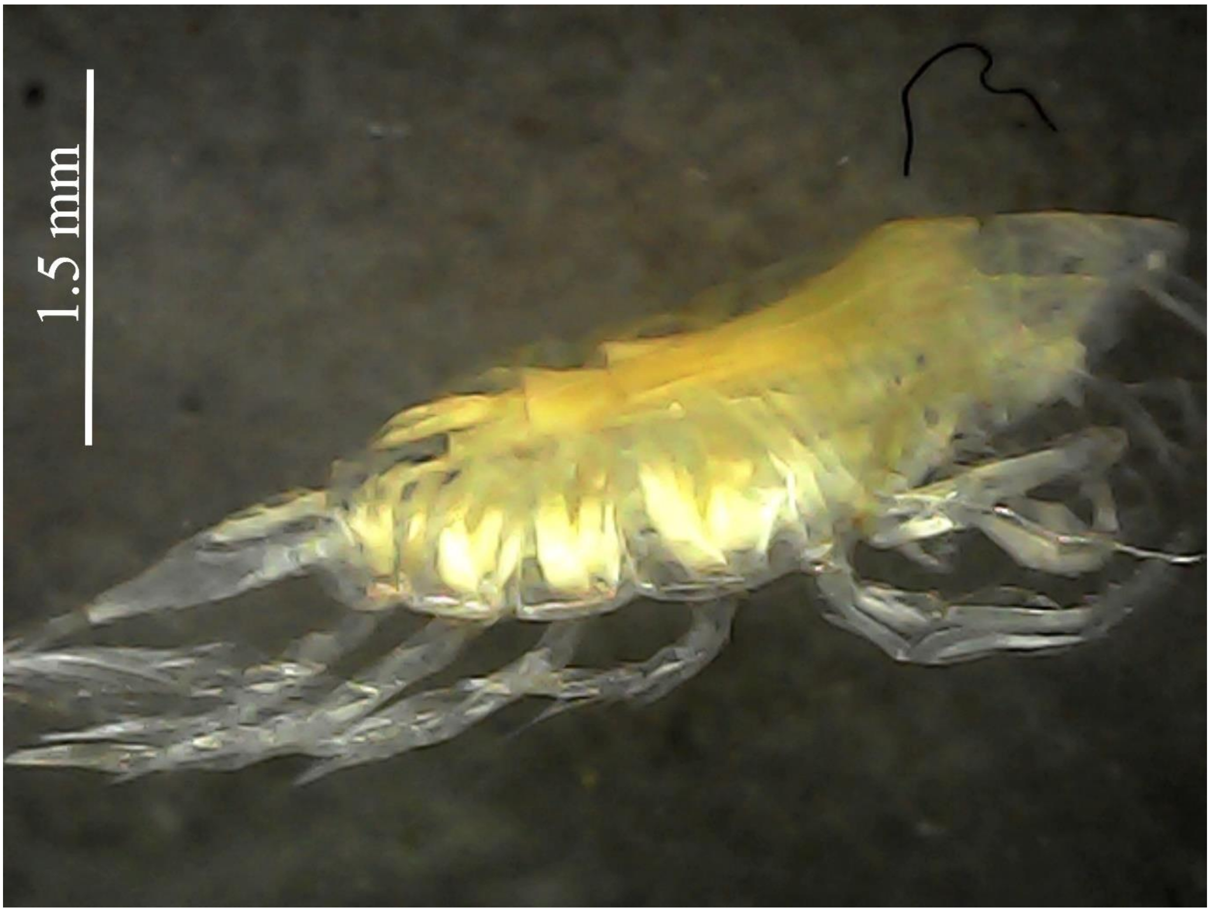

Figure 12. *Arietellus simplex* Sars G.O., 1905. Habitus of female, lateral view.

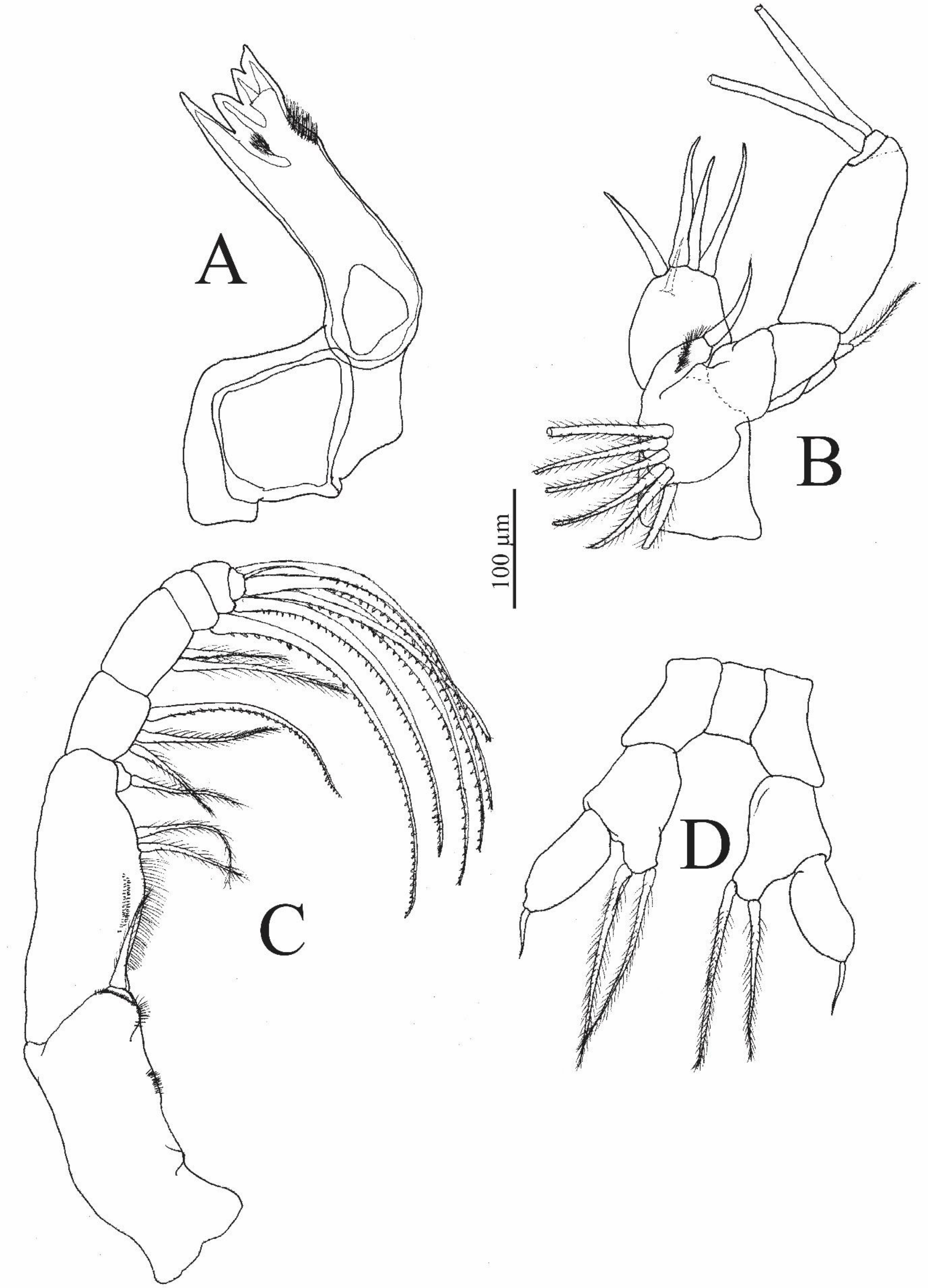

Figure 13. *Arietellus simplex* Sars G.O., 1905. Male (ICML-EMU-13827). (A) Details of the mandibular gnathobase, (B) maxillule, (C) left maxilliped, external view, (D) fifth pair of legs, anterior view.

***Arietellus* sp. 2** (Figures 14-15)

Material examined. 1 F, TALUD VIII, St. 13 (25°20’59’’ N, 110°16’59’’ W), MN, from surface to 1625 m depth (TD, 2100 m), April 18, 2005 (SPS; ICML-EMU-13828).

Female. Length measured from head anterior margin to posterior margin of Cr: 3.97 mm. General appearance of the cuticle translucid (Fig. 14). Prosome slightly wider in thorax region, narrowed head, rostrum short; distal margins of Th5 rounded, symmetrical. Ur with 1 free somite + asm; asm particularly large, longer than Gs + Ur1 length. Cr 0.8 times as long as asm. A1 reaches Cr distal margin, 19-segmented, first segment elongated, segments 3-9 constrained, segments 13-18 elongated. A2 2-segmented Enp .25 times longer than 6-segmented Exp, one distal seta on basis outer margin. Md palp larger than gb, uniramous; gb with 4 strong denticles and two patches of spinules; outer seta absent or not visible (Fig. 15A). Mx1 Enp reduced, distal seta reduced (or lost); Exp 1-segmented, as large as pcx arthrite; pcx arthrite with 5 spines, ied1 with a distal seta and a patch of spinules over its distal margin (Fig. 15B). Mx2 pcx with 1 proximal and 2 distal setae, coxa and basis with 2 strong internal setae, Enp1 well-developed, with 1 strong internal spiniform seta, distal setae ornamented with thick acute spinules. Mp with 1 medial and 1 distal internal seta on the synconxa, also with 2 rows of large spinules on the base of these setae; basis with 1 internal row of setules and 2 outer rows of spinules; Enp setae ornamented with thick acute spinules. P1-P4 with both rami 2-segmented (Fig. 15C). P1 with 1 outer spine on Exp1 and 2 outer and 1 apical spine on Exp2. P2-P4 with 1 outer spine on Exp1 and 3 outer and 1 apical spine on Exp2. P5 modified, Enp 0.5 times as long as Exp, fused to basis, with 2 distal setae; Exp 1-segmented, with 1 apical seta; basis posterior setae reach the distal margin of Exp (Fig. 15D).

Male. Not collected.

Remarks. This species presents several differences with both *A. setosus* and *A. pacificus*, the two previously recorded species in the Mexican Pacific. Differences with *A. setosus* include:

proportions of P5 Enp and Exp apical setae, proportions of Enp, thickness of Mx1 ie seta, ornamentation of Mp syncoxa.

Figure 14. *Arietellus* sp. Habitus of female, lateral view.

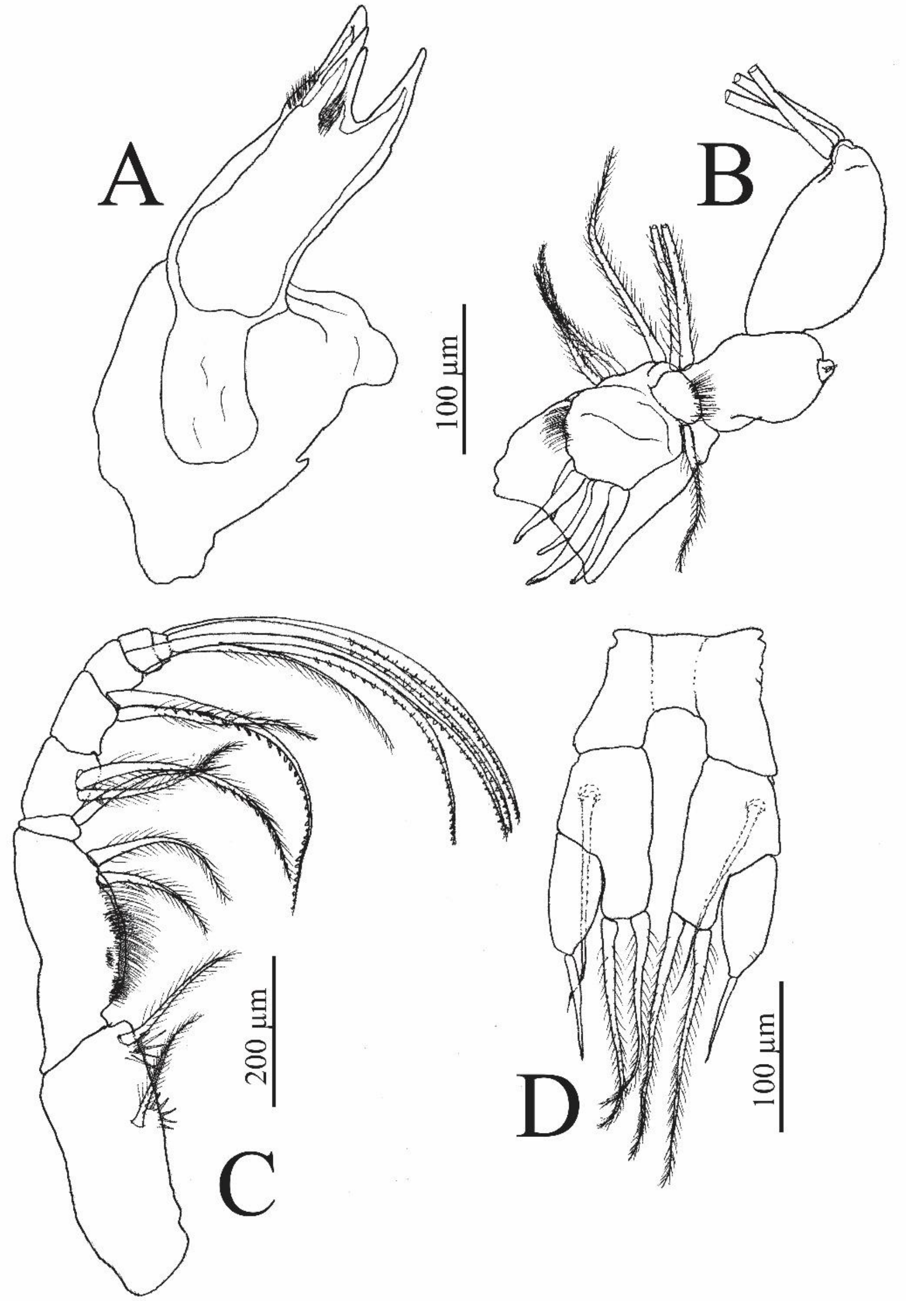

Figure 15. *Arietellus* sp. Male (ICML-EMU-13828). (A) Details of mandibular gnathobase, (B) maxillule, (B) left maxilliped, external view, (D) fifth pair of legs, anterior view.

Sarsarietellus Campaner, 1984

***Sarsarietellus* sp. 1** (Figures 16-17)

Material examined. 1 F, TALUD IX, St. 6 (24°49’38’’ N, 109°47’58’’ W), MN, from surface to 1500 m (TD, 1650 m) November 12, 2005 (SPS; ICML-EMU-13829).

Female. Length measured from head anterior margin to posterior margin of Cr: 4.57 mm. General appearance of the cuticle slightly opaque. Oval prosome, head and Th1 fused, distal margins of Th5 rounded, Th4 and Th5 not fused (Fig. 16). Ur relatively long, 2 free somites + asm; asm as long as Ur1 + Ur2 somites; Gs short, as long as Ur1. Cr as long as asm. A1 extended up to distal margin of Th4, 19-segmented; segments 2-9 constrained, with large setae, segments 10-18 elongated. A2 2-segmented Enp 1.6 times as long as 6-segmented Exp, with 1 distal seta on basis posterior margin; Enp distal setae particularly elongated. Md palp as long as A2 Exp, uniramous, Enp distal setae particularly elongated; gb with 4 strong denticles, outer seta reduced or absent; 2 patches of spinules on its outer margin (Fig. 17A). Mx1 Exp relatively large, as large as pcx arthrite; ied1 with 1 strong seta; Enp reduced to a small protuberance, with no visible seta; pcx arthrite with 5 spines (Fig. 17B). Mx2 with 1 anterior seta on basal endite and 2 on distal endite; coxa and basis with 2 setae on anterior margins, heavily ornamented with strong setules; Enp1 with 1 anterior strong spiniform seta, distal setae of Enp ornamented with strong and acute spinules. Mp with 1 seta on synconxa basal endite and 2 on distal endite; 2 projections on posterior margin of syncoxa, heavily ornamented with long spinules; basis with 2 internal setae and 3 rows of spinules near the base of the setae insertion, also with 1 row of long setules on anterior margin; Enp distal setae ornamented with strong, acute spinules (Fig. 17C). P1-P4 with both rami 3-segmented. P5 modified, 1-segmented Enp and 2-segmented Exp; Enp with 1 distal seta, longer than Enp; Exp1 with 1 outer spine, Exp2 with 2 outer and 2 apical spines, internal spine three times longer than external spine; Exp with an internal spine, visible only on right leg: distal outer spine on left Exp2 is much smaller; basis with outer seta that extends beyond Exp1 (Fig. 17D).

Male. Not collected.

Remarks. There are no previous records of the *Sarsarietellus* genus in the Mexican Pacific. The species examined herein presents several differences with the four previously described species, mainly in the shape of P5. There is no other genus of Arietellidae with higher resemblance to both species of *Sarsarietellus* found during this study. *Sarsarietellus* sp. 1 was only recorded in the Gulf of California.

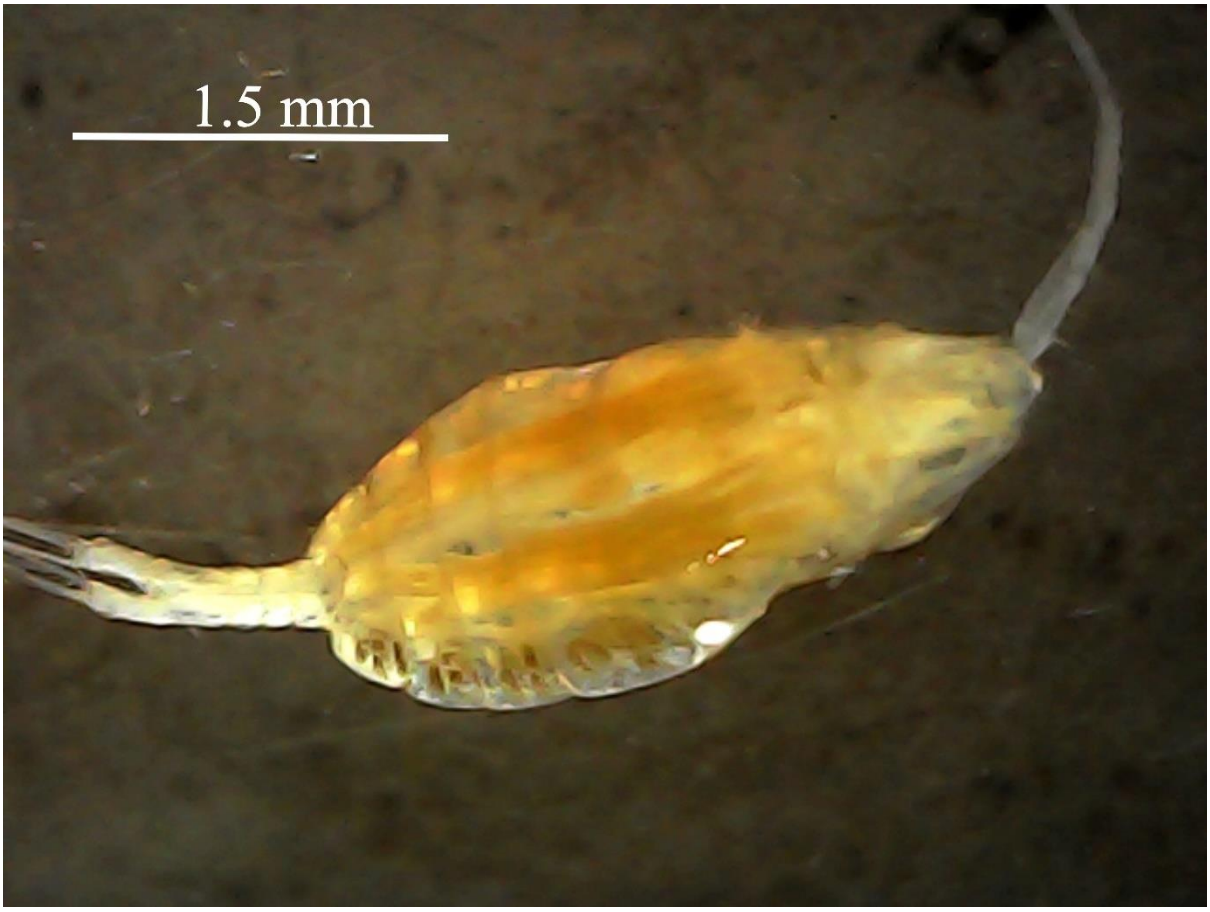

Figure 16. *Sarsarietellus* sp. 1. Habitus of female, dorsal view.

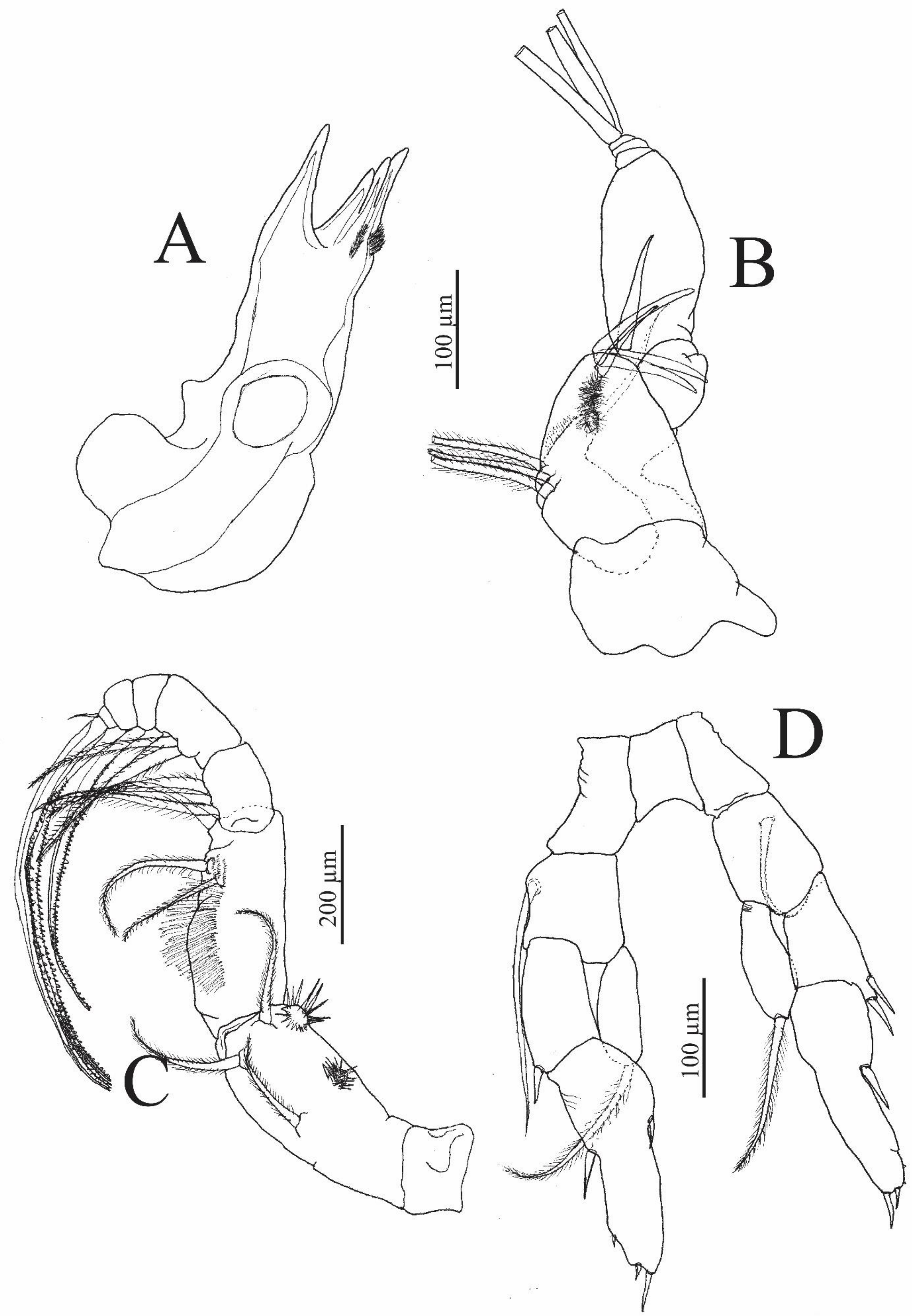

Figure 17. *Sarsarietellus* sp. 1. Female (ICML-EMU-13829). (A) Details of mandibular gnathobase, (B) maxillule, (C) maxilliped, external view, (D) fifth pair of legs, anterior view.

***Sarsarietellus* sp. 2** (Figures 18-19)

Material examined. One F, TALUD XI, St. 6A (16°57’59’’ N, 100°56’59’’ W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (SPS; ICML-EMU-13830).

Female. Length measured from head anterior margin to posterior margin of Cr: 4.65 mm. General appearance of the cuticle slightly opaque. Narrowed head, slim in relation to torax; distal margins of Th5 rounded; Th4 and Th5 not fused (Fig. 18). Ur relatively long, with 2 free somites + asm; asm as long as Ur1 + Ur2 length; Gs as long as Ur1. Cr as long as asm. A1 relatively short, barely surpass Th3 distal margin, 19-segmented; first segment elongated, segments 2-10 constrained, segments 11-18 elongated. A2 2-segmented Enp 1.7 times longer than 6-segmented Exp; 1 seta on basis distal margin. Md palp almost as large as gb, uniramous; gb with 4 strong teeth, no visible outer seta; 2 patches of spinules on outer margin (Fig. 19A). Mx1 Exp as large as pcx arthrite, Enp reduced to a protuberance; pcx arthrite with 5 spines, proximal spine smaller than the rest; ied1 with 1 distal seta and a patch of setules on its margin (Fig. 19B). Mx2 with 1 anterior seta on basal endite and 2 on distal endite; coxa and basis with 2 setae on anterior margins, heavily ornamented with strong setules; Enp1 with 1 anterior strong spiniform seta, distal setae of Enp ornamented with strong and acute spinules. Mp with 1 seta on synconxa basal endite and 2 on distal endite; 1 projection on inner margin of syncoxa, heavily ornamented with long spinules; basis with 2 internal setae and 1 row of spinules on its inner margin, also with 1 row of long setules on anterior margin; Enp distal setae ornamented with strong, acute spinules (Fig. 19C). P1-P4 with both rami 3-segmented. P1 Exp1 and Exp2 with 1 long outer spine and 2 outer and 1 apical long spine on Exp3. P2-P4 with 1 outer spine on Exp1 and Exp2 and 3 outer and 1 apical spine on Exp3, serrated on its outer margin; outer seta on P2 Exp2 larger than in other legs. P5 modified, 2-segmented Exp and 1-segmented Enp; Enp with 1 distal seta, as long as Enp; Exp with 1 outer spine on Exp1, 2 outer and 2 apical subequal spines on Exp2, Exp2 also with an internal spiniform process; posterior setae on basis not visible or lost (Fig. 19D).

Male. Not collected.

Remarks. This species presents several differences with the material of *Sarsarietellus* sp. 1 examined herein, including the ornamentation and armature of Mp, P5 and P2. *Sarsarietellus* sp. 2 was only recorded in the MPT.

Figure 18. *Sarsarietellus* sp. 2. Habitus of female, dorsal view.

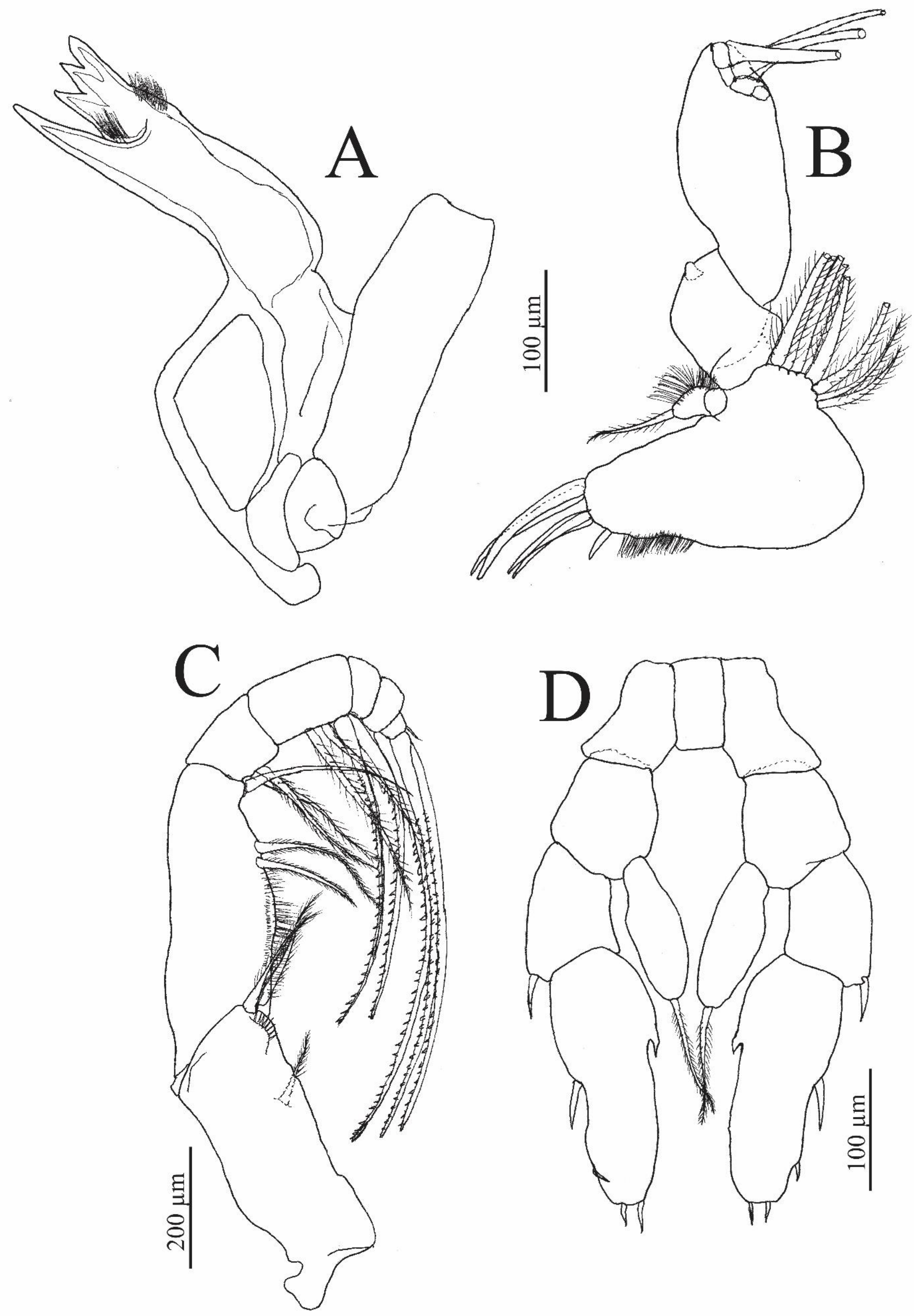

Figure 19. *Sarsarietellus* sp. 1. Female (ICML-EMU-13830). (A) Details of mandibular gnathobase, (B) maxillule, (C) maxilliped, external view, (D) fifth pair of legs, anterior view.

Family Augaptilidae Sars G.O., 1905

Genus *Augaptilus* Giesbrecht, 1889

Augaptilus cornutus **Wolfenden, 1911** (Figure 20-21)

Material examined. 1 F, TALUD X, St. 7 (27°53’09’’ N, 112°16’42’’ W), MN, from surface to 900 m depth (TD, 1191 m), February 9, 2007 (SPS; ICML-EMU-13833).

Female. Length measured from anterior margin of head to posterior margin of Cr: 3.41 mm. General appearance of the cuticle translucid, with very elongated cephalic appendages. Cephalothorax with 3 constrictions, two in the head at A2Mx1 insertion level and at Mp insertion level (Fig. 20). Thorax wider and longer than cephalothorax, partial fusion of the Th4 and Th5. Ur relatively thin, with 2 free somites + asm; Gs longer than Ur. Cr long, 0.8 times as long Ur, with irregular lateral margins. A1 exceeds body length, last 12 segments with slender appearance, longer than proximal segments. Enp and Exp of A2 subequal in length, 2 and 4-segmented, respectively, with small spinules over the anterior margin of Enp2. Md gb elongated, longer than palp; palp reduced, with 2 apical setae in last segment: distal margin of gb with 4 slender and elongated seta-like teeth, with one thick outer seta, ornamented with spinules on its outer margin (Fig. 21A). Mx1 reduced, 3-segmented Enp; Exp is represented by a long seta, accompanied by a smaller seta inserted at the same level; last segment of Enp with 2 apical setae (Fig. 21B). Mx2 with modified ornamentation in anterior margins of distal setae of the last segments, scutum-shaped setules in first half of these setae. cp of Mp with 2 mid and 3 distal inner setae; setae of Enp with scutum-shaped setules. P1 with both rami 3-segmented, Exp1 with 1 large seta, longer than Exp2 + Exp3 length; Exp2 with 1 outer seta and Exp3 with 2 small outer setae and with 2 patches of small spinules, one in proximal and one in distal position: distal patch composed by pore-like spinules on a tubercule-like projection (Fig. 21C). P2-P5 with both rami 3-segmented, Enp smaller than Exp, particularly in legs P3-P5. Exp2 of P5 with 1 large modified inner seta, as long as Exp3 (Fig. 21D).

Male. Not collected.

Remarks. *Augaptilus cornutus* is the only non-tropically distributed species collected in this study. Its distribution is bi-polar and its capture in western Mexico represents a new record for both the Gulf of California and the ETP. It is known to occur between 2000 and 3000 m depth (Mathews, 1972).

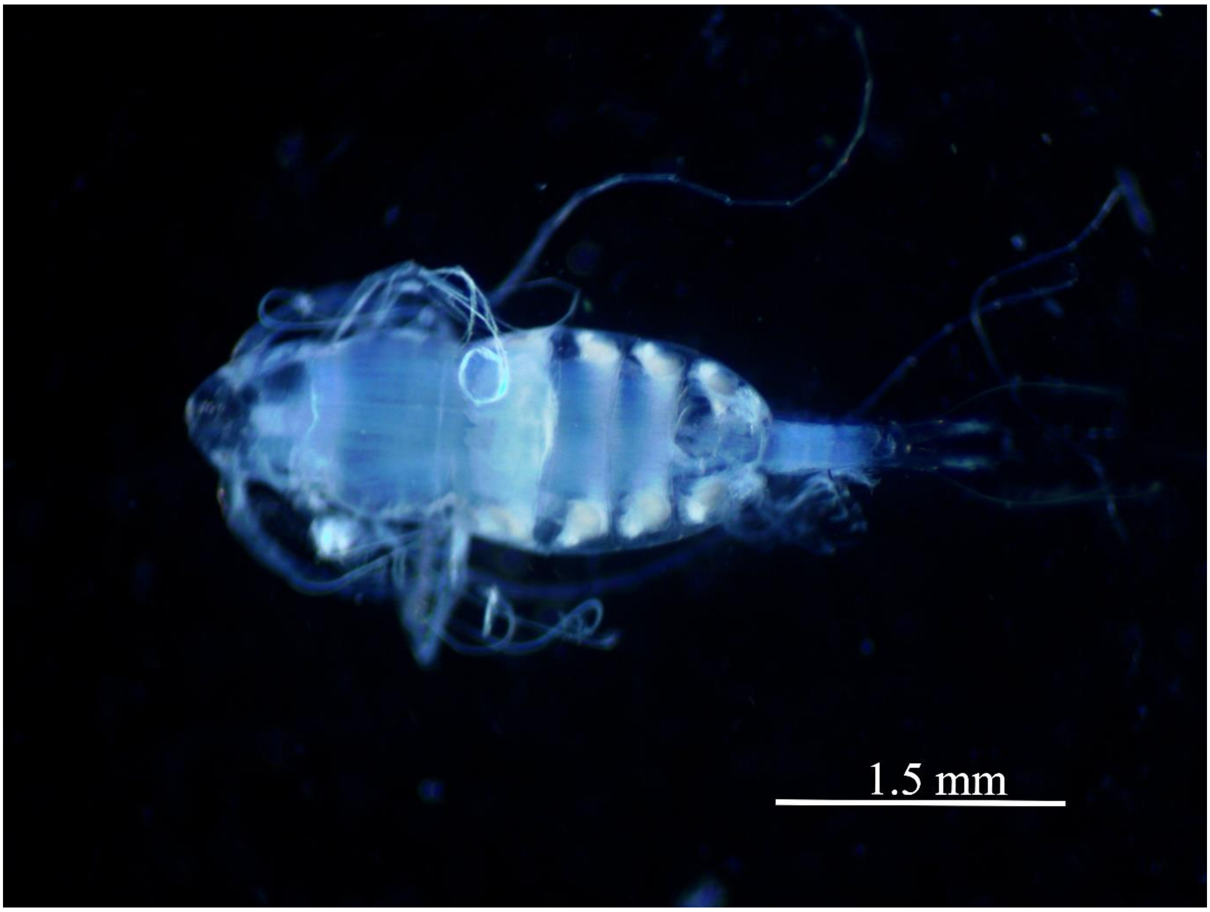

Figure 20. *Augaptilus cornutus* Wolfenden, 1911. Habitus of the female, dorsal view.

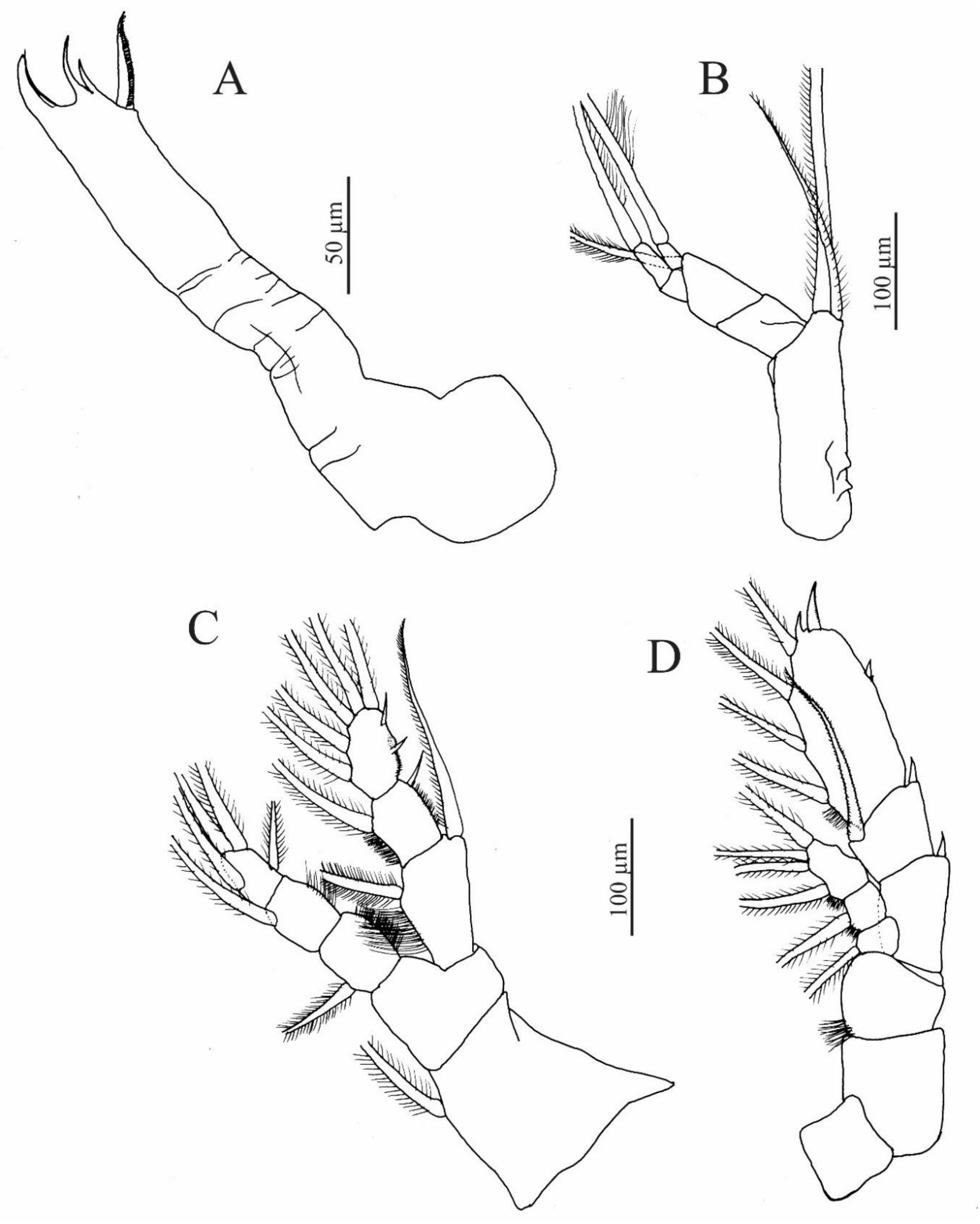

Figure 21. *Augaptilus cornutus* Wolfenden, 1911. Female (ICML-EMU-13833). (A) Mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

***Augaptilus megalurus* Giesbrecht, 1889** (Figures 22-23)

Material examined. 1 F, TALUD IV, St. 36 (25°51’59’’ N, 110°10’59’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (SPS; ICML-EMU-13831).

Female. Length measured from head anterior margin to posterior margin of Cr 5.13 mm. General appearance of the cuticle opaque. Narrow head, body wider at Mp-P1 insertion level in dorsal view (Fig. 22). Cephalosome not fused to Th1; Th4 and Th5 fused. Ur relatively long and slender, with 2 free somites + asm; Gs about as long as Ur. Cr with 2 large lateral setae. A1 of 26 segments, it reaches the posterior margin of caudal setae; distal margin of segment 24 with a plumose seta. A2 relatively large, almost as long as Mp, with both rami about the same length; posterior margin of the Enp2 with spinules. Md with elongated gb and reduced mandibular palp; gb with 4 distal seta-like teeth and 1 strong outer seta (Fig. 23A). Mx1 reduced, with a seta inserted in the posterior margin of the coxa, 2-segmented Enp and Exp represented by 1 seta, accompanied by another smaller seta inserted at same level (Fig. 23B). Mx2 with short ied, with 2 setae each; 2 setae in the inner margin of cp; setae of Enp with scutum-shaped setules. cp of Mp as long as the sum of distal segments, with 2 setae inserted in the mid anterior margin and 3 in anterior distal margin; setae of Enp with scutum-shaped setules. P1 with 1 internal seta in coxa and 1 external in basis, both rami 3-segmented: external spine of the Exp1 overpass the distal margin of Exp3, spine curved; small spinules and setules over external and internal margins of Exp2 and Exp3 (Fig. 23C). P2-P4 with 3 outer spines in Exp3 and one in Exp1-Exp2. P5 with 1 outer spine and 1 apical spine, accompanied in its base by a spiniform process; Enp2 with a small anterior distal projection; coxa with an inner and an outer patch of setules; basis with 2 patches: one proximal and one distal on inner margin (Fig. 23D).

Male. Not collected.

Remarks. *Augaptilus megalurus* distribution seems to be restricted to the NE Pacific, near the coasts of California and Baja California. During our study, this species was found only in the Gulf of California.

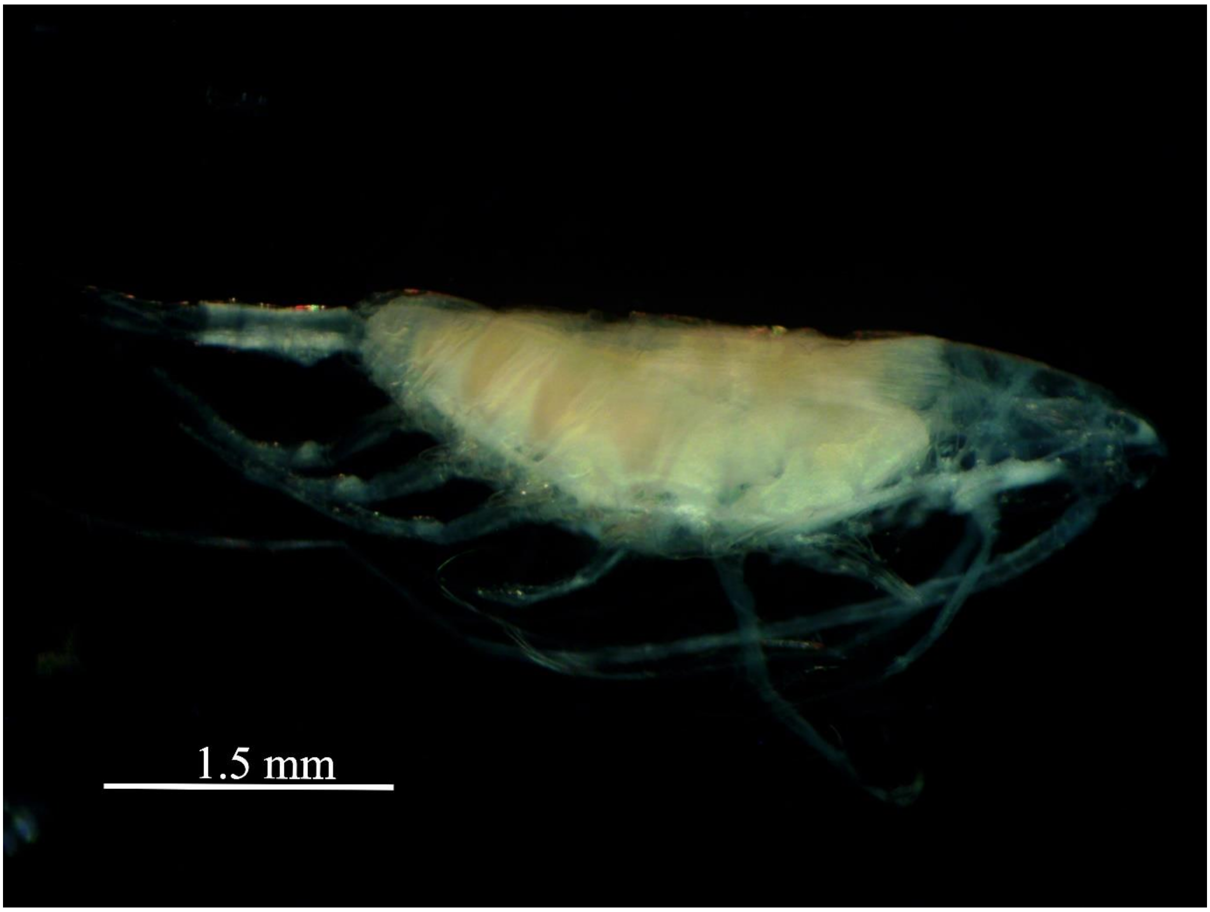

Figure 22. *Augaptilus megalurus* Giesbrecht, 1889. Habitus of the female, lateral view.

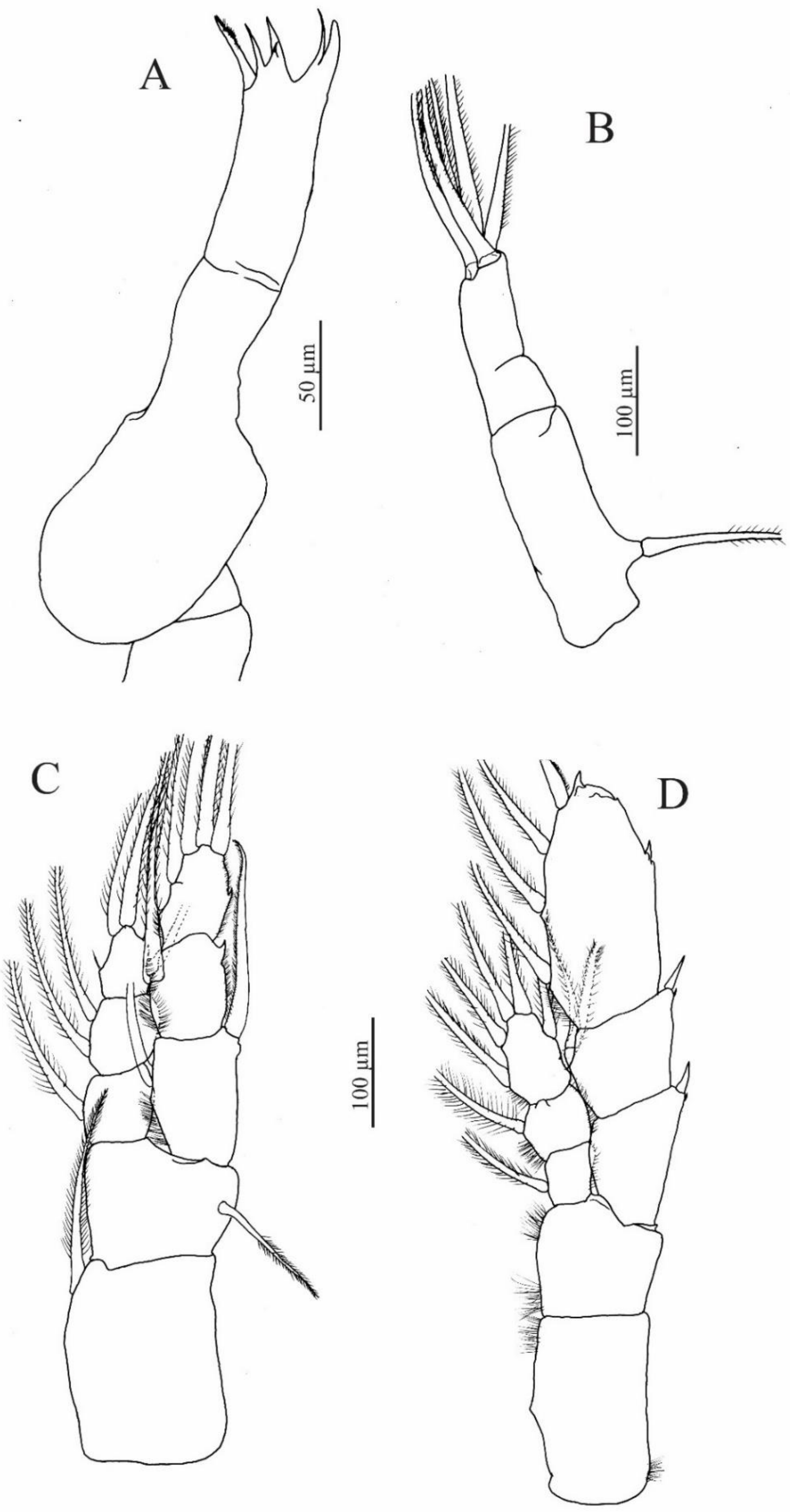

Figure 23. *Augaptilus megalurus* Giesbrecht, 1889. Female (ICML-EMU-13831). (A) Detail of mandibular gnathobase, anterior view, (B) maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

Genus *Centraugaptilus* Sars G.O., 1920

***Centraugaptilus horridus* (Farran, 1908)** (Figure 24-25)

Synonymized names. *Augaptilus horridus* Farran, 1908 (PS); *Augaptilus pyramidalis* Esterly, 1911.

Material examined. 2 F, TALUD IV, St. 36 (25°51'59'' N, 110°10'59'' W), MN, from surface to 1300 m depth (TD, 2100 m), August 27, 2000 (SPS; ICML-EMU-13832-A). 1 F, TALUD XI, St. 19B (17°56'0'' N, 110°'10'0'' W), MN, from surface to 1490 m depth (TD, 1750 m), June 9, 2007 (SPS; ICML-EMU-13832-B).

Female. Length measured from head anterior margin to posterior margin of Cr: 6.43 mm. General appearance of the cuticle translucid, low muscular density (Fig. 24). Dorsal margin of habitus covered by small spiniform projections. Rostrum bifurcated, projected ventrally, shorter than A1 first segment. Cephalothorax constricted at Mx2 insertion level. Cephalothorax is more than 60% of total length. Ur relatively small, with 1 free somite + asm; Gs slightly longer than Ur. A1 relatively short, not extending beyond posterior margin of Th1, with 26 subequal segments. A2 with a much larger 3-segmented Enp than 7-segmented Exp; Enp3 with spinules over distal exterior margin. Md with a large mandibular palp; gb curved inwards, concave, with 2 lateral teeth and 1 outer seta (Fig. 25A). Mx1 with 2 ied, one as large as pcx arthrite, with 3 distal setae; distal setae of pcx arthrite with scutum-shaped setules (Fig. 25B). Mx2 relatively wide: cxp and bsp as long as wide. Distal setae of Enp with scutum-shaped setules. Mp with sub-squared Cxp and enlarged bsp, both relatively wide; cxp with 3 internal setae and bsp with 6 internal setae; distal setae of Enp with scutum-shaped spinules. P1 segments relatively wide, with both rami 3-segmented; outer spine of Exp1 extends beyond the distal margin of Exp3; anterior margin of Exp and Enp of P1 covered with setules, also is the inner anterior margin of basis (Fig. 25C). P2-P5 with both rami 3-segmented; Exp3 with 3 outer spines in P2-P4. Exp3 of the P5 with 2 outer spines; setules over inner margins of the Exp1-Exp3 and over outer margins of Exp2-Exp3 (Fig. 25D).

Male. Not collected.

Remarks. *Centraugaptilus horridus* is a widely distributed species, recorded from California to Chile in the ETP, but so far it hasn't been included in copepod lists for the Mexican Pacific.

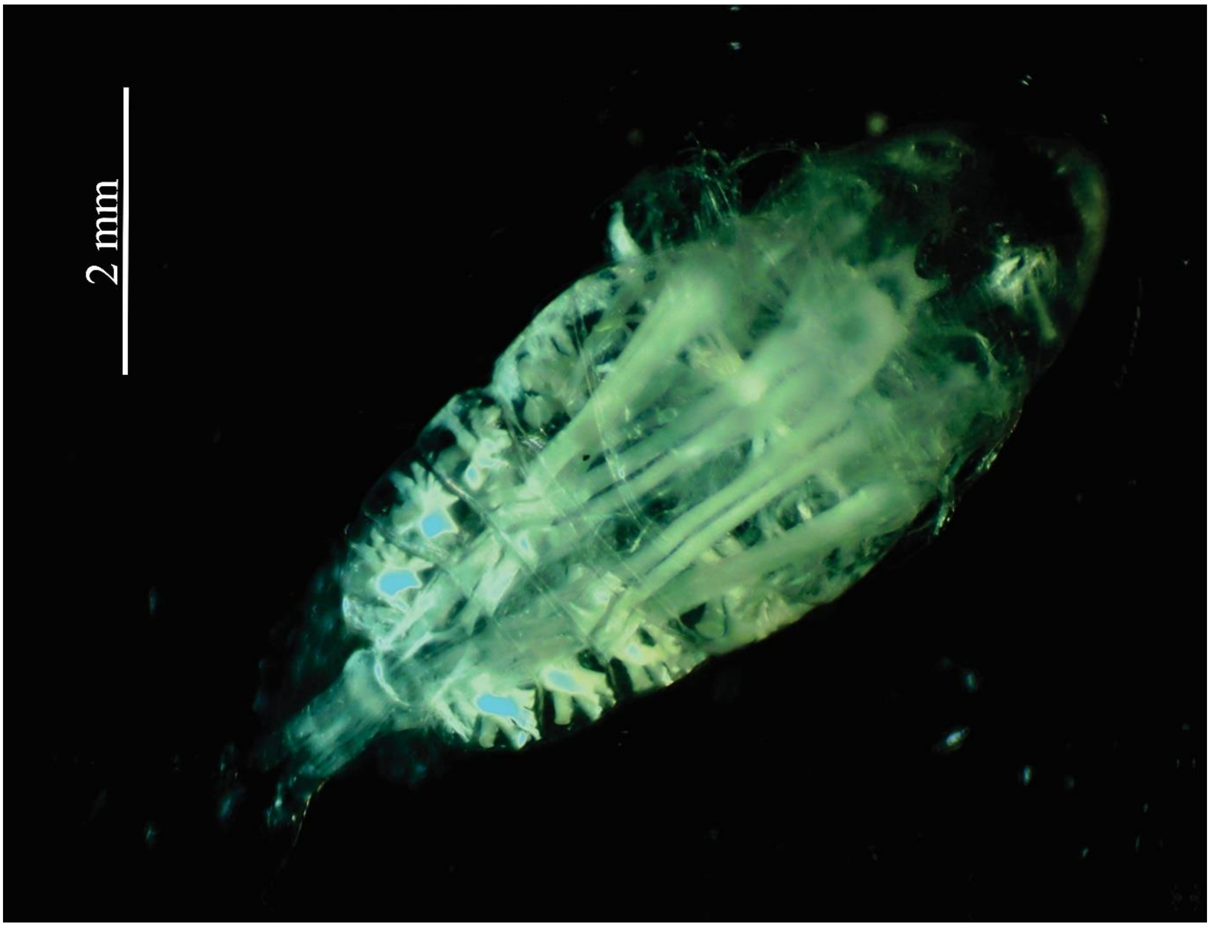

Figure 24. *Centraugaptilus horridus* (Farran, 1908). Habitus of the female, dorsal view.

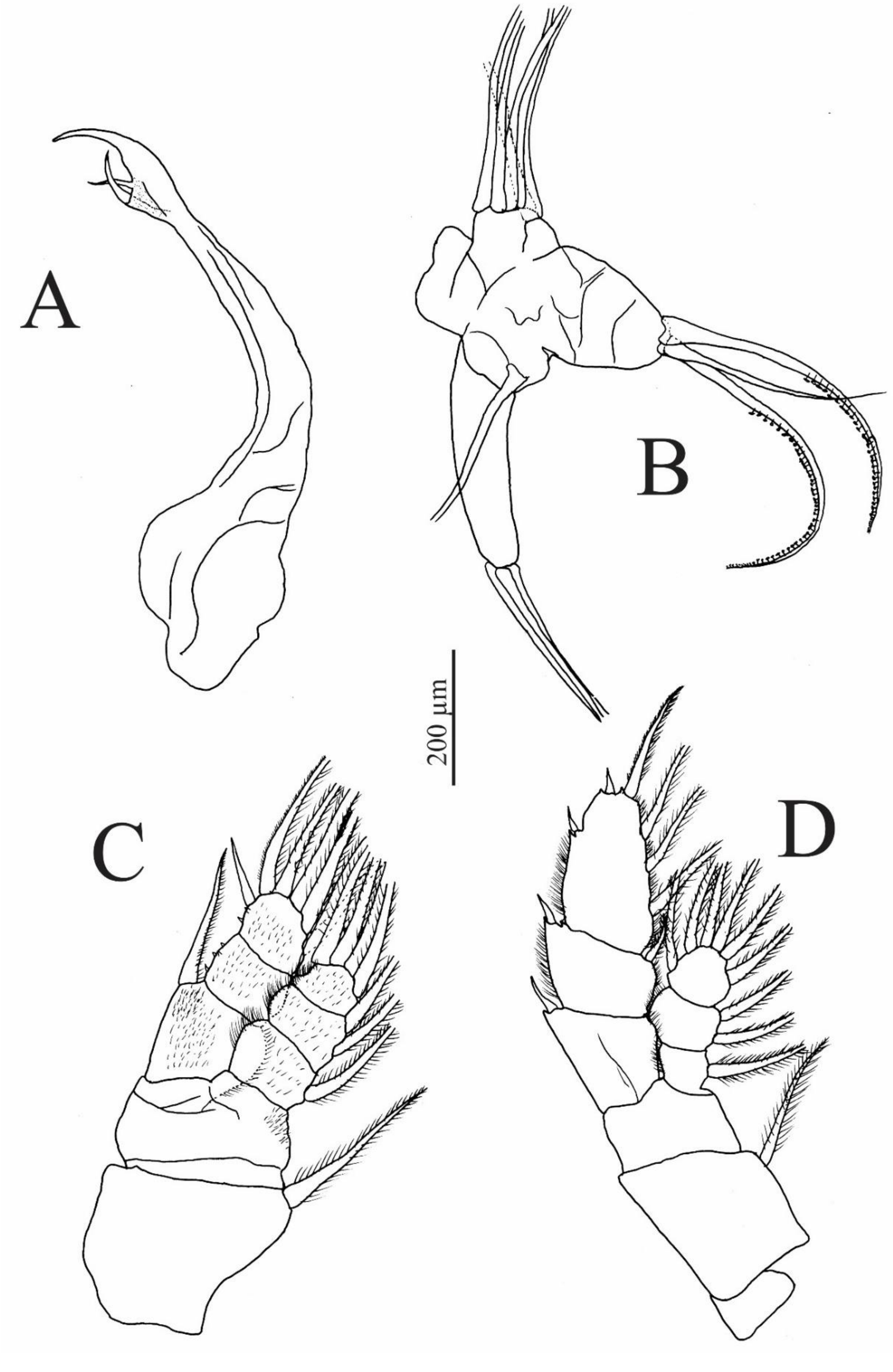

Figure 25. *Centraugaptilus horridus* (Farran, 1908). Female (ICML-EMU-13832-A). (A) Details of mandibular gnathobase, (B), maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

***Centraugaptilus macrodus* (Esterly, 1911)** (Figures 26-27)

Synonymized names. *Augaptilus macrodus* Esterly, 1911 (PS).

Material examined. 1 F, TALUD XI, St. 19B (17°55’59’’ N, 103°10’01’’ W), MN, from surface to 1490 m depth (TD, 1750 m), June 9, 2007 (SPS; ICML-EMU-13833).

Female. Length measured from head anterior margin to posterior margin of Cr: 7.74 mm. General appearance of the cuticle translucid, oval body (Fig. 26). Rostrum bifurcated, projected ventrally, longer than A1 first segment. Prosome shortened, narrow head and a wide thorax, Th4 and Th5 not fused. Ur short, with 1 free somite + asm; Gs and asm are longer than wide, Ur2 somite relatively short; Cr short, of less than a half the length of asm. A1 with 26 subequal segments, segment 22 with a long outer seta, that exceeds the length of distal segments. A2 with a much larger Enp than Exp, with 2 and 7 segments, respectively; allobasis with 2 outer distal setae; Exp7 with 4 terminal setae. Md with elongated gb, with 1 single large tooth and 1 large outer seta (Fig. 27A). Mx1 well-developed, pcx arthrite with a small inner row of spinules and an outer patch of small spinules; Enp with inner and outer rows of spinules; Exp reduced, not visible (Fig. 27B). Mx2 well-developed, with setae ornamented with scutum- shaped setules. Mp large, with a prominent basis and coxa; 3 inner setae in the coxa; 4-segmented Enp, Enp4 short and longer than wide. P1 with 1 outer spine on Exp1, extending beyond the distal margin of Exp3, relatively thick; both rami 3-segmented; anterior inner margin of basis, anterior outer margin of Exp1 and anterior outer margin of Enp3 with patches of short spinules (Fig. 27C). P2-P4 with both rami 3-segmented, 1 outer spine in segments Exp1 and Exp2 and 3 outer spines and 1 apical in segment Exp3. P5 with both rami 3-segmented, Exp1 with one relatively short inner seta; with well separated patches of short spinules over the anterior margins of the Exp segments, basis and Enp2; Exp3 with 1 outer and 2 apical spines (Fig. 27D).

Male. Not collected.

Remarks. This species appears to be restricted to the North Pacific, originally recorded off the California coast by Esterly (1911), later off the eastern Russian coast by Brodsky (Tanaka, 1964), and off the Pacific coast of Canada (SCCSRPRS, 2019). It is a first record for the Mexican Pacific.

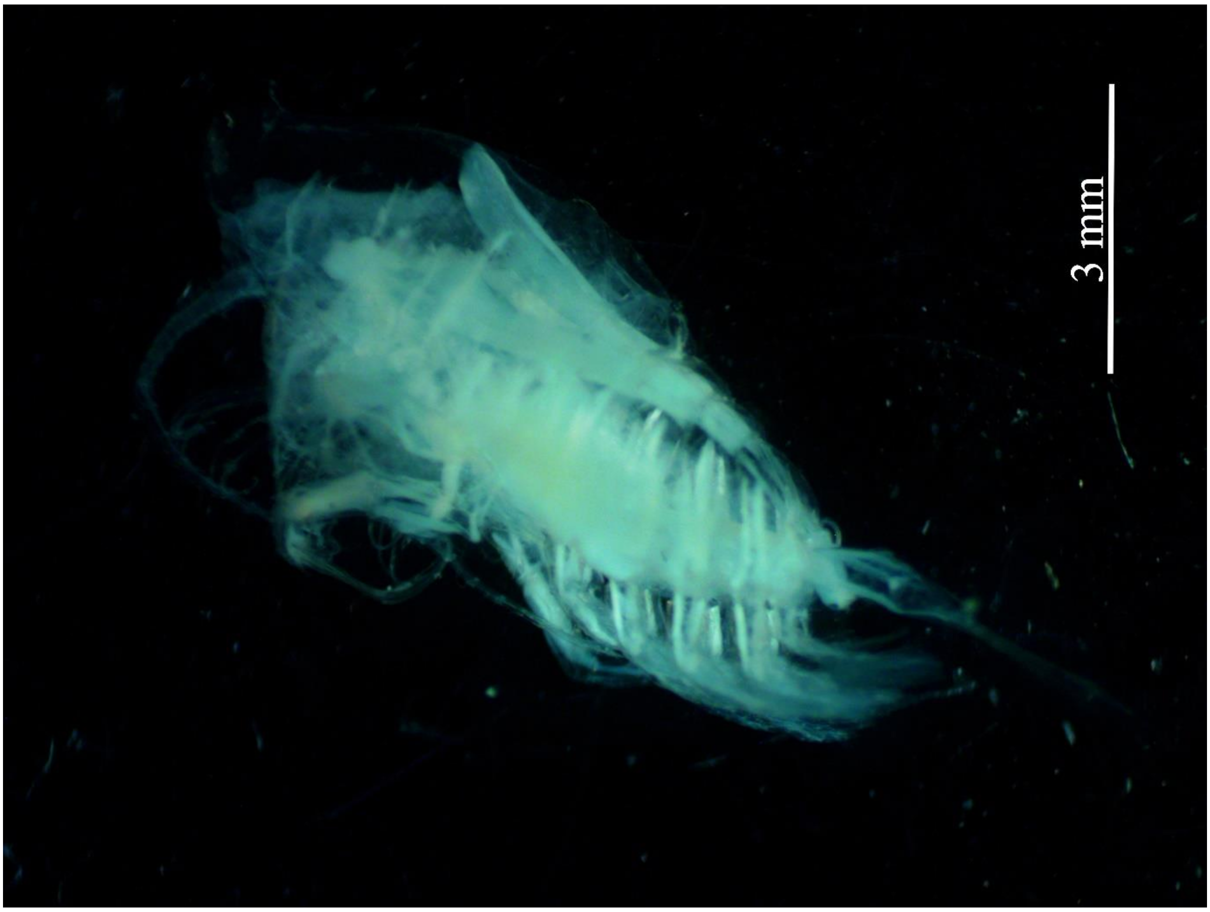

Figure 26. *Centraugaptilus macrodus* (Esterly, 1911). Habitus of female, lateral view.

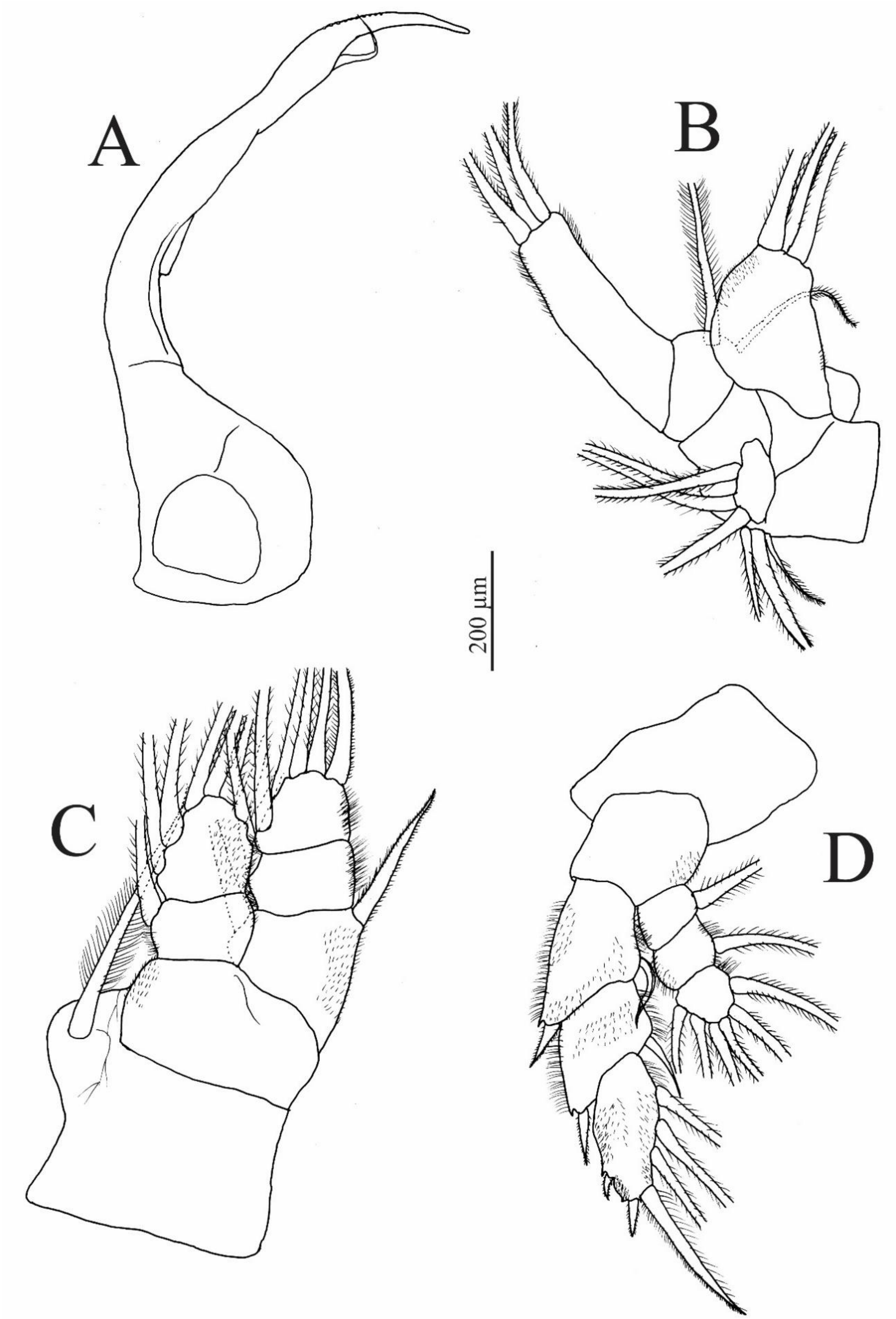

Figure 27. *Centraugaptilus macrodus* (Esterly, 1911). Female (ICML-EMU-13833). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

Genus *Euaugaptilus* Sars G.O., 1920

***Euaugaptilus angustus* (Sars G.O., 1905)** (Figures 28-29)

Synonymized names. *Augaptilus angustus* Sars G.O., 1905 (PS).

Material examined. 1 F, TALUD IV, St. 36 (25°51’59’’ N, 110°10’59’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (SPS; ICML-EMU-13834). 1 F, TALUD V, St. 15 (22°00’57’’ N, 106°40’00’’ W), MN, from surface to 1620 m depth (TD, 1620 m), December 13, 2000 (UD; ICML-EMU-13835-A). 1 F, TALUD VI, St. 15 (23°14'42" N, 107°30'00" W), MN, from surface to 1230 m depth (TD, 2390 m), March 14, 2001 (UD; ICML-EMU-13835-B). 1 F, TALUD VII, St. 15B (23°25'19" N, 107°46'25" W), MN, from surface to 1425 m depth (TD, 2320 m), June 7, 2001 (UD; ICML-EMU-13835-C). 1 F, TALUD VII, St. 29 (25°17'32" N, 109°24'30" W), MN, from surface to 1335 m depth (TD, 2080 m), June 8, 2001 (UD; ICML-EMU-13835-D). 1 F, TALUD VIII, St. 23 (23°03’42’’ N, 110°23’54’’ W), MN, from surface to 2200 m depth (TD, 2200 m), April 19, 2005 (UD; ICML-EMU-13836-A). 1 F, TALUD IX, St. 6 (24°49’38’’ N, 109°47’58’’ W), MN, from surface to 1500 m depth (TD, 1650 m), November 12, 2005. (UD; ICML-EMU-13836-B). 1 F, TALUD X, St. 20 (27°14’41’’ N, 111°33’15’’ W), MN, from surface to 1250 m depth (TD, 1785 m), February 13, 2007 (UD; ICML-EMU-13836-C). 1 F, TALUD X, St. 23 (27°14’41’’ N, 111°33’15’’ W), MN, from surface to 1785 m depth (TD, 1750 m), February 13, 2005 (UD; ICML-EMU-13836-AD).

Female. Length measured from head anterior margin to posterior margin of Cr 6.28 mm. General appearance of the cuticle translucid, robust (Fig. 28). Prosome widened in anterior and posterior margin; head almost as long as wide. Th4 and Th5 not fused. Ur small in proportion with the prosome, with 2 somites; Gs as long as Ur; Cr relatively wide, longer than asm. A1 26-segmented, extended up to the posterior margin of caudal setae; segments 23 and 24 particularly long. A2 with larger Enp than Exp, 2 and 7-segmented, respectively; Exp7 with 2 large and 1 small distal seta. Md with a robust palp, larger than gb; gb with 7 elongated, setiform teeth, outer seta similar in length and shape than the teeth (Fig. 29A). Mx1 well- developed, Enp and Exp not fused, pcx arthrite with 2 small distal spinules on the outer margin (Fig. 29B). Mx2 large, well-developed, almost as large as Mp; Enp1 larger than distal segments, 0.9 times as long as the coxa + basis. Coxa and basis of the Mp similar in length, well-developed Enp, ornamentation of the Enp setae with no particular shapes. P1 with both rami 3-segmented, with 1 outer spine at Exp1-Exp3: spine of the Exp1 reaches the distal margin of Exp3 (Fig. 29C). P2-P4 with both rami 3-segmented, with 1 outer spine on Exp1 and Exp2, 3 at Exp3; Exp3 much larger than proximal segments. P5 with 1 robust inner seta in the distal margin of Exp2, that extends up to half of the Exp3 length; Exp1 and Exp with 1 outer spine, Exp 3 with 1 outer and 2 apical spines (Fig. 29D).

Male. Cephalic and natatory appendages as in female, similar in size. Right P5 with 2 distal spines in Exp3, outer spines in Exp1 and Exp2; left Exp3 with one large distal spine and two smaller lateral spines; Enp of both legs symmetrical.

Remarks. *Euaugaptilus angustus* was the third most frequently collected deep-water species, after *Lucicutia hulsemannae* and *Pseudhaloptilus pacificus*.

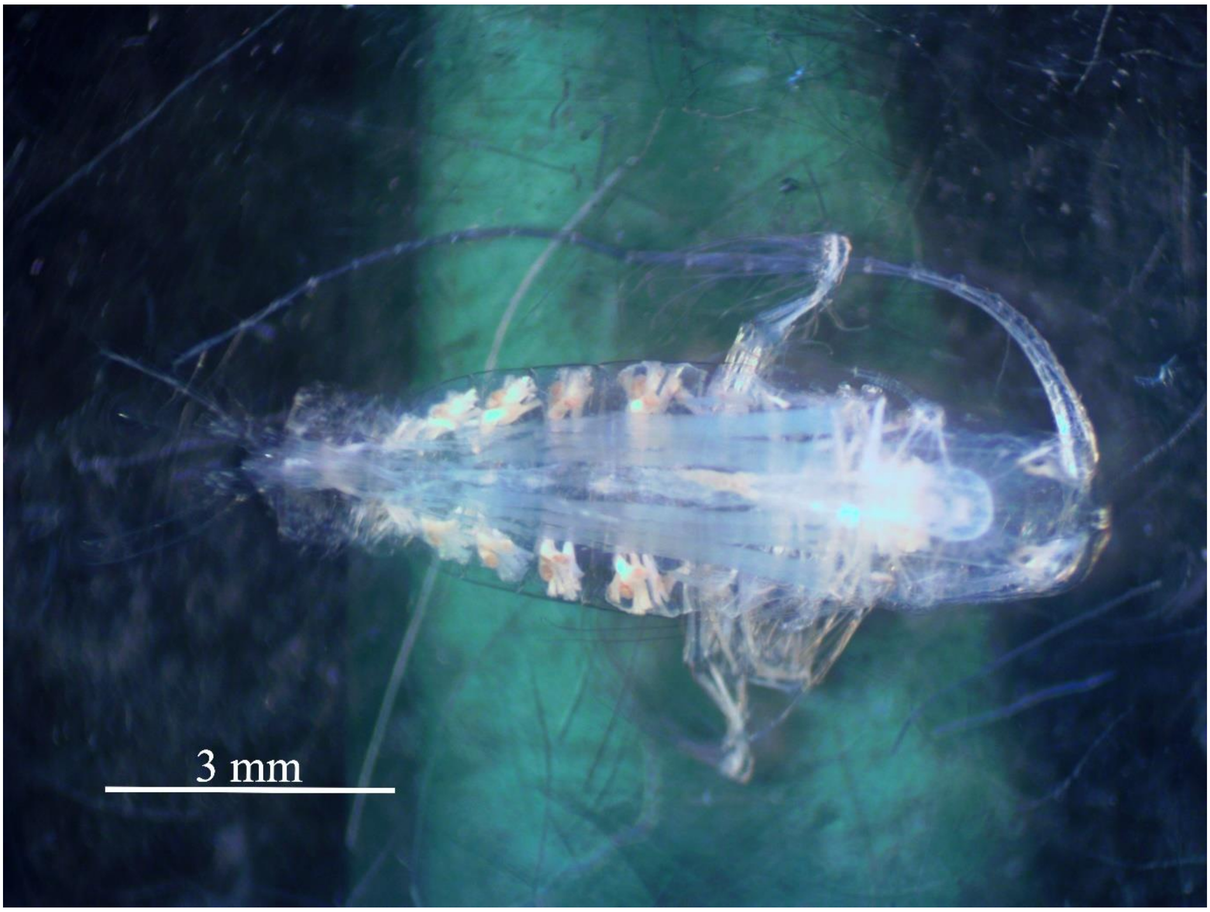

Figure 28. *Euaugaptilus angustus* (Sars G.O., 1905). Habitus of female, dorsal view.

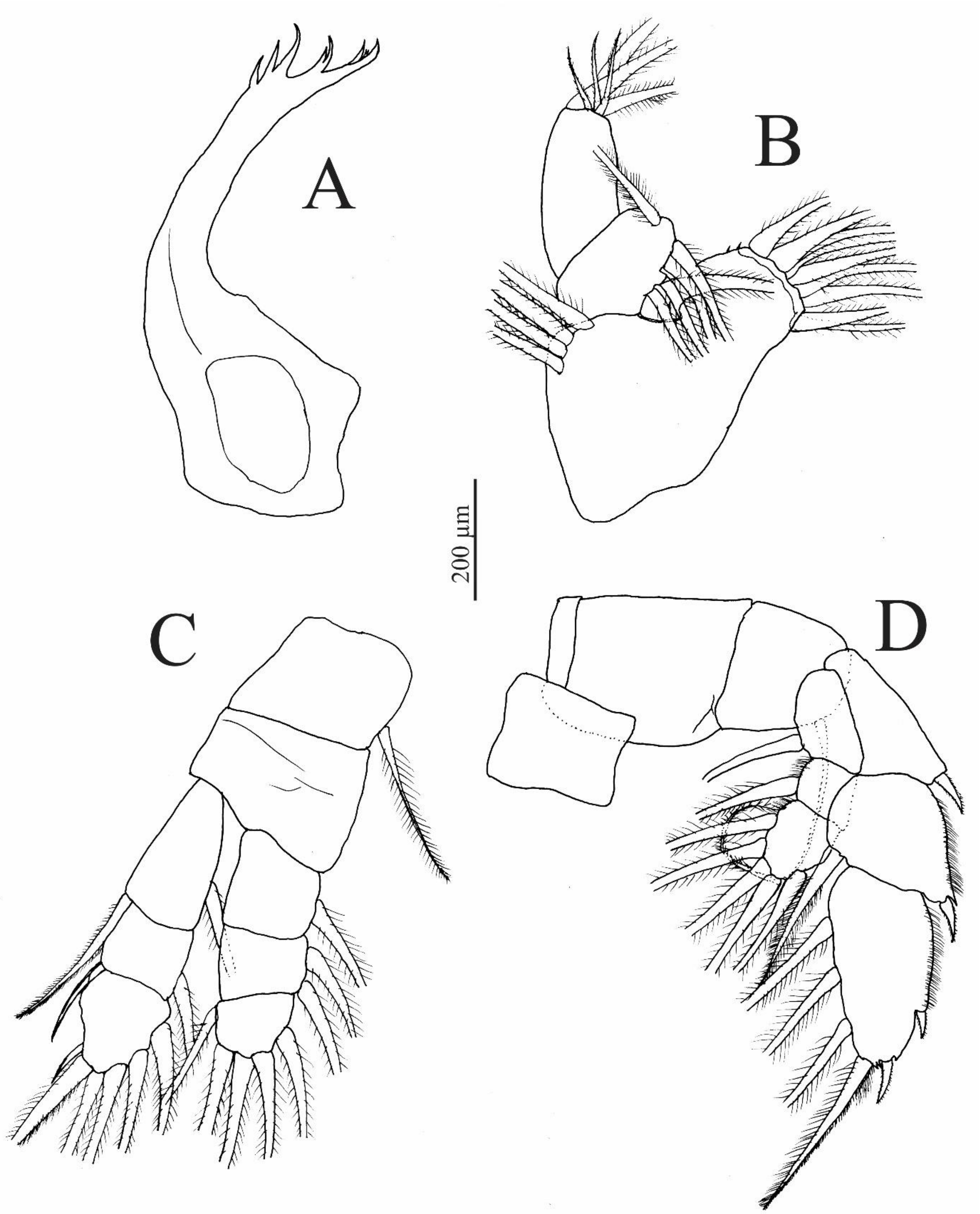

Figure 29. *Euaugaptilus angustus* (Sars G.O., 1905). Female (ICML-EMU-13834). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

Euaugaptilus austrinus **Park, 1993** (Figures 30-31)

Material examined. 1 F, TALUD IX, St. 23 (26°03’59’’ N, 110°24’45’’ W), MN, from surface to 1450 m depth (TD, 2318 m), November 15, 2005. (SPS; ICML-EMU-13837).

Female. Length measured from head anterior margin to posterior margin of Cr: 8.44 mm. General appearance of the cuticle opaque, elongated body (Fig. 30). Prosome much larger than wide, Th4 and 5 fused. Ur relatively short, with 1 free somite + asm; Gs larger than Ur. Cr and asm about as long. A1 with 26 segments, that extends up to the posterior margin of the Gs. A2 relatively large, with elongated Enp1; Exp7 with 4 distal setae. Md with elongated gb, palp slightly smaller than the gb; distal margin of gb with 4 cuspidated teeth and 1 strong outer seta that is ornamented with thick spinules all over its margin (Fig. 31B). Mx1 well-developed, with 2 ied, 1-segmented Exp with 2 distal setae and a 1-segmented Enp with 3 distal setae (Fig. 31A). Mx2 with well-developed basis, with 2 internal setae; Enp setae with scutum-shaped setules. Mp elongated, coxa with 6 internal setae; Enp1 as long as total length of distal segments. Both rami of the P1 3-segmented, with 1 outer spine at Exp1 and Exp2, 2 lateral and one apical (serrated) spine at Exp3; anterior margins of Exp2, Exp3, Enp2 and Enp3 with long spinules (Fig. 31C). P2-P4 with both rami 3-segmented, with 1 outer spine on Exp1 and Exp2 and 3 outer and 1 apical spine on Exp3; apical spines ornamented with small setulae on outer margin and large setulae on inner margin. P5 with 1 outer spine at Exp1 and Exp2, 1 lateral and 2 apical at Exp3; seta of basis as long as the total length of Exp; similar ornamentation than P2-P4 (Fig. 31D).

Male. Not collected.

Remarks. *Euaugaptilus austrinus* is an antartic species. Our material represents the first record for the eastern Pacific. The material examined presents some minor differences compared to the original description (Park 1993b), in particular in the proportional length of Exp1 and Exp3 outer spines.

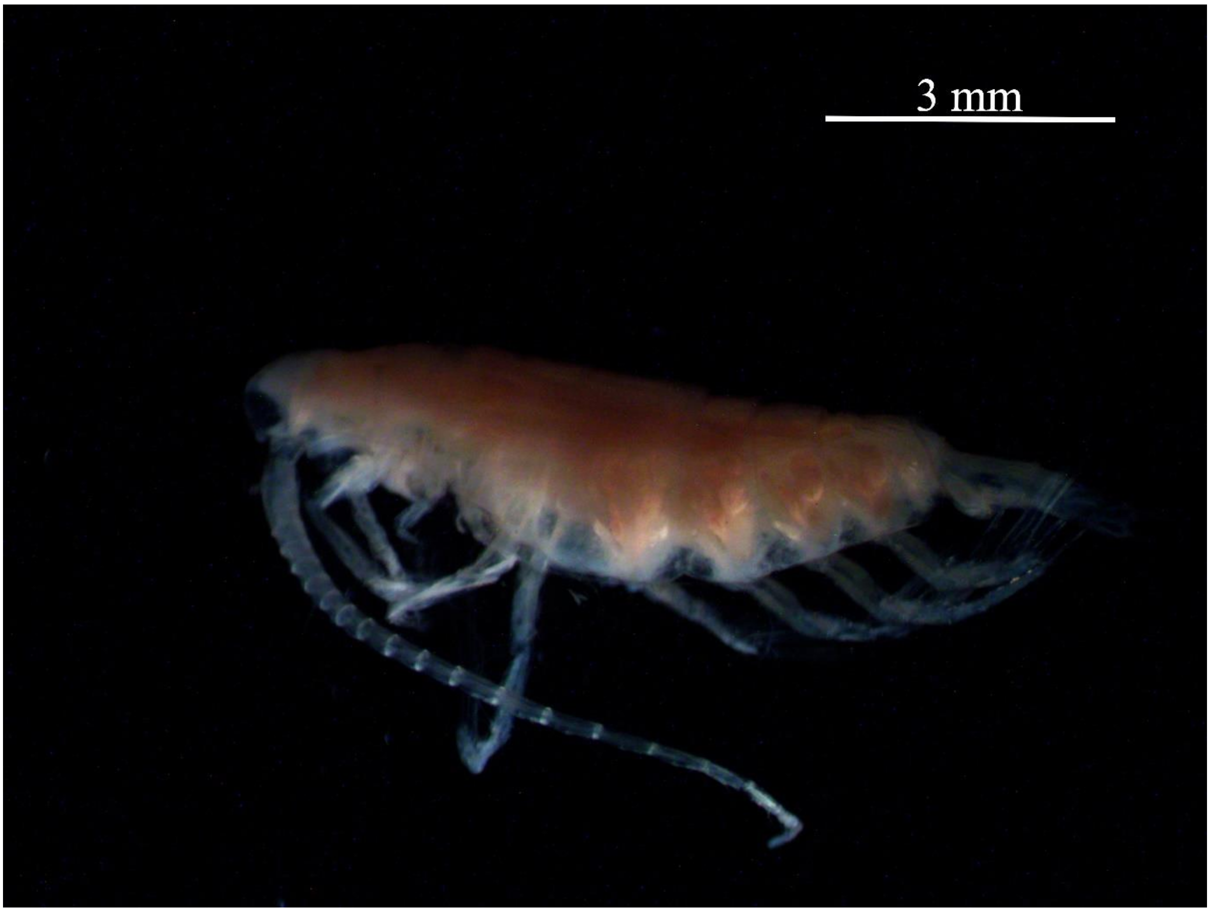

Figure 30. *Euaugaptilus austrinus* Park, 1993. Habitus of the female, lateral view.

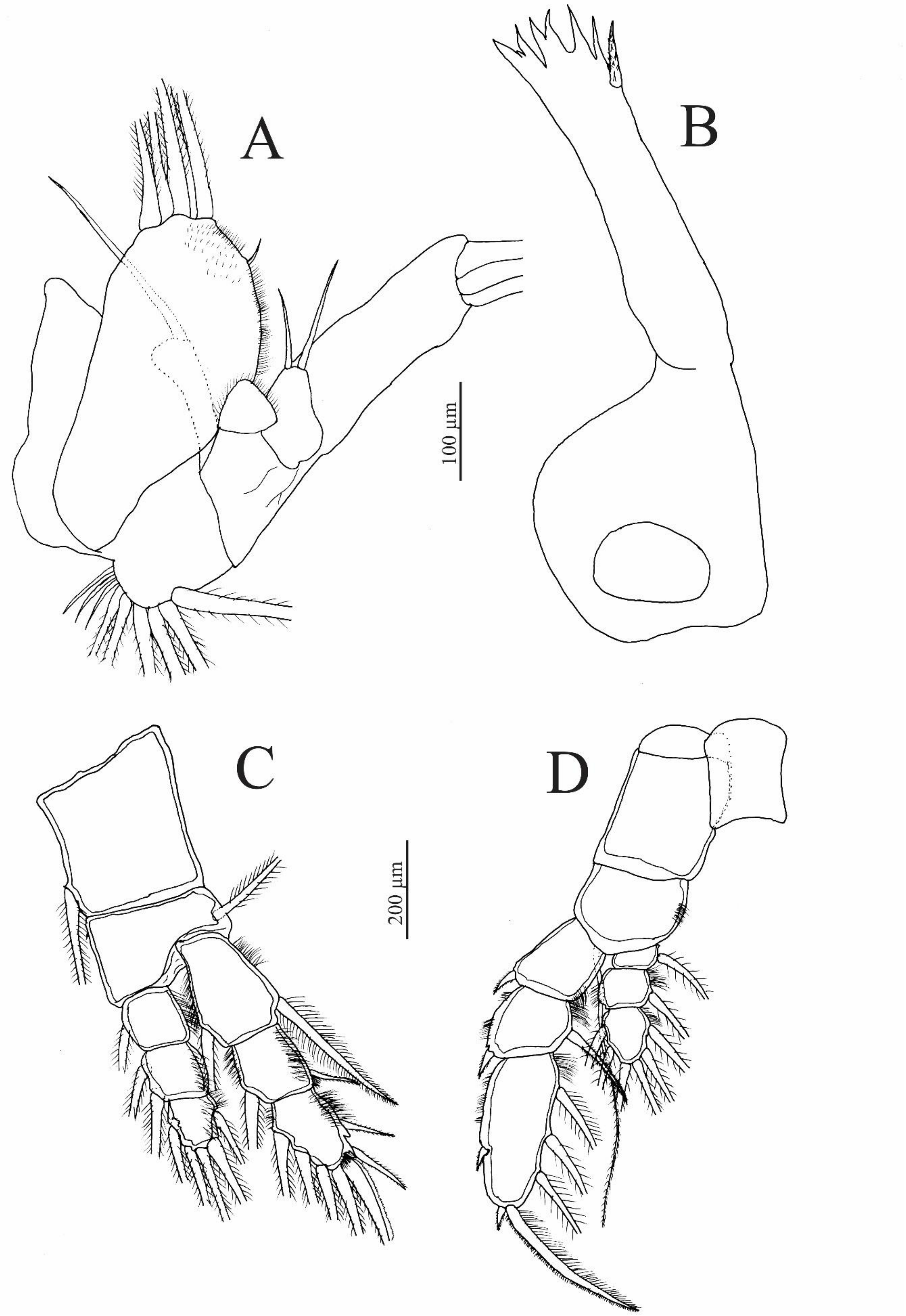

Figure 31. *Euaugaptilus austrinus* Park, 1993. Female (ICML-EMU-13837). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

***Euaugaptilus longimanus* (Sars G.O., 1905)** (Figures 32-33)

Synonymized names. *Augaptilus longimanus* Sars G.O., 1905 (PS).

Material examined. 1 F, TALUD X, St. 23 (27°14’41’’ N, 111°33’15’’ W), MN, from surface to 1785 m depth (TD, 1750 m), February 13, 2005 (SPS; ICML-EMU-13838-A). 1 F, TALUD XI, St. 6A (16°57’59’’ N, 100°56’59’’ W), MN, from surface to 1400 m depth (TD, ND), June 7, 2007 (SPS; ICML-EMU-13838-B).

Female. Length measured from head anterior margin to posterior margin of Cr: 7.06 mm. General appearance of the cuticle slightly opaque, robust body (Fig. 32). Prosome wider in the head, narrowed towards the thorax. Rostrum bifurcated, ventrally projected, longer than first A1 segment. Ur relatively short, with 2 somites; Gs much larger than Ur. 26-segmented A1, extending beyond the posterior margin of Cr. Cr about as long as asm. A2 with large allobasis and relatively small Exp; Enp segments relatively wide, particularly Enp2. Md with elongated gb, with 3 bifurcated teeth and 1 well-developed outer seta (Fig. 33A). Mx1 with a large pcx arthrite that bears 2 distal setae; Enp with 3 distal setae (Fig. 33B). Mx2 with large pcx, partially fused with coxa; robust basis and short Enp, wider than its length, with scutum-shaped setules on Enp setae. Mp distinctively elongated, more than half the length of prosome; coxa, basis and Enp particularly elongated, with scutum-shaped setules on Enp setae. P1 with both rami 3-segmented; Exp1 and Exp2 with 1 outer spine: spine of Exp1 longer than Exp1; Exp3 with 2 outer spines, each accompanied by a rounded process and 1 apical spine: spines ornamented with short setules (Fig. 33C). P2-P5 with both rami 3-segmented; Exp1 and Exp2 of P2-P4 with 1 outer spine; Exp3 with 3 outer and 1 apical spine; P5 with 1 outer and 2 apical spines on Exp3; basal seta slightly shorter than total Exp length (Fig. 33D).

Male. Not collected.

Remarks. This species is widely distributed in the East/West Pacific, but it had not been previously recorded for the Mexican Pacific.

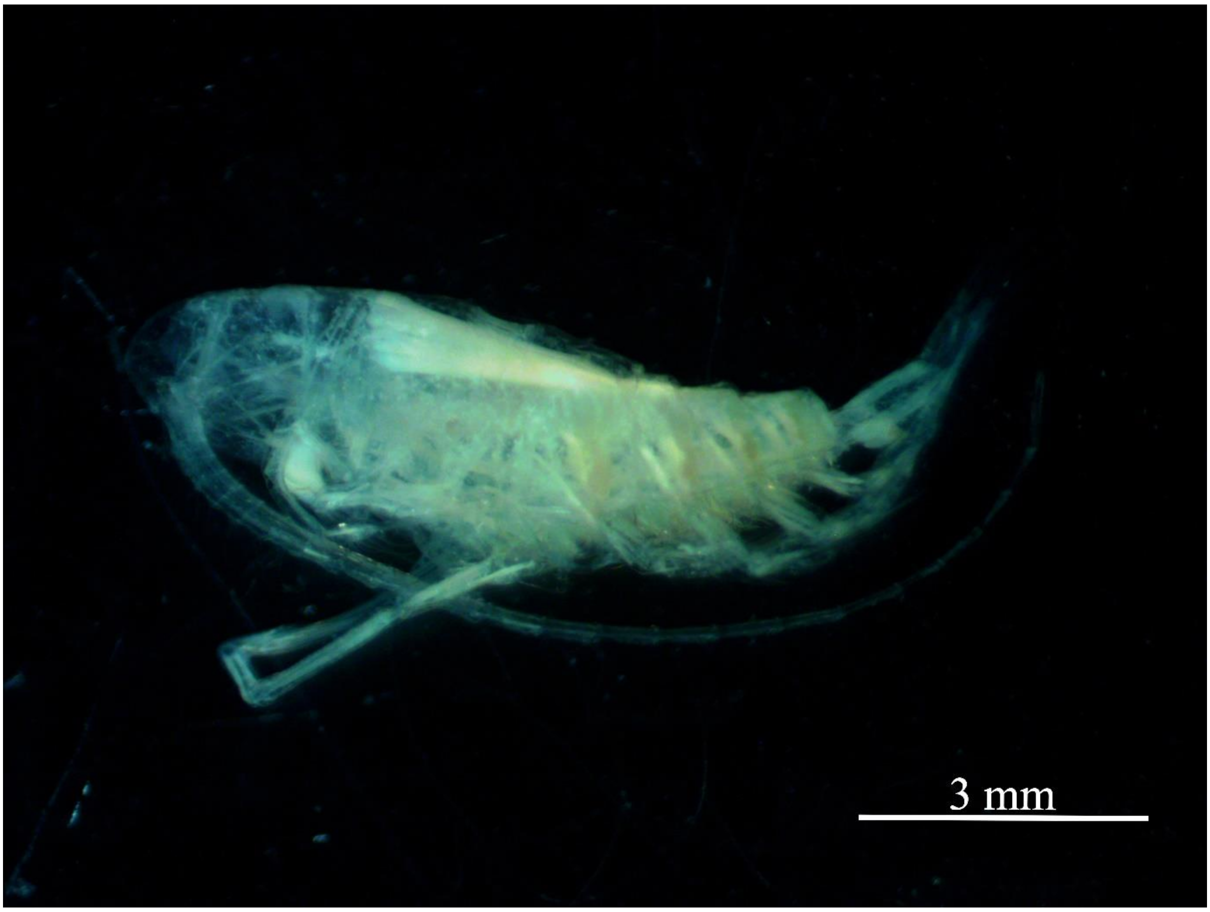

Figure 32. *Euaugaptilus longimanus* (Sars G.O., 1905). Habitus of female, lateral view.

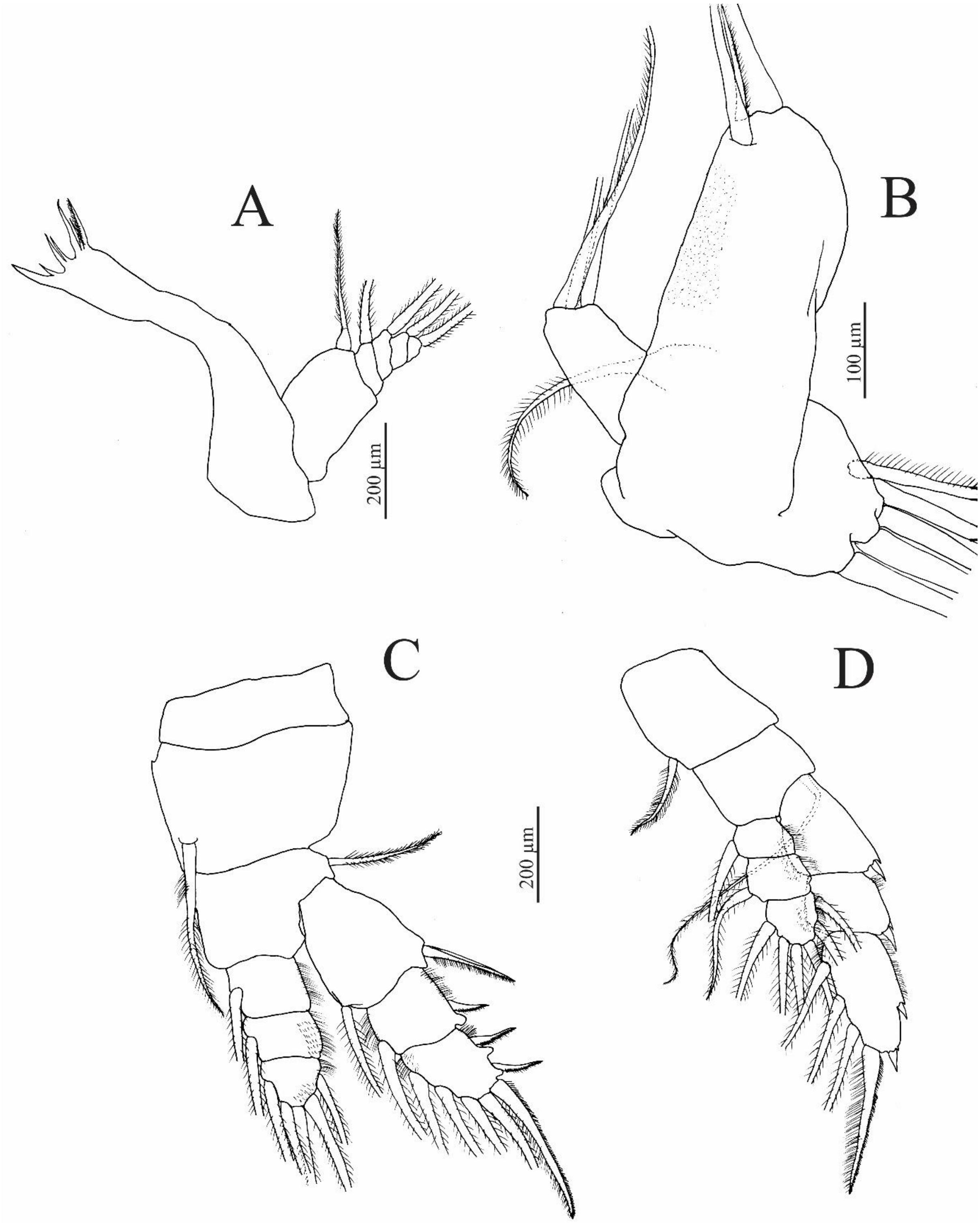

Figure 33. *Euaugaptilus longimanus* (Sars G.O., 1905). Female (ICML-EMU-13838-A). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

***Euaugaptilus nodifrons (*Sars G.O., 1905)** (Figures 34-35)

Synonymized names. *Augaptilus nodifrons* Sars G.O., 1905 (PS); *Augaptilus simplex* Esterly, 1913.

Material examined. 1 F, TALUD IV, St. 36 (25°51’59’’ N, 110°10’59’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (SPS; ICML-EMU-13839). 1 F, TALUD IV, St. 22 (24°17'20" N, 108°50'30" W), MN, from surface to 1325 m depth (TD, ND), August 26, 2000 (UD; ICML-EMU-13840-A). 1 F, TALUD XI, St. 6A (16°58'00" N, 100°57'00" W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (UD; ICML-EMU-13840-B).

Female. Length measure from head anterior margin to posterior margin of Cr: 7.17 mm. General appearance of the cuticle translucid, thoracic muscles dense and opaque (Fig. 34). Prosome relatively short, wider in middle portion where feeding appendages are inserted; cephalosome 1.2 times as long as thorax. Ur relatively short, with 1 free somite + asm; Gs larger than Ur; asm and Cr subequal in length. A1 with 26 subequal segments, that extends up to posterior margin of Cr. A2 robust, with large Enp and reduced Exp. Md gb robust, curved inwards, with 7 teeth, outer seta is robust; mandibular palp well-developed (Fig. 35A). Mx1 well-developed, with large 7-segmented Enp and a smaller 2-segmented Exp; Enp with a patch of spinules over its external margin (Fig. 35B). Mx2 with large Enp, about 0.8 times as long as the pcx + coxa + basis length; heavily ornamented setae, with large and thick setules. Mp very robust, with quitinized and thick setae on Enp segments, particularly in Enp3 and Enp4. P1-P5 with both rami 3-segmented: armature of P1 Exp could not be properly seen due to position, but its similar than the described armature for other augaptilids; outer spine of Exp1 extends up to half the length of Exp3 (Park, 1993b) (Fig. 35C). P2-P4 with 1 outer spine at Exp1 and Exp2, 3 outer and 1 apical spine at Exp3. P5 with 1 outer spine at Exp2 and Exp3, 1 outer and 2 apical spines on Exp3; internal spine of Exp2 robust, as long as the inner length of Exp2, curved outwards (Fig. 35D).

Male. Not collected.

Remarks. This species is widely distributed in the E/W Pacific, but it had not been previously recorded in the Mexican Pacific.

Figure 34. *Euaugaptilus nodifrons* (Sars, 1905). Habitus of female, lateral view.

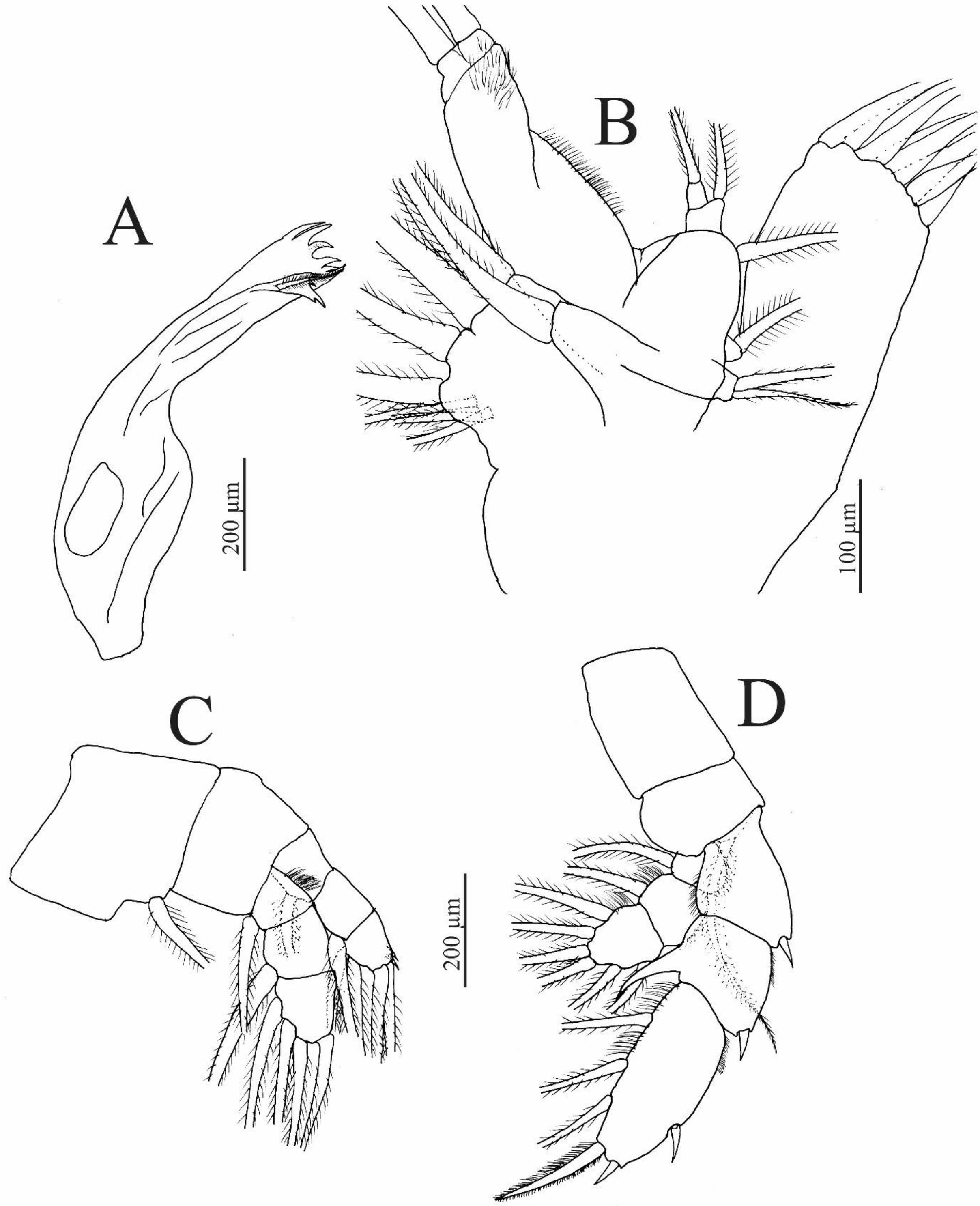

Figure 35. *Euaugaptilus nodifrons* (Sars G.O., 1905). Female (ICML-EMU-13839). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view and (D) right fifth leg, anterior view.

Genus *Pseudhaloptilus* Wolfenden, 1911

Pseudhaloptilus pacificus **(Johnson M.W., 1936)** (Figures 36-37)

Synonymized names. *Pachyptilus pacificus* Johnson M.W., 1936 (PS).

Material examined. 1 F, TALUD XI, St. 6A (16°57’59’’ N, 100°56’59’’ W), MN, from surface to 1400 m depth (TD, 1960 m), November 14, 2005 (SPS; ICML-EMU-13841). 1 F, TALUD IV, St. 29 (24°57'48" N, 109°37'00" W), MN, from surface to 1280 m depth (TD, 2080 m), August 27, 2000 (UD; ICML-EMU-13842-A). 1 F, TALUD V, St. 15 (23°21'30" N, 107°48'12" W), MN, from surface to 1350 m depth (TD, 2384 m), December 14, 2000 (UD; ICML-EMU-13842-B). 1 F, TALUD V, St. 36 (25°54'30" N, 110°11'24" W), MN, from surface to 1340 m depth (TD, 1990 m), December 17, 2000 (UD; ICML-EMU-13842-C). 1 F, TALUD VI, St. 15 (23°14'42" N, 107°30'00" W), MN, from surface to 1230 m depth (TD, 2390 m), March 14, 2001 (UD; ICML-EMU-13842-D). 1 F, TALUD VII, St. 15B (23°25'19" N, 107°46'25" W), MN, from surface to 1425 m depth (TD, 2320 m), June 7, 2001 (UD; ICML-EMU-13843-A). 1 F, TALUD VII, St. 29 (25°17'32" N, 109°24'30" W), MN, from surface to 1335 m depth (TD, 2080 m), June 8, 2001 (UD; ICML-EMU-13843-B). 1 F, TALUD VIII, St. 12 (25°02’00’’ N, 110°27’00’’ W), MN, from surface to 1150 m depth (TD, 1280 m), April 17, 2005 (UD; ICML-EMU-13843-C). 4 F, T IX, St. 1 (24º37'54" N, 109º22'36" W), St. 6 (24º49'38" N, 109º47'58" W), St. 7B (25°11'19" N, 109°42'45" W), St. 12 (25°30’24” N, 110°26’30” W), MN, from 1050, 1500, 850, 1150 m depth (TD, 2285, 1650, 2392, 1595 m depth), November 10-12, 2005 (UD; ICML-EMU-13854). 1 F, TALUD X, St. 23 (27º00'58" N, 110º12'23" W), MN, from surface to 1250 m depth (TD, 1770 m), February 14, 2007 (UD; ICML-EMU-13844-A). 1 F, TALUD XI, St. 6A (16º58'00" N, 100º57'00" W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (UD; ICML-EMU-13844-B). 2 F, TALUD XII, St. 15C (17º27'51" N, 102º10'43" W), St. 28B (18º56'00" N, 104º59'57" W), MN, from surface to 1530, 1450 m depth (TD, 1880, 1425 m), March 31-April 2, 2008 (UD; ICML-EMU-13855).

Female. Length measured from head anterior margin to posterior margin of Cr: 5.10 mm. General appearance of the cuticle vary from slightly opaque to translucid (Fig. 36). Prosome with globular shape, wide and short; cephalosome and thorax about of the same length. Ur with 2 free somites + asm, Gs longer than Ur. Cr about as long as Ur1 + Ur2. A1 21-segmented; extends beyond the posterior margin of caudal setae; segments 12-24 particularly long. A2 with both rami well-developed, about equal in length, with 3 distal setae in Enp7. Md relatively large, with well-developed gb, curved inwards and 8 teeth; small spinules between sixth and seventh teeth and on the anterior margin of the third tooth (Fig. 37A). Mx1 well-developed, with setules on the inner margin of the Exp (Fig. 37B). Mx2 with 3 large coxal endites, Enp relatively short, about of ¼ of the length of the basis. Mp coxa and basis almost as wide as long; 5-segmented Enp, slightly longer than the basis. P1-P4 with both rami 3-segmented; Exp1 and 2 with 1 outer spine in P1-P4, P1 with 1 outer and 2 apical spines on Exp3 (Fig. 37C), P2-P4 with 2 outer and 2 apical spines at Exp3. P5 with 1-segmented Enp and 2-segmented Exp; Exp1 with 1 outer spine, Exp2 with 2 outer and 2 apical spines (Fig. 37D).

Male. Not collected.

Remarks.

This was the second most frequent deepwater species collected during this survey, and it was found both in the CGC and the MPT in more than 30% of the samples. All specimens were females.

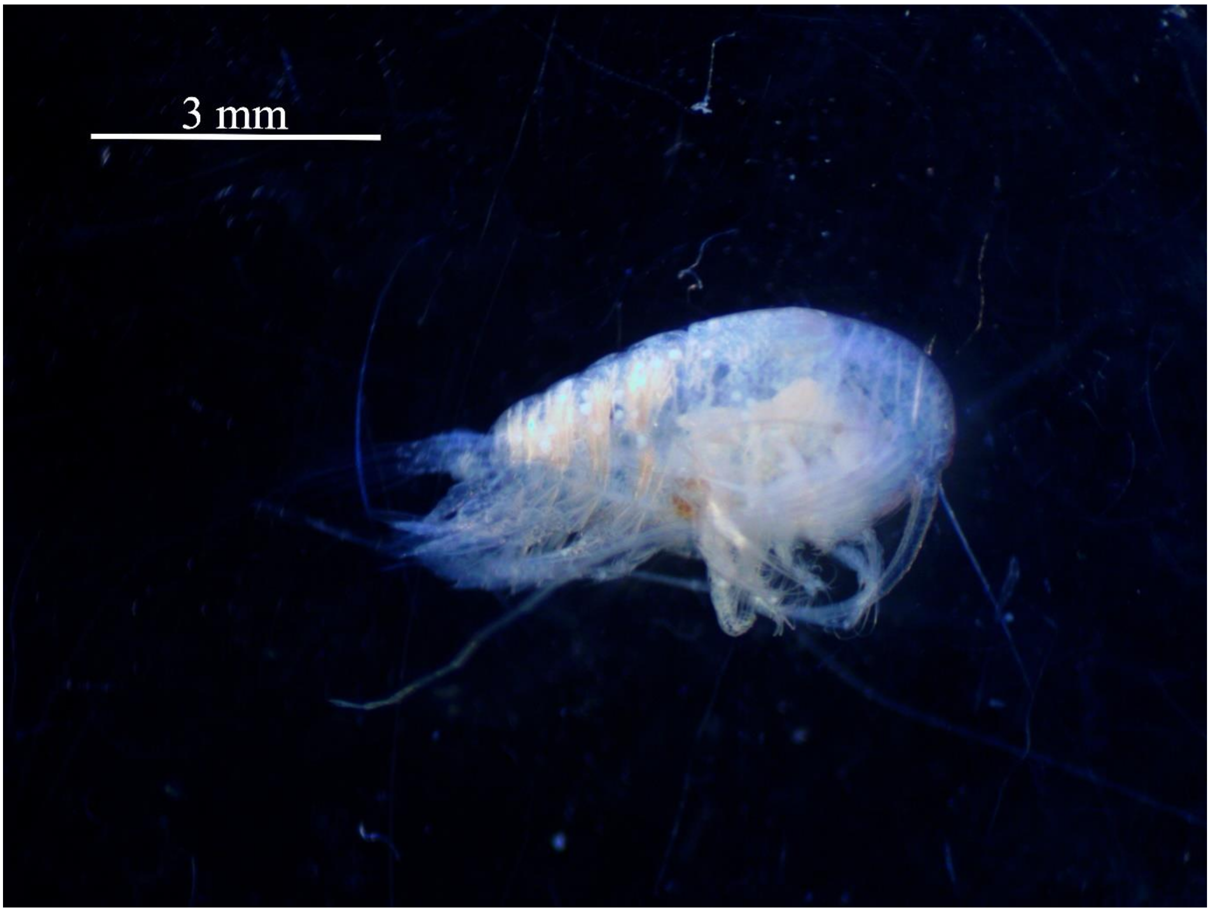

Figure 36. *Pseudhaloptilus pacificus* (Johnson, 1936). Habitus of female, lateral view.

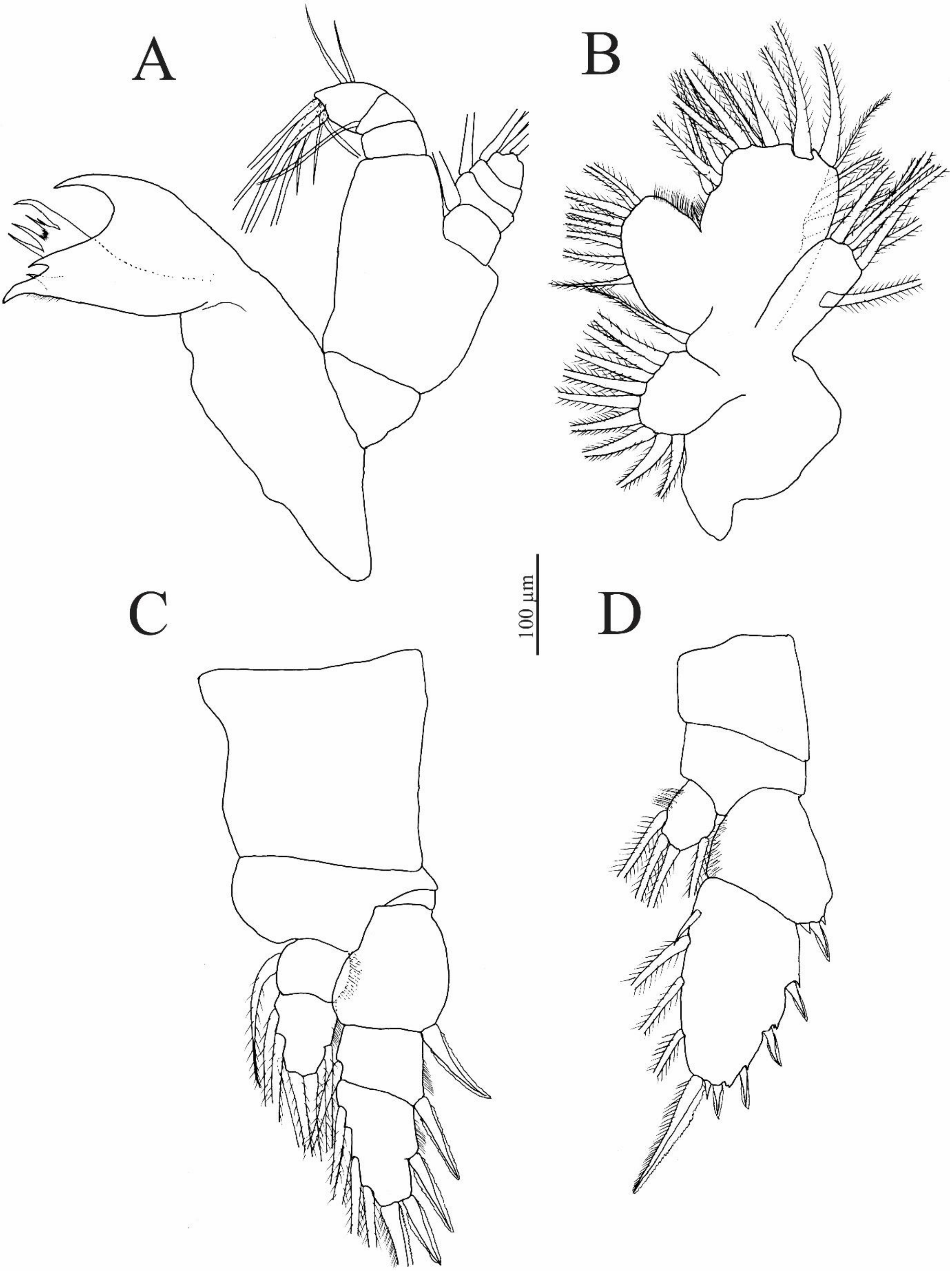

Figure 37. *Pseudhaloptilus pacificus* (Johnson, 1936). Female (ICML-EMU-13841). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

Family Candaciidae Giesbrecht, 1893

Genus *Candacia* Dana, 1846

***Candacia elongata* (Boeck, 1872)** (Figures 38-39)

Synonymized names. *Candace elongata* Boeck, 1872 (PS); *Candacia inermis* Cleve, 1904; *Candacia rotunda* Wolfenden, 1904; *Candacia obtusa* Sars G.O., 1905.

Material examined. 1 F, TALUD IV, St. 36 (25°51'59'' N, 110°10'59'' W), MM, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (SPS; ICML-EMU-13845).

Female. Length measured from head anterior margin to posterior margin of Cr: 3.47 mm. General appearance of the cuticle translucid, slender body: all the appendages look long in proportion to the body (Fig. 38). Prosome straight in ventral margin and curved in dorsal margin, cephalosome about as long as thorax. Ur with 1 free somite + asm; asm 1.2 times as long as Cr; Gs as long as Ur1 + asm length. A1 with 26 segments, that extends up to the posterior margin of Th5. A2 relatively large, Enp reduced, represented by 1 single free segment; segments 1-6 fused. Md palp larger than gb; gb presents a simple teeth disposition, with only 1 tooth on an inner cuticular projection and 1 outer cuticular projection; inner projection with small spinules over its margin (Fig. 39A). Mx1 with a large coxal endite and fused Enp-Exp; coxal endite with 1 large and 2 smaller distal setae (Fig. 39B). Mx2 with a large coxa, a basis of about a half of the length of the coxa and a reduced Enp with 3 large and 2 small setae. Mp relatively small compared to other appendages, with a small 5 segmented Enp of about the same length of the basis (Fig. 39C). P1-P4 with 3 segmented Exp and 2 segmented Enp; Exp of the P1 with 1 outer spine on the Exp1 and Exp, the Exp3 with 1 outer and 2 apical spines; P2-P4 with 3 outer and 1 apical spine: apical spines of P1-P4 are relatively thick and covered by a quitinous membrane. P5 modified, with only 1 exopodal rami at both legs, symmetrical; Exp1 with 1 small outer seta; Exp2 with 3 outer spiniform processes and 2 apical spines: the inner apical spine is about 0.7 times as long as the Exp2, while the outer apical spine is slightly larger than the lateral processes (Fig. 39D).

Male. Not collected.

Remarks. *C. elongata* has been previously recorded near the Galapagos islands. Our material represents the first record in the Mexican Pacific.

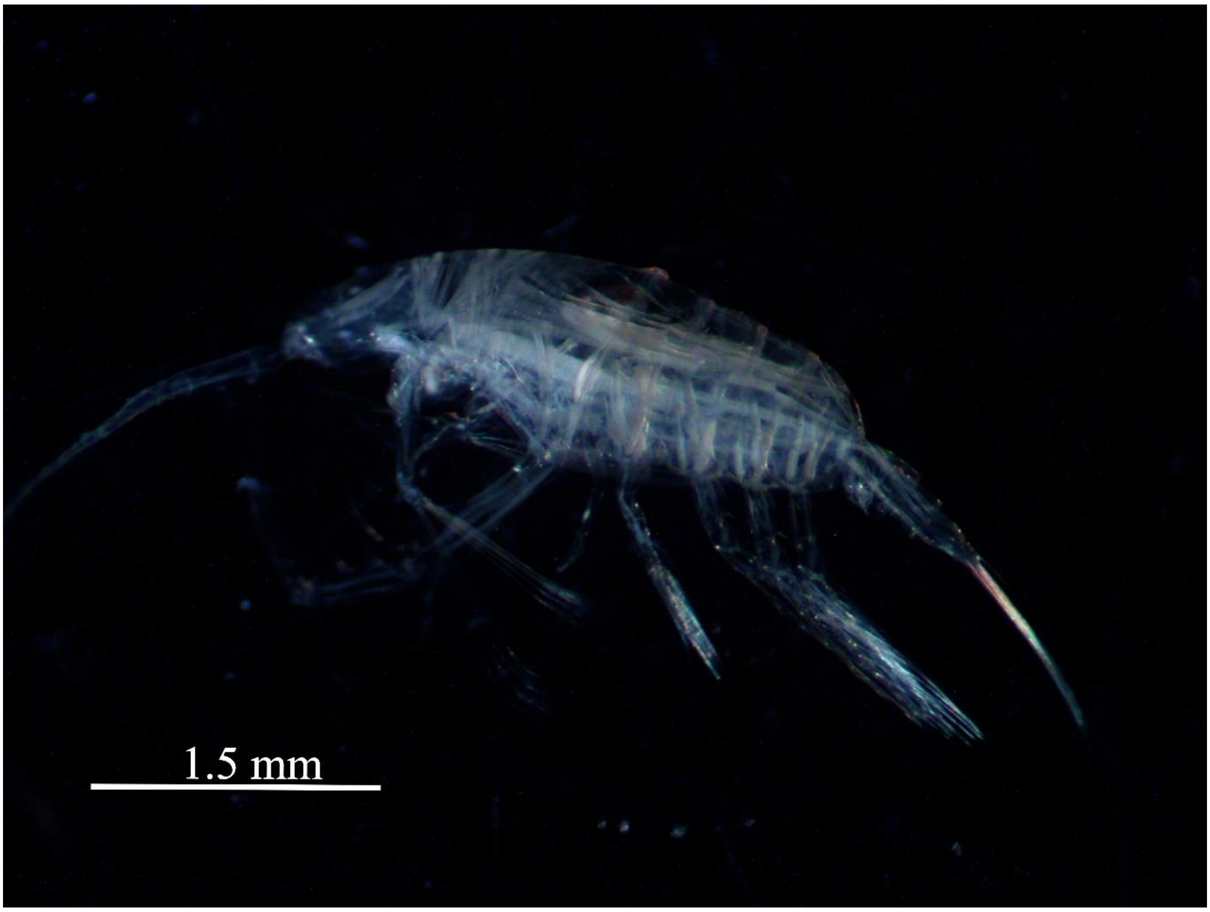

Figure 38. *Candacia elongata* (Boeck, 1872). Habitus of female, lateral view.

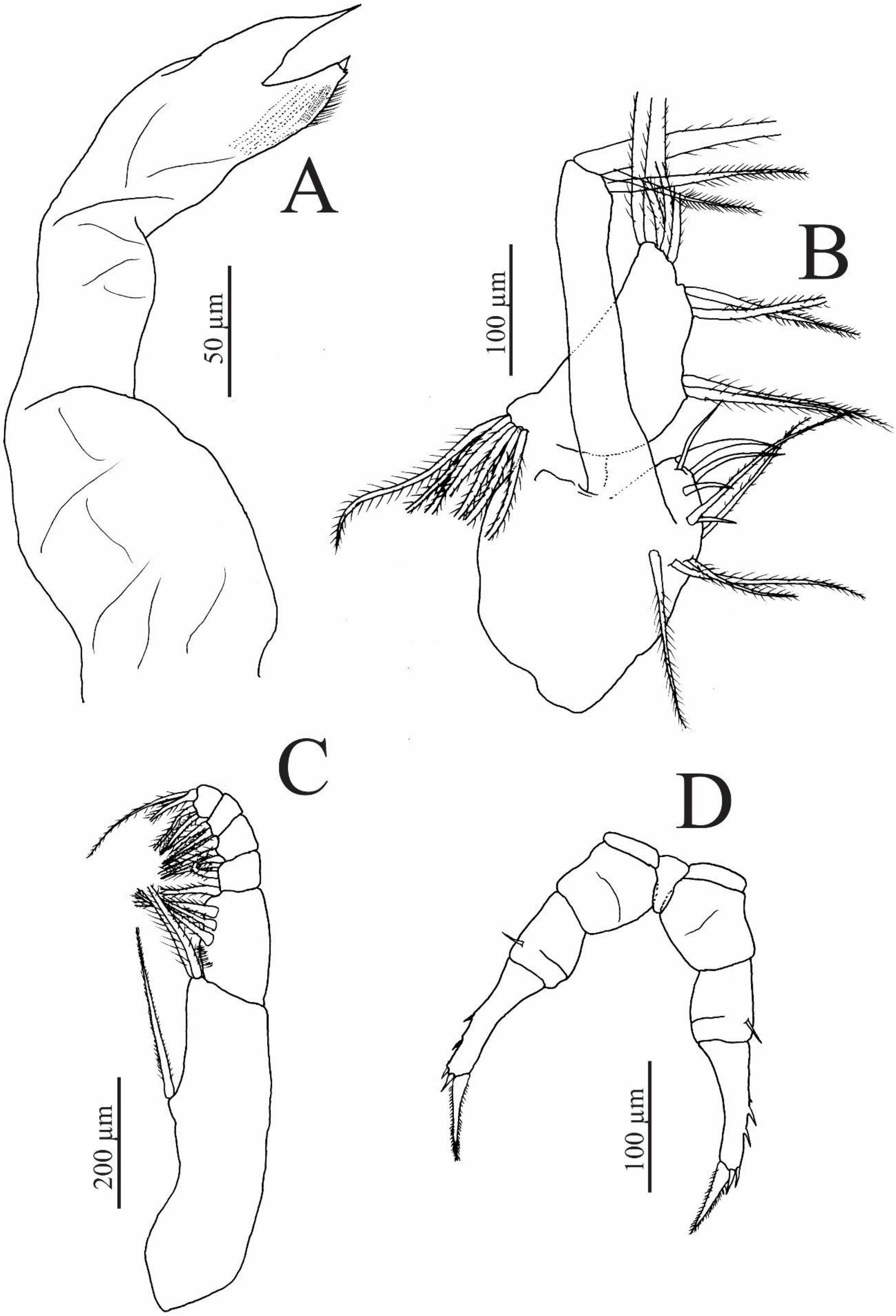

Figure 39. *Candacia elongata* (Boeck, 1872). Female (ICML-EMU-13845). (A) Details of mandibular gnathobase, (B) maxillule, (C) right maxilliped, external view, (D) fifth pair of legs, anterior view.

Family Bathypontiidae Brodsky, 1950

Genus *Temorites* Sars G.O., 1900

***Temorites elongata* (Sars G.O., 1905)** (Figures 40-41)

Synonimized names. *Bathypontia elongata* Sars G.O., 1905 (PS); *Bathypontia major* (Wolfenden, 1906); *Isocalanus major* (Wolfenden, 1911).

Material examined. 1 F, TALUD IX, St. 23 (26°03’69’’ N, 110°24’45’’ W), MN, from surface to 1450 m depth (TD, 2318 m), November 14, 2005 (SPS; ICML-EMU-13846).

Female. Length measured from head anterior margin to posterior margin of Cr: 3.65 mm. General appearance of the cuticle opaque. Prosome with about the same width along all its length; Th1 and cephalosome not fused, Th4 and Th5 not fused (Fig. 40). Ur with 2 free somites + asm: Gs slightly longer than Ur; asm and Cr relatively short, about as long as wide. A1 with 23 segments, that reaches the posterior margin of Th5. A2 with both rami of equal size; Exp3-Exp6 fused. Md strong, with dense musculature, with 9 teeth on the distal margin of the gb and two setae on the outer margin, accompanied in their base by strong and straight setules (Fig. 41A). Mx1 Enp and Exp fused: Enp curved inwards, with the shape of a hook (Fig. 41B). Mx2 robust, the coxa is about as long as wide; basis and Enp fused. Mp with 1 basal and 1 anterior mid seta, also with 3 anterior distal setae: one larger than the other two. P1 with Exp 3-segmented and Enp 1-segmented, with no anterior or posterior ornamentation; 1 outer and 2 apical spines on Exp3 (Fig. 41C). P2-P4 with both rami 3-segmented, subequal in length; one outer spine on Exp1 and Exp2, 2 outer and 2 apical spines on Exp3. P5 modified, both legs unirrameous and with two segments; right leg with 1 outer spine, inserted at the same level as Exp2; left Exp2 with no outer spine; Exp2 of both legs ornamented with a row of spinules all over its inner/anterior margins. External margin of apical spines of all legs serrated (Fig. 41D).

Male. Not collected.

Remarks. *Temorites elongata* distribution in the eastern Pacific includes the Galapagos and Chile. This is the first record of this species for the Mexican Pacific.

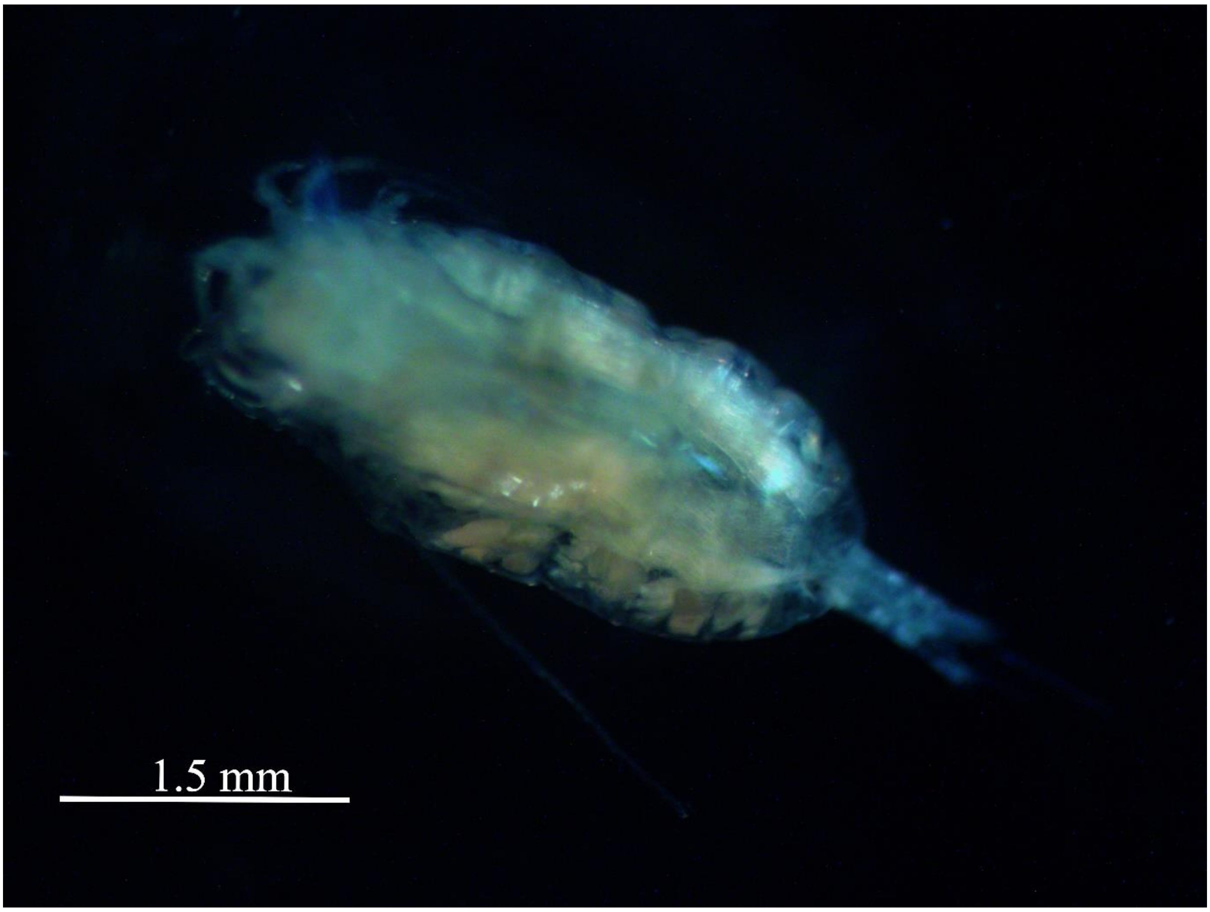

Figure 40. *Temorites elongata* (Sars G.O., 1905). Habitus of female, dorsal view.

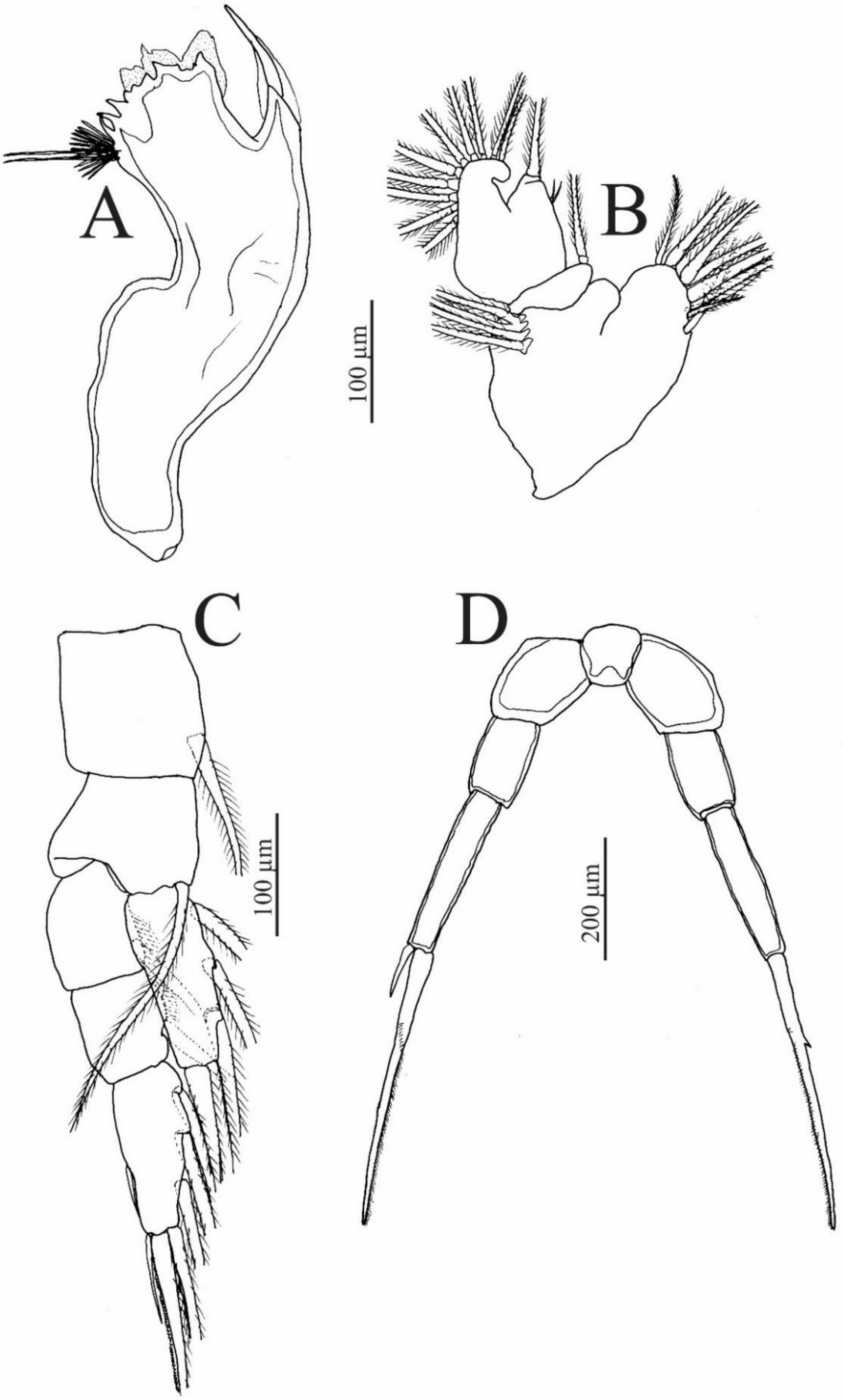

Figure 41. *Temorites elongata* (Sars G.O., 1905). Female (ICML-EMU-13846). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

Family Heterorhabdidae Sars G.O., 1902

Genus *Disseta* Giesbrecht, 1889

***Disseta palumbii* Giesbrecht, 1889** (Figures 42-43)

Synonymized names. *Disseta palumboi* Giesbrecht, 1889 (PS); *Heterorhabdus grandis* Wolfenden, 1904; *Disseta grandis* Esterly, 1906; *Disseta atlantica* Wolfenden, 1911.

Material examined. 1 F, TALUD IX, St. 36 (25°51’59’’ N, 110°10’59’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (SPS; ICML-EMU-13847).

Male. Length measured from head anterior margin to posterior margin of Cr: 6.86 mm. General appearance of the cuticle slightly opaque, slender (Fig. 42). Prosome elongated, constricted behind the head; Th1 and cephalosome not fused, Th4 and Th5 not fused. Ur relatively large, with 3 free somites + asm: Gs shorter than Ur. Cr and asm partially fused. A1 with 21 segments, geniculated between segments 17 and 18, that extends beyond the posterior margin of Cr. A2 with an Enp much larger than Exp; 2 and 7-segmented, respectively. Md with gb and palp about the same size; gb strong, with 4 large teeth and 5 smaller teeth, with spinules over the smaller teeth in external view (Fig. 43A); Md palp with spinules on first and second Enp segments (Fig. 43B). Mx1 well-developed, with a row of setules over the inner margin of Exp and 6 rows of spinules over the external margin of Enp2; pcx arthrite with various rows of spinules over its external margin (Fig.43C). Mx2 with subequal endites on pcx, coxa and basis; Enp reduced. Mp with well-developed Enp and large basis, basis with 5 rows of strong spinules over the external margin. P1-P4 with both rami 3-segmented and 1 outer spine on Exp1 and Exp2. P1 with 1 outer and 2 apical spines on Exp3, P2 and P3 with 2 outer and 2 apical spines. P4 with a more oval shape, with 1 outer and 2 apical spines: outer apical spine reduced; inner apical spines of P1-P4 ornamented with a hyaline membrane. P5 modified, with 3-segmented Exp and 2-segmented Enp; right basis with a thumb-shaped projection, with setules over the inner margin; inner margin of left coxa with setules; lateral margins of Enp1 of both legs with setules. Exp1 of both legs with 1 outer spine; right Exp2 with 1 large spine and left Exp2 with 1 spine and 1 spiniform projection at the same level: right Exp3 with 1 apical claw and 1 lateral smaller spine; left Exp3 with 1 large apical claw and 1 lateral spine (Fig. 43D).

Female. Not collected.

Remarks. *Disseta palumbii* is distributed from California to Chile, but the material examined represents a first record for the Mexican Pacific.

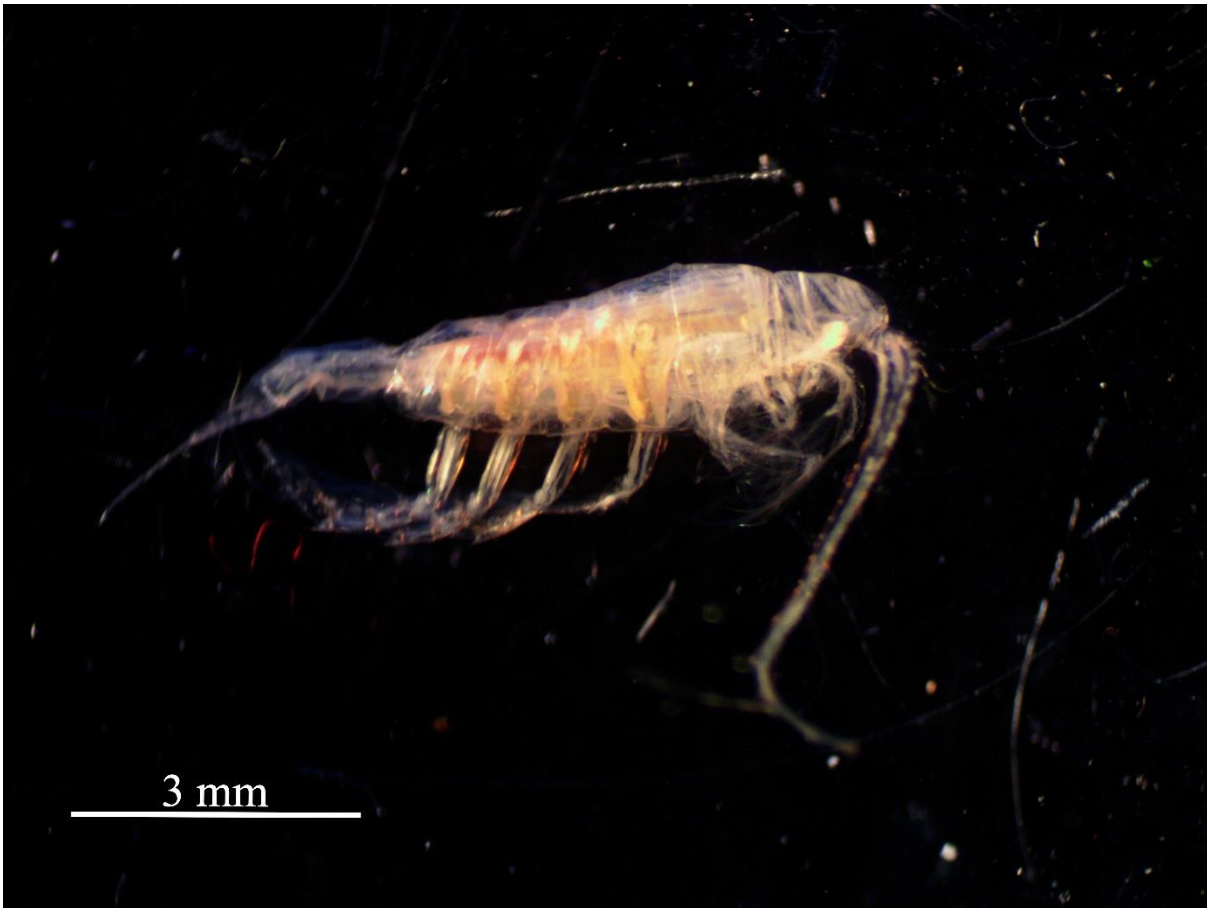

Figure 42. *Disseta palumbii* Giesbrecht, 1889. Habitus of male, lateral view.

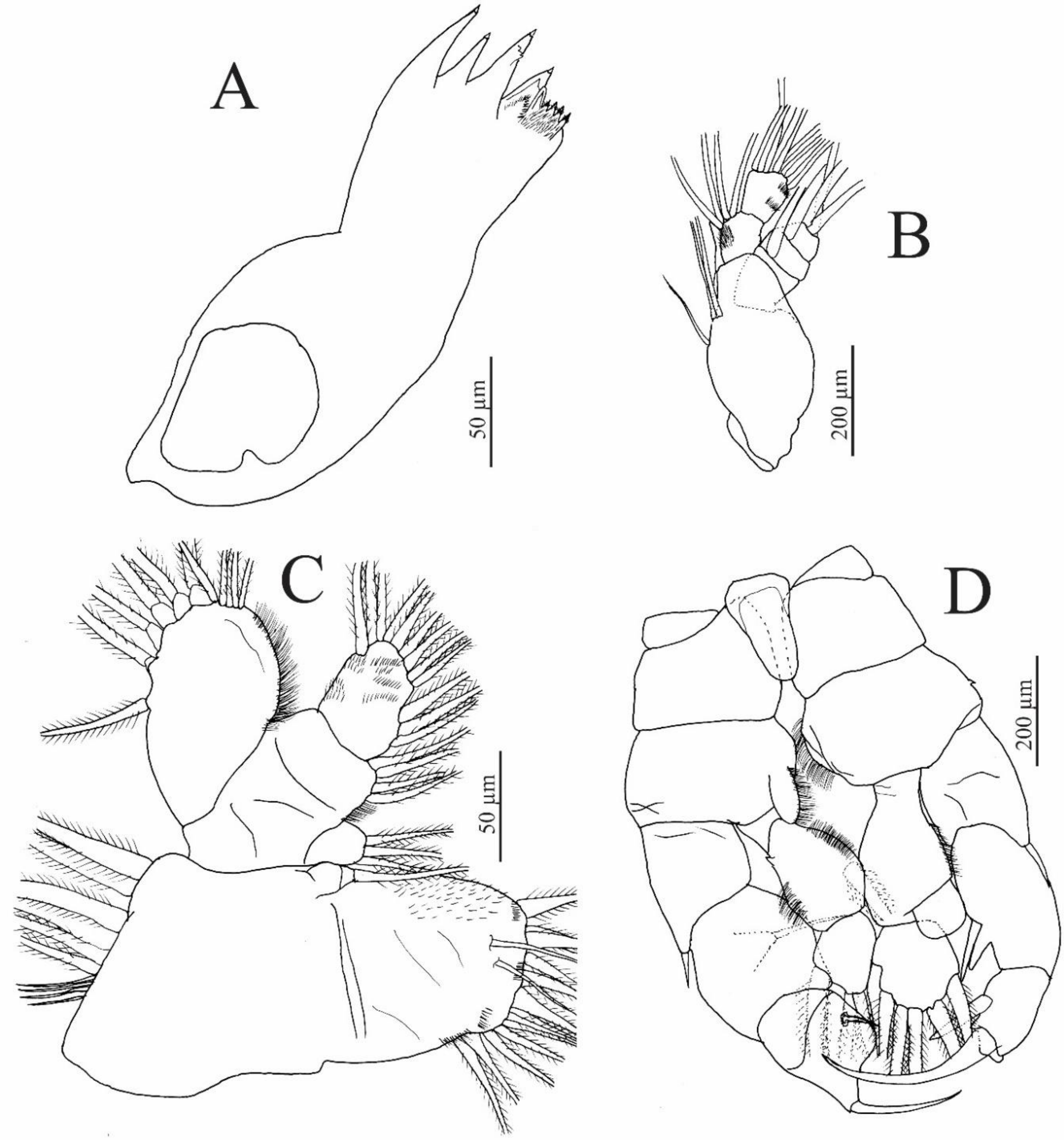

Figure 43. *Disseta palumbii* Giesbrecht, 1889. Male (ICML-EMU-13847). (A) Details of mandibular gnathobase in external view, (B) mandibular palp, (C) maxillule, external view and (D) fifth pair of legs, anterior view.

***Disseta scopularis* (Brady, 1883)** (Figures 44-45)

Synonymized names. *Leuckartia scopularis* Brady, 1883 (PS); *Lucicutia scopularis* (Brady, 1883); *Disseta maxima* Esterly, 1911.

Material examined. One M, TALUD IV, St. 36 (25°51’59’’ N, 110°10’59’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (SPS; ICML-EMU-13848).

Male. Length measure from head anterior margin to posterior margin of Cr: 7.69 mm. General appearance of the cuticle opaque. Prosome elongated and relatively thin, constricted behind the head; Th1 and cephalosome not fused; Th4 and Th5 fused (Fig. 44). Ur relatively large, 0.4 times the length of the body, with 3 free somites + asm; Gs and Ur1, Ur2 and Ur3 of subequal length; asm slightly shorter. Cr relatively long, of about the same length than Ur. A1 with 21 segments, right A1 geniculated between segments 17-18. A2 with both rami well developed, Exp slightly shorter. Md with larger palp than gb; gb with 7 teeth and 1 large external seta of about the same length as external tooth (Fig. 45A); Enp1 with setules on exterior margin and Enp3 two rows of spinules on exterior margin (Fig. 45B). Mx1 well developed, with 2-segmented Enp; Exp with 1 row of setules over its distal anterior margin (Fig. 45C). Mx2 with large Enp1, anteriorly projected. Mp with large Enp, with about the same length than basis. P1 with both rami 3-segmented: outer spines of Exp1 (1), Exp2 (1) and Exp3 (2) relatively large, about as long as Exp segments; apical spine of Exp3 without ornamentation. P2-P4 with both rami trisegmented: outer spines are not particularly large. P5 modified, with 1 large process on the inner margin of right coxa, ornamented on its margin with setules; left coxa ornamented with setules on its inner margin. Right Exp2 with 3 claw-like spines and 1 row of setules on inner margin; left Exp3 elongated, claw-shaped on distal margin and with 3 claw-like spines on inner margin (Fig. 45D).

Female. Not collected.

Remarks. In the eastern Pacific, *Disseta scopularis* is distributed from Vancouver Island to Chile, but it’s a first record for the Mexican Pacific.

Figure 44. *Disseta scopularis* (Brady, 1883). Habitus of male, lateral view.

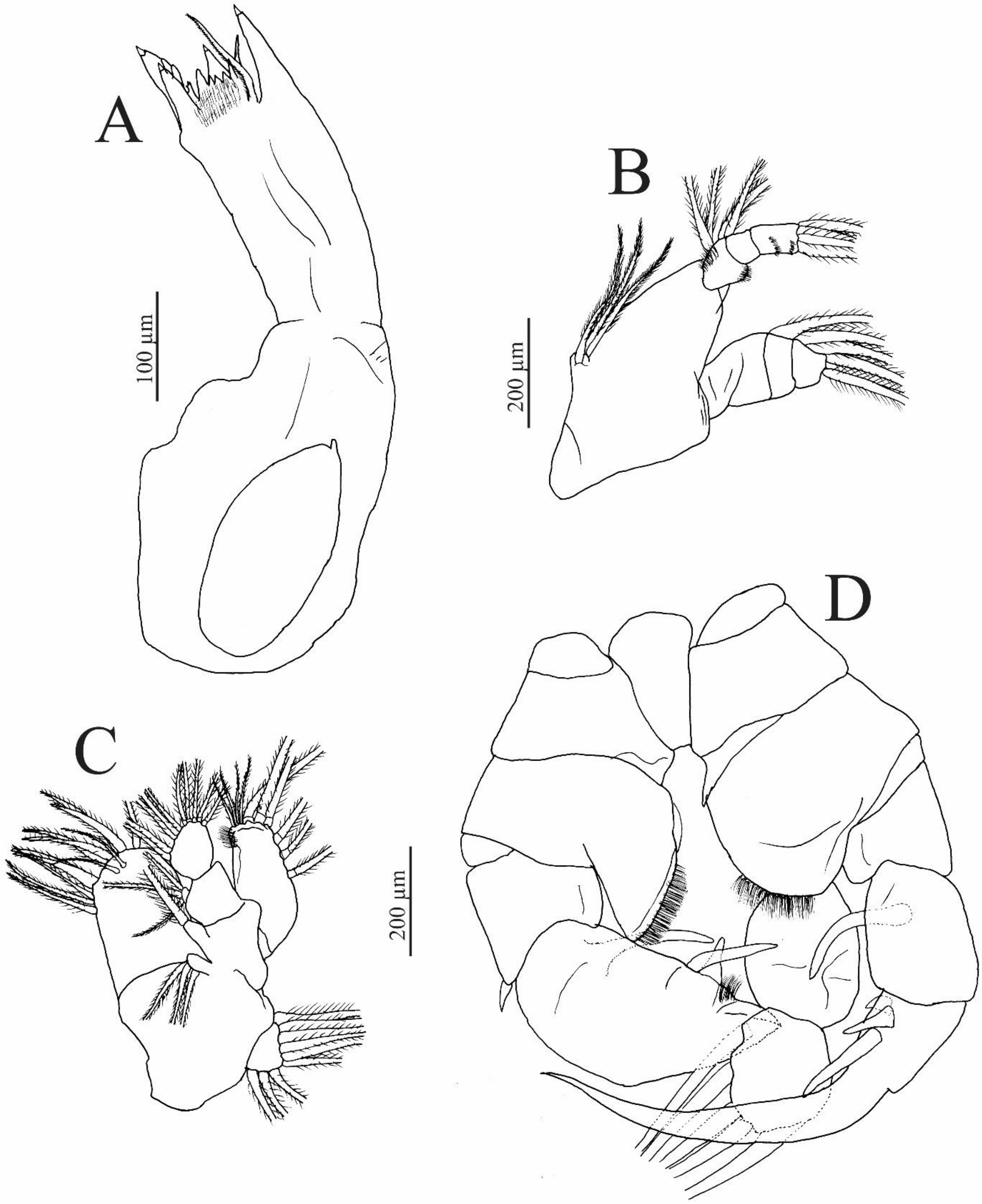

Figure 45. *Disseta scopularis* (Brady, 1883). Male (ICML-EMU-13848). (A) Details of mandibular gnathobase, (B) mandibular palp, (C) maxillule, (D) fifth pair of legs, anterior view (D).

Genus *Heterostylites* Sars G.O., 1920

***Heterostylites major* (Dahl F., 1894)** (Figures 46-47)

Synonymized names. *Heterochaeta major* Dahl F., 1894 (PS); *Heterorhabdus major* (Dahl F., 1894); *Heterochaeta zetesios* Wolfenden, 1902; *Heterorhabdus zetesios* (Wolfenden, 1902).

Material examined. 1 M, TALUD IX, St. 23 (23°03’59’’ N, 110°24’45’’ W), MN, from surface to 1450 m depth (TD, 2318 m), November 14, 2005 (SPS; ICML-EMU-13849).

Male. Length measured from head anterior margin to posterior margin of Cr: 3.83 mm. General appearance of the cuticle slightly opaque, elongated body (Fig. 46). Prosome elongated, relatively thin, constricted behind the head; Th1 and cephalosome not fused; Th4 and Th5 not fused. Ur relatively large, with 3 free somites + asm; Gs and somites of Ur about the same length; asm relatively long, 1.1 times the length of the Cr. Right A1 with 22 segments: segments 18-21 particularly long; geniculation between segments 17-18 (Figure 47A). A2 with both rami well developed, 2-segmented Enp, 7 segmented Exp. Md with well-developed palp, larger than gb; distal margin of gb with 2 inner, acute teeth and 2 outer, cuspidated teet; outer seta well developed (Fig. 47B). Mx1 with large Enp that bears 5 distal setae; Exp short, with 5 distal setae; pcx arthrite relatively elongated (Fig. 47C). Mx2 with straight margins, with a large Enp1 that bears 1 thick projection, larger than Enp1 projection, and two smaller setae. Mp relatively long and slender, with a large Enp, about as long as basis. P1 with both rami 3-segmented; 1 outer spine on Exp1 and Exp2; 1 lateral and 2 apical spines on Exp3. P2-P5 with both rami 3-segmented, with 2 outer and two apical spines on Exp3; outer spines of Exp of P4 less sharpened; apical spines of Exp3 of P1-P4 with hyaline membrane on outer margin, serrated. P5 modified, with large projections on inner distal margins of right and left basis, ornamented with setules; 1 outer spine at distal margin of right basis and another at distal margin of left Exp1; right Exp3 with 1 distal claw and 1 inner seta, left Exp3 with 1 large distal claw and 2 smaller claw-like spines (Fig. 47D).

Female. Not collected.

Remarks. In the eastern Pacific, *Heterostylites major* is distributed from Alaska to Chile, but the material examined represents the first record in the Mexican Pacific.

Figure 46. *Heterostylites major* (Dahl, 1894). Habitus of male, lateral view.

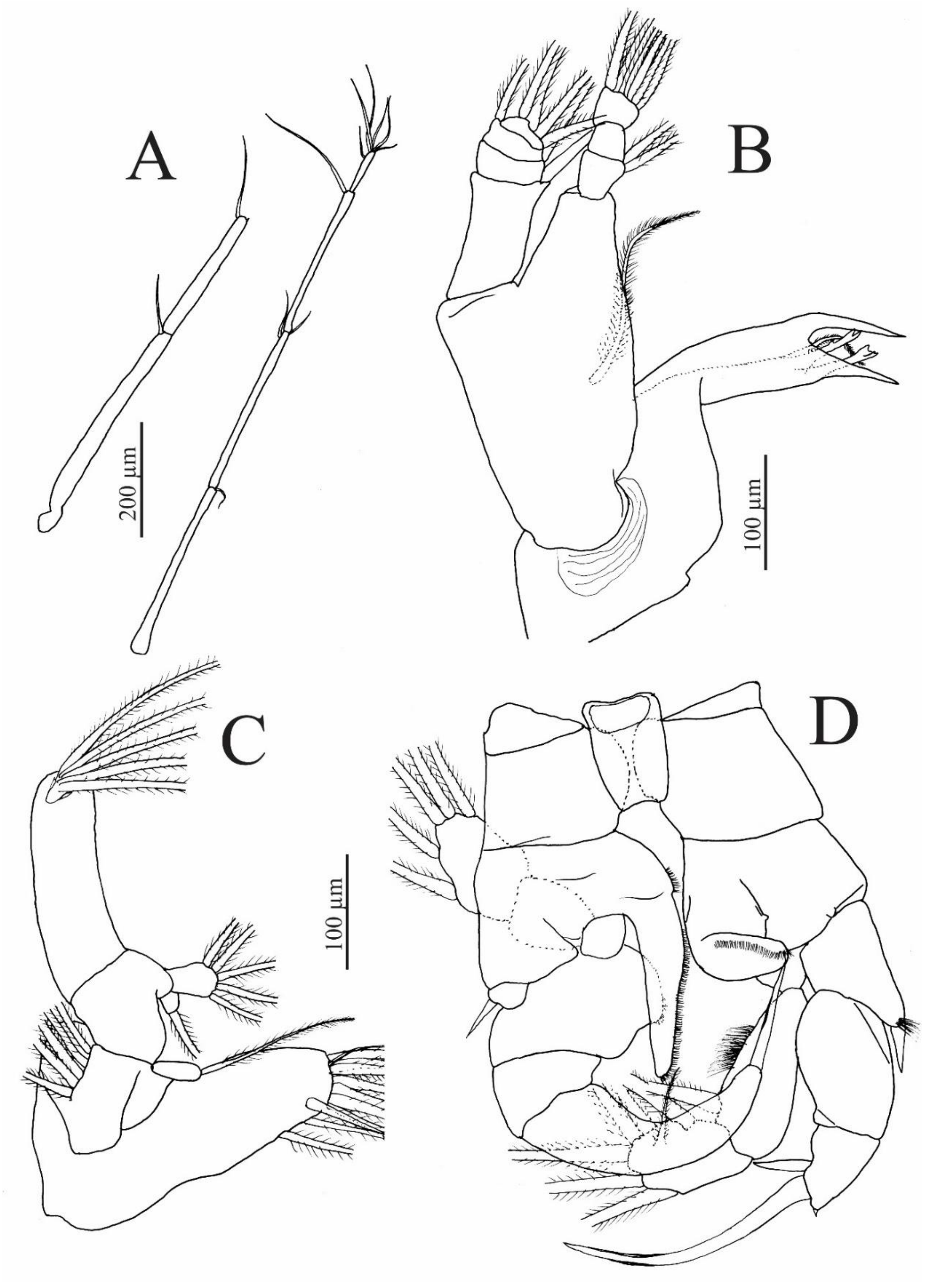

Figure 47. *Heterostylites major* (Dahl, 1894). Male (ICML-EMU-13849). (A) Details of last 6 right antennular segments, (B) mandible, (C) maxillule, (D) fifth pair of legs, anterior view.

Genus *Mesorhabdus* Sars G.O., 1905

***Mesorhabdus angustus* Sars G.O., 1907** (Figures 48-49)

Material examined. 1 F, TALUD X, St. 11 (27°34’16’’ N, 111°40’30’’ W), MN, from surface to 1220 m depth (TD, 1800 m), February 10, 2007 (SPS; ICML-EMU-13850).

Male. Length from head anterior margin to posterior margin of Cr: 7.77 mm. General appearance of the cuticle opaque, robust body (Fig. 48). Prosome with Th1 and cephalosome not fused, strong constriction behind the head; Th4 and Th5 partially fused. Ur relatively large, with 3 free somites + asm; Gs and Ur somites about of the same length; Cr about 1.2 times the length of asm. Left A1 with 25 segments, right A1 with 21 segments: geniculation between segments 17-18. A2 with both rami well developed, Enp and Exp of 2 and 7 segments, respectively. Md with large and robust palp; gb with 6 teeth: third teeth larger and cuspidated; outer seta relatively large with spinules near its base and on last 2 teeth base (Fig. 49A). Mx1 well developed, with 1 strong seta on the distal margin of pcx arthrite, larger than segment; 2-segmented Enp and a relatively large Exp, much larger than Enp + basis + ied size (Fig. 49B). Mx2 robust and relatively short: coxa and basis fused; anterior setae of Enp1 and Enp2 massively developed, about 0.8 times the length of the whole appendage. Mp elongated: basis and Enp with similar lengths (Fig. 49C). P1 with both rami 3-segmented, with one inner hook-like process on basis; apical spine of Exp3 almost as long as Exp length. P2 with a large, curved outer spine on Exp1, outer spines of P2 are larger than those of other pairs of legs. P3-P4 with 2 outer and 2 apical spines on Exp3. P5 modified, with a large, ornamented process on the right inner distal margin of basis; outer spines at right and left basis; 2 hook-like processes on right inner margin of Exp2, 1 large, straight distal claw and 1 small seta on right Exp3; left Exp2 with 1 claw-like process, left Exp3 with 1 large distal claw and 2 smaller spines on the inner margin (Fig. 49D).

Female. Not collected.

Remarks. *Mesorhabdus angustus* has been previously recorded in California and Central America, but the material examined represents a first record for the Mexican Pacific.

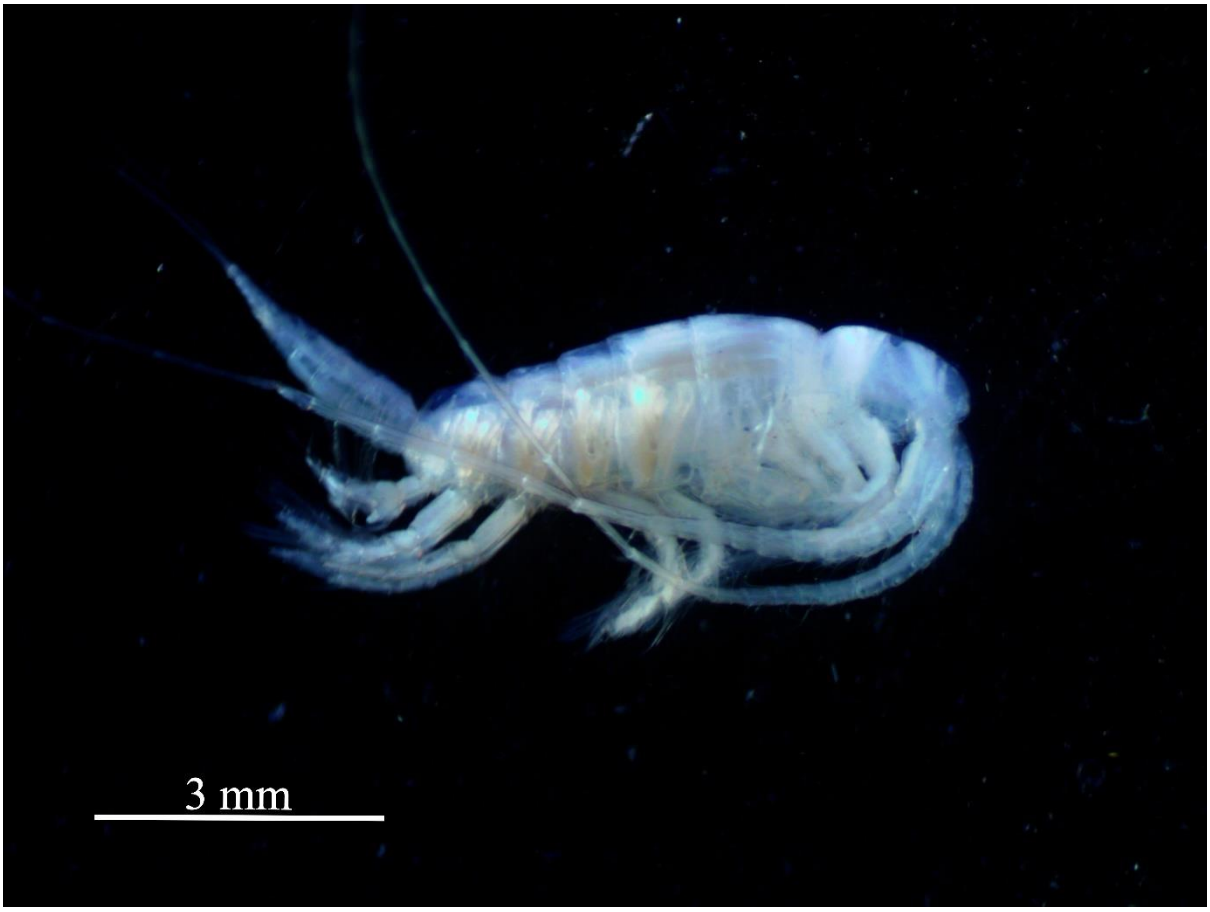

Figure 48. *Mesorhabdus angustus* Sars G.O., 1907. Habitus of male, lateral view.

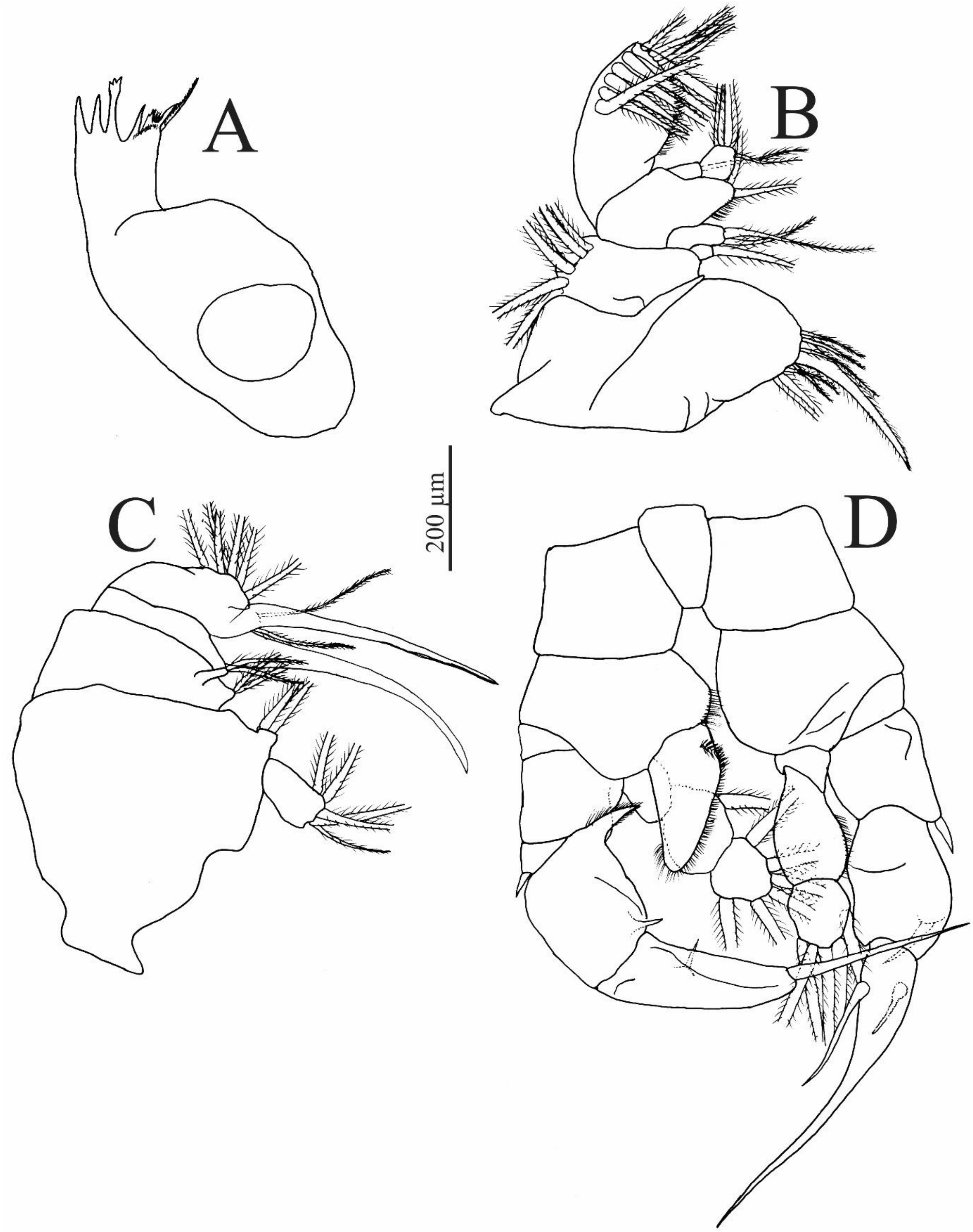

Figure 49. *Mesorhabdus angustus* Sars G.O., 1907. Male (ICML-EMU-13850). (A) Details of mandibular gnathobase, (B) maxillule, (C) maxilla, (D) fifth pair of legs, anterior view.

Genus *Paraheterorhabdus* Brodsky, 1950

***Paraheterorhabdus compactus* (Sars G.O., 1900)** (Figures 50-51)

Synonymized names. *Heterochaeta compacta* Sars G.O., 1900 (PS); *Heterorhabdus compactus* (Sars G.O., 1900).

Material examined. 1 F, TALUD X, St. 20 (27°14’41’’ N, 111°33’15’’ W), MN, from surface to 1250 m depth (TD, 1785), February 13, 2007 (SPS; ICML-EMU-13851). 1 F, TALUD IV, St. 36, (25°51'59'' N, 110°11'00'' W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (UD; ICML-EMU-13852-A). 1 F, TALUD VIII, St. 18 (25º50'00'' N, 110º34'00'' W), MN, from surface to 690 m depth (TD, 1300 m), April 19, 2005 (UD; ICML-EMU-xxxxx).1 F, TALUD VIII, St. 23 (26º03'42'' N, 110º23'54'' W), MN, from surface to 2200 m depth (TD, 2200 m), April 19, 2005 (UD; ICML-EMU-13852-C). 1 F, TALUD IX, St. 7A (25°11'30'' N, 109°41'06'' W), MN, from surface to 1510 m depth (TD, 2377 m), November 15, 2005 (UD; ICML-EMU-13853-A). 1 F, TALUD X, St. 20 (27°14'41'' N, 111°36'15'' W), MN, from surface to 1250 m depth (TD, 1785 m), February 13, 2007 (UD; ICML-EMU-13853-B). 1 F, TALUD XI, St. 6A (16°58'00'' N, 100°57'00''W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (UD; ICML-EMU-13853-C). 1 F, TALUD XII, St. 28B (18°56'00'' N, 104°59'57'' W), MN, from surface to 1450 m depth (TD, 1450 m), April 2, 2008 (UD; ICML-EMU-13853-D).

Female. Length measured from head anterior margin to posterior margin of Cr: 3.03 mm. General appearance of the cuticle slightly opaque, compact body (Fig. 50). Prosome relatively short, less than twice as long as wide; Th1 and cephalosome not fused. Ur with 3 free somites + asm; Gs as long as somites of Ur; Cr about 1.2 times as long as asm. A1 with 24 segments, that surpass the posterior margin of Th5; segment 24 particularly short, 0.3 times the length of segment 23. Distal setae of A2 basis strong, 0.8 times as long as Enp1; both rami well-developed. Md gb with one large inner tooth and three smaller, acute and ornamented outer teeth, similar in length to outer seta; inner tooth presents an additional claw-shaped projection (Fig. 51A). Mx1 with reduced Enp and large Exp, ie with a large seta, of similar length than pcx setae (Fig. 51B). Mx2 with well-developed coxa and relatively short basis, both segments present 1 patch of setules, with hairy appearance; Exp1 projected in the insertion of the largest seta, with 1 row of spinules in basal position (Fig. 51C). Mp with three setae in the distal third, 1 stronger, spine-like shaped. P1 with both rami 3-segmented; with 1 strong, acute and long spine at Exp1 and Exp2, 3 at Exp3: apical spine as long as Exp3; Exp1 with 1 inner row of setules. P2-P4 with both rami 3-segmented, with 1 outer spine on segments Exp1 and Exp2; 3 outer and 1 apical spine on Exp3: apical spines are not longer than 0.3 times the length of Exp, but the spine on P3 is particularly small. P5 with 1 outer spine at Exp1 and Exp2, with 2 outer and 1 apical spine at Exp3, apical spine is almost as long as Exp3; 1 strong inner spine on Exp2, longer than Exp3 (Fig. 51D).

Male. Not collected.

Remarks. *Paraheterorhabdus compactus* was one of the most frequently collected species during this survey, but it was never abundant (1 or 2 specimens per sample).

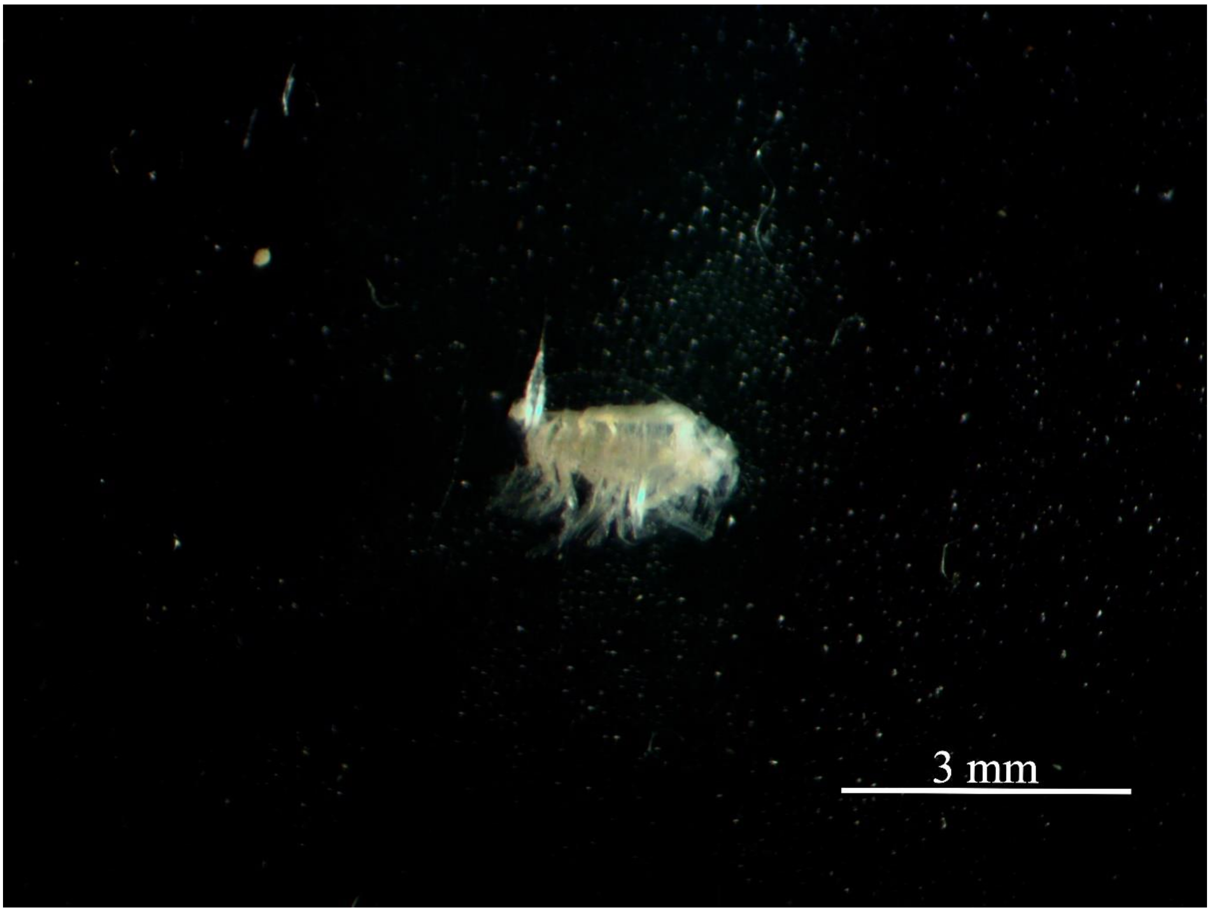

Figure 50. *Paraheterorhabdus compactus* (Sars G.O., 1900). Habitus of female, lateral view.

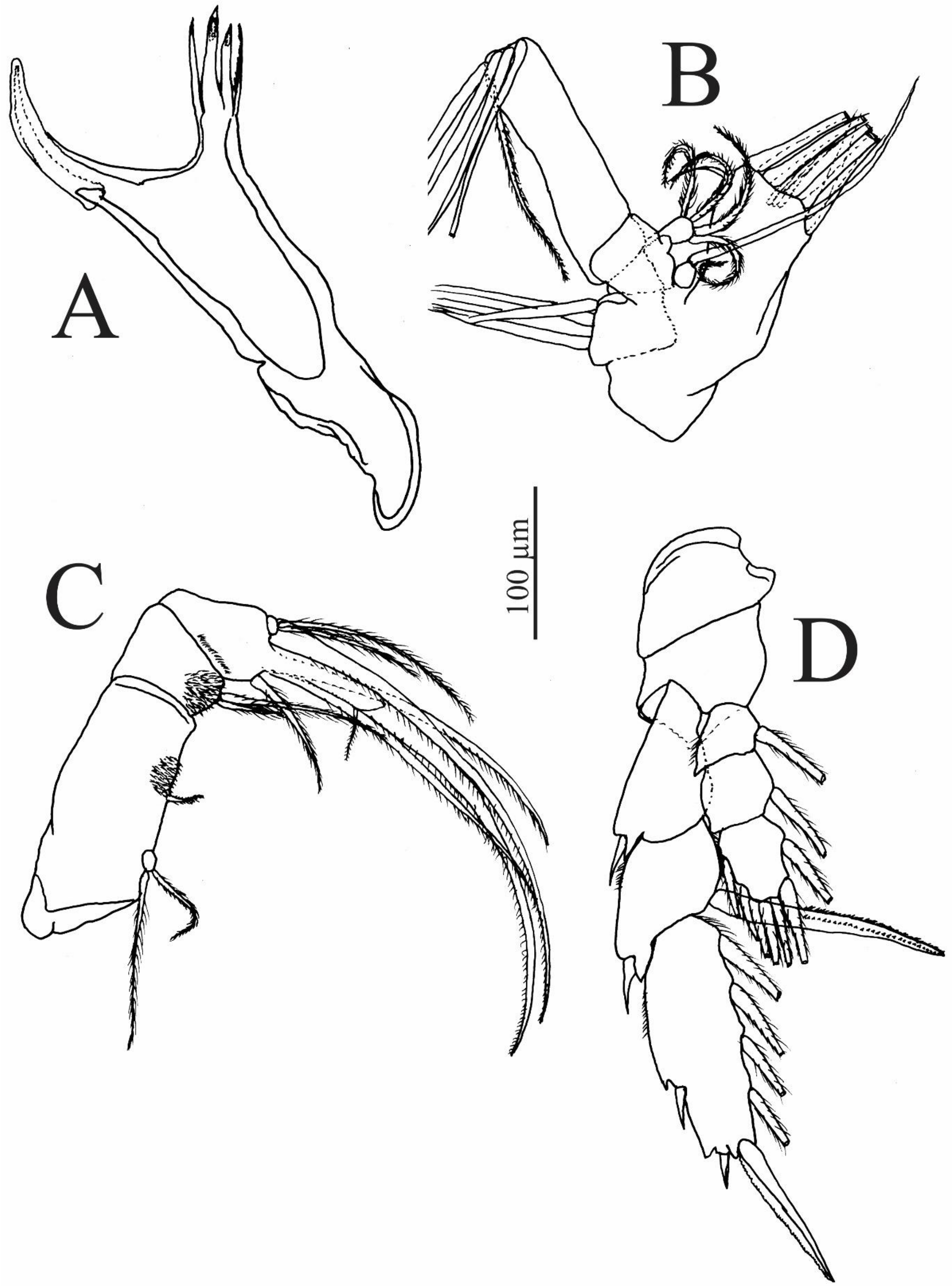

Figure 51. *Paraheterorhabdus compactus* (Sars G.O., 1900). Female (ICML-EMU-13851). Detail of mandibular gnathobase, (B) maxillule, (C) maxilla, inner view, (D) right fifth leg, anterior view.

***Lucicutia hulsemannae* Markhaseva and Ferrari, 2005** (Figures 52-53)

Material examined. 1 M, TALUD XI, St. 6A (17°12’28’’ N, 100°50’15’’ W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (SPS; ICML-EMU-13856). 10 F, TALUD IV, St. 7 (22°00'22" N, 106°49'18" W), St. 22 (24°17'20" N, 108°50'30" W), St. 29 (24°57'48" N, 109°37'00" W), St. 36 (25°51'59" N, 110°11'00" W), MN, from surface to 500, 1325, 1280, 1000 m depth (TD, 1970, 1325, 1280, 2100 m), August 23-27, 2000 (UD; ICML-EMU-13858). 10 F, TALUD V, St. 15 (23°21'30" N, 107°48'12" W), St. 29 (25°14'36" N, 109°24'15" W), St. 36 (25°54'30" N, 110°11'24" W), MN, from surface to 1350, 1390, 1340 m depth (2384, 2040, 1990 m), December 14-17, 2000 (UD; ICML-EMU-13859). 10 F, TALUD VI, St. 7 (22°21'39" N, 107°01'42" W), St. 15 (23°14'42" N, 107°30'00" W), St. 22 (24º17'26" N, 108º50'05" W), St. 36 (25°53'15" N, 110°10'08" W), MN, from surface to 1305, 1230, ND, 1360 m depth (TD, 2100, 2390, ND, 2000 m), March 14-17, 2001 (UD; ICML-EMU-13860). 10 F, TALUD VII, St. 15B (23°25'19" N, 107°46'25" W), St. 22 (24°31'34" N, 108°55'10" W), St. 29 (25°17'32" N, 109°24'30" W), St. 36 (25°42'37" N, 110°04'35" W), MN, from surface to 1425, 1415, 1335, 1390 m depth (TD, 2320, 2000, 2080, 2400 m), June 7-9, 2001 (UD; ICML-EMU-13861). 10 F, TALUD VIII, St. 12 (25º02'00" N, 110º27'00" W), St. 13 (25º21'00" N, 110º17'00" W), St. 23 (26º03'42" N, 110º23'54" W), MN, from surface to 1150, 1625, 2200 m depth (TD, 1280, 2100, 2200 m), April 17-19, 2005 (UD; ICML-EMU-13862). 10 F, TALUD IX, St. 1 (24º37'54" N, 109º22'36" W), St. 6 (24º49'38" N, 109º47'58" W), St. 7A (25°11'30" N, 109°41'06" W), St. 7B (25°11'19" N, 109°42'45" W), St. 12 (25°30’24” N, 110°26’30” W), St. 18 (25°49'38" N, 110°34'45" W), St. 23 (26º03'59" 110º24'45"), MN, from surface to 1050, 1500, 1510, 850, 1657, 1150, ND, 1450 m depth (TD, 2285, 1650, 2377, 2392, 1657, 1595, ND, 2318 m), November 10-15, 2005 (UD; ICML-EMU-13863). 10 F, TALUD X, St. 7 (27°53'09" N, 112°16'42" W), St. 11 (27°34'16" N, 111°40'30" W), St. 20 (27°14'41" N, 111°36'15" W), St. 23 (27°00'30" N, 111°12'00" W), MN, from surface to 900, 1220, 1250, 1250 m depth (TD, 1191, 1800, 1785, 1770 m), February 10-14, 2007 (UD; ICML-EMU-13864). 10 F, TALUD XI, St. 6A (16°58'00" N, 100°57'00" W), St. 19B (17°56'00" N, 103°10'00" W), MN, from surface to 1400, 1490 m depth (TD, 1960, 1750 m), June 7-9, 2007 (UD; ICML-EMU-13865). 10 F, TALUD XII, St. 4 (16°59'39" N, 100°58'07" W), St. 15C (17°27'51" N, 102°10'43" W), St. 22 (18°11'27" N, 103°52'29" W), MN, from surface to 1200, 1530, 1340 m depth (TD, 1995, 1880, 2200 m), March 28-31, 2008 (UD; ICML-EMU-13866).

Male. Length measure from head anterior margin to posterior margin of Cr: 5.88 mm. General appearance of the cuticle opaque, robust body. Prosome with rounded head: lateral-ventral margins of the thoracic somites slightly proyected, oval shape (Fig. 52). Ur with 3 free somites + asm; Gs much smaller than Ur1, Ur1-Ur3 subequal in length; asm relatively short, 0.8 times the length of Ur3. Cr relatively large, about as long as Ur3 + asm length. A1 not particularly long, 25-segmented left A1 and 21-segmented right A1: geniculation between segments 17-18. A2 robust, with both rami well developed; Enp and Exp similar in length; Enp1 with rows of setules on the outer margin; Enp2 with rows of setules on the posterior and exterior margins (Fig. 53B). Md with palp and gb well developed, robust; 4 large and 6 smaller teeth: only teeth 3-5 are cuspidated; rows of small spinules on the outer margin, near the base of smaller teeth (Fig. 53A). Mx1 well developed, with large Exp, as long as Enp + basis length. Mx2 with well-developed ied; Enp1 ied large, projected; Enp reduced. Mp with 4 setae on the basis; Enp slightly larger than the basis; one row of spinules near the insertion of the distal setae of the coxa and one row of spinules near the insertion of the most-proximal seta on the basis (Fig. 53C). P1 with both rami 3-segmented; Exp1 and Exp2 with 1 outer spine, Exp3 with 2 outer and 1 apical spine, ornamented with setules on the inner margin and with a serrated membrane on the outer margin; basis presents a cilindrical projection with 1 distal small seta. P2-P4 with similar segmentation and armature as P1, except for Exp3 that presents 2 outer and 2 apical spines. P5 modified, with a large projection on the inner distal margin of right leg, ornamented with spiniform projections; both right and left Exp 3-segmented: right Enp is 3-segmented and left Enp is 2 segmented; right and left Exp1 and Exp2 with 1 outer seta each; right Exp3 with 2 lateral and 1 distal spine; left Exp3 with 2 distal and 1 lateral spine (Fig. 53D).

Female. Not collected.

Remarks. *Lucicutia hulsemannae* was the most frequent deep-water species during this survey, present in 67% of the samples. It is known for the Mexican Pacific, where it was described from samples collected near a submarine volcano (Markhaseva and Ferrari, 2005). There are not previous records from the Gulf of California. Morphological variation in the ornamentation of the male P5 coxa was observed; some specimens presented stronger spinules on the distal margin of these segments.

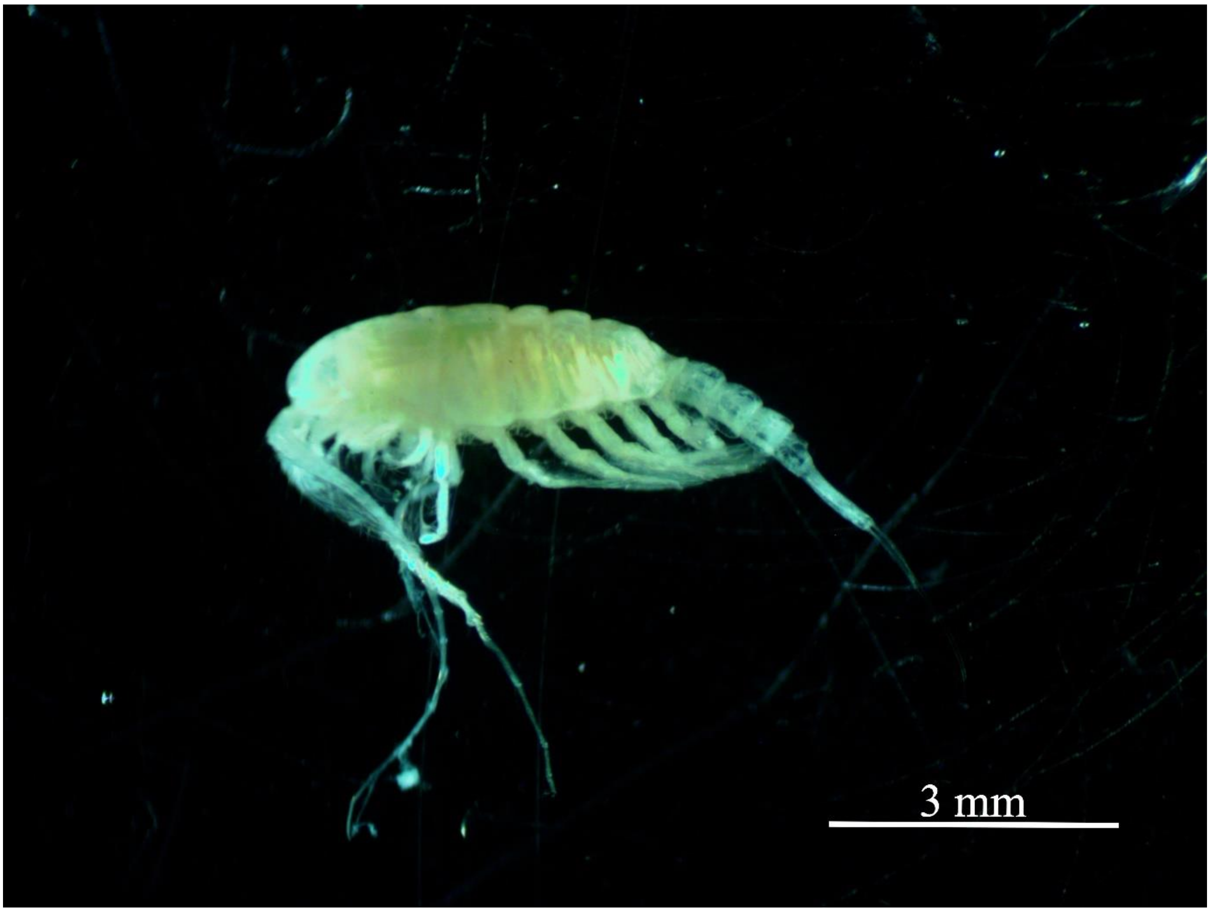

Figure 52. *Lucicutia hulsemannae* Markhaseva and Ferrari, 2005. Habitus of male, lateral view.

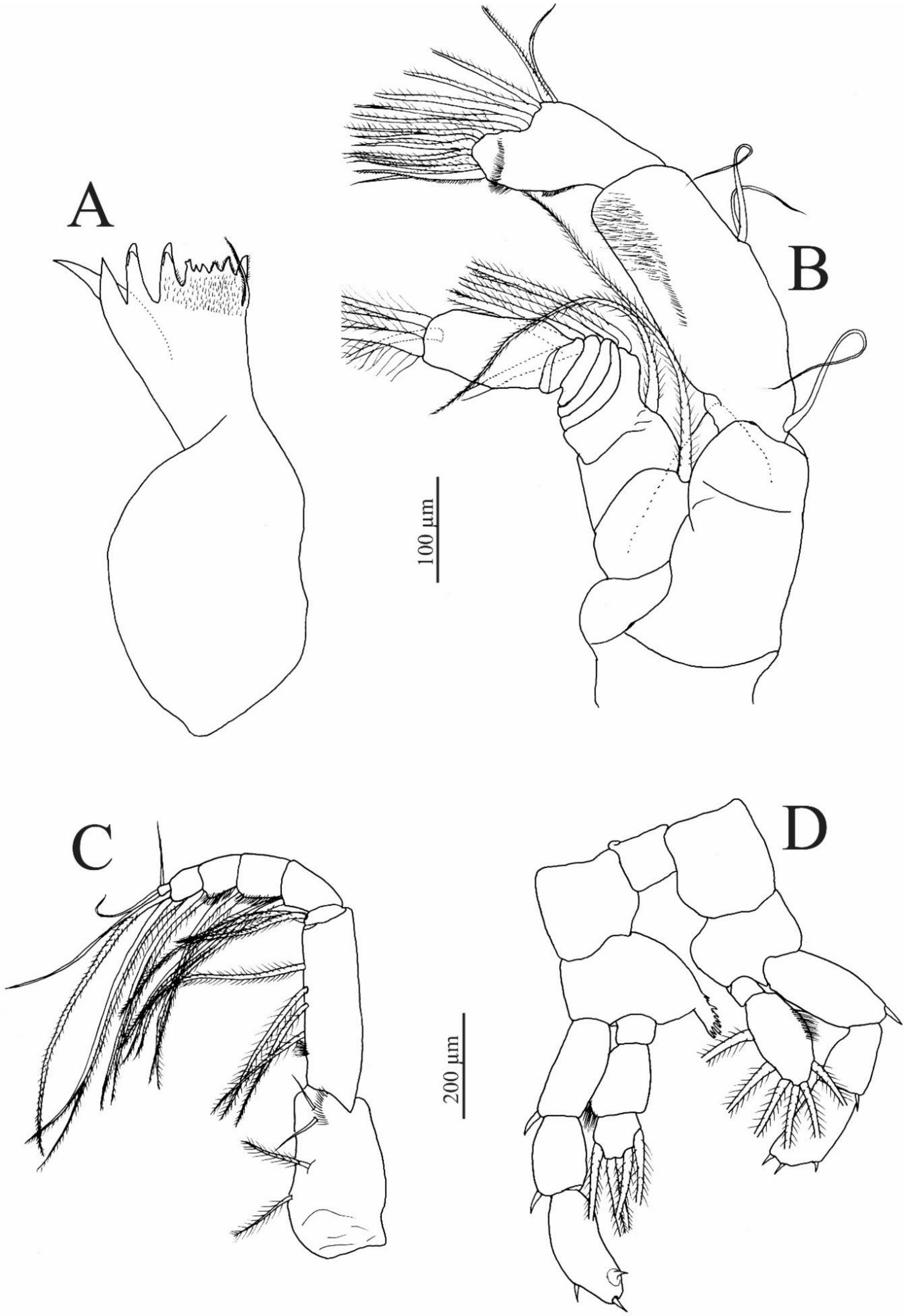

Figure 53. *Lucicutia hulsemannae* Marhaseva and Ferrari, 2005. Male (ICML-EMU-13856). (A) Details of mandibular gnathobase, (B) antenna, exterior view, (C) right maxilliped, external view, (D) fifth pair of legs, anterior view.

Family Megacalanidae Sewell, 1947

Genus *Megacalanus* Wolfenden, 1904

***Megacalanus frosti* Bradford-Grieve, Blanco-Bercial and Boxshall, 2017** (Figures 54-55)

Material examined. 1 F, TALUD IV, St. 36 (25°51’59’’ N, 110°11’00’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (SPS; ICML-EMU-13867-A). 1 F, TALUD VI, St. 15 (23°14’42’’ N, 107°30’00’’ W), MN, from surface to 1230 m depth (TD, 2390 m), March 14, 2001 (SPS; ICM-EMU-13867-B). 1 F, TALUD VII, St. 26 (25°42’37’’ N, 110°04’35’’ W), MN, from surface to 1500 m depth (TD, 1220 m), June 9, 2001 (SPS; ICM-EMU-13867-C).

Female. Length measured from head anterior margin to posterior margin of Cr: 10.48 mm. General appearance of the cuticle opaque, robust body. Prosome elongated, almost rectangular; narrow head, constricted behind A2 insertion: head anterior margin anteriorly projected; Th1 and cephalosome not fused; Th4 and Th5 not fused (Fig. 54). Ur relatively small, with 2 free somites + asm; Gs 2 times longer than Ur 1; Ur somites subequal in length. A1 relatively large, with 25 segments, almost twice as long as body. Cr as long as asm. A2 with both rami well developed, similar in size, with spinules over posterior margins of Enp1 and Exp2. Md strong, palp larger than gb; basis of palp with 4 setae on inner margin; gb with 5 large, queratinized teeth, 1 smaller cuspidated tooth, 1 small, elongated tooth and 1 outer seta: outer margin of gb bears strong spinules near the base of the outer teeth; spinules over inner margin of proximal section of gb, near palp insertion (Fig. 55A). Mx1 with tick Enp; ied1 with 4 setae. Mx2 with large basal endites, Enp1 large, with dell developed ied (Fig. 55B). Mp relatively large, with 3 setae in coxal endite 1, 4 setae in coxal endite 2 and 4 setae on coxal endite 3; basis slightly longer than coxa, with 9 anterior setae disposed in 3 groups. P1 with both rami 3-segmented; basis with a bifurcated claw-like projection on the inner distal margin of basis (Fig. 55C); Exp1 and Exp2 with 1 outer spine each, Exp3 with 1 outer and 2 apical spines: spines longer than their segments; outer spine of Exp3 curved; inner apical spine ornamented with small spinules over its margin. P2-P4 with 3 outer and 2 apical spines on Exp3, Exp1 and Exp2 with 1 outer spine; outer margin of proximal third of Exp3 and Exp2 of these legs ornamented with setules, resulting in plumose appearance; inner apical spine of these legs ornamented with dense setules on the outer margin and with regular setules on the inner margin. P5 not modified, with 2 segmented Enp and Exp; Exp1 with 1 outer spine, Exp2 with 2 outer and 2 apical spines, also with spiniform projections near the base of outer spines; ornamentation as described for P2-P4 (Fig. 55D).

Male. Not collected.

Remarks. *Megacalanus frosti* was described very recently (Bradford-Grieve et al. 2017), and is known to occur along most of the eastern Pacific. It has also been reported in the Arabian Sea (Razouls et al. 2024). This is a first record for the Mexican Pacific.

Figure 54. *Megacalanus frosti* Bradford-Grieve, Blanco-Bercial and Boxshall, 2017. Habitus of female, dorsal view.

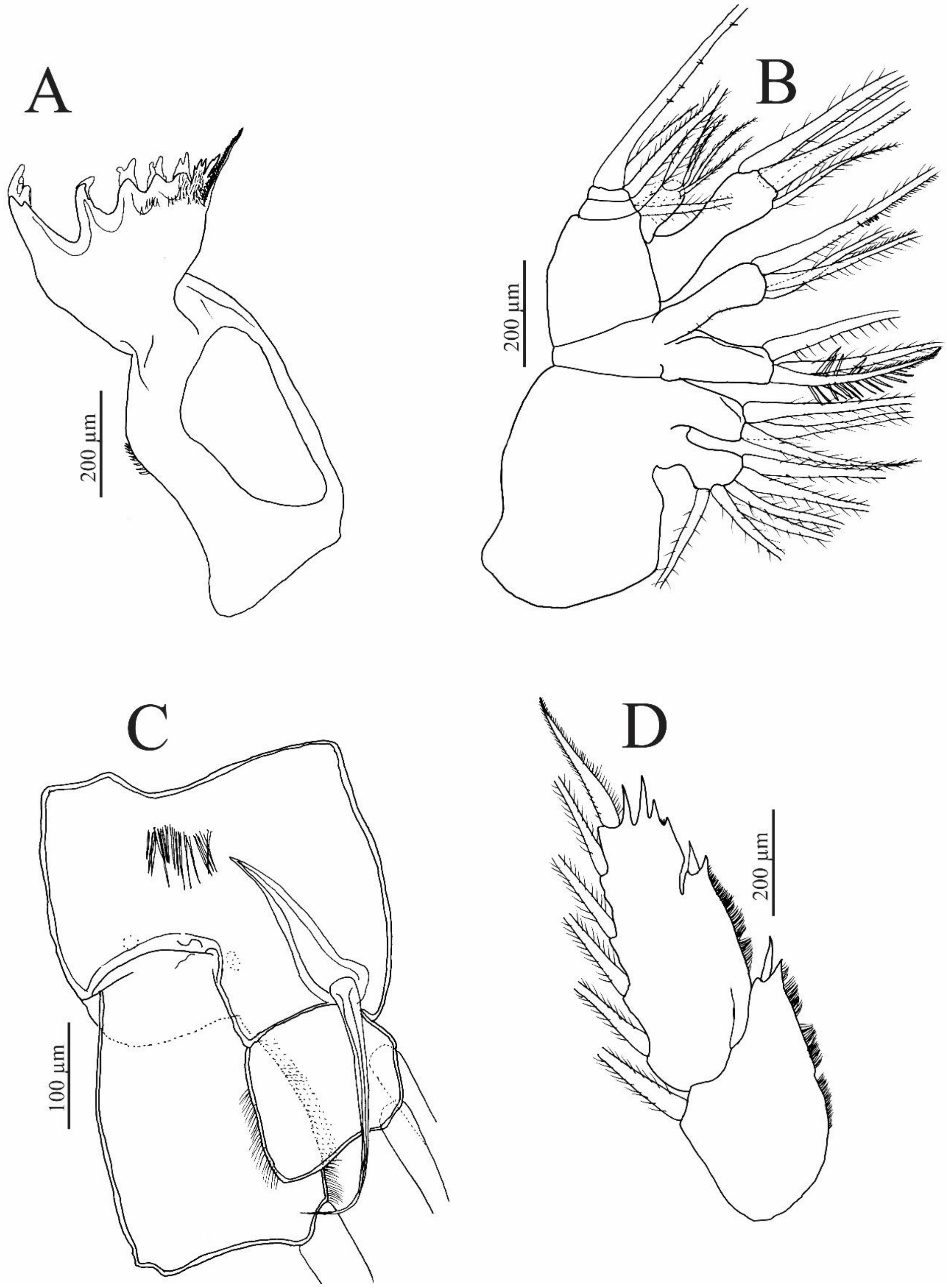

Figure 55. *Megacalanus frosti* Bradford-Grieve, Blanco-Bercial and Boxshall, 2017. Female (ICML-EMU-13867-A). (A) Details of mandibular gnathobase, (B) maxilla, (C) basis and first segments of right first leg, anterior view, (D) exopodites 2-3 of right fifth leg, anterior view.

Family Nullosetigeridae Soh, Ohtsuka, Imabayashi and Suh, 1999

Genus *Nullosetigera* Soh, Ohtsuka, Imabayashi and Suh, 1999

***Nullosetigera auctiseta* Soh, Ohtsuka, Imabayashi and Suh, 1999** (Figures 56-57)

Material examined. 1 F, TALUD IV, St. 36 (25°51’59’’ N, 110°11’00’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (SPS; ICML-EMU-13868-A). 1 M, TALUD X, St. 23 (27°00’30’’ N, 112°11’00’’ W), MN, from surface to 1250 m depth (TD, 1770 m), February 13, 2007 (SPS; ICML-EMU-13868-B).

Female. Length measured from head anterior margin to posterior margin of Cr: 2.95 mm. General appearance of the cuticle opaque, colorful appearance (Fig 56). Prosome wider behind the head; head anterior margin straight; Th1 and cephalosome not fused, Th4 and Th5 fused. Ur relatively small, with 2 free somites + asm; Gs as long as Ur1 + Ur2 length; Ur somites and asm subequal. Cr twice as long as asm. A1 with 24 segments, relatively short, extending up to Th2 posterior margin. A2 with both rami well developed, Exp slightly longer than Enp; Enp with 1 seta on coxa and 1 on basis. Md with strong gb, with 4 cuspidated teeth and 1 outer seta; 2 patches of short setules on the outer margin, located in the curve of the gb (Fig. 57A). Mx1 well developed, with an enlarged pcx arthrite, that represents the majority of the appendage volume, with 2 ied and a 1-segmented Enp, relatively small (Fig. 57B). Mx2 with 1 basal ied in coxa, projected as an independent segment with 4 setae; 2 setae in mid portion, with similar length, and 3 setae in distal portion: inner seta particularly larger. Mp with robust, subsquared coxa and long basis; 5 segmented Enp, relatively long, 0.8 times the basis length. P1 with 1 strong internal seta on coxal distal and one on basis outer margin; both rami 3-segmented, with 1 outer spine at Exp1 and Exp2; 2 outer and 1 apical spine on Exp3, ornamented with setules and spinules, respectively (Fig. 57C). P2-P4 with both rami 3-segmented, with 1 spine on segments Exp1 and Exp2 and 2 outer + 2 apical spines on Exp3; internal apical spines relatively large and thick, with a hyaline serrated membrane on outer margin. P5 modified, relatively small, both legs unirrameous and symmetrical; Exp1 with 1 robust outer spine, Exp2 with 1 inner seta and acute projections on outer margin, with one small projection on anterior margin. Exp3 with outer acute cuticular projections, 2 small anterior cuticular projections and 1 apical spine; Exp3 twice as long as Exp2 (Fig. 57D).

Male. Cephalic and swimming appendages as described in female. Right A1 with 20 segments, geniculated between segments 17-18, with large ae and modified seta at almost every segment. P5 with 1 large claw on ie; Enp only visible in right leg, with lamelliform shape; basis and Exp1 with 1 spine on the anterior margin; right Exp2 with 1 proximal internal acute projection and a claw at the distal end, forming a quela with a cuticular projection of the segment; left Exp 3 ornamented with setules all over its margin.

Remarks. *Nullosetigera auctiseta* has been recorded only in the Japan Sea (Soh et al. 1999). The material examined is the first record for the eastern Pacific and outside the Japan Sea. There were no morphological differences between the original description description (Soh et al. 1999) and the material examined. This species was relatively frequent, occurring in 8% of the samples, although it always presented low abundances (1 or 2 specimens per sample).

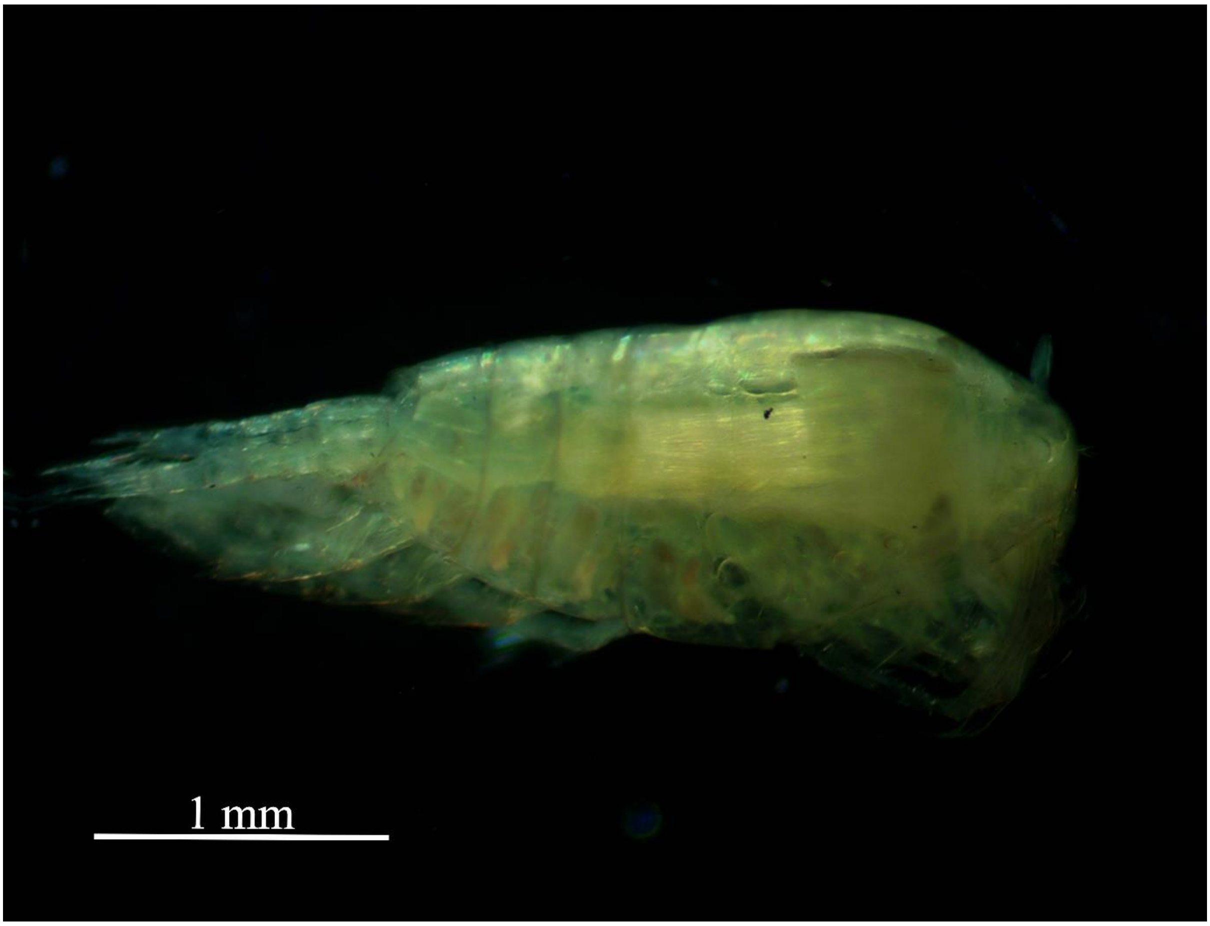

Figure 56. *Nullosetigera auctiseta* Soh, Ohtsuka, Imabayashi and Suh, 1999. Habitus of female, dorsal-lateral view.

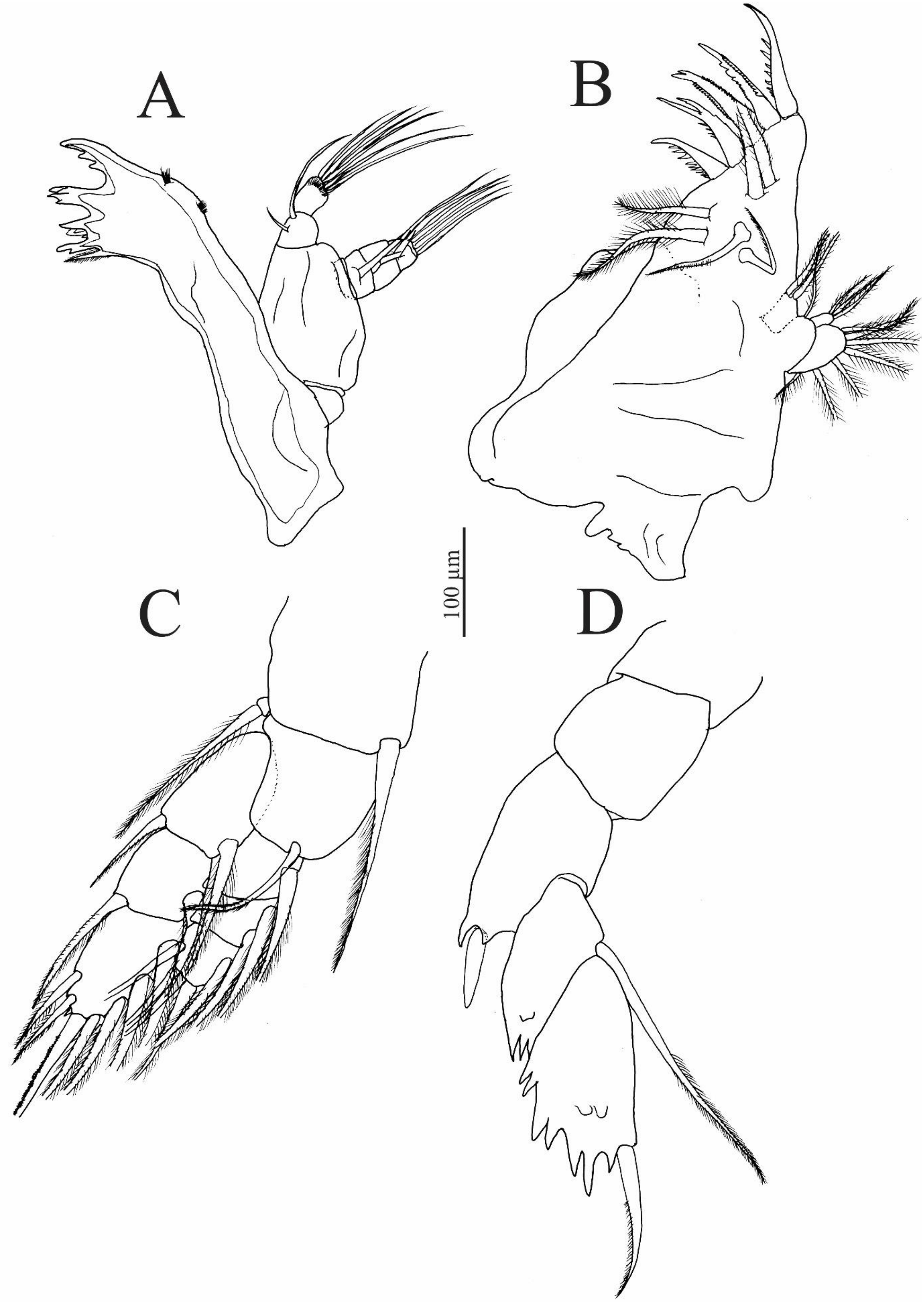

Figure 57. *Nullosetigera auctiseta* Soh, Ohtsuka, Imabayashi and Suh, 1999. Female (ICML-EMU-13868-A). (A) Details of mandible, internal view, (B) maxillule, internal view, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

***Nullosetigera mutica* (Sars G.O., 1907)** (Figures 58-59)

Synonymized names. *Phyllopus muticus* Sars G.O., 1907.

Material examined. 1 F and 1 M, TALUD XII, St. 15C (17°27’51’’ N, 102°10’43’’ W), MN, from surface to 1530 m depth (TD, 1880 m), February 11, 2007 (SPS; ICML-EMU-13869).

Female. Length from head anterior margin to posterior margin of Cr: 4.45 mm. General appearance of the cuticle slightly opaque. Prosome relatively long; head anterior margin straight; Th1 and cephalosome not fused; Th4 and Th5 fused (Fig. 58). Ur relatively large, with 2 free somites + asm; Gs two times as long as Ur1; Ur somites subequal in length. Cr as long as asm. A1 relatively short, extending up to posterior margins of Th2. A2 with both rami well developed, with similar lengths; Exp7 with long setules over posterior margin; setae of basis well developed, thick. Md well developed; gb with 3 cuspidated teeth and 1 straight, smaller tooth, with similar length than outer seta; inner margin of gb with 1 row of setules, below the innermost tooth (Fig. 59A). Mx1 with a well-developed, enlarged pcx arthrite, that comprises the majority of appendage volume; ied with a relatively thick-large seta and another one relatively smaller, both distal; 2-segmented Enp with 1 and 3 setae on Enp1 and Enp2, respectively; Exp with 6 setae (Fig. 59B). Mx2 with one basal internal projection thar bears 3 setae, 2 setae on mid-internal endite and 3 setae on distal-internal endite; robust basis and reduced Enp. Mp with 4 setae on coxa anterior margin; basis with 3 setae; Enp 0.6 times as long as basis. P1 with 1 inner seta on coxa, 1 outer seta on basis and 1 internal-distal seta on basis, near Enp insertion; both rami 3-segmented, 1 outer spine on Exp1 and Exp2; Exp with 1 outer and 2 apical spines; Enp with hairy appearance on anterior margin of Enp1 and Enp2, given by dense setules (Fig. 59C). P2-P4 with both rami 3-segmented; Exp1 and Exp2 with 1 outer spine; Exp3 with 2 outer and 2 apical spines; apical spines relatively large, ornamented with hyaline membranes, serrated on outer margins. P5 modified, both legs unirrameous; basis with 1 outer and 1 distal spine; Exp1 with 1 large spine and distal acute projections; Exp2 with large acute projections and 1 large inner seta; Exp3 with acute outer projections and 1 distal spine; Exp2 and Exp3 subequal in length (Fig. 59D).

Male. Length measured from head anterior margin to posterior margin of Cr: 4.15 mm. Cephalic and swimming appendages similar as described for female. P5 presents 1 large projection on ie, on left side; left Exp3 and right Exp2 massively engrossed; right Exp2 ending in a chela.

Remarks. *Nullosetigera mutica* has been reported as a tropical and subtropical species. The female and male were described from different regions of the world (Razouls et al. 2024). Our material includes specimens of both sexes collected in the same sampling area. In the eastern Pacific it has been recorded off the Easter Island and is now recorded for the first time from the Mexican Pacific.

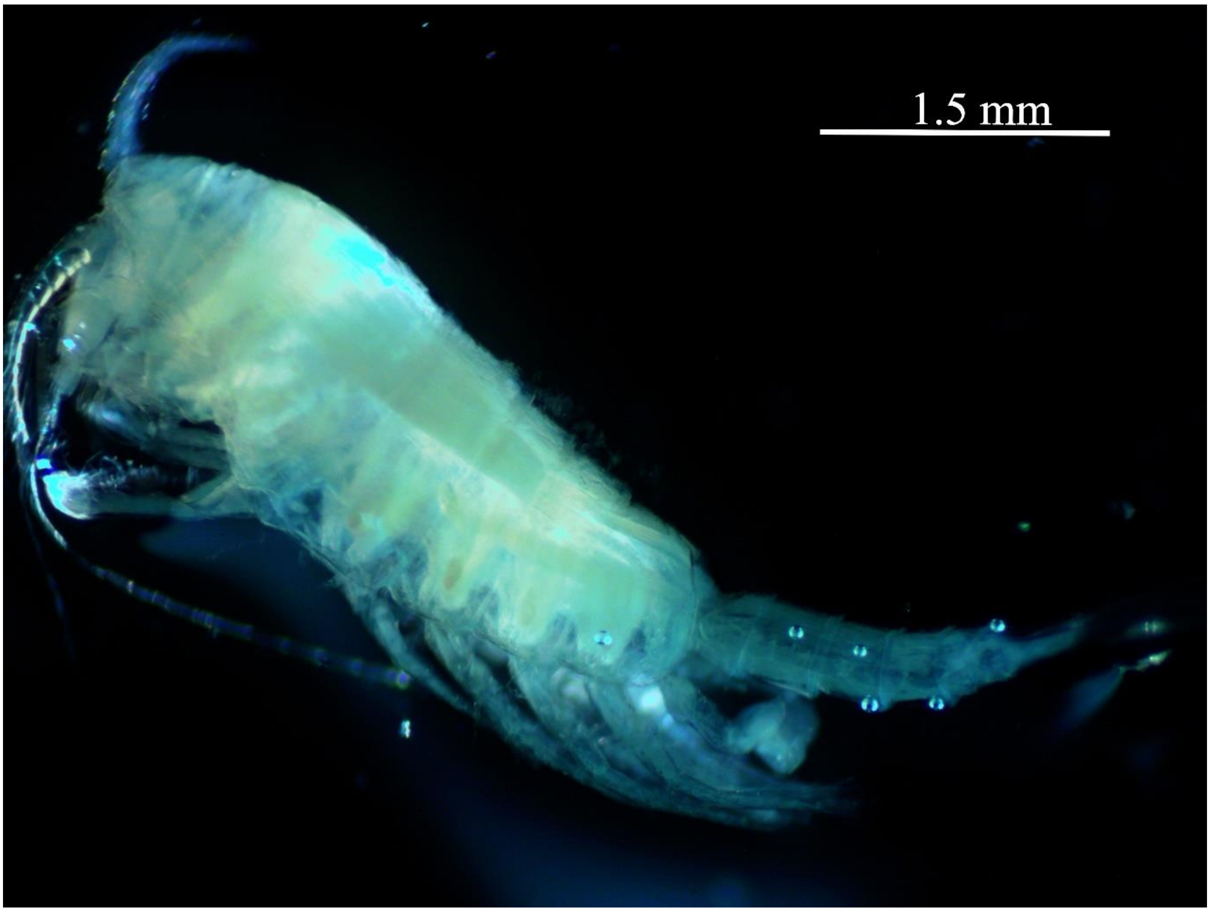

Figure 58. *Nullosetigera mutica* (Sars G.O., 1907). Habitus of male, lateral view.

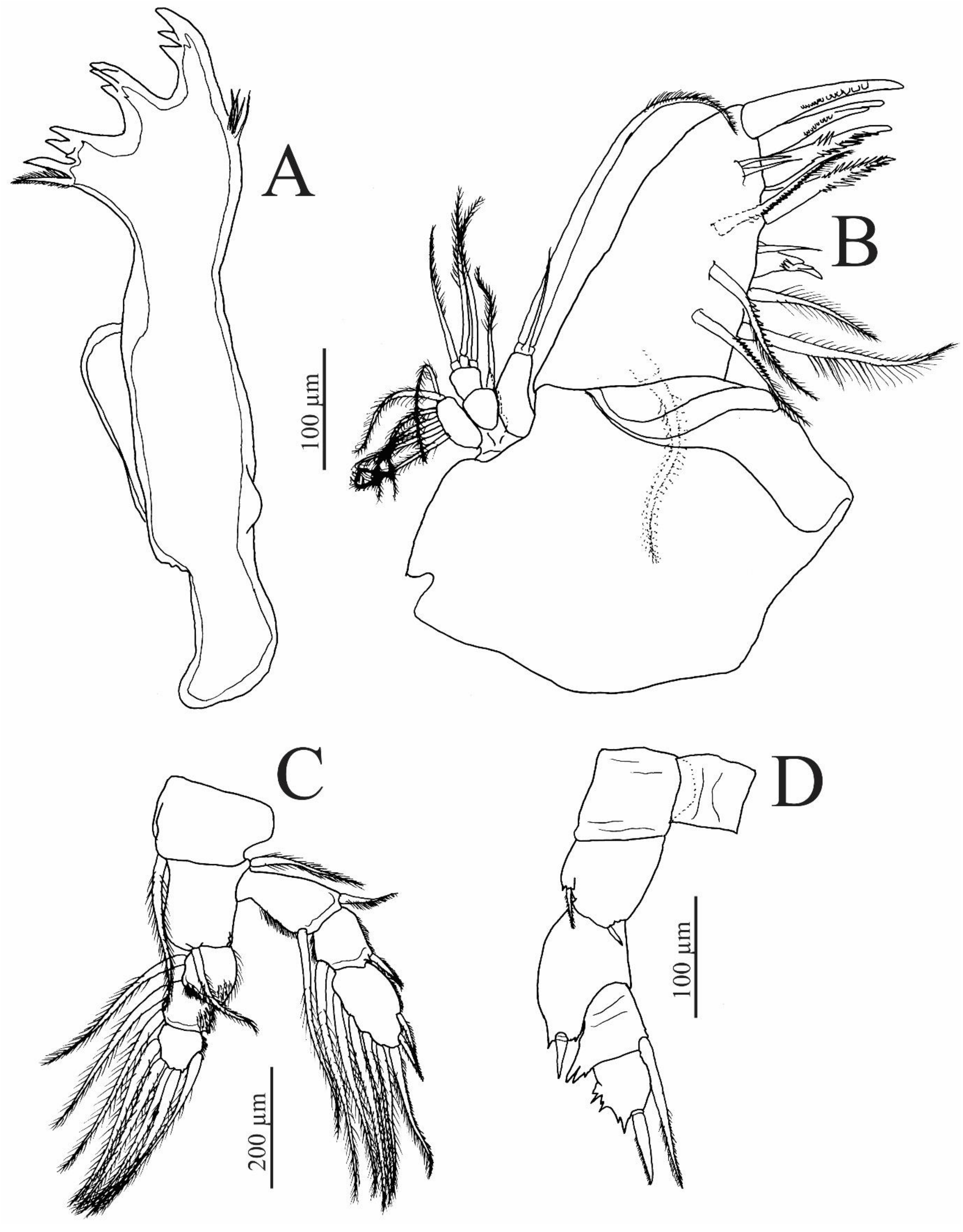

Figure 59. *Nullosetigera mutica* (Sars G.O., 1907). Female (ICML-EMU-13869). (A) Details of mandible, internal view, (B) maxillule, internal view, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

Family Phaenidae Sars G.O., 1902

Genus *Cephalophanes* Sars G.O., 1907

***Cephalophanes* sp.** (Figures 60-61)

Material examined. 1 F, TALUD XII, St. 22 (18°11’27’’ N, 103°52’29’’ W), MN, from surface to 1340 m depth (TD, 2200 m), March 21, 2008 (SPS; ICML-EMU-13870).

Female. Length measure from head anterior margin to posterior margin of Cr: 4.46 mm. General appearance of the cuticle slightly opaque, oval body. Prosome slightly constricted between A1 and A2 insertion, head with large cuticular lenses that occupy the whole head dorsal margin (Fig. 60). Cephalosome and Th1 not fused, Th4 and Th5 not fused; Th5 posteriorly projected, cone-shaped ending. Ur relatively short, with 1 free somite + asm; Gs larger than Ur1 and asm, asm and Ur subequal in length. Cr relatively short, shorter than asm. A1 relatively large, extended beyond distal margin of Cr setae, 25-segmented; segment2 2 particularly elongated, as last 3 segments. A2 2-segmented Enp and 7-segmented Exp almost subequal in length, with 1 seta on outer coxal margin and 2 on outer distal margin. Md palp with 3 setae on its basis inner margin, biramous; 2-segmented Enp and 3-segmented Exp; gb with 7 cuspidated teeth, outer seta relatively small; a patch of short spinules on its outer margin and another on one middle tooth (Fig. 61A). Mx1 pcx spines relatively long, 1.3 times as long as pcx arthrite, 2-segmented Enp slightly larger than 1-segmented Exp; ied with 2 distal setae (Fig. 61B). Mx2 coxa and basis fused in a large segment; Enp reduced, with distal setae strong and relatively long. Mp syncoxa and basis massively developed, syncoxa with 2 internal setae on each ie, basis with 1 basal seta, 2 on the middle and 1 near to distal margin; Enp reduced, distal setae relatively short. P1 with 3-segmented Exp and 1-segmented Enp, 1 outer spine on Exp1 and Exp2, 1 outer and 1 apical spine on Exp3; Enp1 ornamented with spinules on the anterior margin, on a rounded projection (Fig. 61C). P2-P4 with both rami 3-segmented, Enp1 and Enp2 with strong posterior spinules; Exp1 and Exp2 with 1 outer spine, Exp3 with 3 outer and 1 large spine, serrated on its outer margin. P5 modified, with asymmetrical ornamentation, particularly on basis: coxa with large and thick spinules on both legs, basis with strong spinules on its internal and external anterior margins; uniramous on both legs, Exp1 with 4 anterior strong spinules, with 2 distal and 1 external spine, left leg also with an internal spine (Fig. 61D).

Male. Not collected.

Remarks. The material examined presents differences with the three species described for this genus: *Cephalophanes tectus* (Esterly, 1911), *C. frigidus* Wolfenden, 1911 and *C. refulgens* Sars G.O., 1907. These differences include variation in the ornamentation of P2-P4 and P5. It is not particularly similar to any of these three species if the shape and ornamentation of P5 is considered, and it is probably an undescribed species.

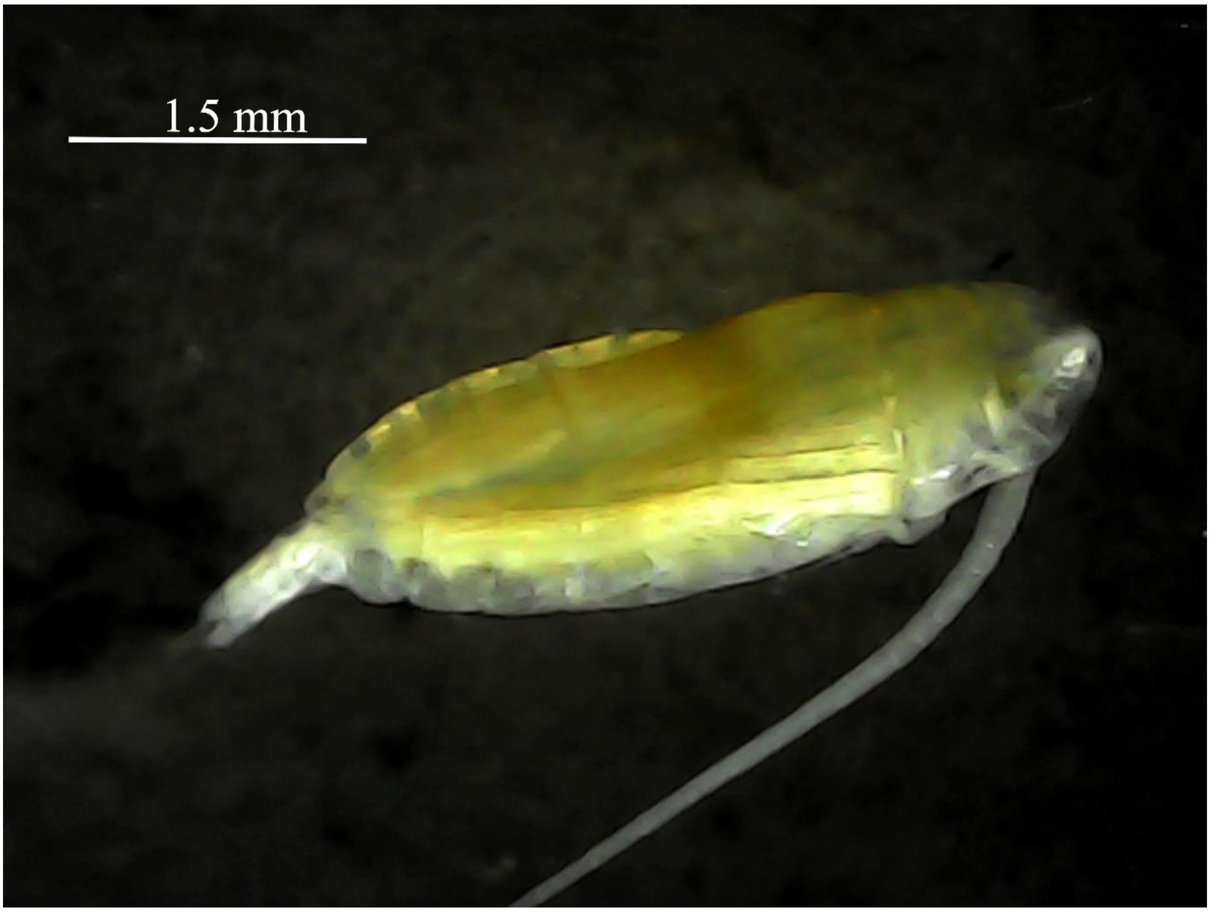

Figure 60. *Cephalophanes* sp.1. Habitus of female, dorsal view.

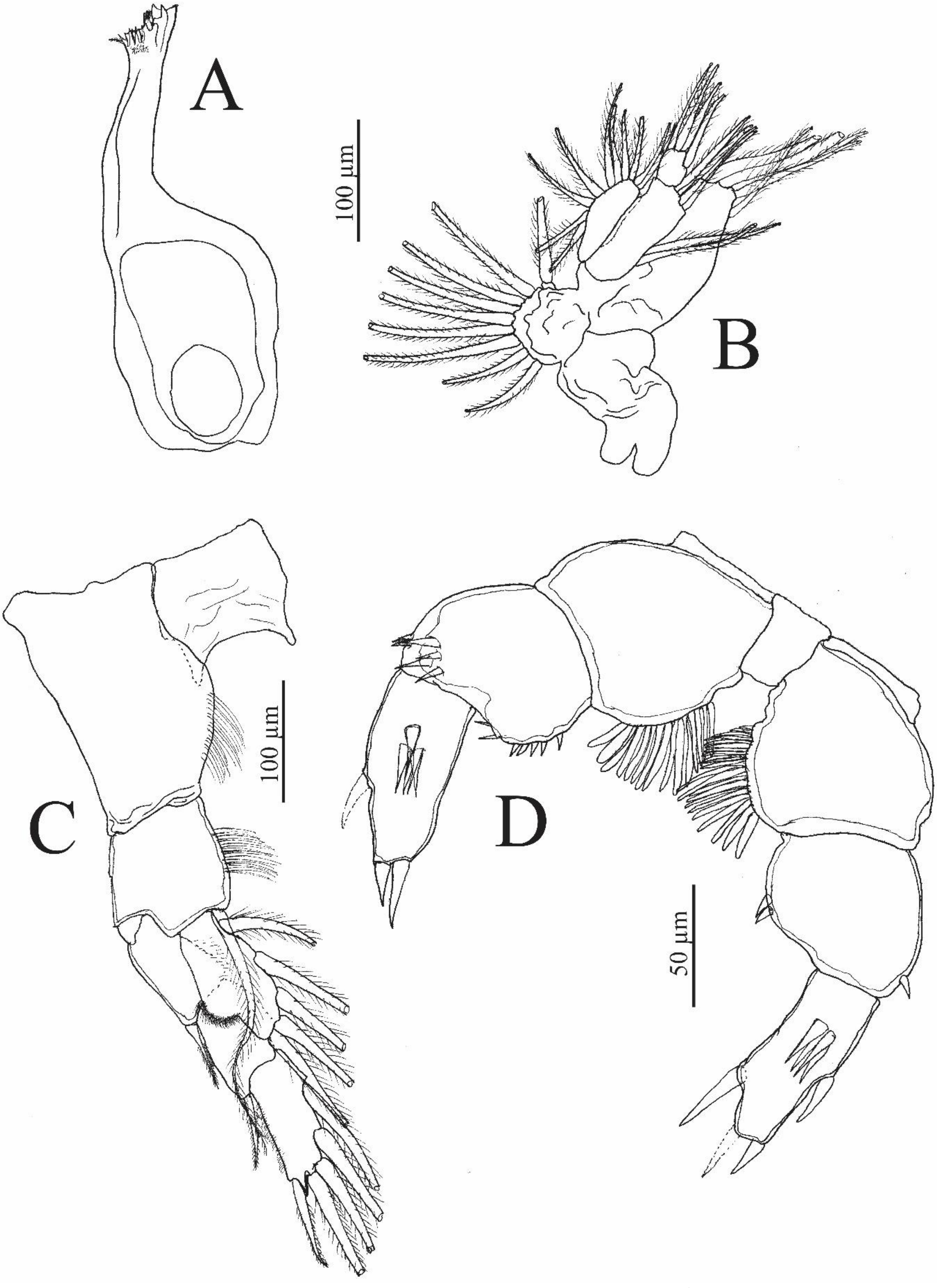

Figure 61. *Cephalophanes* sp. 1. Female (ICML-EMU-13870). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) fifth pair of legs, anterior view.

Genus *Xanthocalanus* Giesbrecht, 1893

***Xanthocalanus* sp. 1** (Figures 62-63)

Material examined. 1 F, TALUD IX, St. 6 (24°49’38’’ N, 109°47’58’’ W), MN, from surface to 1500 m depth (TD, 1650 m), November 12, 2005. (SPS; ICML-EMU-13871).

Female. Length measure from head anterior margin to posterior margin of Cr: 4.68 mm. General appearance of the cuticle opaque. Rostrum with two filaments that extends beyond the antennae insertion; cephalosome and Th1 not fused. Ur relatively small, with 2 free somites + asm; Gs has the same length as Ur (Fig. 62). Cr relatively short, asm relatively short. A1 with 24 segments that extends slightly beyond Cr. A2 with both rami well-developed, segments 2-6 of Exp constrained. Md with 3 setae on basis outer margin; mandibular gb with 8 complex teeth, the outermost tooth presents an enlarged and ornamented distal margin. Some of the teeth presents spiniform or setiform distal processes; inner margin of distal portion of gb with small spinules that goes from the outer setae insertion to the middle portion of gb; with two dense patches of setules near the insertion of gb (Fig. 63A). Mx1 with a very large Enp, almost twice as long as pcx arthrite; 1-segmented Exp (Fig. 63B). Mx2 with strong, well-developed setae on coxal and basal endites; 3-segmented Enp with 5 worm-like setae and 2 brush-like setae. Mp coxa and basis similar in length, with 3 proximal and 2 distal setae on coxa anterior and 3 on basis anterior margin; Enp with 4 segments. P1 with 1-segmented Enp and 3-segmented Exp, with 1 ornamented outer spine at Exp1-Exp3, with 1 ornamented anterior projection on Enp1, similar than that of some aetideids; with 1 large seta on anterior distal margin of basis (Fig. 63C). P2-P4 absent in the observed specimen, but according to Bradford-Grieve et al. (2004), these should present strong spinules on anterior margins of Enp segments, similar to those of some scolecithricids. Both P5 legs unirrameous, with 1 anterior patch of strong setules on basis, almost as long as the segment; Exp1 with strong spine-like processes on anterior margin, with 1 inner, 1 apical and 1 outer spines: apical spine fused to the segment; inner coxa and basis margins with spinules (Fig. 63D).

Male. Not collected.

Remarks. The genus *Xanthocalanus* is represented by many deep-water species, not found in epipelagic samples. Jiménez-Pérez and Lara-Lara (1988) reported one species of this genus in the Gulf of California as *Xanthocalanus* sp. Wiebe et al. (1988) also reported one species of *Xanthocalanus* for the Gulf, identified as *X. pinguis* Farran, 1905, collected from samples taken from more than 2000 m depth. Our material of *Xanthocalanus* sp. presents differences if compared to *X. pinguis*, including the ornamentation of the fifth pair of legs.

Figure 62. *Xanthocalanus* sp. Habitus of female, lateral view.

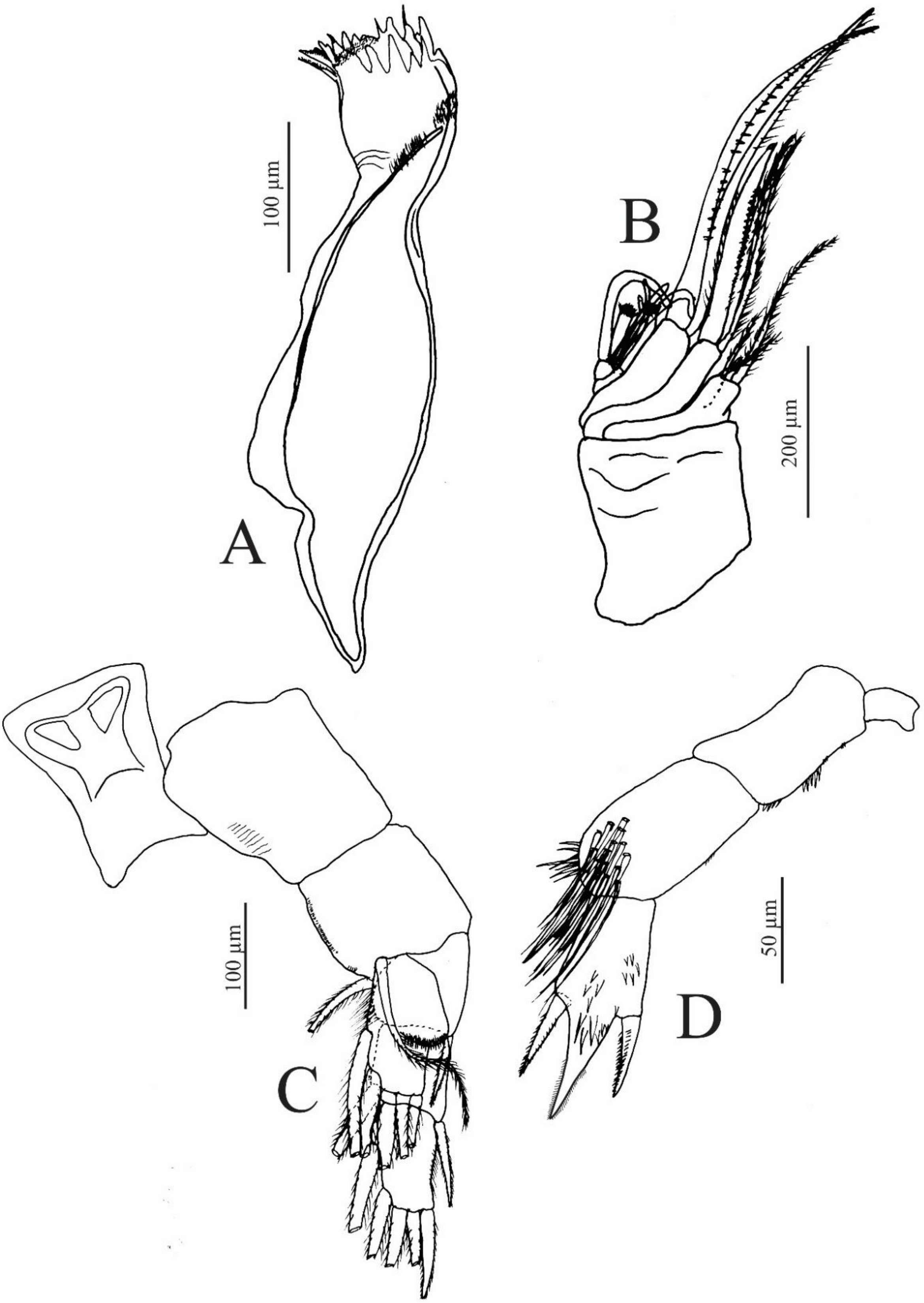

Figure 63. *Xanthocalanus* sp. Female (ICML-EMU-13871). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) right fifth leg, anterior view.

Family Scolecithricidae Giesbrecht, 1893

Genus *Lophothrix* Giesbrecht, 1895

Lophothrix frontalis **Giesbrecht, 1895** (Figure 64-65)

Synonymized names. *Scolecithrix frontalis* (Giesbrecht, 1895).

Material examined. 1 F, TALUD VIII, St. 13 (25°21’00’’ N, 110°17’00’’ W), from surface to 1650 m depth (TD, 2100 m), April 17, 2005 (SPS; ICML-EMU-13872). 1 F, TALUD VII, St. 22 (24°31'34" N, 108°55'10" W), MN, from surface to 1415 m depth (TD, 2000 m), June 7, 2001 (UD; ICML-EMU-13873-A). 1 F, TALUD IX, St. 6 (24°49’36"N, 109°47’59"W), MN, from surface to 1500 m depth (TD, 1650 m), November 12, 2005, (UD; ICML-EMU-13873-B). 1 F, TALUD X, St. 23 (27°14’41’’ N, 111°33’15’’ W), MN, from surface to 1785 m depth (TD, 1750 m), February 13, 2005 (UD; ICML-EMU-13873-C). 1 F, TALUD XI, St. 6A (16°58'00" N, 100°57'00" W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (UD; ICML-EMU-13874-A). 1 F, TALUD XII, St. 28B (18°56'00" N, 104°59'57" W), MN, from surface to 1450 m depth (TD, 1450 m), April 2, 2008 (UD; ICML-EMU-13874-B).

Female. Length measure from head anterior margin to posterior margin of Cr: of 5.78 mm. General appearance of the cuticle translucid, robust prosome (Fig. 64). Head anterior margin with a cephalic crest. Prosome relatively long and wide; the cephalosome comprises mor than 70% of the total body length, fused with Th1; Th4 and Th5 fused. Ur relatively small, with 4 somites; Gs not particularly large, almost as long as somites of Ur. Cr very short, shorter than asm. A1 of 24 segments, that extends up to the posterior margin of Th5. A2 with both rami well-developed, same size; Exp7 with 2 distal setae. Md relatively short and robust, palp and gb of similar size; distal margin of gb with 4 queratinized and cuspidated teeth, robust appearance; outer seta relatively long (Fig. 65A). Mx1 with a short and rounded Exp; segments of Enp partially fused. Mx2 with large coxa and constrained basis; 3-segmented Enp very reduced, with 4 distal brush setae. Mp with 4 setae on proximal half of coxa and with 3 setae on distal anterior margin; basis with 3 anterior setae and spinules on anterior margin; Enp well-developed, 0.7 times the length of basis. P1 with 1-segmented Enp and 3-segmented Exp; Exp2 with 1 outer spine, Exp3 with 1 outer and 1 apical spine, ornamented with setules on both margins. P2 Enp 2-segmented, Exp 3-segmented; P3-P4 with both rami 3-segmented; with 1 outer spine at Exp1 and Exp2; 2 outer and 2 apical spines on Exp3, apical spines ornamented with strong spinules, serrated margin. P2-P4 Exp-Enp anterior margins with strong spinules, conforming patterns (Figs. 65B, 65C). P5 modified, reduced, both legs unirrameous, 1-segmented; Exp1 with 1 inner, 1 outer and 1 or 2 apical spines, all ornamented with setules (Fig. 65D).

Male. Not collected.

Remarks. In the eastern Pacific, *Lophothrix frontalis* is distributed from California to Chile, with records off western Baja California, Mexico. The material examined represents a first record for the Gulf of California.

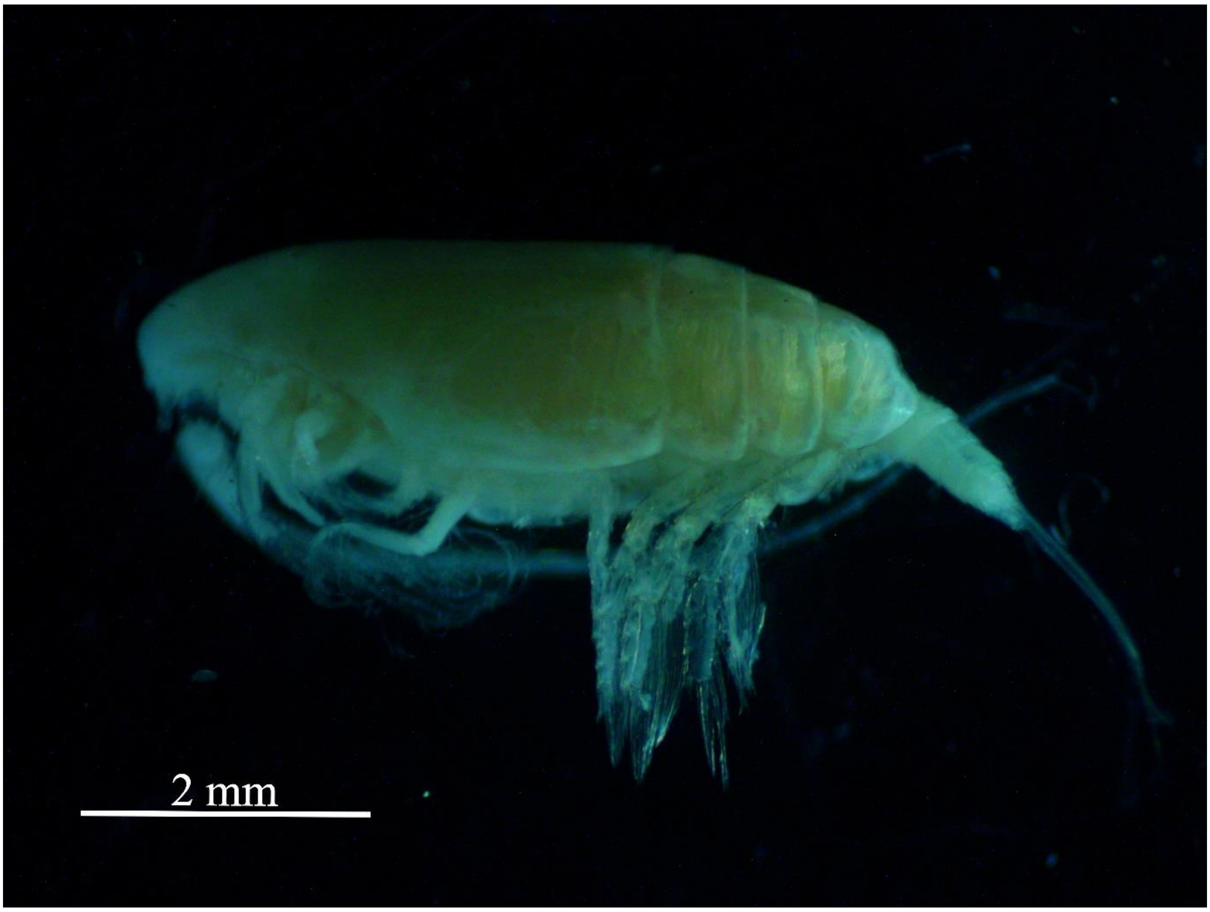

Figure 64. *Lophothrix frontalis* Giesbrecht, 1895. Habitus of female, lateral view.

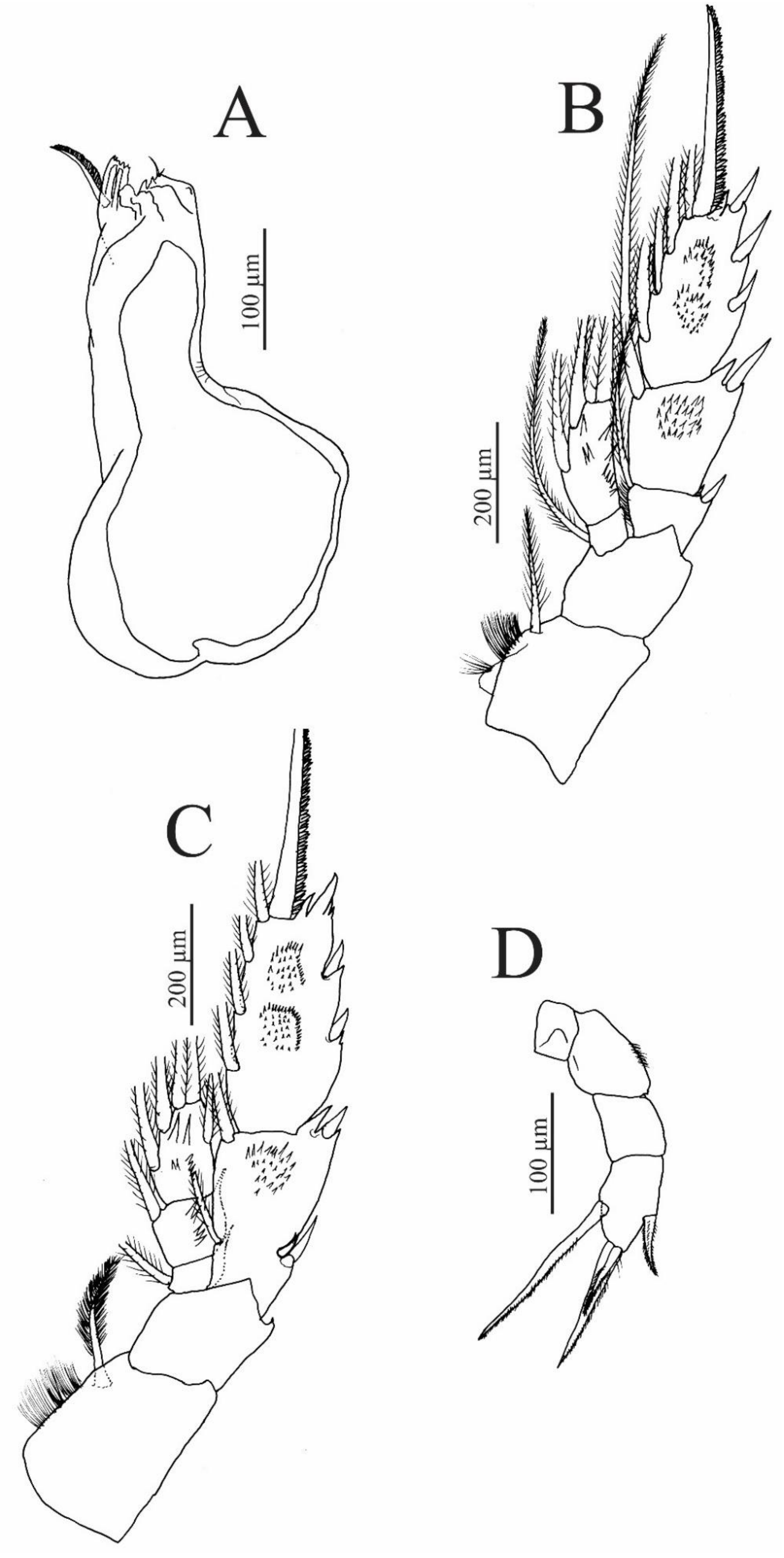

Figure 65. *Lophothrix frontalis* Giesbrecht, 1895. Female (ICML-EMU-13872). (A) Details of mandibular gnathobase, (B) right second leg, anterior view, (C) right third leg, anterior view, (D) fifth pair of legs, anterior view.

Genus *Pseudoamallothrix* Vyshkvartzeva, 2000

***Pseudoamallothrix inornata* (Esterly, 1906)** (Figures 66-67)

Synonymised names. *Scolecithrix inornata* Esterly, 1906 (PS); *Amallothrix inornata* (Esterly, 1906).

Material examined. 1 F, TALUD XI, St. 6A (16°58’00’’ N, 100°57’00’’ W), MN, from surface to 1400 m depth (TD, 1960), June 7, 2007 (SPS; ICML-EMU-13875-A). 1 F, TALUD X, St. 20 (27°14’41’’ N, 111°33’15’’ W), MN, from surface to 1250 m depth (TD, 1785 m), February 13, 2007 (SPS; ICML-EMU-13875-B). 1 F, TALUD IV, St. 36 (25°51'59" N, 110°11'00" W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (UD; ICML-EMU-13876-A). TALUD XI, St. 6A (16°57’59’’ N, 100° 56’59’’ W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (UD; ICML-EMU-13876-B). TALUD XII, St. 28B (18°56'00" N, 104°59'57" W), MN, from surface to 1450 m depth (TD, 1450 m), April 2, 2008 (UD; ICML-EMU-13876-C).

Female. Length measure from head anterior margin to posterior margin of Cr: of 3.93 mm. General appearance of the cuticle slightly opaque, robust body (Fig. 66). Prosome relatively short, wider at Mp insertion level; cephalosome and Th1 fused, that comprises more than 65% of total body length; Th4 and Th5 fused. Head anterior margin with no crest, rostrum projected in ventral view. Ur relativey short, with 1 free somite + asm; Gs somite slightly larger than Ur1. Cr short, fused to asm. A1 with 24 segments; first 2 segments relatively large, extends up to posterior margin of Th5. A2 with both rami well developed, equal lengths, with 3 distal setae on Exp7. Md relatively short and robust; gb with 4 cuspidated and queratized teeth; 1 row of setules on the outer margin of gb, in mid position (Fig. 67A). Mx1 with well-developed Enp and reduced Exp; pcx arthrite relatively large. Mx2 relatively short; basis and Enp constrained, with 4 brush setae on Enp. Mp with 3 setae on proximal half, with 3 setae on distal anterior margin; basis with 2 anterior setae; Enp well-developed. P1 with 1-segmented Enp and 3-segmented Exp; Exp1 and Exp2 with 1 outer spine, Exp3 with 1 outer and 1 apical spine, ornamented with setules. P2 with 2-segmented Enp and 3 segmented Exp; 1 outer spine at Exp1 and Exp2, 2 outer and 2 apical spines at Exp3; Anterior margins of Exp and Enp segments heavily ornamented with spinules (Fig. 67B). P3-P4 with both rami 3-

segmented, similar armature and ornamentation as in P2 (Fig. 67C). P5 modified, reduced, with both legs birrameous, 1-segmented; basis with 1 small spine in anterior view that represents the Enp; Exp1 with 1 inner and 1 apical spine, apical spine ornamented with short spinules and inner spine ornamented with setules (Fig. 67D).

Male. Not collected.

Remarks. Adult specimens of *Pseudoamallothrix inornata* presented wide variation in size, from 3.5 to 5.5 mm. This species appears to be distributed only in the North Pacific, as well as in the East Atlantic.

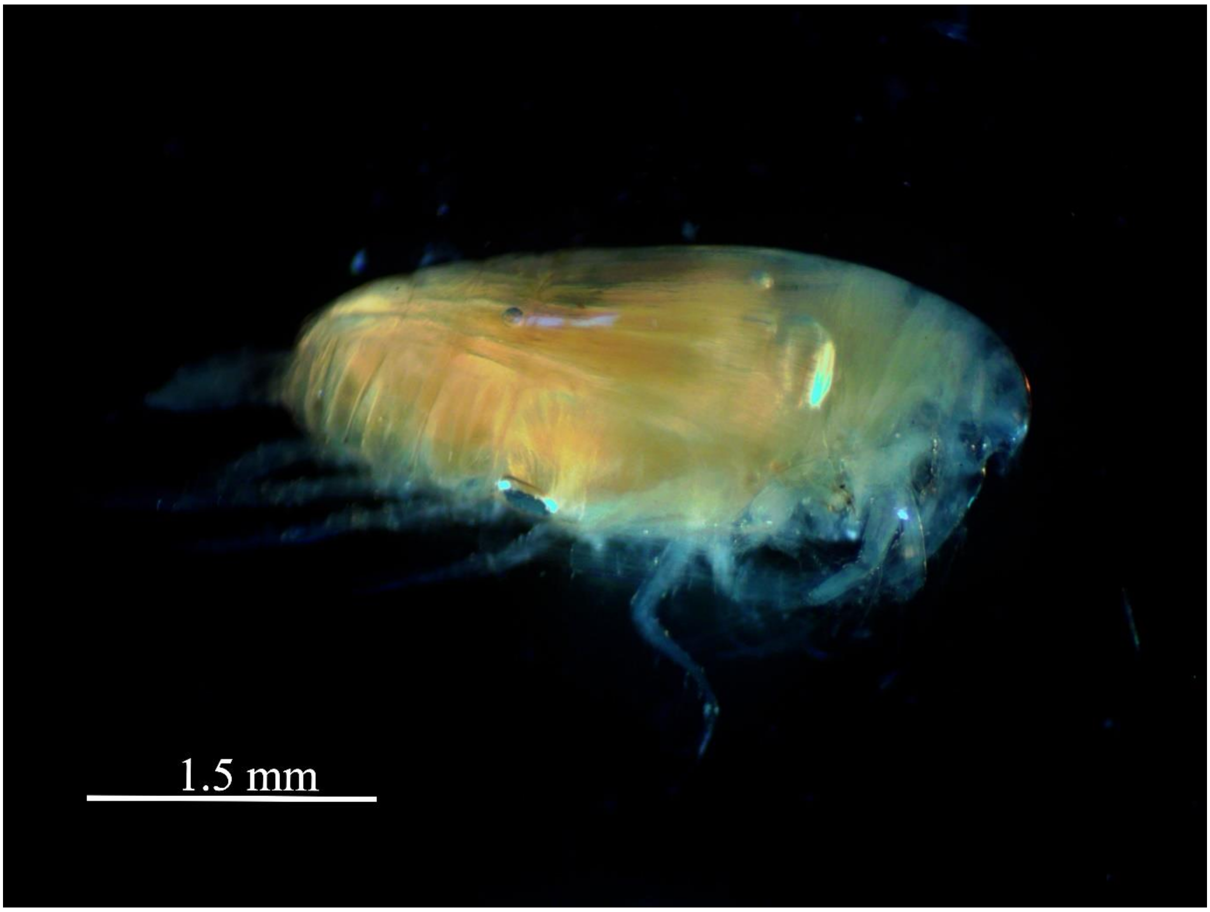

Figure 66. *Pseudoamallothrix inornata* (Esterly, 1906). Habitus of female, lateral view.

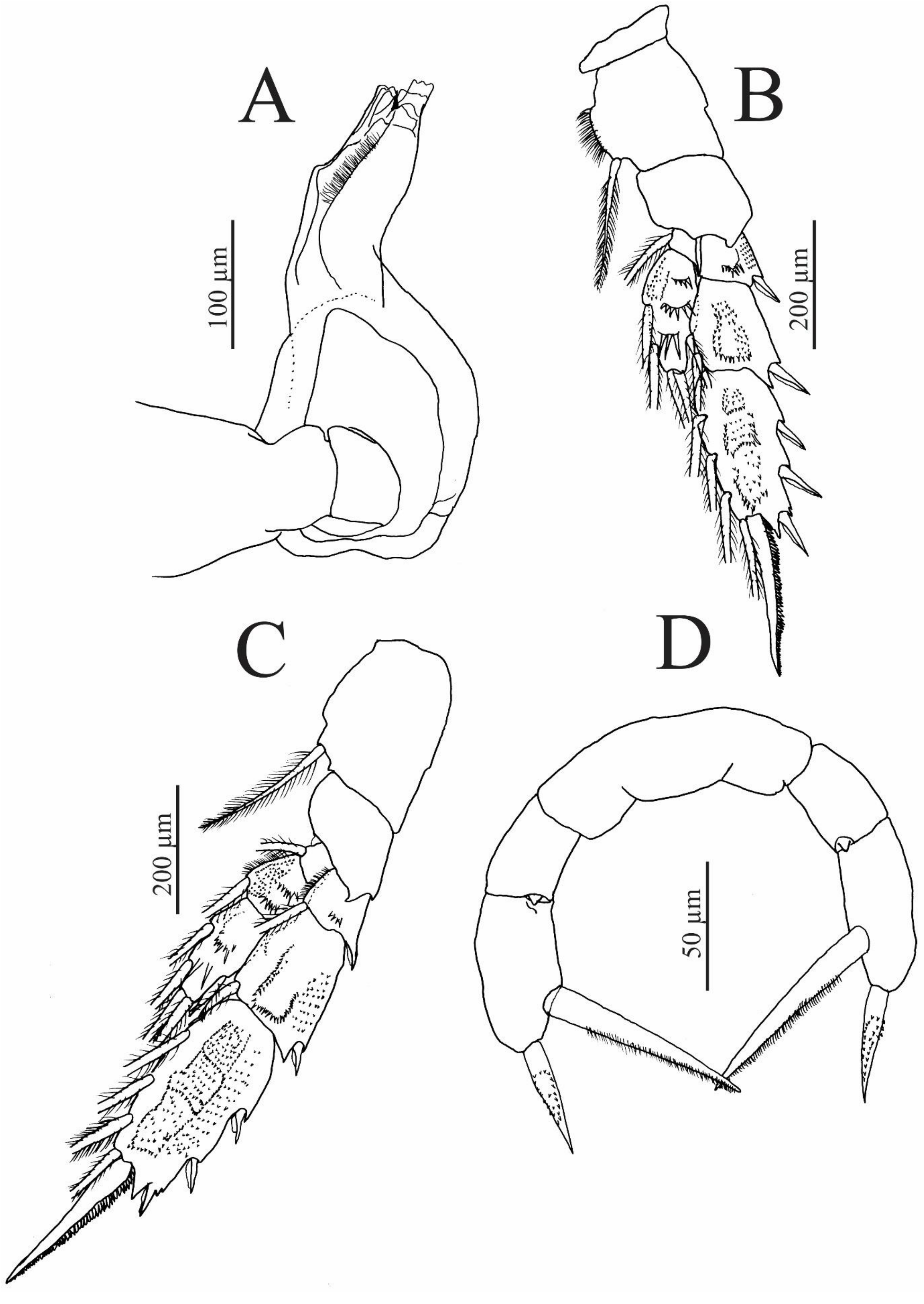

Figure 67. *Pseudoamallothrix inornata* (Esterly, 1906). Female (ICML-EMU-13875-A). (A) Details of mandibular gnathobase, (B) right second leg, anterior view, (C) right third leg, anterior view, (D) fifth pair of legs, in anterior view.

Genus *Scaphocalanus* Sars G.O., 1900

***Scaphocalanus affinis* (Sars G.O., 1905)** (Figures 68-69)

Synonymized names. *Amallophora affinis* Sars G.O., 1905.

Material examined. 1 F, TALUD X, St. 20, (27°14’41’’ N, 111°33’15’’ W), MN, from surface to 1250 m depth (TD, 1785 m), February 13, 2007 (SPS; ICML-EMU-13877). 1 F, TALUD IV, St. 36 (25°51’59’’ N, 110°11’00’’ W), MN, from surface to 1000 m depth (TD, 2100 m), August 27, 2000 (UD; ICML-EMU-13878-A). 1 F, TALUD VI, St. 15 (23°14’42’’ N, 107°30’00’’ W), MN, from surface to 1230 m depth (TD, 2390 m), March 14, 2001 (UD; ICM-EMU-13878-B)

Female. Length from head anterior margin to posterior margin of Cr: 6.04 mm. General appearance of the cuticle slightly opaque, with oval body. Prosome relatively long, the cephalosome comprises more than 65% the total body length; with a crest on head anterior margin (Fig. 68). Ur relatively small, with 2 free somites + asm; Gs 1.3 times the length of Ur somites; asm very short, about 0.25 times the length of Ur2. Cr short, but longer than asm. A1 relatively short, extending up to the posterior margin of Th3, 24-segmented. A2 with Exp slightly shorter than Enp, 3 distal setae on Exp7; Enp1 much larger than Enp2. Md relatively short and robust; palp and gb of same size; gb with 4 or more cuspidated and queratinized teeth, last outer 3 teeth elongated, thin and ornamented with small spinules all over their margins; outer margin of gb ornamented with 1 row of setules and with a patch of pores (Fig. 69A). Mx1 with Enp and Exp relatively well developed, both 2-segmented. Mx2 relatively short; basis and Enp reduced; basal endites well-developed, Enp with 4 distal brush setae. Mp with 4 setae on proximal half, one of these terminated with a bunch of small setules, paintbrush appearance; basis with 1 basal and 5 distal setae; Enp 0.9 times as long as basis (Fig. 69B). P1 with 1-segmented Enp and 3-segmented Exp; Exp3 with 1 outer and 1 long apical spine, longer than the whole Exp. P2 with 2-segmented Enp, heavily ornamented with spinules; Exp with 2 outer and 2 apical spines, inner apical spine ornamented with spinules over the outer margin. P3-P4 with 3-segmented Enp and Exp, similar ornamentation and armature as P2. P4 with anterior and posterior patches of spinules over the margins of coxa, basis, Exp and Enp (Fig. 69C). P5 modified, reduced, both legs birrameous, 1-segmented;

Enp1 with 1 small distal claw; Exp1 with 1 large, ornamented with spinules and setules, inner spine, 1 small outer spine and 2 unequal distal claws, with setules near their base, at the distal margin of the segment; inner claw 8 times longer than outer claw (Fig. 69D).

Male. Not collected.

Remarks. The description by Tanaka (1961) of the P5 of what he referred to as the “other specimen” fits perfectly with what was observed in the material examined. The two specimens described in Tanaka’s (1961) work probably belongs to two different species, based on the proportions of Exp outer and apical spines.

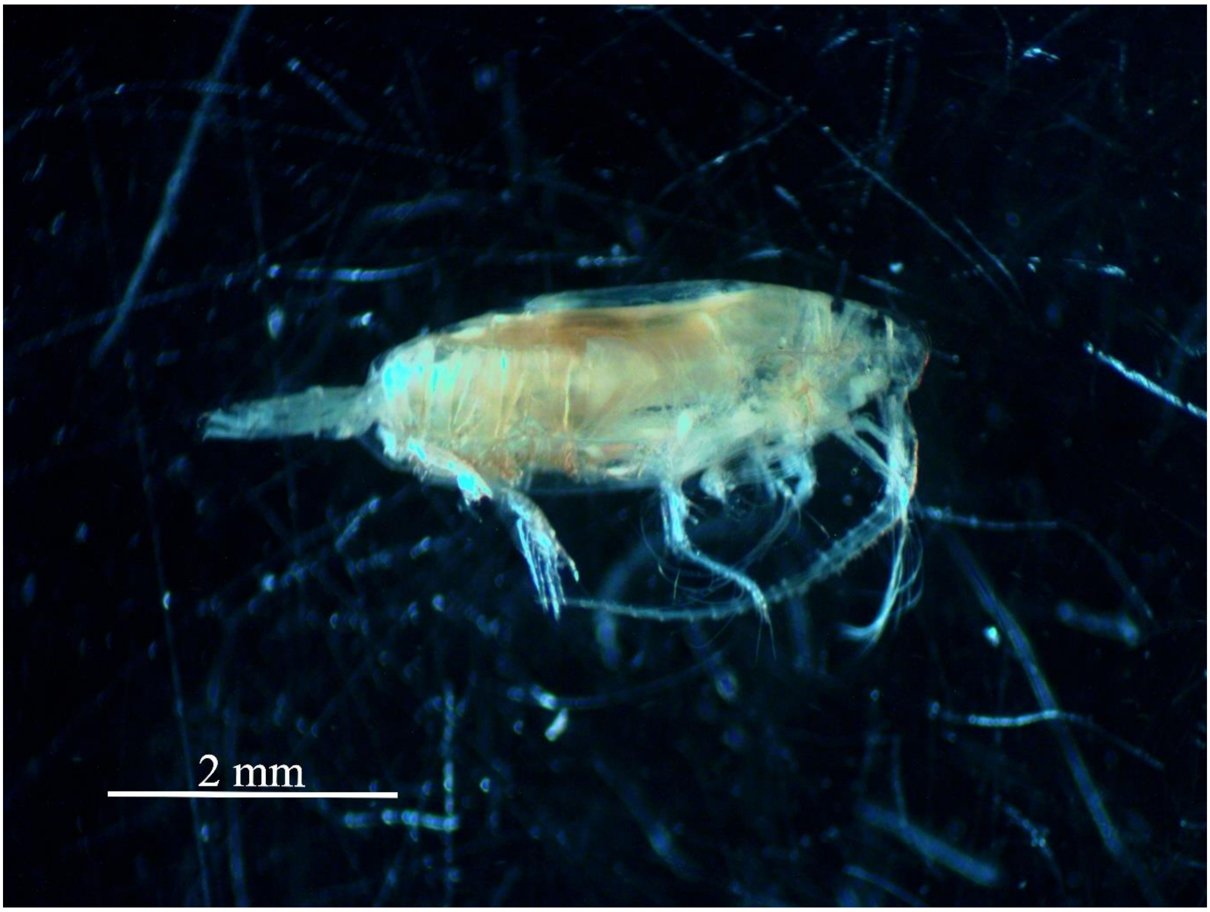

Figure 68. *Scaphocalanus affinis* (Sars G.O., 1905). Habitus of female, lateral view.

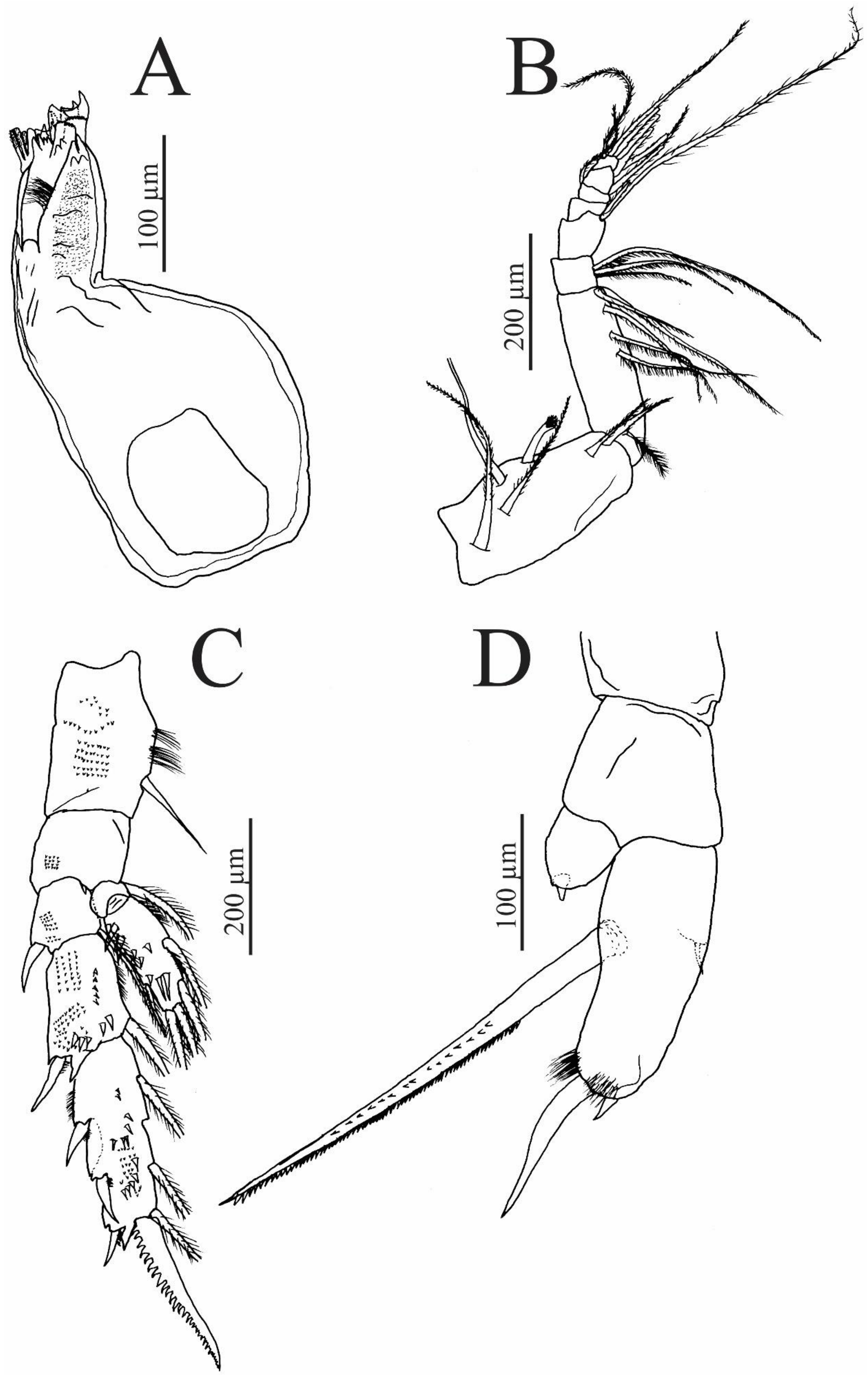

Figure 69. *Scaphocalanus affinis* (Sars G.O., 1905). Male (ICML-EMU-13877). (A) Details of mandibular gnathobase, (B) maxilliped, (C) right second leg, anterior view, (D) fifth pair of legs, anterior view.

***Incertae sedis* cf. Scolecithricidae** (Figures 70-71)

Material examined. 1 F, TALUD XI, St. 6A (16°57’59’’ N, 100° 56’59’’ W), MN, from surface to 1400 m depth (TD, 1960 m), June 7, 2007 (SPS; ICML-EMU-13879).

Female. Length measure from head anterior margin to posterior margin of Cr: 3.41 mm. General appearance of the cuticle slightly opaque, oval body. Prosome with no constrictions; cephalosome and Th1 fused; Th4 and Th5 not fused (Fig. 70). Ur relatively small, less than 1/5 of total body length, with 2 free somites + asm; Gs short, as long as Ur1, but larger; asm almost twice as long as Ur2. Cr relatively short, 1.8 times as long as asm. A1 extends beyond Cr distal margin, 23-segmented, large setae on segments 3, 7 and 8. A2 2-segmented Enp and 7-segmented Exp almost equal in length; Exp2 with an anterior projection and a small seta on it; basis with 1 middle anterior seta and 2 distal setae. Md palp and gb almost same sized, palp with 3 setae on basis; 2-segmented Enp with 3 terminal setae and 4-segmented Exp with 3 terminal setae (Fig. 71A). Mx1 with 2 ie, with 4 distal setae on ie1 and 3 distal setae on ie2, with spinules on ie2 inner margin; 2-segmented Enp, Enp1 much larger than Enp2; 1-segmented Exp, with spinules on its inner margin (Fig. 71B). Mx2 pcx, coxa and basis partially fused, with 5 ie, Enp reduced, with 4 distal setae, unmodified; Enp distal setae not modified. Mp syncoxa and basis well-developed, almost subequal in length; syncoxa with 4 anterior and 2 distal setae, one much longer than another; basis with 3 inner setae; Enp well developed. P1 1-segmented Enp with anterior projection, ornamented with spinules; 3-segmented Exp with 1 outer spine on Exp1 and Exp2, 1 outer and 1 apical spine on Exp3 (Fig. 71C). P2 2-segmented Enp, both segments with spinules on posterior margin; Exp with 1 outer spine on Exp1 and Exp2, 3 outer and 1 apical spine on Exp3. P3-P4 with both rami 3-segmented, similar armature and ornamentation as P2. P5 reduced, uniramous; right Exp apparently 2-segmented, but it may be only a folded segment; 2 apical spines on Exp, inner spine twice as long as outer spine (Fig. 71D).

Male. Not collected.

Remarks. The only female examined could not be catalogued in any family. It presents several characters of the families Scolecithricidae and Phaennidae, but the distal setae on Mx2 Enp are not modified, and no worm or brush setae are present. Posterior spinules of P2-P4 are not as conspicuous as in any of these two families. The specimen here described was not in perfect state and lacks some legs, but it presents adult segmentation. Based on the Mx1 anatomy, this species probably belongs to the Scolecithricidae, but the P5 is somewhat different compared with other species of this family. According to Bradford (1973), the number of worm setae in proportion to brush setae on Enp last segment is the main character to distinguish between both families, although there are species that do not conform with any of both families. Diaixidae and Tharybidae are the other closest families, but these also present modified setae on Mx2 distal Enp.

Figure 70. *Incertae sedis* cf. Scolecithricidae. Habitus of female, lateral view.

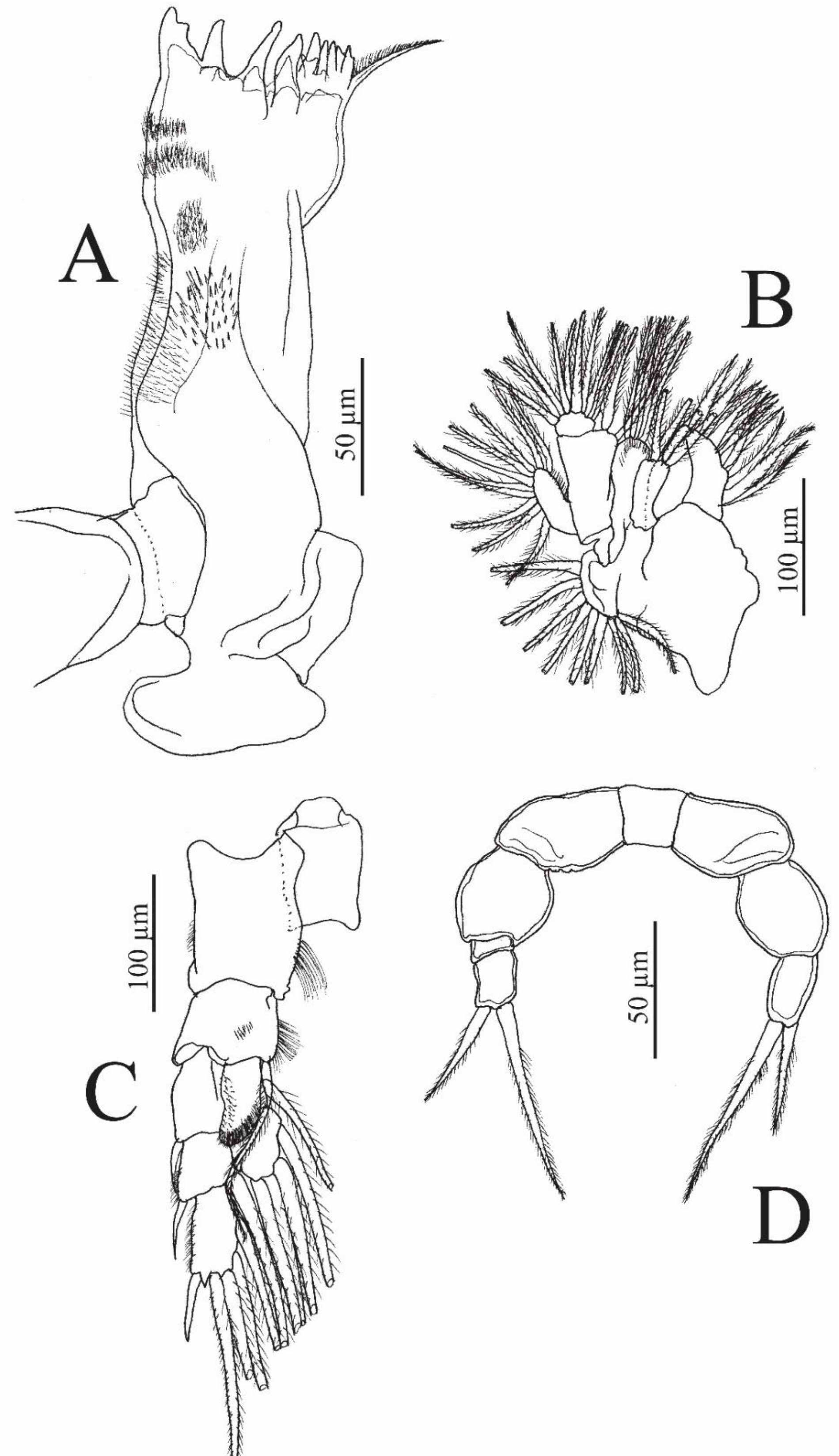

Figure 71. *Incertae sedis* cf. Scolecithricidae. Female (ICML-EMU-13879). (A) Details of mandibular gnathobase, (B) maxillule, (C) right first leg, anterior view, (D) fifth pair of legs, anterior view.

7a.4.3. *Spatial variation of the pelagic copepods collected during the TALUD cruises.*

The CLUSTER analysis placed EGC stations as more similar to MPT stations. EGC southernmost stations and MPT stations were placed in a subgroup, while the rest of EGC stations conformed another subgroup. Most CGC and SGC samples conformed one single subgroup. A small subgroup was composed by stations that share a set of less-deeper samples, most of these obtained during the TALUD I and III cruises. The SIMPROF test indicates that the conformation of the four subgroups is statistically significant (Fig. 72).

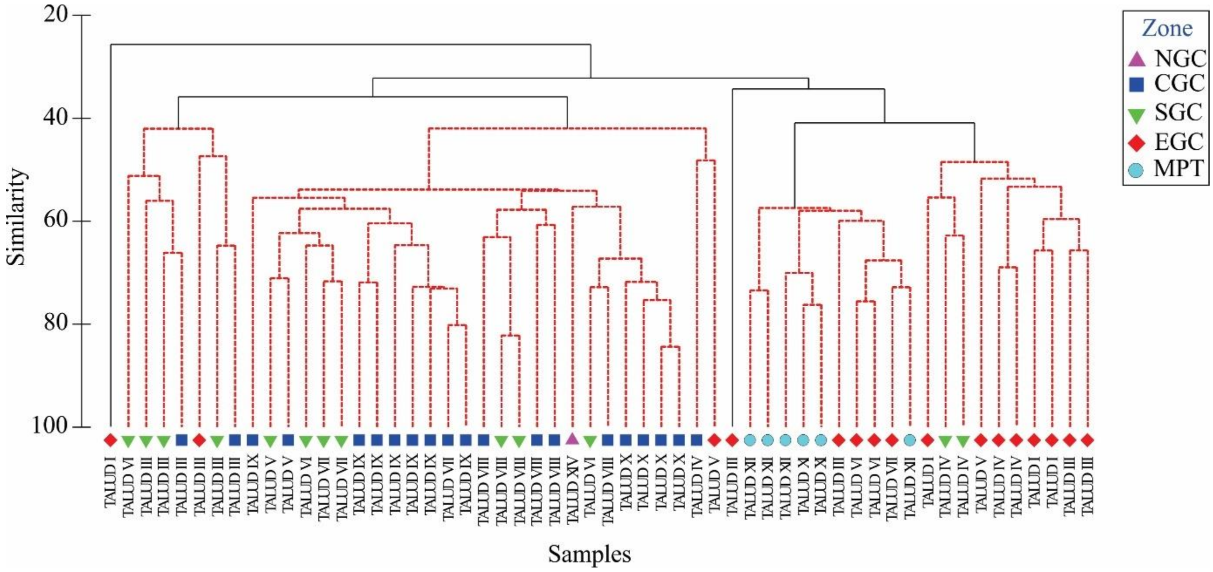

Figure 72. Classification of the 56 samples of pelagic copepods collected during the TALUD I-XIV cruises. The red dotted lines indicate the groups supported by the SIMPROF test. NGC, northern Gulf of California, CGC, central Gulf of California, SGC, southern Gulf of California, EGC, entrance of the Gulf of California, MPT, Mexican Pacific Transition.

As expected, considering the mesh aperture used in this survey, the copepod composition was dominated by large calanoids. There were clear differences between samples of the CGC-SGC and the EGC-MPT subgroups, due to higher dominance of *Rhincalanus nasutus* and *Paraeucalanus sewelli*. Samples collected in the EGC and MPT zones presented strong dominance of *Eucalanus hyalinus*, while *R. nasutus* was much less abundant (Fig. 73). *Lucicutia hulsemannae* was the most widespread distributed deep-water species in both CGC-SGC and EGC-MPT subgroups. It was also one of the most frequent species, recorded in 67% of the samples. Among the deep-water calanoid, the most frequent and abundant species were *Lucicutia hulsemannae*, *Euaugaptilus angustus*, *Metridia princeps*, *Pseudhaloptilus pacificus*, *Paraheterorhabdus compactus*, *Pseudochirella obesa* and *Megacalanus frosti*. These species occurred throughout all the Gulf and the MPT, with relative abundances of between 0.5 (*P. compactus*) and 8.0% (*L. hulsemannae*).

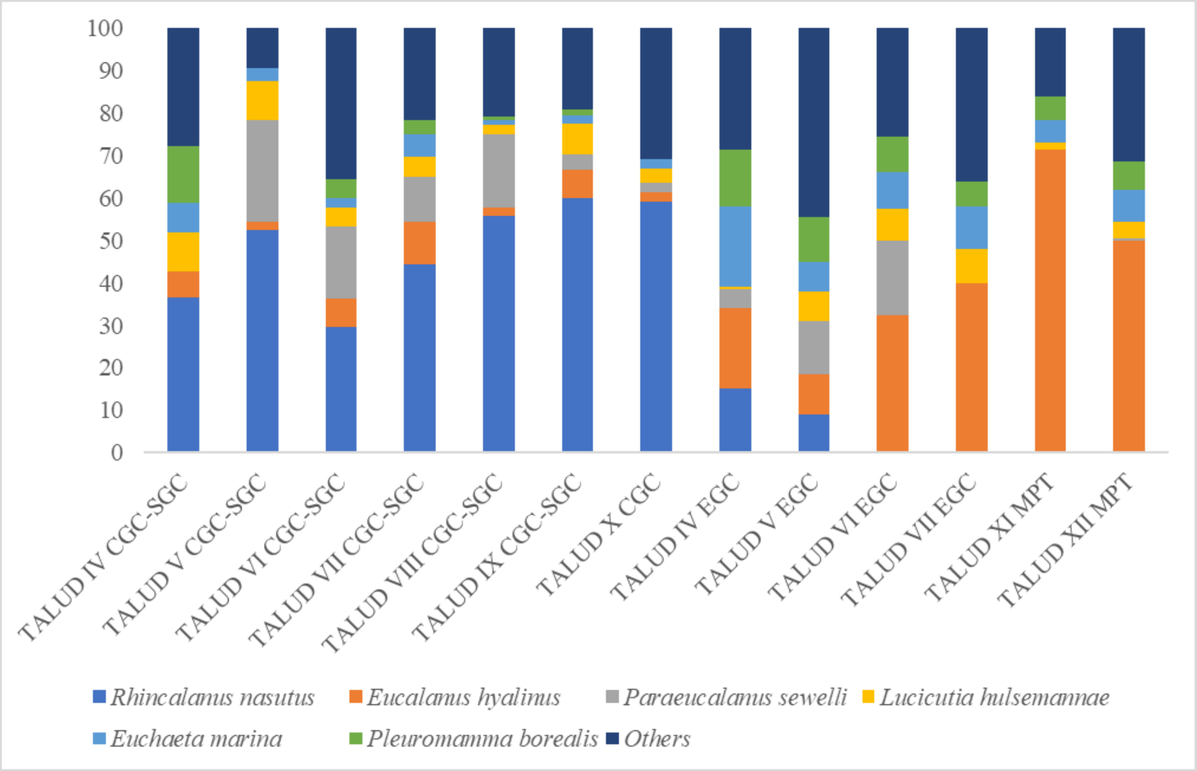

Figure 73. Graphical display of the relative abundances (in %) of the pelagic copepod species in the Mexican Pacific collected during the TALUD I-XIV cruises. Values corresponding to the more abundant and frequent species are represented using a distinctive color code. NGC, northern Gulf of California, CGC, central Gulf of California, SGC, southern Gulf of California, EGC, entrance of the Gulf of California, MPT, Mexican Pacific Transition.

Five subgroups were conformed in the species-level NMDS ordination: most CGC and SGC stations were placed into one subgroup, mainly characterized by high dominance of *R. nasutus* and low dominance of *Pleuromamma* borealis and *Euchirella bitumida* as well as by some epipelagic species. Most EGC stations were placed into the second subgroup, characterized by high dominance of *P. borealis* and *E. bitumida*. MPT and southern EGC stations were placed together; this subgroup was characterized by high dominance of *Euaugaptilus angustus* and *Eucalanus hyalinus*, as well as low dominance of epipelagic species such as *Oncaea venusta*, *Corycaeus furcatus* or *Aetideus armatus.* Some SGC and

EGC stations that are located near the transition zone were placed in an independent subgroup with high dominance of *R. nasutus*, *P. borealis* and *E. bitumida*. Finally, TALUD I-III samples (less deep) were placed in a subgroup characterized by the high dominance of epipelagic species such as *O. venusta, C. furcatus* and *A. armatus*, as well as low dominance of *E. hyalinus, E. angustus* or *L. hulsemannae* (Fig. 74). Most of TALUD I-III stations had in common sampling depths of less than 500 m. EGC stations were, in general, characterized by low dominance of deep-water species, while MPT stations presented high dominance of the most frequent deep-water species: *L. hulsemannae* and *E. angustus*. The family-level arrangement of the samples showed a similar pattern, except the MPT was actually more similar to the CGC and the SGC than to the EGC (Fig. 75).

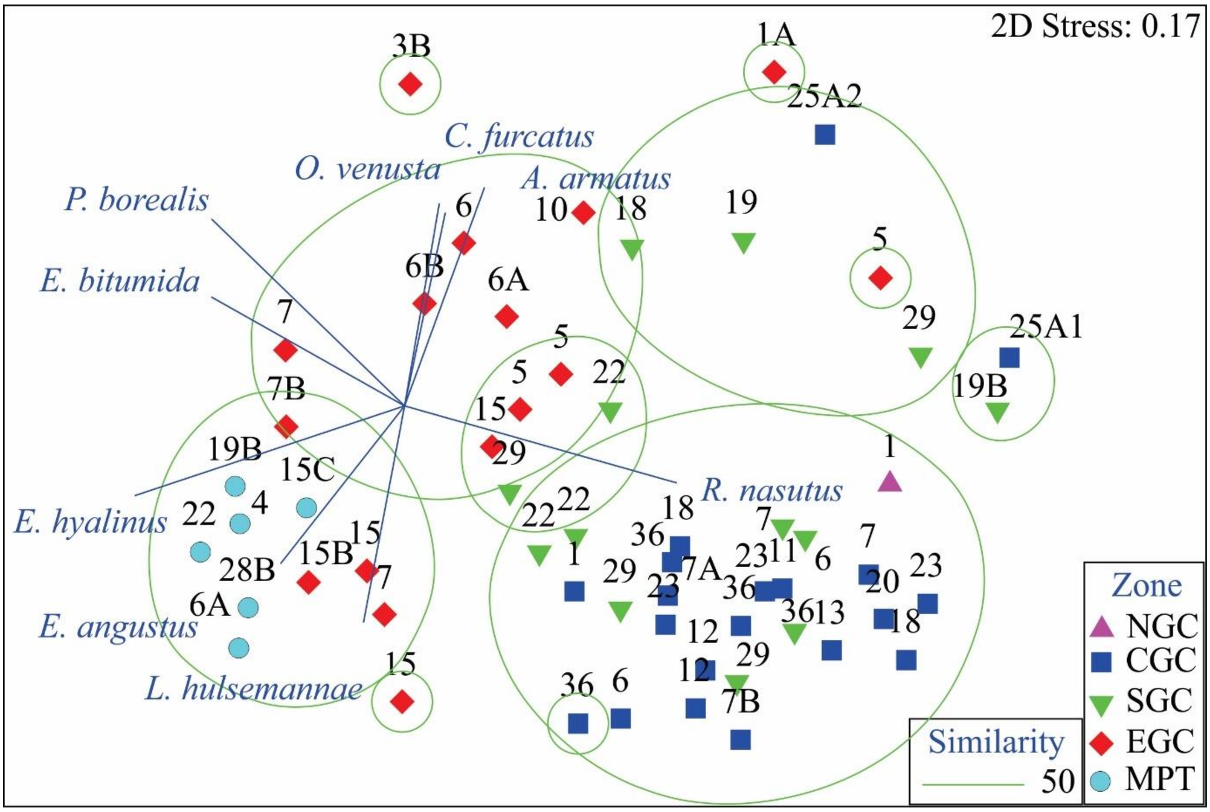

Figure 74. NMDS ordination of the 56 samples collected during the TALUD I-XIV cruises, based on the composition of the pelagic copepods at species level. Green circles indicate the groups conformed in the cluster with a 50% of similarity. Blue vectors indicate the relative abundance of the copepod species correlated with the samples. NGC, northern Gulf of California, CGC, central Gulf of California, SGC, southern Gulf of California, EGC, entrance of the Gulf of California, MPT, Mexican Pacific Transition.

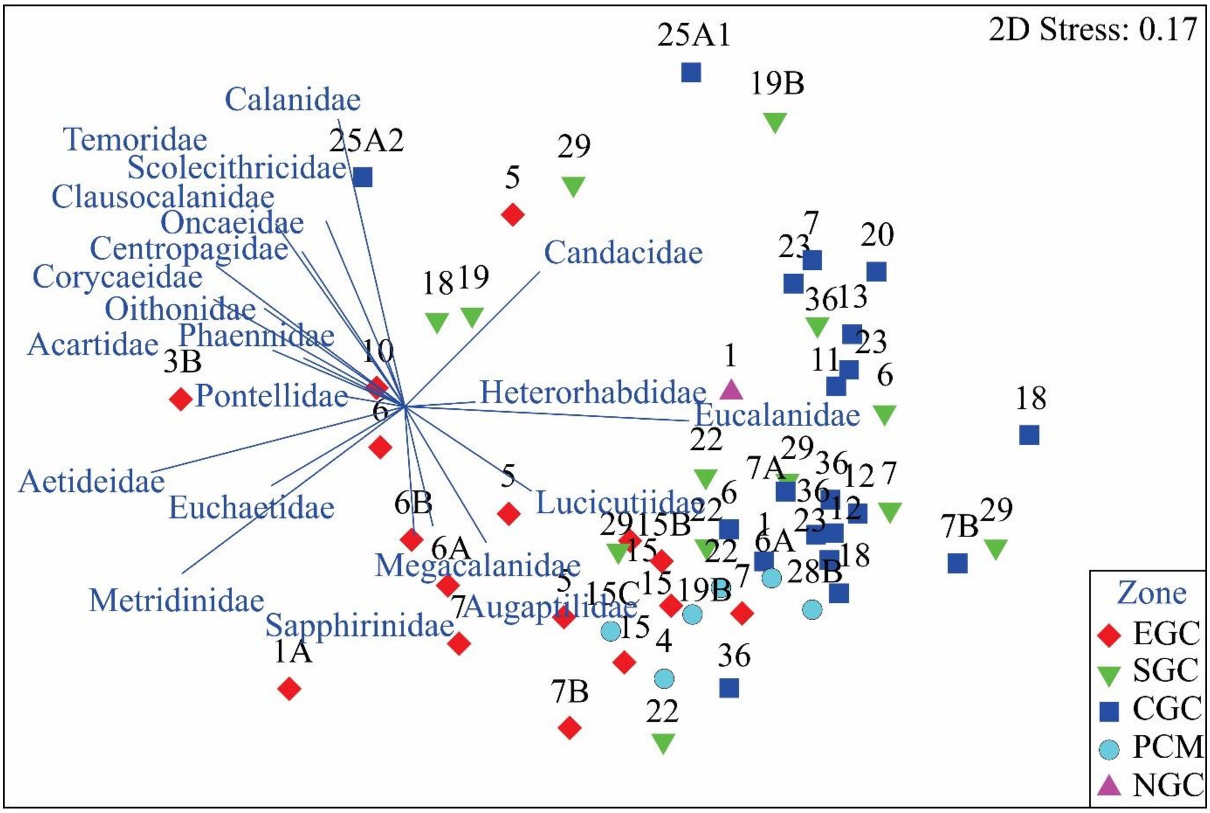

Figure 75. NMDS ordination of the 56 samples collected during the TALUD I-XIV cruises, based on the composition of the pelagic copepods at family level. Green circles indicate the groups conformed in the cluster with a 50% of similarity. Blue vectors indicate the relative abundance of the copepod species correlated with the samples. NGC, northern Gulf of California, CGC, central Gulf of California, SGC, southern Gulf of California, EGC, entrance of the Gulf of California, MPT, Mexican Pacific Transition.

Based on the ecological indices of the copepod community, EGC stations presented high diversity and evenness, as well as most SGC samples. CGC samples, together with part of SGC and MPT samples shared higher dominance values. MPT samples shown a less clear pattern, scattered according to their evenness and diversity. One subgroup was composed by samples of the stations 6A (TALUD XI), 19B (TALUD XI) and 28B (TALUD XII) (Fig. 76), but these did not share either similar latitude or closeness to the coastline. Although MPT stations were characterized by high abundance of some deep-water species, these also presented relatively low richness values for both deep-water and epipelagic species: 21 vs. 29 recorded in the Gulf. Samples collected from shallow waters (i.e., St. 1A, 3B, 7B, 5, 25A1, 19B, 6, 7) presented low richness values, as well as lack of deep-water species.

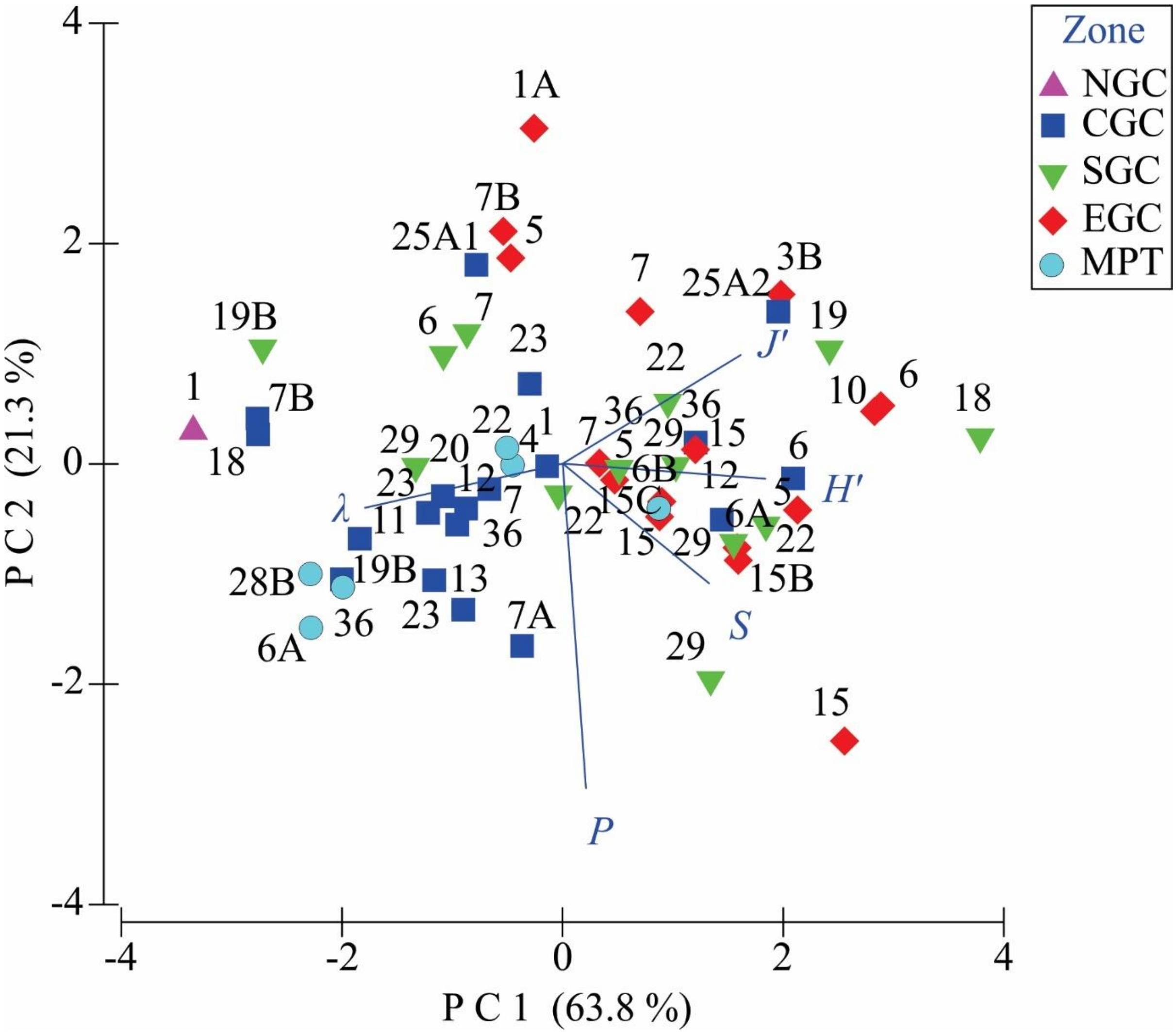

Figure 76. PCA ordination of the 56 samples collected during the TALUD I-XIV cruises, based on the ecological indices of the copepod cmmunity. The blue vectors represent the Shannon's diversity (H'), Pielou's evenness (J'), richness (S), dominance (λ) and the maximum depth of sampling (D) . NGC, northern Gulf of California, CGC, central Gulf of California, SGC, southern Gulf of California, EGC, entrance of the Gulf of California, MPT, Mexican Pacific Transition.

7a.5. *Discussion*

7a.5.1. *Copepod richness and Composition*

Of the more than 330 recorded species of copepods in the ETP (see Chen 1986; Suárez-Morales and Gasca 1998; Fernández-Alamo and Farber-Lorda 2006; Palomares-García et al. 2018; Razouls et al. 2024; Velázquez-Ornelas and Hendrickx 2023) we identified 85 species from the TALUD samples: 27 of these represent new records for the Gulf of California and 25 for the Mexican Pacific. Based on these new records, the copepod list for the Gulf increases by approximately 8%. The material and the data gathered during the deep-water TALUD project have resulted in more than 139 publications, including new information on benthonic and parasitic copepods, making this the largest sampling effort in the Mexican Pacific for both pelagic and benthic realms. Despite of their ecological importance, deep-water pelagic copepods collected during this project had so far received very little if any attention. Two species recorded in the Gulf of California during our study were recently described: *Lucicutia hulsemannae* in 2005 (Markhaseva and Ferrari 2005) and *Megacalanus frosti* in 2017 (Blanco-Bercial and Boxshall 2017), both originally described from ETP material. Other deep-water species, previously recorded in the ETP, had never been found in the Mexican Pacific until today (see table 2). The world distribution of the deep-water copepod species recorded during the TALUD cruises is presented below (Table 2).

Table 2. Known distribution of deep-water copepods collected during the TALUD project. New records for the Gulf of California are marked with “*’’, new records for the Mexican Pacific are marked with “**”. GC, Gulf of California; MPT, Mexican Pacific Transition; CP, cosmopolitan; T, tropical; ST, subtropical; PN, distributed in the north hemisphere; PS, distributed in the south hemisphere; RD, restricted distribution; IP, Indo-Pacific Ocean; CAL, California, PAC, Pacific Ocean; ETP, eastern tropical Pacific; EP, eastern Pacific; JS, Japan Sea. Based on Razouls et al. (2024).

Species	**Previous records in the Pacific Ocean**	**Province**	**World distribution**
Arietellus setosus Giesbrecht, 1892*	Phillipines, China, Japan, California, W equatorial current, Chile, ET Pacific	GC	CP, T-ST
Arietellus Giesbrecht, 1893 sp.??	ND	MPT	ND
Augaptilus cornutus Wolfenden, 1911**	NW Pacific	GC	CP, ST-PS
Augaptilus megalurus Giesbrecht, 1889*	California, W Baja California, Marquesas islands	GC	CP, T
Candacia elongata (Boeck, 1872)**	T and N St Pacific, New Zealand, Philipines, Galapagos	GC	CP, T
Centraugaptilus horridus Farran, 1908**	Japan, California, Panama, Peru, Chile, New Zealand, SE and Eq Pacific	GC, MPT	CP, T-ST
Centraugaptilus macrodus (Esterly, 1911)**	NE Pacific, California	MPT	RD, CAL
Cephalophanes Sars G.O., 1907 sp.**	ND	MPT	ND
Disseta palumbii Giesbrecht, 1889**	China, Taiwan, Tropical Pacific, California, Ecuador, Peru, Chile	GC	CP, T-ST
Disseta scopularis (Brady, 1883)**	Phillipines, China, Japan, Vancouver Island, Tropical Pacific, Peru, Chile	GC	RD, PAC
Euaugaptilus angustus (Sars G.O., 1905)**	China, Taiwan, Japan, British Columbia, Tropical Pacific, Peru	GC, MPT	CP, T-ST
Euaugaptilus austrinus Park, 1993**	SE Pacific	GC, MPT	PS, IP
Euaugaptilus longimanus (Sars G.O., 1905)**	Japan, Phillipines, China, New Zealand, W Equatorial Current, Peru, Chile	GC, MPT	CP, T
Euaugaptilus nodifrons (Sars G.O., 1905)**	China, Taiwan, Japan, New Zealand, Vancouver Island, Californa, Peru, Chile	GC	CP, T-ST-PS
Gaetanus kruppii Giesbrecht, 1903**	Phillipines, Vancouver Island, New Zealand, California, Peru, Chile	GC, MPT	CP, T-ST

Gaetanus miles Giesbrecht, 1888*	Pacific gyre, California, Baja California, Gulf of Tehuantepec, Costa Rica, Peru	GC, MPT	CP, T-ST-PN
*Gaetanus pileatus Farran, 1903***	China, Japan, Australia, New Zealand, W Equatorial Current, California, Peru, Chile	GC	CP, T-ST-PN-PS
Heterostylites major (Dahl F., 1894)**	Phillipines, Bering Sea, Okhotsk Sea, Aulentian basin, Pacific central, Alaska, Chile	GC	CP, T-ST-PS
Lophothrix frontalis Giesbrecht, 1895*	China, Japan, Alaska, NE Pacific, California, W Baja California, Ecuador, Chile	GC, MPT	CP, T-ST
Lucicutia bicornuta Wolfenden, 1905	China, Taiwan, Japan, NE/NW Pacific, Gulf of California, Costa Rica, Chile	GC, MPT	CP, T-ST
Lucicutia hulsemannae Markhaseva & Ferrari, 2005*	Tehuantepec, Costa Rica	GC, MPT	RD, ETP
Megacalanus frosti Bradford-Grieve, Blanco-Bercial & Boxshall, 2017**	California-Chile	GC, MPT	RD, EP
Mesorhabdus angustus Sars G.O., 1907**	Phillipines, China, Okhotsk Sea, California, W Central America Pacific	GC	CP, T
Metridia princeps Giesbrecht, 1889	Gulf of California, Western Equatorial Current	GC, MPT	CP, T-ST-PN
Nullosetigera auctiseta Soh, Ohtsuka, Imabayashi & Suh, 1999**	Japan Sea	GC	RD, JS
Nullosetigera mutica (Sars G.O., 1907)**	Easter Island, Japan	MPT	CP, T-ST
Paraeuchaeta copleyae Park, 1993	Gulf of California	GC	RD, GC
Paraheterorhabdus compactus (Sars G.O., 1900)	China, Japan, Bering Sea, British Columbia, California, Gulf of California, Chile	GC	CP, T-ST-PN-PS
Pseudhaloptilus pacificus (Jhonson, M.W., 1936)**	Bering Sea, Aulentian basin, Canada, Japan, SE Pacific	GC, MPT	CP, T-ST-PN-PS
Pseudoamallothrix inornata (Esterly, 1906)**	Japan, SE Hokkaido, N Pacific, Okhotsk Sea, Bering Sea, Aleutian basin, S California	GC, MPT	CP, ST
Pseudochirella obesa Sars G.O., 1920*	China, Japan, Equatorial Pacific, Peru, Juan Fernandez Island	GC, MPT	CP, T-ST-PS
Sarsarietellus Campaner, 1984 sp. 1**	ND	GC	ND
Sarsarietellus Campaner, 1984 sp. 2??	ND	MPT	ND
Scaphocalanus affinis (Sars G.O., 1905)**	Japan, SE Hokkaido, Aulentian Island, British Columbia, New Zealand, Peru, Chile	GC	CP, T-ST
Temorites elongata (Sars, G.O., 1905)**	China, New Zealand, NE Marquesas, Galapagos, Chile	GC	CP, T
Xanthocalanus Giesbrecht, 1893 sp.??	ND	GC	ND

Specimens of five copepod taxa could not be assigned to any described species due to their particular morphology. If these five species are included as new records, the total number is of 27 species for the Gulf of California, and 25 for the Mexican Pacific. *Arietellus* sp. presents several morphological differences in relation to *A. setosus*, e.g., the length of the female P5 Exp and Enp apical setae (proportionally longer in *Arietellus*. sp.), the size of female P5 Enp in relation to Exp (larger in *Arietellus*. sp.), the shape of Mx1 ied seta and the armature-ornamentation of Mp synconxa. The only other *Arietellus* species recorded in the Mexican Pacific, *A. pacificus*, presents considerably different morphology of female P5. There are 15 described species of this genus (Walter and Boxshall 2024), but *Arietellus*. sp. is not particularly similar to any of these.

Sarsarietellus sp. 1 and sp.2 represent new records for the Pacific, since species of this genus are known to be distributed exclusively in the Atlantic or the Indian oceans (Razouls et al., 2024). *Sarsarietellus* sp. 1 and sp.2 can be assigned to the genus by the combination of the following characters: a well-developed pcx arthrite of the Mx1 with a large basis and endopod; similar morphology of selected appendage with other arietellids; a thick md gb with one thick inner projected tooth and four outer thick teeth (no outer seta); a large A1 first segment, much larger than distal segments; a reduced, biramous P5 in the female; 1-segmented Enp and 3-segmented Exp with 2 outer and 2 apical spines. Arietellidae is considered to be a deep-water family of copepods, although species of *Arietellus* or *Paraugaptilus* can occasionally be found in the first 200 m layer (Stephen and Rao 1980). *Sarsarietellus* species occur mainly in deep-waters, near the sea floor, except for *S. orientalis* (Soh et al. 2013). Both *Sarsarietellus* taxa could not be assigned to any of the four described species of the genus because of the difference in the shape the female P5.

Two of the three species of the genus *Cephalophanes*, *C. tectus* (Esterly, 1911) and *C. frigidus* Wolfenden, 1911 are recorded in the eastern Pacific. *Cephalophanes refulgens* is known to be distributed only in the Japan sea. The examined material of *Cephalophanes* sp. presents more morphological similitude with *C. tectus*, but the coxal interior spinules and the ornamentation on the anterior Exp margin are different. Other differences are in the P2 Enp ornamentation, and Enp1 bears strong spinules, unlike in *C. tectus* (see Tanaka and Omori 1992). Species of this genus are clearly bathypelagic and present adaptations to feed on bioluminescent organism (Nishida et al. 2002). A record of *Cephalophanes* was made by Wiebe et al (1988), but it was not identified at species level.

Xanthocalanus sp. is another case of taxonomical uncertainty. There are currently 84 accepted species of this genus (Walter and Boxshall 2024), three of these recorded for the Mexican Pacific (Razouls et al. 2024). Our material of *Xanthocalanus* sp. presents morphological resemblance with *Xanthocalanus harpagatus* Bradford and Wells, 1983, in particular the number and disposition of the brush setae of the Mx2, the shape of P5 in the female, and the disposition of the setae on the Mp basis. However, there are differences in the ornamentation of the female P5 and in the shape of the teeth in the md gb; thus, this is probably either one new record for the Mexican Pacific or an undescribed species. The only species of this genus recorded in the Mexican Pacific are *Xanthocalanus pinguis* Farran, 1905, *X. pulcher* Esterly, 1911 and *X. similis* Esterly, 1906, according to Razouls et al (2024).

Paraeuchaeta copleyae is believed to be endemic to the Gulf of California. There are up to 35 species of *Paraeuchaeta* Scott A., 1909 for the ETP (Razouls et al. 2024), eight in the Gulf of California (Suárez-Morales and Gasca 1998). This genus presents mostly mesopelagic-bathypelagic species (Razouls et al. 2024). *Paraeuchaeta* presents the combination of the following characters: appendicular caudal seta geniculated; first inner lobe of Mx1 with 1 anterior, 9 marginal, and 3 posterior setae; three first inner teeth of md gb well-developed and queratinized in the female; md gb of the male reduced; basis of MP with heavily armed setae and P2 Exp3 with a protrusion between the third and second external lobes. *Paraeuchaeta copleyae* can be distinguished from other species of the genus based on the shape of the serrated lamella and the digitiform process of P5 Exp2. A male juvenile (ICML-EMU-xxxxx) of *Paraeuchaeta* was found, but presented cephalic appendages similar to the female. This male presents a md gb, P2 Exp3 and armature-ornamentation of cephalic appendages very similar to those of the female of the *P. malayensis* species group (Park 1993a), although the shape (and presence) of the fifth pair of leg indicate that this is indeed a male. *Paraeuchaeta copleyae* was first described from samples collected below 1500 m of depth (Park 1993a). *Lucicutia hulsemannae* is also believed to be endemic, this one to the Mexican Pacific (Markhaseva and Ferrari 2005), although this is the most extense distribution ever recorded for this species. *Centraugaptilus macrodus* is another species with restricted distribution in the western coast of California, but it has not been previously included in species lists for either the Gulf of California or the Mexican Pacific.

A description of a monstrilloid species resulted from this work: *Monstrilla* sp. nov., distinguished by a unique combination of characters including: 1, lack of eye-related structures; 2, strong, thick antennules with segments 2–4 partly fused; 3, antennule armature with strongly developed apical elements on segment 5 and spinous processes or modified setae on segments 2–5; 4, fifth legs bilobed, exopodal lobe armed with two apical setae, endopodal lobe digitiform, unarmed. Gulf of California monstrilloids currently includes 5 species: *Monstrilla gibbosa* Suárez-Morales and Palomares-García, 1995, *Siponomonstrilla spinosa* Suárez-Morales, 2019, *Cymbasoma californiense* Suárez-Morales and Palomares-García, 1999, and *Monstrilla leucopis* Sars, 1921 (Suárez-Morales and Velázquez-Ornelas 2023). Both of these records are further discussed in chapters VIIIA and VIIIB.

7a.5.2. *Distribution and zoogeographic affinities of the pelagic copepods collected during the TALUD project*

As expected, most calanoid species recorded during the TALUD cruises are considered to be tropically or sub tropically distributed. There were also species mainly distributed towards the northern pole (e.g., *Gaetanus kruppii*, *Megacalanus frosti*, *Pseudhaloptilus pacificus*) or the southern pole (e.g., *Augaptilus cornutus*, *Heterostilytes major*, *Pseudochirella obesa*). Most pelagic copepods are widely distributed in the world oceans because the marine boundaries are not strong enough to limit their distribution (Acha et al. 2020), but a change in the composition among different ecoregions can be noticed if the spatial variation in the copepod community is analyzed. There were plenty of species that were only observed either in the GC or in the MPT samples. For example, heterorhabdids and some augaptilids (i.e., *Augaptilus cornutus*, *Euaugaptilus longimanus*, *E. austrinus*) were only found in the GC, while *Centraugaptilus macrodus*, *Cephalophanes* sp., or *Sarsarietellus* sp. 2 were only found in the MPT. However, most were extremely rare in terms of abundance and frequency (i.e., 1 or 2 specimens in total), thus it is not possible to discard the possible occurrence in both areas.

CLUSTER analysis results show the GC and the MPT as different groups, but the similitude of the EGC with the MPT was much higher than with the SGC or the CGC. Large discrepancies in the collection dates of each cruise represents a high uncertainty source, since marine boundaries tend to vary along time (Acha et al., 2019). These differences in the collection season or year are accompanied by seasonal and spatial shift in the composition of the marine communities (see Peterson and Keister 2003; Raybaud et al. 2008; Palomares-García et al. 2013; Deschamps et al. 2023). Nevertheless, the conformation of the groups maintained an expected pattern, given the particular oceanographic conditions in the Gulf of California (see Álvarez.Borrego and Galindo 1974; Lavín et al. 1995; Angulo-Campillo et al. 2011; Lavaniegos et al. 2012; Lavín et al. 2014).

Although significant spatial variation was observed among the sampling areas during this study, the uncertainty sources are too many to consider these statistical analyses. Differences in terms of the season, year, depth, and sampling methods would not allow to analyze the real latitudinal variation of the copepod community, but this appears to show a pattern based on the constant presence of certain species inside the Gulf: there was a clear higher dominance of *Rhincalanus nasutus* in all the samples of the Gulf of California, but this species was almost entirely replaced by *Eucalanus hyalinus* towards the EGC and virtually absent in the MPT. Both species are active vertical migrators, thus presenting wide vertical distribution range (Deevey and Broks 1971; Harding 1974). The presence and abundance of *Paraeucalanus sewelli* was not significant in the MPT, while it was a dominant species in the Gulf. This spatial variation in the copepod communities could be attributed to the strong differences in water salinity and temperature observed among the California Current, the Gulf of California and the warm Equatorial waters (see Álvarez-Borrego and Schwartzlose 1979; Fiedler and Tadler 2006; Portela et al. 2016). The effect of seasonality strongly affects the spatial variation of the copepod communities at species level, but it is not as marked at family level, even at different times of the year or among different years because copepod families can be represented by several species, but are hardly completely replaced (González et al. 2020). The family-level arrangement of the copepod samples in the study area revealed a very similar, but less marked, pattern, still allowing to identify the subgroups conformed by the EGC and the MPT zones, as well as high similitude among the CGC and SGC samples. Thus, the general pattern of the spatial variation of the copepods remained more or less solid in despite of the seasonality, the interannual variation or the differences in the sampling efforts.

If only meso and bathypelagic species are considered, *Lucicutia hulsemannae* was the most abundant and frequent species, collected at least in one station during each cruise (67% of the samples), averaging a contribution of 3.8% of the total abundance. This species is described by Markhaseva and Ferrari (2005) as a relatively large copepod (5.8-6.3 mm) that is distributed in the ETP; it was later recorded by Feng and Liu (2019) in the south China sea and it is known to occur below 600 m of depth (Markhaseva and Ferrari 2005). *Euaugaptilus angustus* is known to be distributed worldwide and to occur between 600 and 1400 m of depth (Matthews 1972). *Metridia princeps* is one of the only deep-water calanoid with previous records in the Gulf of California and, although it is currently considered to be a cosmopolitan species, its distribution range could be overestimated due to confusion with other large metridinid species (Markhaseva 2001). *Pseudhaloptilus pacificus* is also a widely distributed species, previously recorded for the Mexican Atlantic (Campos-Hernández and Suárez-Morales 1994; Razouls et al. 2024). *Paraheterorhabdus compactus* was not found in samples collected in the MPT, and it has not been recorded there yet (Razouls et al. 2024); it is known to occur between 500 and 2000 m depth (Deevey and Broks 1971; Harding 1974). *Pseudochirella obesa* was very frequent, but mostly juvenile individuals were found; it is considered a meso-bathypelagic species, but it has also been recorded near the surface (Markhaseva 1996).

The lack of records of these common deep-water species can be partly explained by the presence of a very wide OMZ in most of the ETP. Mimimum oxygen values have been recorded mostly in the 300-500 m depth range (< 4.5 μmol kg^{-1}) (Karstensen et al. 2008). OMZs affect vertical distributions of zooplankton, reducing biomasses and abundances of mesozooplankton above and below the OMZs cores (Wishner et al. 2008). Although the OMZ is an ecological barrier for pelagic organisms, a significant number of taxa can perform diel vertical migration (DVM) standing severe hypoxia, but some copepod taxa (especially small species) appear to be restricted to shallow, well-oxygenated waters (Tutasi and Escribano 2020). Eucalanids have been described as capable to realize DVM trough the OMZ core (Hidalgo et al. 2005), thus their dominance in deep-water samples is not surprising. *Lucicutia hulsemannae*, the most common deep-water species in this survey, presents an inverse response to low-oxygen conditions in relation with temperature, increasing its tolerance when temperature increases (Wishner et al. 2020). This species is considered as a low-oxygen indicator, actively growing and developing in the extreme low-oxygen parts of the OMZ (Wishner et al. 2000; 2013; 2020).

7a.6. *Conclusions*

Of the 85 species recorded during the TALUD cruises, 36 are known to occur in meso and bathypelagic waters. Twenty-seven of these deep-water species are first records for the Gulf of California, and as many as twenty-five are new for the Mexican Pacific. The most abundant and frequent deep-water species were *Lucicutia hulsemannae*, *Euaugaptilus angustus*, *Metridia princeps*, *Pseudhaloptilus pacificus*, *Paraheterorhabdus compactus*, *Pseudochirella obesa*, and *Megacalanus frosti*. None of these species are known to be distributed in epipelagic waters of the Gulf of California or the Mexican Pacific. *Arietellus* sp., *Cephalophanes* sp., *Sarsarietellus* sp. 1 and sp. 2, and *Xanthocalanus* sp. present several differences to the described species of these genera; all specimens are mature. The pattern of the spatial variation was similar in terms of species-level and family-level composition, being the GC significantly different than the MPT; the EGC was actually more similar to the MPT than to the CGC or the SGC, particularly at species level. This work increases the copepod list for the Mexican Pacific by almost 8% and increases the known distribution of 11 species in the study area.

7a.7. *References*

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VIIB. FIRST RECORD OF *Monstrilla leucopis* G. SARS, 2021 (COPEPODA, MONSTRILLOIDA, MONSTRILLIDAE) FROM THE EASTERN PACIFIC

Publicado en Crustaceana: Suárez-Morales E and Velázquez-Ornelas KE 2023. First record of *Monstrilla Leucopis* G.O. Sars, 1921 (Copepoda, Monstrilloida, Monstrillidae) from the eastern Pacific. *Crustaceana*, 96 (11-12): 1183–1190.

8b.1.1. *Abstract*

Members of the copepod order Monstrilloida Sars, 1901 are endoparasites of benthic marine invertebrates. Non-feeding, planktonic adult males and females of different species are known mostly from coastal habitats including estuaries, coastal lagoons, coral reefs (Sale et al. 1996; Suárez-Morales 2001) and rocky shore tidepools (Cruz et al. 2021). Deep oceanic waters were an unlikely source of monstrilloid specimens for taxonomic studies, mainly because of their limited swimming capacity and their need to remain close to their potential benthic hosts (Suárez-Morales 2001, 2011). The taxonomic examination of an adult female *Monstrilla* collected incidentally with a deep-water plankton net operated at a depth range of 0-1360 m in oceanic waters (65-80 km from the coastline) off the southern Gulf of California, eastern Pacific, allowed us to recognize this individual as *Monstrilla leucopis* Sars, 1921, previously known only from northern Europe; this finding is documented herein, including illustrations of its main distinctive characters. This is the first published record of this monstrilloid copepod from the eastern Pacific, the first of the genus from deep oceanic waters, and the third record of *Monstrilla* in the Gulf of California. A brief morphological account of *M. leucopis* is provided together with a key to related species.

7b.1.2. *Resumen*

Los copépodos del orden *Monstrilloida* Sars, 1901 son organismos endoparásitos de invertebrados bentónicos marinos. Los machos y hembras adultos no se alimentan, su forma de vida es planctónica. Estos se distribuyen principalmente en ambientes costeros, como son estuarios, lagunas costeras, arrecifes de coral o lagunas de marea. El océano profundo es una fuente poco convencional para obtener especímenes de monstriloides para estudios taxonómicos, principalmente debido a la poca capacidad natatoria y su necesidad de permanecer cerca de especies bentónicas que puedan utilizar como huéspedes. La examinación taxonómica de una hembra adulta del género *Monstrilla* Dana, 1849,

recolectada de manera incidental con una red de arrastre en aguas profundas, en el intervalo de los 0 a los 1360 m y en aguas oceánicas (a 65-80 km de la línea de costa) en el sur del golfo de California, Pacífico Este, nos permitió reconocer a este individuo como *Monstrilla leucopis* Sars, 1921, previamente conocido solamente para el norte de Europa; este hallazgo se documenta aquí con ilustraciones de los principales caracteres distintivos. Este es el primer registro ilustrado para esta especie de copépodo monstriloide para el Pacífico Este, el primer registro del género en aguas oceánicas profundas y el tercer registro del género *Monstrilla* en el golfo de California. Se presenta una breve diagnosis de *M. leucopis*, junto con una clave para las especies relacionadas.

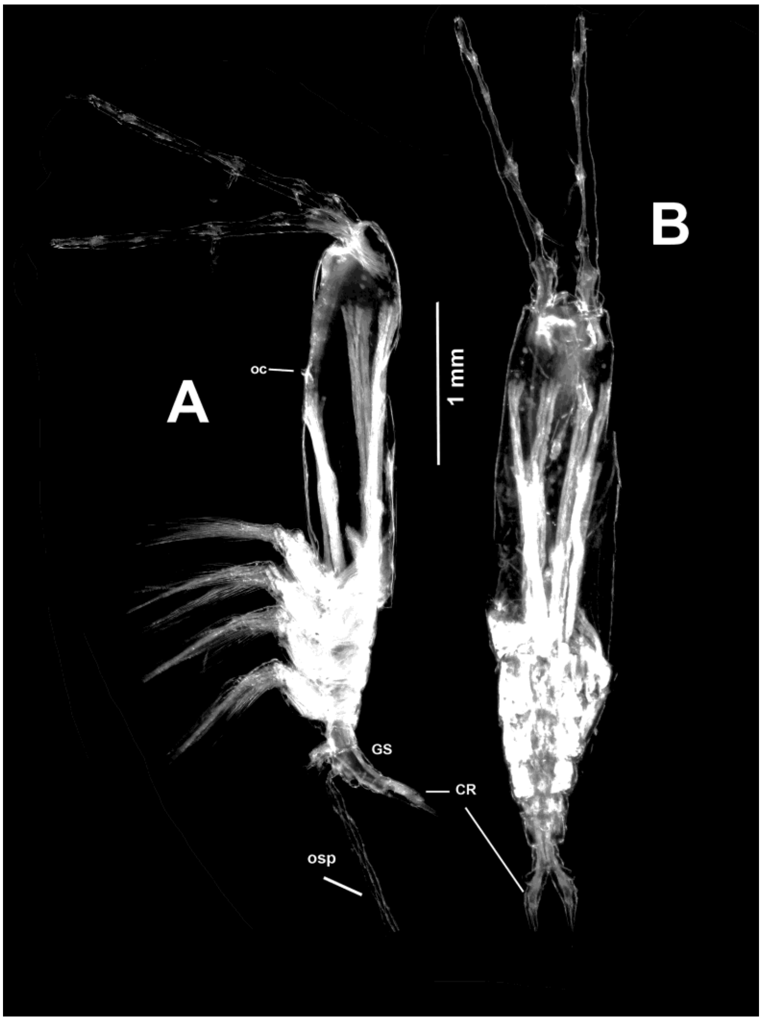

Fig. 1. *Monstrilla leucopis* Sars, 1921 adult female from the Gulf of California. A, Habitus, lateral view; B, same, dorsal view. CR, caudal rami; GS, genital double-somite; OC, oral cone; OSP, ovigerous spines.

7b.2. *Systematics*

Order Monstrilloida Sars, 1901

Family Monstrillidae Dana, 1849

Genus *Monstrilla* Dana, 1849

Monstrilla leucopis Sars, 1921 (Figs. 1-4)

Material examined. Adult female, partially dissected, semi-permanent slides mounted in glycerin (ECO-CHZ-011859). Zooplankton net (maximum depth = 1360 m), southern Gulf of California, Mexico, eastern Pacific (25°53'15''N 110°10'08''W), collected March 17, 2001.

Diagnosis of female. Large (3.23 mm) female *Monstrilla* with slender cylindrical cephalothorax representing about 60% of total body length, forehead flat, eye-related structures poorly developed. Antennules slender, about 80% as long as cephalothorax, first segment unarmed; segments 2-4 fused, intersegmental mar- gins marked by weak constrictions, setal groups (sensu Grygier & Ohtsuka 1995) of segments 1-3 recognizable; segments 4-5 fused, with reduced armature, integumental patches of unknown function distributed along antennule surface. Apical element 62 with small proximal spur. Ovigerous spines reaching beyond distal end of caudal setae. Genital double-somite with rounded ventral protuberance on distal margin, somite lacking dorsal suture. Fifth pediger with integumental ridges on dorsal surface; fifth leg with single robust lobe armed with two subequally long terminal setae. Caudal rami with five setae.

Male. As described by Sars (1921) and redescribed by Suárez-Morales (2010).

Host. Unknown.

Remarks. The female specimen from the Gulf of California is assignable to *Monstrilla leucopis* Sars, 1921 because its possession of: (1) long, slender antennules, representing between 40 and 50% of total body length and 65-80% of cephalothorax length; (2) antennule segments 2-5 fused, first segment unarmed; (3) fifth pedigerous somite with rugose dorsal surface; (4) fifth leg armed with two terminal setae; (5) caudal rami with five setae (see Suárez-Morales 2010). *Monstrilla leucopis* was originally described from Kvaløy, Norway by Sars (1921). It was successively considered as a synonym of *M. conjunctiva* Giesbrecht, 1902 and *M. anglica* Lubbock, 1857 (Sewell 1949; Isaac 1974, 1975). More recently, *M. leucopis* type material was examined by Suárez-Morales (2010), who concluded that *M. leucopis* is a valid species and that most records outside Norway may be questionable, like that of Wilson (1950) from the Philippine Archipelago and Sewell's (1949) Indian Sea records. The status of Isaac's (1974, 1975) records from Britain and the Mediterranean (as *M. leucopsis*) remain uncertain (Suárez- Morales 2010; Suárez-Morales & Grygier 2021). The nominal species was mentioned from the western Caribbean by Suárez- Morales & Gasca (1990) and the same specimens were then recognized as an undescribed species, *M. elongata* Suárez-Morales, 1994. Overall, the species' distributional range appears to be restricted to North European waters (Suárez-Morales 2010), thus highlighting the discovery of this species in oceanic waters of the Gulf of California. This species belongs to a group of congeners sharing relatively long, poorly segmented female antennules: the most widespread are *M. longiremis* Giesbrecht, 1893 and *M. longicornis* Thompson, 1890 (= *M. clavata* Sars, 1921), but *M. grandis* Giesbrecht, 1891, *M. elongata* Suárez-Morales, 1994, and *M. grygieri* Suárez-Morales, 2000 are also related species sharing these characters.

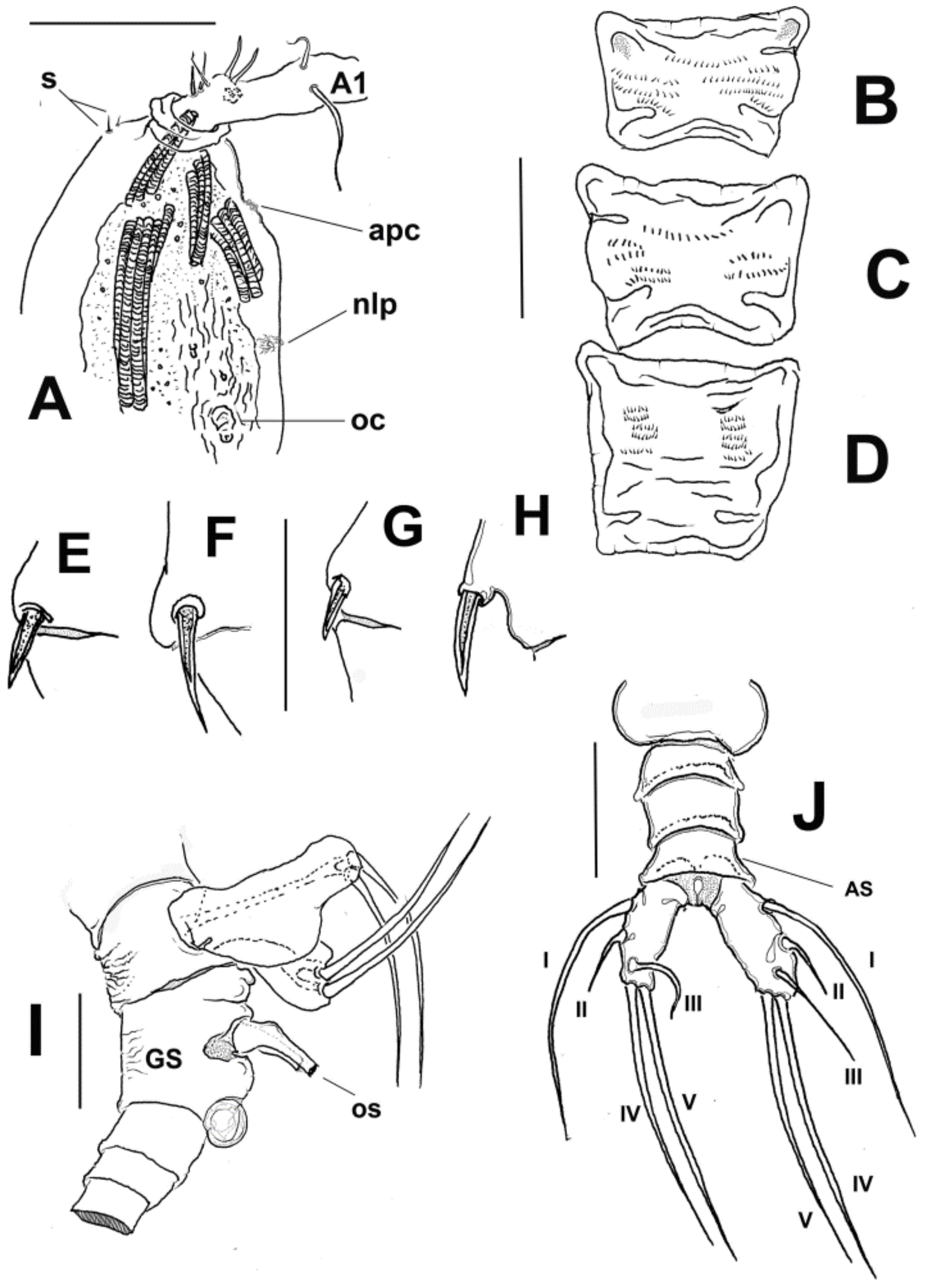

Fig. 2. *Monstrilla leucopis* Sars, 1921 adult female from the Gulf of California. A, anterior part of cephalothorax, lateral view; B-D, coxal sclerites of legs 2-4 showing ornamentation; E-H, outer spine of first exopodal segment of legs 1-4; I, urosome, lateral view; J, same, dorsal view. A1, antennule; s, sensilla; apc, anteriormost pore cluster; nlp, nipple-like process; oc, oral cone. Scale bars A, I, J = 225 µm, B-D = 50 µm, E-H = 25 µm.

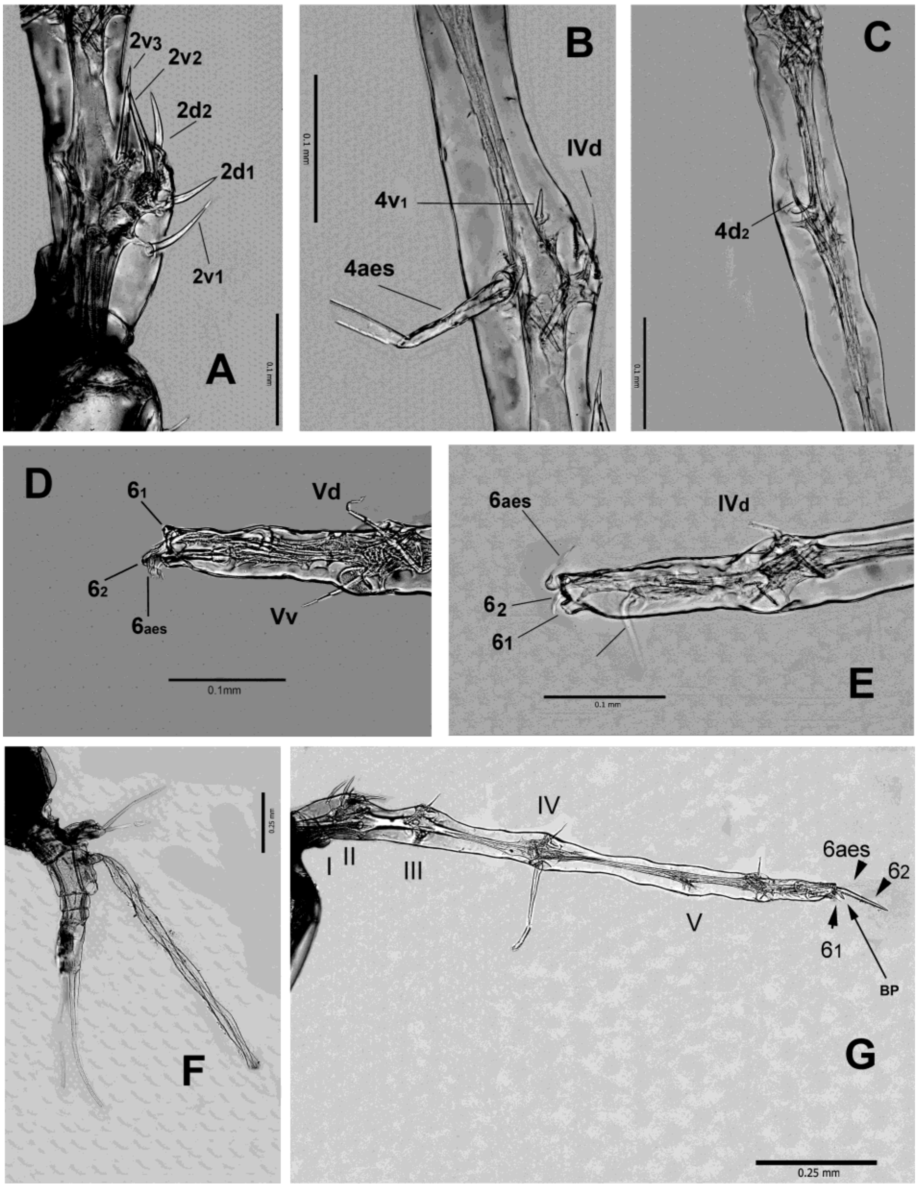

Fig. 3. *Monstrilla leucopis* Sars, 1921, adult female from the Gulf of California, digital photos. A, First and second antennule segments showing setal groups following Grygier & Ohtsuka's (1995) nomenclature; B, fourth setal group on putative segment IV; C, isolated element (4d2) of fourth setal group; D-E, distal segment with apical armature and elements (sensu Grygier & Ohtsuka, 1995) of segment V; F, urosome with ovigerous spines, lateral view; G, right antennule, dorsal view showing putative segments I-V. 2v1, 2v2, 2v3, 2d1, 2d2 IIIv, IIId, 3, 4v1, IVd, 4aes, 2v1, 2d1, 2v2, 2v3, 2d2, IVd, Vd, Vm, IVv, 5, 6aes, 61, 62, individual setal elements identified following Grygier & Ohtsuka's (1995) nomenclature; I-V, approximate position of antennule segments; BP, basal process on element 62.

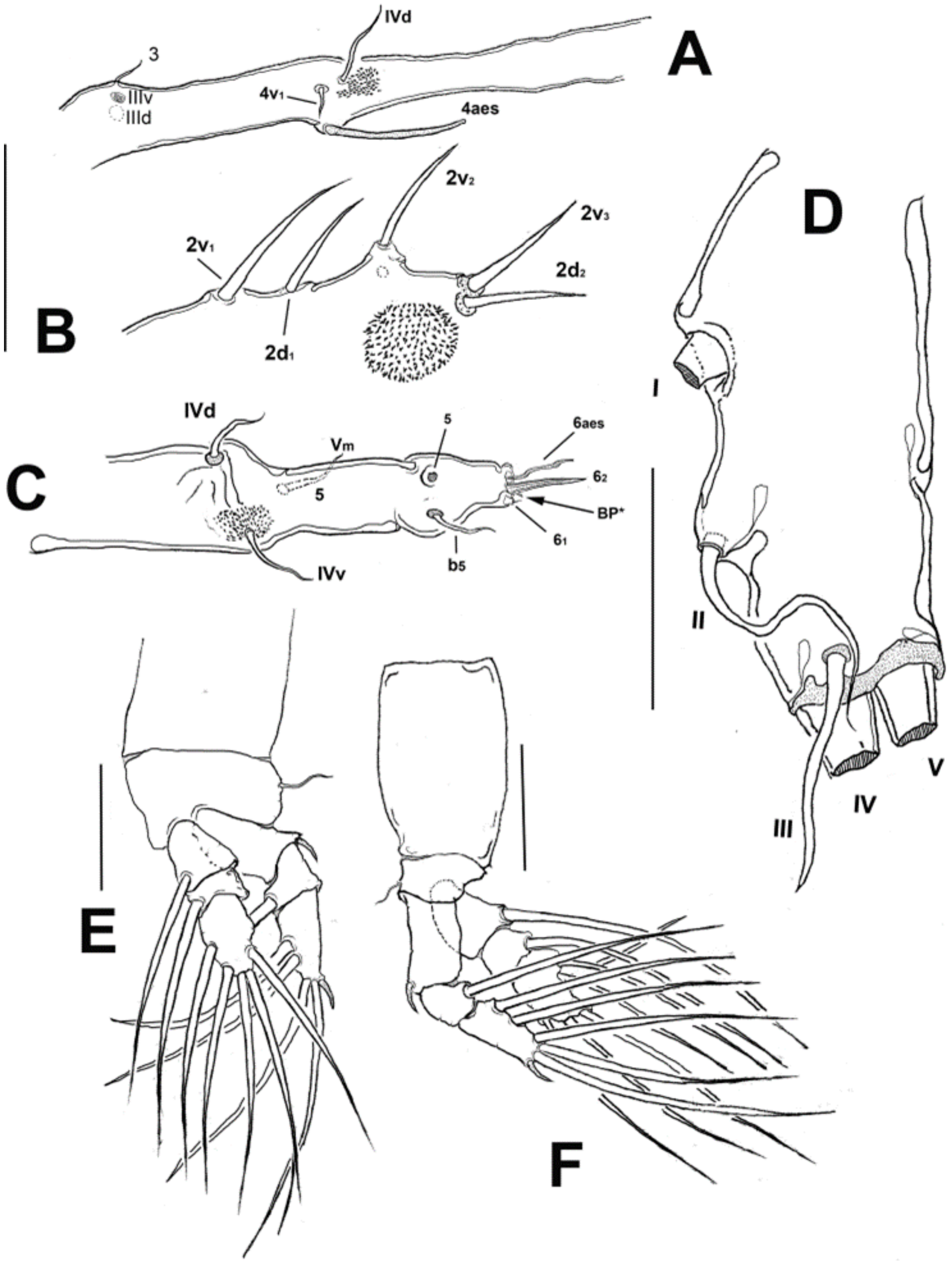

Fig. 4. *Monstrilla leucopis* Sars, 1921 adult female from the Gulf of California. A, Antennule segmental groups III and IV showing spinule patch; B, antennule segmental group II; C, distal antennule armature with patch; D, left caudal ramus, dorsal view; E, leg 1, anterior view; F, leg 2. I-V, caudal setae numbering; IIIv, IIId, 3, 4v1, IVd, 4aes, 2v1, 2d1, 2v2, 2v3, 2d2, IVd, Vm, IVv, 5, 6aes, 61, 62, individual setal elements identified following Grygier & Ohtsuka's (1995) nomenclature; BP, basal process. Scale bars: A-C = 100 µm, D = 75 µm, E, F = 100 µm.

7b.3. *Key to the identification of females of some Monstrilla species with elongate, poorly segmented antennules*

1. Fifth leg with 5 setae…………………………………......…*M. grandis* Giesbrecht, 1891

1A. Fifth leg with 4 setae………………………………………………………………………...2

2. Antennule with element 1 (sensu Grygier & Ohtsuka, 1995) present…………………3

2A. Antennule lacking element 1…………………………………………………………...5

3. Fifth leg with 1 inner and 3 distal setae………………………………………………..4

3A. Fifth leg with two inner, two outer setae……………....*M. grygieri* Suárez-Morales, 2000

4. First swimming leg with hook-like process on inner margin………………………………………………………... *M. longiremis* Giesbrecht, 1893

4A. First swimming leg basipod lacking hook-like process………………………………………………………..*M. longicornis* Thompson, 1890

5. Antennule with rounded integumental processes or spinule patches distributed along its surface, antennule lacking element 1 (sensu Grygier & Ohtsuka, 1995)…………………………………………………………………*M. leucopis* Sars, 1921

5A. Antennule lacking integumental processes along its surface, antennule lacking element 1………………………………………………………... *M. elongata* Suárez-Morales, 1994

Particularly, *Monstrilla leucopis* and *M. longiremis* share the same body pro- portions and type of antennule, with segments 2-5 fused, but according to Sars (1921) and Suárez-Morales (2010), antennules are relatively longer (60% of total body length) in the latter than in the former (38%) species. Yet, these two species can still easily be distinguished by several characters: (1) in *M. longiremis* the fifth leg is armed with four setae, three on the exopodal lobe, one on the inner endopodal lobe (Sars 1921; Huys & Boxshall 1991), vs. only two setae on the exopodal lobe and an unarmed endopodal lobe in *M. leucopis*; (2) in *M. leucopis* the first antennulary segment is unarmed, whereas element 1 (sensu Grygier & Ohtsuka 1995) is present in *M. longiremis* (cf. Sars 1921; Huys & Boxshall 1991); (3) the cephalothorax is relatively robust in *M. longiremis*, vs. a slenderer body in *M. leucopis*; (4) in *M. leucopis* the antennules carry several rounded areas or integumental windows or spinule patches of unknown function, distributed along its surface (see Suárez-Morales 2010; present specimen); these patches are absent in *M. longiremis*; (5) in *M. longiremis* the genital double-somite has a suture on its dorsal surface (Sars 1921), vs. suture lacking in *M. leucopis* (cf. Suárez-Morales 2010). The actual depth of collection of this specimen is uncertain, but its poor eye development suggests that it was collected below the oceanic photic zone. Only two other monstrilloids of the genus *Cymbasoma* have been caught from mesopelagic depths (Suárez-Morales & Mercado-Salas 2023).

7b.4. *References*

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VIIIC. A NEW SPECIES OF *Monstrilla* DANA, 1849 (COPEPODA: MONSTRILLOIDA: MONSTRILLIDAE) FROM THE GULF OF CALIFORNIA, MEXICO

7c.1.1. *Abstract*

Monstrilloid copepods are protelean endoparasites of benthic invertebrates, including polychaetes, mollusks, and sponges. Their free-living adult forms are known mostly from coastal systems, estuaries, coral reefs, shallow neritic waters, and rocky tidepools. Aside of recently observed material from the North Atlantic collected in oceanic waters within the 120–300 m depth range, there are no documented records of monstrilloids from fully oceanic waters worldwide. Based on deep-water (700–750 m) biological samples obtained from the southern Gulf of California, Pacific coast of Mexico, a new species of the monstrilloid copepod genus *Monstrilla* Dana, 1849 is described based on an adult female collected with a n epibenthic sledge. *Monstrilla* n. sp. is distinguished by a unique combination of characters including: (1) lack of eye-related structures, (2) strong, thick antennules with segments 2–4 partly fused, (3) antennule armature with strongly developed apical elements on segment 5 and spinous processes or modified setae on segments 2–5, (4) fifth legs bilobed, exopodal lobe armed with two apical setae, endopodal lobe digitiform, unarmed. The species has some affinities with other surface *Monstrilla* like *M. helgolandica* Claus, 1863, *M. hamatapex* Grygier & Ohtsuka, 1995, *M. mariaeugeniae* Suárez-Morales & Islas-Landeros, 1993, and *M. leucopis* Sars, 1921. This finding in oceanic waters significantly adds to our knowledge of the habitat range of this copepod order. This is the fourth record of species of the order Monstrilloida in the Gulf of California.

7c.1.2. *Resumen*

Los copépodos monstriloides son endoparásitos proteleanos de invertebrados bentónicos como poliquetos, moluscos y esponjas. Sus formas adultas son de vida libre y se conocen principalmente en sistemas costeros, estuarios, arrecifes de coral, aguas neríticas poco profundas y pozas de marea. Aparte de material observado recientemente en el Atlántico norte y recolectado en aguas oceánicas en el intervalo 120–300 m, no hay registros documentados de monstriloides en aguas totalmente oceánicas a nivel mundial. Con base en muestras biológicas de aguas profundas (700–750 m) obtenidas en el sur del Golfo de California, México, se describe una nueva especie de *Monstrilla* Dana, 1849 con base en una hembra adulta recolectada con un trineo epibentónico. *Monstrilla* sp. n. se distingue por una

combinación única de caracteres que incluyen: (1) ausencia de estructuras oculares, (2) anténulas robustas, con los segmentos 2 a 4 parcialmente fusionados, (3) anténulas con elementos apicales notablemente desarrollados en el segmento 5 y apófisis espinosas o setas modificadas en los segmentos 2–5, (4) quinta pata bilobulada, lóbulo exopodal armado con dos setas apicales, lóbulo endopodal digitiforme, desarmado. La especie presenta algunas similitudes con otros congéneres de superficie como *M. helgolandica* Claus, 1863, *M. hamatapex* Grygier & Ohtsuka, 1995, *M. mariaeugeniae* Suárez-Morales & Islas-Landeros, 1993, y *M. leucopis* Sars, 1921. Este hallazgo en aguas profundas aumenta nuestro conocimiento sobre el hábitat de este orden de copépodos. Este es el quinto registro de especies del orden Monstrilloida en el Golfo de California.

7c.2. *Introduction*

Members of the copepod order Monstrilloida Sars, 1901 are protelean parasites of benthic marine invertebrates. Their infective nauplii and the non-feeding, reproductive adult stages are planktonic. Their postnaupliar and juvenile stages are endoparasitic on benthic polychaetes (*i.e.,* species of families Syllidae, Capitellidae, Serpulidae, Spionidae), mollusks, and sponges (Huys et al. 2007; Suárez-Morales et al. 2010, Suárez-Morales 2011, 2018; Suárez-Morales et al. 2010, 2014; Jeon et al. 2018). Overall, they have been reported chiefly from a wide range of coastal habitats including shallow estuaries, coastal lagoons, coral reefs (Suárez-Morales & Gasca 1990, Sale et al. 1996, Suárez-Morales 2001), embayments, and rocky shore tidepools (Cruz et al. 2021), but deep oceanic waters were an unlikely source of monstrilloid specimens for taxonomical studies, mainly because of their limited dispersal capacity and their need to remain close to their potential benthic hosts (Suárez-Morales 2001, 2011, 2018).

The order is currently represented by a single family (Monstrillidae) containing seven valid genera: *Monstrilla* Dana, 1849; *Cymbasoma* Thompson, 1888; *Monstrillopsis* Sars, 1921; *Maemonstrilla* Grygier & Ohtsuka, 2008; *Australomonstrillopsis* Suárez-Morales & McKinnon, 2014; *Caromiobenella* Jeon, Lee & Soh, 2018, and *Spinomonstrilla* Suárez-Morales, 2019 (Suárez-Morales et al. 2020). Currently, the genus *Cymbasoma* (78 nominal species) is the most diverse within the order (Suárez-Morales & McKinnon 2016; Razouls et al. 2023; Walter & Boxshall 2022). The taxonomic examination of an adult female monstrilloid collected incidentally with a deep-water benthic sledge operated at a depth range of 700-750 m on oceanic waters of the southern Gulf of California, Mexico, allowed us to recognize this individual as representative of an undescribed species of *Monstrilla* which is herein described following upgraded standards (Grygier & Ohtsuka 1995) and compared with its known congeneric species. This is the third published record of monstrilloid copepods from deep oceanic waters (see Suárez-Morales & Mercado-Salas in press) and the third record of *Monstrilla* in the Gulf of California.

7c.3. *Material and Methods*

An adult female of a monstrilloid copepod was collected incidentally with a mesopelagic plankton net from off the Pacific coast of northwestern Mexico, in the Gulf of California. (25°53'15" N, 110°10'08" W) on March 17, 2001. The maximum sampling depth was 750 m.

Immediately after collection, the organisms were preserved in a 4% formalin solution. The female monstrilloid individual obtained was tentatively identified as a member of the genus *Monstrilla* Dana, 1849 and sorted out for further taxonomic examination. The separation of specimens and preliminary observations were made under an Olympus SZ51 stereomicroscope and further taxonomic examination was made with an Olympus BX51 with Nomarski DIC microscope. The specimen was partially dissected, appendages (swimming legs 1–4, cephalothorax+ antennules) were separately mounted in glycerol, and slides were sealed with acrylic nail varnish; they were deposited in the collection of Zooplankton (ECO-CHZ) held at El Colegio de la Frontera Sur /ECOSUR), Unidad Chetumal, Mexico. Our taxonomic examination of this specimen allowed us to determine that it represents an undescribed species that is herein described following current descriptive standards in monstrilloid taxonomy. The general morphological terminology followed Huys & Boxshall (1991). The nomenclature of the antennular setation followed Grygier & Ohtsuka (1995).

7c.4. *Systematics*

Order Monstrilloida Sars, 1901

Family Monstrillidae Dana, 1849

Genus *Monstrilla* Dana, 1849

***Monstrilla* n. sp.** (Figs. 1-4)

Material examined. Holotype. One adult female, partially dissected, semi-permanent slides mounted in glycerin, sealed with acrylic nail varnish. Deep water sledge (depth range = 710-750 m), TALUD XVI B cruise, Station 7, southern Gulf of California, May 31, 2014.

Type locality. Southern Gulf of California (29°21'00" N, 115°39'14" W), Mexico.

Etymology. The species is pretended to be named after Dr. Michel E. Hendrickx (ICMyL-UNAM) for his sustained efforts and achievements in exploring the crustacean fauna of the Gulf of California and the Mexican Pacific. Nomen in genitive case, gender is masculine.

Diagnosis. Large (2.9 mm) female *Monstrilla* with robust cylindrical cephalothorax representing about 60% of total body length, eye-related structures absent. Antennules thick, about 1/3 as long as cephalothorax; antennulary segments 2-4 partly fused, segment 3 with modified setae, segments 2, 4 and 5 each furnished with a conical or spinous process. Segments 4-5 partly fused, last segment with distinctive apical armature. Genital double-somite with ventral surface carrying long ovigerous spines. Fifth leg bilobed, with exopodal lobe armed with two subequally long terminal setae; inner endopodal lobe digitiform, unarmed. Caudal rami with six setae, innermost (VI) shortest, outer proximal (I) longest.

Description of adult female. Body robust; shape and tagmosis as usual in female *Monstrilla* (Suárez-Morales 1994, 2023). Total body length: 2.92 mm, measured from anterior end of cephalothorax to posterior margin of anal somite. Cephalothorax length = 1.74 mm, representing about 60 % of total body length, containing thick egg mass (Fig.1A). Oral cone located 0.53 of way back along ventral surface of cephalothorax. Cephalic region with weakly produced forehead (Fig. 2A). Naupliar eye and usual adjacent pigment cups absent (Figs. 1A, B, 2A, 3D). Cephalic preoral area with ventral ornamentation comprising small nipple-like cuticular processes (nlp) with adjacent fields of integumental wrinkles and anterior cluster of pores (apc) (Figs. 3D, 4B). Antennules relatively short, thick, representing 33 % of cephalothorax length and almost 20 % of total body length (Fig. 1A). Antennular length of holotype = 588 µm. Antennules slender, indistinctly 5-segmented (1-5 in Fig. 1B), segments 1-2 separate, segments 2-3 and 3-5 partly fused (Figs. 1B, 3A); intersegmental division 2-3 marked by weak constriction. In terms of basic setal nomenclature of Grygier & Ohtsuka (1995) for armature of female monstrilloid copepod antennules, element 1 present on first segment (Fig. 3A), second segment with usual armature including elements 2v1-3, 2d1,2, and long element IId (Figs. 3A, B, 4C); segment with conical process on distal inner margin (arrowed in Fig. 3B). Purported third segment with setiform element 3, but usually long, setiform elements IIIv and IIId modified into pair of short spinous elements (Fig. 3A). Purported fourth segment armed with elements 4v1-3, long 4aes, and elements IVd and IVv (Fig. 3A), segment with spinous conical process on inner proximal margin (arrowed in Fig. 3A). Distalmost fifth segment with setal elements Vv, Vd, Vm, apical elements 61, 2, long aesthetasc 6aes, and two setal elements of the "b" group (sensu Grygier & Ohtsuka, 1995): elements b6 and b3 on outer margin, both unbranched. Segment with distal spinous process at insertion of elements 61, 2, and 6aes (Figs. 2B, 3C). First pedigerous thoracic somite incorporated into cephalothorax, succeeding three free pedigerous somites each bearing pair of biramous swimming legs. Pedigerous somites 2–4 accounting for 31.3 % of total body length (Fig. 1A). Endopodites and exopodites of swimming legs 1–4 triarticulated and with same armament pattern, except for leg 1 exopod which has one seta less on the last segment (Fig. 4D). Swimming legs 1–4 with exopods longer than endopods.

Armature formula of swimming legs as:

Legs	Basis	Endopodite	Exopodite
Leg 1	1-0	0-1; 0-1;1-2-2	I-1; 0-1; I-2-2
Legs 2–4	1-0	0-1; 0-1;1-2-2	I-1; 0-1; I-2-3

Coxae of legs 1–4 unarmed, legs medially joined by subrectangular intercoxal sclerite about 1.3 times as long as broad, with anterior margin curved; sclerites 2-4 with anterior surface ornamented with rows of minute hyaline spinules. Basis separated from coxae posteriorly by diagonal articulation. Basis of legs 2-4 lacking usual basipodal outer seta. Outer distal corner of first and third exopodal segments of swimming legs 1–4 each with short, slender spinelike element. Spine on first and third exopodal segments about 1/3 as long as carrying segments. All natatory setae lightly and biserially plumose except for spiniform seta on outer distal corner of third exopodal segments of legs 1–4, this being lightly setulated along inner side, but with continuous row of small denticles along outer margin (Fig. 4D).

Fifth legs medially conjoined, arising ventrally from posterior margin of fifth pedigerous somite, Legs represented by elongate bilobed segment with an outer (exopodal) lobe armed with two apical subequally long setae. Endopodal lobe arising from proximal inner margin of outer lobe, almost reaching its distal margin. Endopodal lobe unarmed, smooth (Fig.4A). Urosome short (length = 389 µm), consisting of fifth pedigerous somite, genital double-somite, two free abdominal somites, and caudal rami (Fig.4a, 1C). Urosome accounting for 13.1 % of total body length. Genital double somite representing about 1/3 (28.8%) of length of urosome. Preanal somite about half as long as anal somite (Fig. 4A). Medial ventral surface of genital double-somite moderately swollen, bearing long, basally conjoined ovigerous spines (Fig. 4A). Ovigerous spines moderately long, 21% of total body length, reaching half-length of caudal setae (os in Figs.1D, 4A), spines tapering at its distal half into thin, seta-like section (Figs. 1D, 4A). Caudal rami subrectangular, 1.25 times as long as wide, moderately divergent, bearing three terminal strong and subequally long setae, as usual in genus (Figs. 1D, 4A). Caudal setation complete in holotype specimen, comprising six setal elements (I-VI), with innermost seta VI being shortest, proximal outer seta (I) longest (Fig. 4A).

Male. Unknown.

Host. Unknown.

Remarks. The female of *M*onstrilla n. sp. from the Gulf of California can be readily assigned to the genus *Monstrilla* by its possession of the genus characters for females, including the presence of two somites between the genital double-somite and the anal somite, six caudal setae, and oral cone located nearly at half-length of cephalothorax ventral surface (Isaac 1975; Suárez-Morales 1994). The sampling gear used to collect this specimen was a sledge, not a plankton net, which is more efficient to capture the planktonic adult monstrilloids. Epi-mesopelagic monstrilloids (118-302 m) collected by a sledge have been reported from the North Atlantic (Suárez-Morales & Mercado-Salas in press), but the collected individuals were badly damaged despite the fact that the sledge had a plankton collector (Brandt et al. 2014). It was fortunate that the specimen recovered from the TALUD XVI-B sledge sample was in good condition for taxonomic study.

The distinctive characters of *M*. n. sp. include: 1) eyes and eye-related structures absent; 2) antennules short, robust, representing nearly 33 % of cephalothorax length, with segments 2-

5 partly fused; 3) segments 2-5 furnished with modified setae or strong spiniform processes, 3) fifth antennulary segment with remarkably long apical elements; 4) fifth leg bilobed, with digitiform endopodal lobe unarmed, exopodal lobe with 2 terminal setae; 5) six caudal setae, innermost seta (VI) being shortest, proximal outer seta (I) longest. This is the only monstrilloid copepod in which eye-related structures are absent, although weakly developed visual structures have been observed previously in deep-living species (Suárez-Morales & Mercado-Salas in press). This character contrasts with the usually well-developed naupliar eyes and adjacent structures, including highly pigmented ocelli. These organs are extremely important for the adult planktonic phase of monstrilloids, likely allowing to migrate at different light conditions in the water column (Suárez-Morales & Gasca 1990) (Suárez-Morales 2018). Deep-living monstrilloids tend to have a weak eye development, likely resulting from their aphotic habitat conditions.

There are only a few known species of the genus sharing a bilobed fifth leg with two setae on the outer (exopodal) lobe, like: *M. helgolandica* Claus, 1863, *M. hamatapex* Grygier & Ohtsuka, 1995, *M. mariaeugeniae* Suárez-Morales & Islas-Landeros, 1993, Davis, 1949, and *M. leucopis* Sars, 1921. The new species differs from *M. helgolandica*, *M. leucopis* and *M. hamatapex* by having a long, digitiform endopodal lobe, which is absent in these three species (Grygier & Ohtsuka 1995; Sars 1921; Chang 2014). Like *M. wandelii* Stephensen, 1913, *M. mariaeugeniae* and *M. nichollsi* Davis, 1949 have a small, subtriangular, unarmed endopodal lobe (Suárez-Morales & Islas-Landeros 1993; Park 1967; Nicholls 1944), thus diverging from the elongate, digitiform endopodal lobe observed in *M. hendrickxi* n. sp. *Monstrilla nichollsi* was originally described and illustrated as *Monstrilla* n. sp. by Nicholls (1944), but it was named by Davis (1949) based solely on Nicholl's (1944) illustrations, which include a drawing of the fifth leg (Nicholls 1944, fig. 26), thus allowing me to add *M. nichollsi* to the group of congeneric species with two exopodal setae on the fifth leg exopodal lobe.

A partly or completely fused antennule segments 2-5 is found in several species of *Monstrilla*, like: *M. ilhoii* Chang, 2016, *M. mariaeugeniae*, *M. satchmoi* Suárez-Morales & Dias, 2001, *M. grandis* Giesbrecht, 1891, *M. gracilicauda* Giesbrecht, 1893, and *M. elongata* Suárez-Morales, 1994. None of these species has the remarkable development of apical elements 61, 62, and 6aes (sensu Grygier & Ohtsuka 1995) observed in the new species *Monstrilla* n. sp. The only illustration of *M. nichollsi* antennules (see Nicholls 1944) show a very long apical element on its fifth segment, probably corresponding to the aesthetasc 6aes. Overall, no other congeneric species has modified setal elements on segment 3 or large spiniform or conical processes on segments 2, 4, and 5 like those described in the new species. This is the fifth record of species of the copepod order Monstrilloida in the Gulf of California, after *Monstrilla gibbosa* Suárez-Morales & Palomares-García, 1995, *Spinomonstrilla spinosa* Suárez-Morales, 2019 (originally recorded as *Monstrilla spinosa*), Cymbasoma californiense Suárez-Morales & Palomares-García, 1999, and recently *M. leucopis* Sars, 1921 (Suárez-Morales & Palomares-García 1999; Suárez-Morales & Vásquez-Yeomans, 2004; Suárez-Morales & Velázquez-Ornelas 2023).

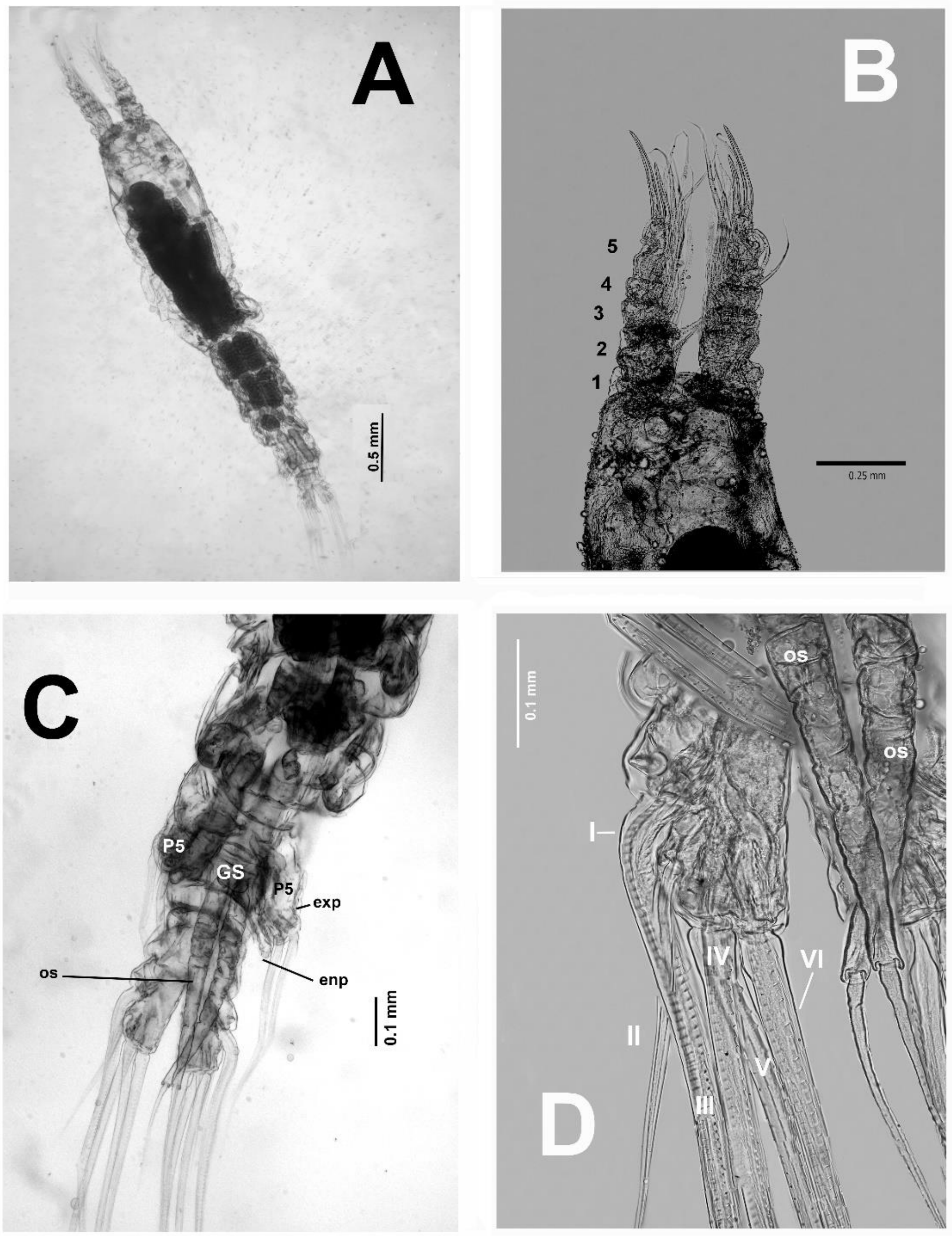

Figure. 1. *Monstrilla* n. sp., from the Gulf of California, holotype female, digital photos. A. habitus, ventral view: B. anterior half of cephalothorax with 5- segmented antennules (1-5); Urosome, showing ovigerous spines (os) and fifth legs (P5) endopodal (enp) and exopodal (exp) lobes, ventral view. D. caudal rami showing setae I-VI and ovigerous spines (os), ventral view.

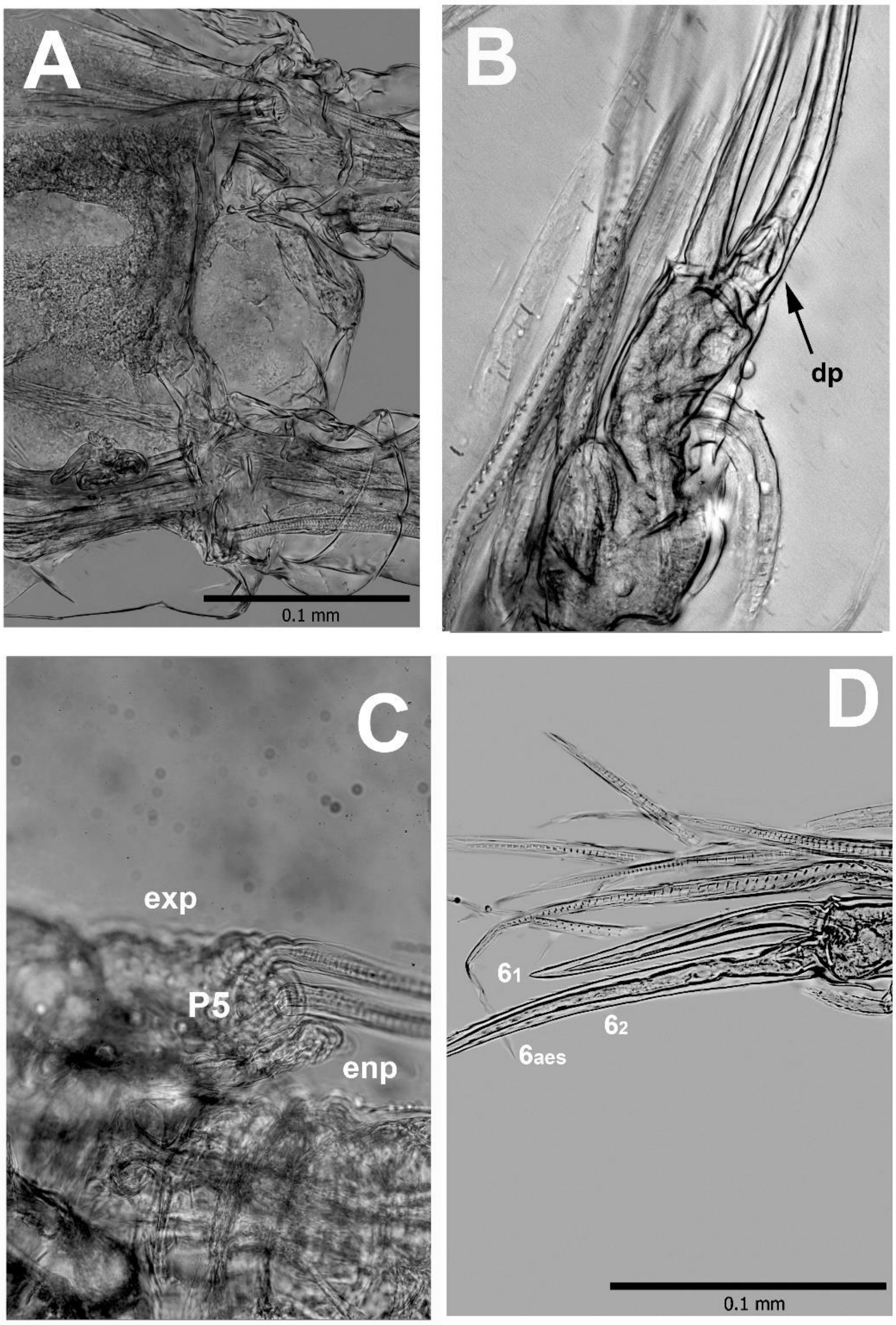

Figure 2. *Monstrilla* n. sp., from the Gulf of California, holotype female, digital photos. A, anterior part of cephalothorax showing weakly produced forehead and lack of eyes. B, distal segment of antennule showing setation and distal process(dp) arising from distal margin, C, fifth leg (P5) showing exopodal (exp) and endopodal (enp) lobes, ventral view. D, apical elements 6_1, 6_2, 6 aes) of fifth antennulary segment.

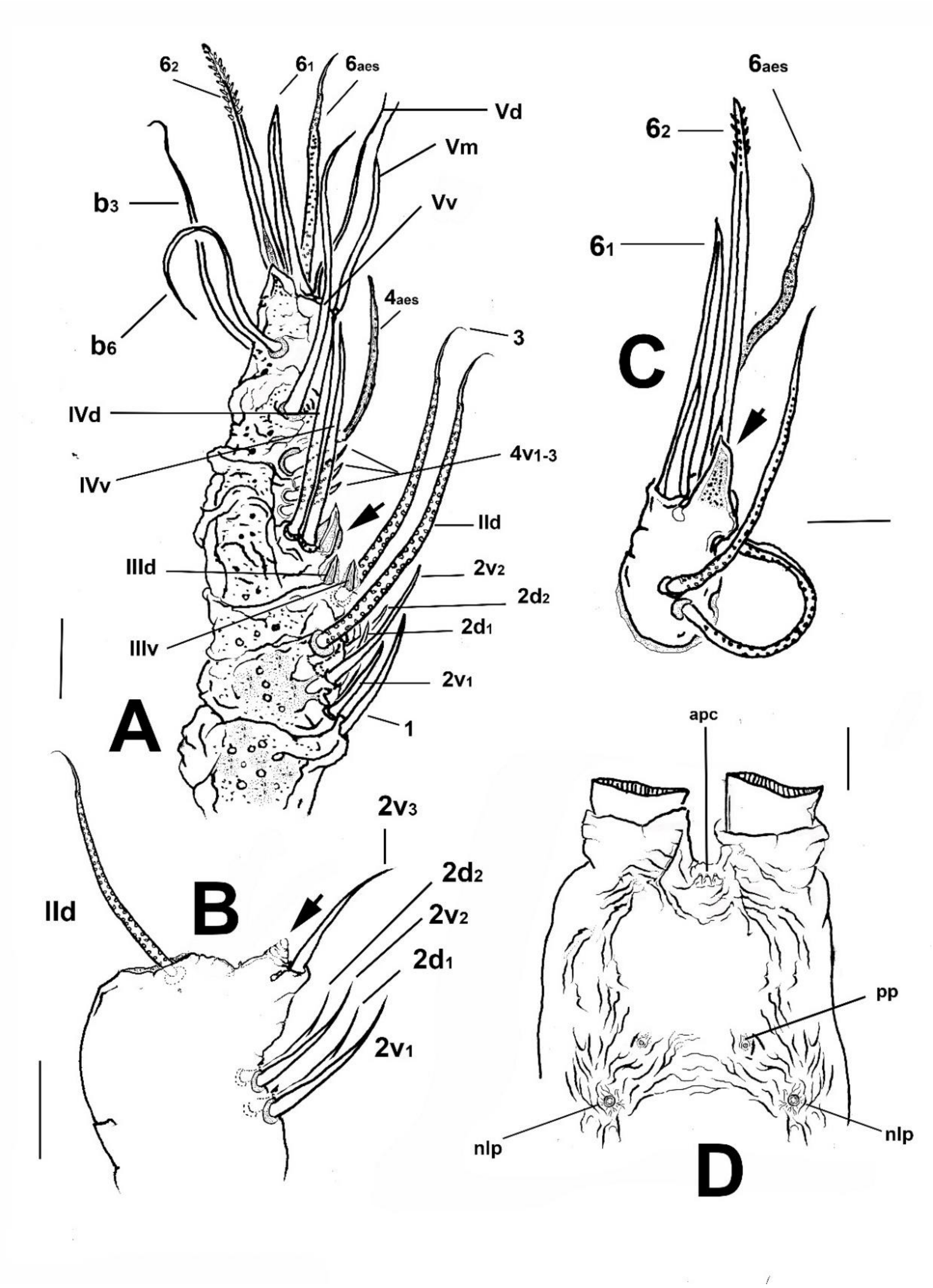

Figure 3. *Monstrilla* n. sp., from the Gulf of California, holotype female. A, antennule showing setation pattern following Grygier & Ohtsuka's (1995) nomenclature, ventral view. B, setation pattern of second antennulary segment following Grygier & Ohtsuka's (1905) nomenclature and inner distal conical process on segment (arrow), ventral view. C, distal (fifth) segment of antennule showing setation and distal process(arrow) arising from distal margin, ventral view. D, anterior 1/3 of cephalothorax showing integumental ornamentation with nipple -like processes (nlp), anterior pore cluster (apc), and preoral pores(pp). Scales A-D = 100 µm.

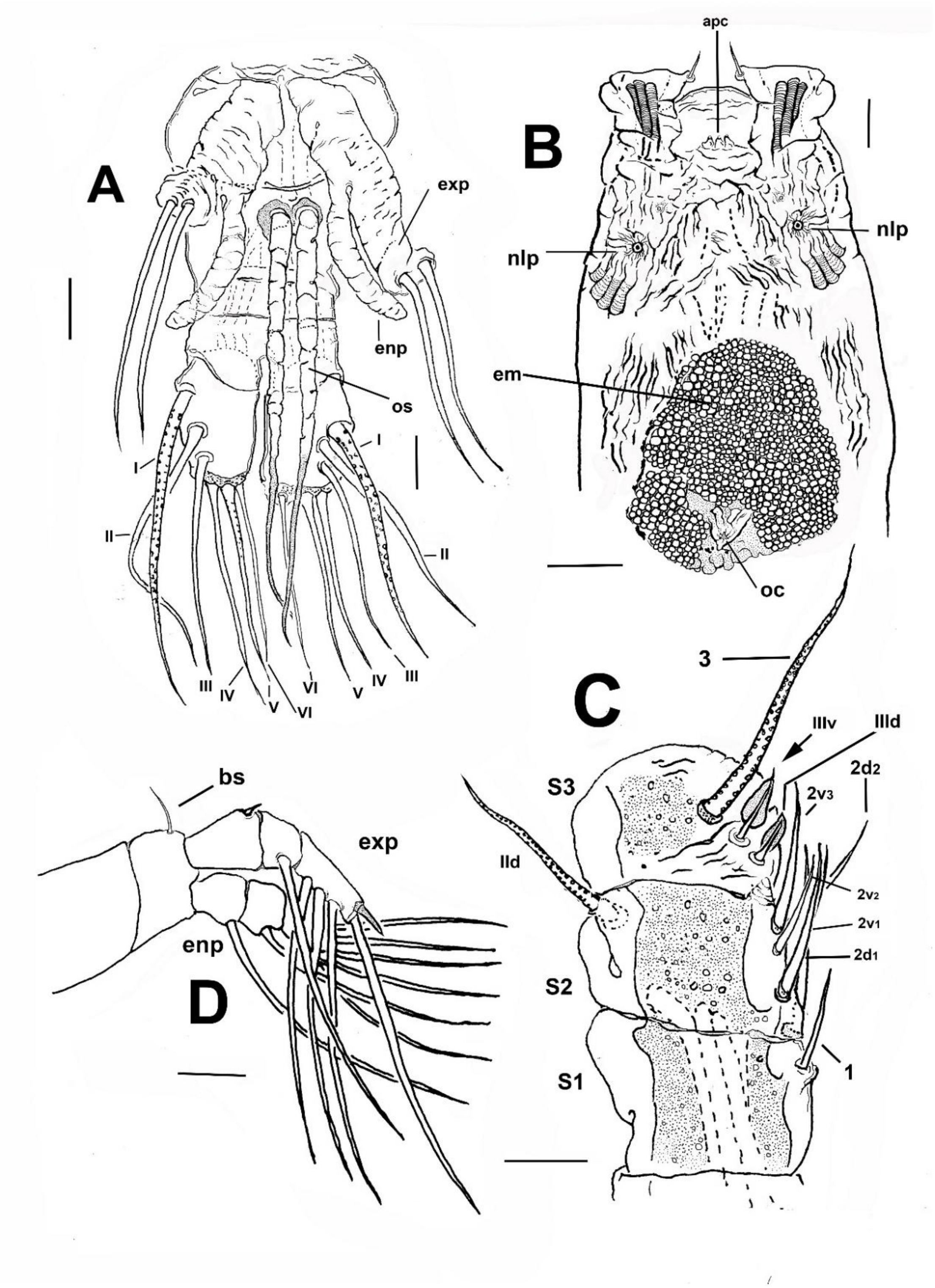

Figure 4. *Monstrilla* n. sp., from the Gulf of California, holotype female. A, Urosome showing bilobed fifth leg with exopodal (exp) and endopodal (enp) lobes, ovigerous spines (os), and caudal rami setation, setae I-IV, ventral view. B, anterior half of cephalothorax showing egg mass (em), oral cone (oc), and nipple-like processes(nlp), ventral view. C, antennule segments 1-3 (S1-S3), showing setation pattern following Grygier & Ohtsuka's (1995) nomenclature, including modified setae IIIv and IIId, ventral view. D, leg 1 showing complete setation including basipodal spine (bs) and exopodal(exp) and endopodal (enp) rami. Scales A-D = 100 µm.

7c.5. *References*

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VIII. UPDATED CHECKLIST AND DISTRIBUTION OF THE PELAGIC COPEPODA OF THE MEXICAN PACIFIC

8.1.1. *Abstract*

There are more than 500 pelagic copepod species have been recorded in the eastern Pacific; nearly 330 of these species are known for the Mexican Pacific. The Mexican Pacific economic exclusive zone is subdivided into five ecoregions: the Southern Californian Pacific (SCP), the Gulf of California (GC), the Mexican Pacific Transition (MPT), the Middle American Pacific (MAP), and the Montereyan Pacific Transition (MtPT). An updated list of pelagic copepods known to occur in the Mexican Pacific is provided, including new records obtained from extensive sampling offshore the Pacific coast of Mexico, both in the neritic and oceanic realms. Samples obtained during 23 research cruises (1982-2014) collected from surface to a maximum depth of 1625 m were reviewed. List of species from these cruises were added to the current list available for the entire Mexican Pacific, including a previously published checklist dating from 1998. The updated pelagic copepod list includes 382 species: 289 Calanoida, 79 Cyclopoida, 6 Harpacticoida, 6 Monstrilloida, and 2 Siphonostomatoida. The updated list of pelagic copepods represents an increase of 90% compared to the 1998 updated checklist. Of these 382 species, 269 were registered in the GC, 272 in the SCP-MtPT, 184 in the MPT, and 80 in the MAP. The updated checklist includes 25 deep-water species not previously collected in the Mexican Pacific and increases the known distribution for 11 deep-water species. The SCP-MtPT and MPT ecoregions were the most similar in terms of species-level composition, while the GC was placed as a sister subgroup. As noted in previous contributions, the MAP was found to be different from the rest of the Mexican Pacific. Family-level composition matches the biogeographic boundaries based in pelagic species proposed by Spalding (2007), with the SCP-MtPT as more similar to the GC than to the MPT.

8.1.2. *Resumen*

Existen más de 500 especies de copépodos pelágicos registrados en el Pacífico este, de las que más de 330 se han observado en aguas del Pacífico mexicano. Se han propuesto distintos patrones para subdividir el Pacífico mexicano en provincias zoogeográficas, basados en la distribución de especies pelágicas y bentónicas. Para la zona económica exclusiva de México, se reconocen 5 ecorregiones en el Pacífico mexicano: Pacífico Sudcaliforniano (SCP), Transición del Pacífico de Monterey (MtPT), el Golfo de California (GC), la Transición del Pacífico mexicano (MPT) y el Pacífico americano intermedio (MAP). Este trabajo tiene como objetivo principal el actualizar la lista de especies de copépodos pelágicos del Pacífico mexicano a partir del material recolectado durante 23 campañas oceanográficas: CORTES, SIPCO, CEEMEX y TALUD, a profundidades de hasta 1625 m en el caso de las campañas TALUD. La lista incluye registros publicados desde la última actualización para el Pacífico mexicano, en 1998. La lista actualizada de copépodos pelágicos es de 382 especies: 289 calanoides, 79 ciclopoides, 6 harpacticoides, 6 monstriloides y 2 sifonostomatoides. La riqueza por cada una de las 5 ecorregiones del Pacífico mexicano se muestra a continuación: GC 269 especies, SCP-MtPT 272 especies, MPT 184 especies, MAP 80 especies. La lista actualizada incluye 25 nuevos registros para el Pacífico mexicano, obtenidos del material recolectado durante las campañas TALUD, además de que amplía la distribución conocida de 11 especies de aguas profundas. Este trabajo incrementa la lista de especies de copépodos pelágicos de Pacífico mexicano en un 90% en relación a la última actualización, hecha por Suárez-Morales y Gasca (1998). También se incrementa la distribución conocida para 11 especies de copépodos pelágicos de aguas profundas encontradas durante las campañas TALUD. Las zonas SCP-MtPT y GC fueron las más similares en términos de composición a nivel de especie y conformaron un subgrupo, mientras que la zona MPT fue la más similar a este subgrupo. A nivel de familia, las zonas más similares, GC y SCP-MtPT, conformaron un subgrupo; la zona MPT fue de nuevo la más similar a este subgrupo. La zona MAP fue la más distinta del resto del área de estudio en ambos análisis, debido al bajo número de especies que también se ha observado en contribuciones realizadas en países adyacentes.

8.2. *Introduction*

According to Razouls et al. (2024), there are more than 500 recorded pelagic copepod species in the eastern Pacific. Suárez-Morales and Gasca (1998) included nearly 200 records of pelagic species for the Mexican Pacific. Recent contributions, however, have increased the list for the Mexican Pacific up to 330 records (see Fernández-Álamo et al. 2000; Hernández-Trujillo et al. 2004; Kozak et al. 2014a; Palomares-García et al. 2017; Velázquez-Ornelas et al. 2023). The number cited above (200 species) excludes benthic harpacticoid, monstrilloid, siphonostomatoid and ergasilid species. If benthonic and parasitic species are considered, the list of Suárez-Morales and Gasca (1998) is of 236 species for the Mexican Pacific. Gómez and Morales-Serna (2014) reported a list of nearly 136 harpacticoid species that habit in marine or brackish waters, while Morales-Serna et al. (2012) estimations are of around 160 marine parasitic species. Several harpacticoid species have been described after 2014 for the Gulf of California and the Eastern Tropical Pacific (e.g., Gómez 2018a, b, c; Gómez 2020; Gómez and Cruz-Barraza 2021; Gómez and Yañez-Rivera 2023).

Marine boundaries usually determine the spatial distribution of planktonic organisms, which is related to the oceanic properties of water masses and also to environmental variables such as rain regime or solar radiation (Acha et al. 2019; Wang et al. 2019). Most copepod species, however, display wide ranges of horizontal distribution due to lack of oceanic physical barriers, in contrast with the strong vertical stratification (Bode et al. 2018). Copepods are mostly aggregated in the first 200 m-depth layer due to the oxygen and food limitation in deeper waters (Gonzalez et al. 2020). Most records for pelagic copepods have typically been obtained from relatively shallow sampling (see Palomares-García et al. 1998), leaving most of the Mexican Pacific below 200 m depth virtually unexplored.

The main objective of this contribution is to update the list of pelagic copepods known to occur in the Mexican Pacific and to provide a comparative analysis of the composition of the copepod fauna in each ecoregion delimited in the Mexican Pacific. A large series of records was obtained from review of samples collected during the CORTES 1 (1982), CORTES 2 (1985), CORTES 3 (1985), SIPCO I (1981), SIPCO II (1981), SIPCO III (1982), CEEMEX-P4 (1991), CEEMEX-P5 (1991), and TALUD I-XVI (1989-2014) cruises. We include the first records obtained from this material to complete the list of 327 available species in published contributions.

8.3. *Material and Methods*

8.3.1. *Study area*

The Mexican Pacific extends from the ca. 32°27’ N to the ca. 14°32’ N, and comprises up to 68% of the Mexican littoral. The Mexican Pacific can be subdivided into five different marine ecoregions. From north to south, these ecoregions are the southern portions of the Southern Californian Pacific and the Montereyan Pacific Transition, the Gulf of California, the Mexican Pacific Transition and the Middle American Pacific (see Spalding et al. 2007; Wilkinson et al. 2009). These are equivalent in extension to the zoogeographic provinces defined by Brusca and Wallerstein (1979) and Espinoza and Hendrickx (2006), based mainly on benthic organisms. Other proposed divisions for the Mexican Pacific are based on pelagic organisms; Hastings (2000) described the biogeography of the ETP based on chaenopsid fish distribution; Spalding et al. (2012) proposed the world ocean biogeography based in pelagic organisms, defining basically two different subregions in the Mexican Pacific: the California Current and the eastern tropical Pacific. The spatial pattern proposed by Spalding (2012) is supported by the work of Fernández-Álamo and Färber-Lorda (2006). Marine ecoregions of the Mexican Pacific have been determined based on the known distribution of different invertebrates' taxa, as isopods, decapod crustaceans, and mollusks (Brusca and Wallerstein 1979; Lancellotti and Vásquez 1999; Espinosa-Pérez and Hendrickx 2006; Spalding et al. 2007; Wilkinson et al. 2009), and were used as reference for the spatial analysis of the pelagic copepods in this study.

The Montereyan Pacific Transition (MtPT) stretches from Point Conception to Cape Mendocino, USA. In Mexico is represented by a small portion in the west limit of the Southern Californian Pacific. The MtPT is herein considered as part of the SCP due to its limited size and lack of specific records. Moderately high productivity is produced by the upwellings along the coastline (Wilkinson 2009). The Southern Californian Pacific (SCP) extends from Punta Concepción (South California, USA) to Bahía Magdalena (Baja California Sur, México). The SCP is characterized by cold and productive waters in the north portion and warmer waters in the south portion (Wilkinson et al. 2009). The Gulf of California (GC) presents a large portion of endemic species (Hendrickx 1992; Correa-Sandoval and Rodríguez-Cortés 1998) and particular oceanographic conditions caused by the seasonal shift in the wind circulation, higher salinities due to evaporation and inwards displacement of Equatorian and Californian Currents waters (Álvarez-Borrego and Schwartzlose 1979; Badan-Dangon et al. 1985; Lavín et al. 1995; Lavín et al. 2014). The GC province extends up to the coast of Punta Banderas (Jalisco, Mexico) (Hendrickx et al. 2005). The Mexican Pacific Transition (MPT) goes from Punta Banderas to Tangola Tangola (Oaxaca, Mexico). The MPT is dominated by the California Current in winter, and by the Costa Rica Current in Sumer (Wilkinson et al. 2009). Finally, the Middle American Pacific (MAP) extends south of Tangola Tangola to Paita, Peru, and in Mexico corresponds to the states of Oaxaca and Chiapas (see Espinosa and Hendrickx 2006; Wilkinson et al. 2009; Spalding et al. 2007). The influence of the California Current is essentially absent in the MAP, thus it is a tropical sea (Wilkinson et al. 2009).

8.3.2. *Fieldwork*

Copepods were collected during 23 cruises onboard the R/V "El Puma" of the Universidad Nacional Autónoma de México: CORTES 1 (1982), CORTES 2 (1985), CORTES 3 (1985), SIPCO I (1981), SIPCO II (1981), SIPCO III (1982), CEEMEX-P4 (1991), CEEMEX-P5 (1991), TALUD I, III, IV, V, VI, VII, X, XI, XII, XVIII, XIV, XIV, and XVI (1989-2014). Cruises operated from the northern Gulf of California to the Gulf of Tehuantepec (Fig. 1). A total of 124 zooplankton samples were examined. These samples were obtained with different gear, including Bongo nets with a mouth diameter of 60 cm, equipped with 333 or 505 µm mesh aperture nets (CORTES, SIPCO, and CEEMEX cruises), 0.9 m x 0.9 m micronekton nets with a mesh aperture of 1 mm (TALUD cruises), and an Isaac-Kidds mid-water net (TALUD III) (Fig. 1). All samples were taken obliquely, between surface and to a maximum depth of 250 m, mostly to 200 m, except for the TALUD samples that were obtained between surface and to a maximum depth of 1625 m. Samples were fixed onboard with a 4% formaldehyde solution and later washed and preserved in 70% ethanol. Copepods were separated and identified to species level.

8.3.3. *Literature review*

Additional records for the different provinces were obtained essentially from 25 contributions, published after Suárez-Morales and Gasca (1998), with particular emphasis on contributions dealing with the California Current area, which was not sampled during our study. The full checklist includes the contributions listed below (Table 1), placed in the same order as shown in Table 2.

Table 1. List of references included in this updated checklist. MP, Mexican Pacific, SCP, Southern Californian Pacific, GC, Gulf of California, MPT, Mexican Pacific Transition, MAP, Middle American Pacific. The number indicates the position of the references in Table 2 “Reference” column.

Reference	**Number**	**Ecoregion**
Suárez-Morales and Gasca (1998)	1	MP
Hernández-Trujillo (1999)	2	SCP
Hernández-Trujillo et al. (2004)	3	SCP
Jiménez-Pérez and Lavaniegos (2004)	4	SCP
Hernández-Trujillo and Esqueda-Escárcega (2006)	5	SCP

Lavaniegos and Jiménez-Pérez (2006)	6	SCP
López-Ibarra and Palomares-García (2006)	7	SCP
Jiménez-Pérez and Lavaniegos (2014)	8	SCP
Cruz-Hernández et al. (2019)	9	SCP
Lavaniegos-Espejo and González-Navarro (1999)	10	GC
González-Armas et al. (2002)	11	GC
Palomares-García et al. (2013)	12	GC
Álvarez-Tello et al. (2015)	13	GC
Cruz-Hernández et al. (2018)	14	GC
Beltrán-Castro et al. (2020)	15	GC
Velázquez Ornelas and Hendrickx (2023)	16	GC
Gómez-Gutiérrez et al. (2014)	17	MPT
Kozak et al. (2014a)	18	MPT
Kozak et al. (2014b)	19	MPT
Jiménez-Pérez (2016)	20	MPT
Kozak et al. (2018)	21	MPT
Férnandez-Alamo et al. (2000)	22	MAP
Álvarez-Silva et al. (2003)	23	MAP
Álvarez-Silva et al. (2006)	24	MAP
Palomares-García et al. (2018)	25	GC

8.3.4. *Data analysis*

The spatial variation of the composition among the four zoogeographic provinces of the Mexican Pacific was analyzed with a CLUSTER analysis (Sorensen Similitude matrix; group average method) based on the presence of each species per province. Sorensen similarity index is calculated as following: SSI = [c /1/2(A+B)] 100, where c = number of common species, A = total species number in community A and B = total species number in community B (Badii et al. 2007). A second CLUSTER analysis was performed based on the family-level composition, by sum for family indicator (Euclidean distance matrix, group average method). The CLUSTER test results were supported by SIMPROF tests for the significance of the groups conformation, with 10,000 permutations and 5% of significance level. Both analyses were done considering both the data gathered during the oceanographic cruises and the data gathered from the literature revision for the study area.

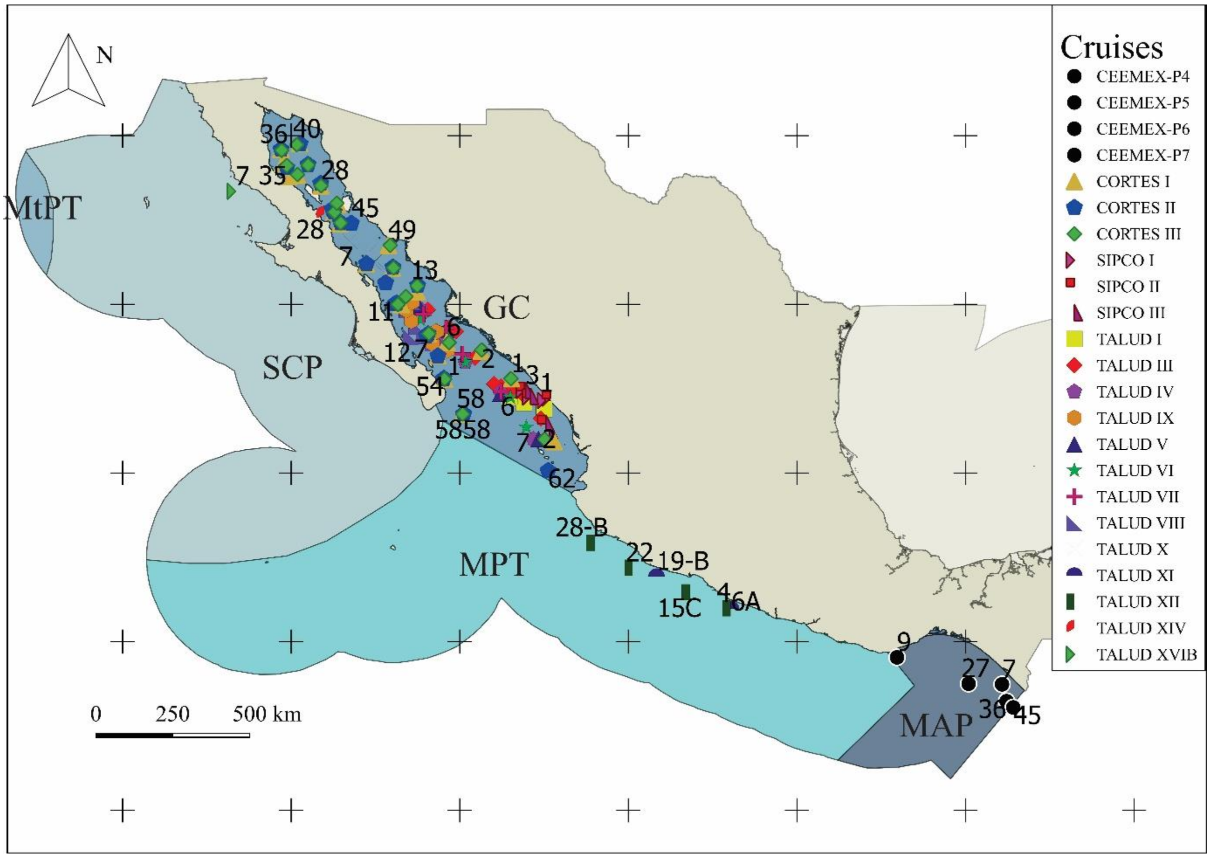

Figure 1. Sampling stations of the cruises considered for this study. GC, Gulf of California; MPT, Mexican Pacific Transition; SCP, Southern Californian Pacific; MAP, Middle American Pacific Transition.

8.4. *Results*

8.4.1. *Checklist of pelagic copepods in the Mexican Pacific*

The list of pelagic copepods recorded for the Mexican Pacific during the CORTES, SIPCO, CEEMEX and TALUD cruises (1982-2014) includes 132 species: 96 Calanoida, 29 Cyclopoida, 3 Harpacticoida, 2 Monstrilloida, and 2 Siphonostomatoida. Pontellidae, Augaptilidae and Sapphirinidae were the families with the highest richness: 16, 11 and 10 species, respectively. Overall, the richest genera were, in decreasing order: *Sapphirina* (8 species), *Euaugaptilus* (5 species), *Euchaeta* (5 species), and *Labidocera* (5 species). Based on these records and the review of the literature available post-1998, the updated checklist of pelagic copepods is now set at 382 species (Table 2). This number represents an overall increase of approximately 182 species, thus 90% larger than the value (200 species) presented by Suárez-Morales and Gasca (1998). Pontellidae, Corycaeidae and Aetideidae are the most diverse families, with 33, 28 and 25 species, respectively. The number of species registered for each province was in the Mexican Pacific is 269 species for the GC, 272 species for the

SCP, 184 for the MPT, and 80 for the MAP (Mexican part). Of the 382 species, 289 belong to the order Calanoida, 79 to the order cyclopoida, 6 to the orders Harpacticoida and Monstrilloida, respectively, and 2 to the order Siphonostomatoida. Notably, the updated checklist includes 25 new records of deep-water species for the Mexican Pacific, all collected during the TALUD cruises.

Table 2. Table 1. Updated checklist of the species of pelagic copepods distributed in the Mexican Pacific and occurrence of each species in each ecoregion. (GC) Gulf of California, (SCP) Southern Californian Pacific, (MPT) Mexican Pacific Transition, (MAP) Middle American Pacific. *, species recorded in the present work.

Family	**Species**	**Ecore-gion**	**Reference**
Acartiidae	*Acartia (Acanthacartia) bacorehuiensis* Zamora-Sanchez & Gomez-Aguirre, 1985	GC	1
	Acartia californiensis Trinast, 1976	SCP, MPT	1
	Acartia clausi Giesbrecht, 1892	GC, SCP, MAP	1,3,4,5,6,7,8,11,13,14,15,22,25
	Acartia danae Giesbrecht, 1889	GC, SCP, MPT, MAP	1,2,3,4,5,6,7,8,10,11,12,14,15,18,19,20,22,25
	Acartia longiremis (Lilljeborg, 1853)	GC, SCP, MPT	1,25
	Acartia negligens Dana, 1849	GC, SCP	1,3,4,6,7,10,25
	Acartia (Acanthartia) tonsa Dana, 1849*	GC, SCP, MPT, MAP	1,3,4,7,8,10,12,13,15,16,17,18,19,20,24,25
	Acartia (Odontacartia) lilljeborgii Giesbrecht, 1889*	GC, SCP, MPT, MAP	1,3,7,10,12,13,14,17,18,19,20,24,25
Aetideidae	*Aetidiopsis multiserrata* (Wolfenden, 1904)	GC, SCP, MPT	1
	Aetideus acutus Farran, 1929	GC, SCP	1,3,4,6,8
	Aetideus armatus (Boeck, 1872)*	GC, SCP, MPT, MAP	1,3,4,5,7,12,14,16,18,19,22,25
	Aetideus bradyi Scott A., 1909	GC, SCP, MPT	1,3,4,6,8,12,14,18,19,21
	Aetideus giesbrechti Cleve, 1904	SCP, MAP	1,3,4,8,22
	Aetideus truncatus Bradford, 1971	GC, SCP-MPT	1
	Chiridius popei Giesbrecht, 1892	SCP	3
	Chirundina streetsii Giresbrecht, 1895	SCP-MPT	1
	Euchirella amoena Giesbrecht, 1888	SCP	1,3,4,5,8
	Euchirella bella Giesbrecht, 1888	SCP, MAP	1,4,8,22
	Euchirella bitumida With, 1915*	GC, SCP, MPT	1,4,8,16
	Euchirella curticauda Giesbrecht, 1888	GC, SCP, MPT	1,4,6,8,14
	Euchirella messinensis messinensis (Claus, 1863)	SCP	8
	Euchirella pulchra (Lubbock, 1856)	GC, SCP	1,4,8,14
	Euchirella rostrata (Claus, 1866)*	GC, SCP	1,4,8,16
	Euchirella truncata Esterly, 1911	SCP	4,8
	Euchirella venusta (Giesbrecht, 1888)	GC, MPT	1,18,19
	Gaetanus armiger Giesbrecht, 1888	SCP-MPT	1,5

	Gaetanus brevicornis Esterly, 1906	SCP-MPT	1
	Gaetanus kruppii Giesbrecht, 1903*	GC, MPT	1
	Gaetanus miles Giesbrecht, 1888*	GC, SCP, MAP	3,4,8,22
	Gaetanus minor Farran, 1905	SCP	4,6,8
	Gaetanus pungens Giesbrecht, 1895	SCP	3,4,5,6,8
	Gaetanus pileatus Farran, 1903*	GC, MPT	TALUD
	Gaetanus robustus (Sars, 1905)	SCP, MPT	1
	Pseudochirella obesa Sars G.O., 1920*	GC, MPT	TALUD
	Pseudochirella pacifica (Brodsky, 1950)	GC	12
	Undeuchaeta intermedia Scott, 1909	SCP, MPT	1,4,5,6,8
	Undeuchaeta plumosa (Lubbock, 1856)	SCP	4,8
	Valdiviella brevicornis Sars G.O., 1905	SCP, MPT	1
Arietellidae	*Arietellus pacificus* Esterly, 1913	SCP-MPT	1
	Arietellus plumifer Sars G.O., 1905	SCP	4,8
	Arietellus setosus Giesbrecht, 1892*	SCP, MPT	1,5,8
	Arietellus Giesbrecht, 1893 sp.*	GC	TALUD
	Paraugaptilus buchani Wolfenden, 1904	SCP, MPT	1
	Sarsarietellus Campaner, 1984 sp. 1*	GC	TALUD
	Sarsarietellus Campaner, 1984 sp. 2*	MPT	TALUD
Augaptilidae	*Augaptilus cornutus* Wolfenden, 1911*	GC	TALUD
	Augaptilus longicaudatus (Claus, 1863)	GC, SCP	1,3,4,8
	Augaptilus megalurus Giesbrecht, 1889*	GC	1
	Centraugaptilus horridus Farran, 1908*	GC, MPT	TALUD
	Centraugaptilus macrodus (Esterly, 1911)*	GC, MPT	TALUD
	Euaugaptilus angustus (Sars G.O., 1905)*	GC, MPT	TALUD
	Euaugaptilus austrinus Park, 1993*	GC	TALUD
	Euaugaptilus filigerus (Claus, 1863)*	GC, MPT	1
	Euaugaptilus longimanus (Sars G.O., 1905)*	GC, MPT	TALUD
	Euaugaptilus nodifrons (Sars G.O., 1905)*	GC, MPT	TALUD
	Euaugaptilus squamatus (Giesbrecht, 1889)	SCP-MPT	1
	Haloptilus acutifrons (Giesbrecht, 1892)	GC, SCP, MAP	1,3,4,8,14,22
	Haloptilus austini Grice, 1959	SCP	4,8
	Haloptilus chierchiae (Giesbrecht, 1889)	GC	1
	Haloptilus fertilis (Giesbrecht, 1892)	MAP	1,22
	Haloptilus longicornis (Claus, 1863)	GC, SCP, MAP	1,3,4,6,8,22
	Haloptilus mucronatus (Claus, 1863)	SCP	1,3,4,7,8
	Haloptilus ornatus (Giesbrecht, 1893)*	GC, SCP, MAP	1,3,4,5,6,8,16,22
	Haloptilus oxycephalus (Giesbrecht, 1889)	SCP-MPT	1
	Haloptilus paralongicirrus Park, 1970*	GC	TALUD
	Haloptilus spiniceps (Giesbrecht, 1893)	SCP	4,6,8
	Pseudhaloptilus pacificus (Johnson, M.W., 1936)*	GC, SCP, MPT	4,8
Bathypontidae	*Temorites elongata* (Sars G.O., 1905)*	GC	TALUD
Calanidae	*Calanus pacificus* Brodsky, 1948*	GC, SCP	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,25
	Canthocalanus pauper (Giesbrecht, 1888)	GC, SCP, MPT, MAP	1,3,4,7,8,10,12,14,15,17,18,19,21,22,24,25

	Cosmocalanus darwinii darwinii (Lubbock, 1860)*	GC, SCP, MPT, MAP	1,3,4,6,8,10,11,15,18,19,20,21,22,25
	Mesocalanus lighti (Bowman, 1955)	SCP-MPT	1
	Mesocalanus tenuicornis (Dana, 1849)	GC, SCP, MPT	1,4,6,8,18,19,21
	Nannocalanus minor (Claus, 1863)*	GC, SCP, MPT, MAP	1,3,4,5,6,7,8,9,10,11,12,14,15,16,18,19,20,21,22,25
	Neocalanus cristatus (Krøyer, 1848)	SCP-MPT	1,4,5,6,8
	Neocalanus gracilis (Dana, 1852)	GC, SCP-MPT	1,4,6,8
	Neocalanus robustior (Giesbrecht, 1888)	GC, MPT	1,18,19
	Undinula vulgaris (Dana, 1849)*	GC, SCP, MPT, MAP	1,2,3,4,6,7,8,9,10,11,12,14,15,16,17,18,19,20,21,22
Candacidae	*Candacia aethiopica* (Dana, 1849)	GC, SCP	1,3,4,6,7,8,14,25
	Candacia armata Boeck, 1872	GC	14
	Candacia bipinnata (Giesbrecht, 1889)	GC, SCP	1,2,3,4,5,6,8
	Candacia bispinosa (Claus, 1863)	SCP	4,8
	Candacia bradyi (Scott, 1902)	SCP	1,3,5
	Candacia catula Giesbrecht, 1889	GC, SCP, MPT, MAP	1,2,3,4,5,7,8,9,10,14,15,17,18,19,20,22,25
	Candacia columbiae Campbell, 1929	SCP-MPT	1
	Candacia curta (Dana, 1849)*	GC, SCP, MPT, MAP	1,3,4,5,6,7,8,10,11,15,16,18,19,22,25
	Candacia discaudata (Scott, 1909)	GC, SCP	1,3,5,12,14
	Candacia elongata (Boeck, 1872)*	GC	TALUD
	Candacia falcifera Farran, 1929	GC	12
	Candacia longimana (Claus, 1863)	SCP	1,3,4,7,8
	Candacia pachydactyla (Dana, 1849)	GC, SCP, MPT, MAP	1,2,4,5,8,11,14,18,19,22,25
	Candacia pectinata Giesbrecht, 1892	GC, SCP, MPT	1,5,11,25
	Candacia pofi Grice & Jones, 1960	GC, SCP, MPT	1,25
	Candacia simplex (Giesbrecht, 1889)*	GC, SCP	3,4,6,8,16
	Candacia tenuimana (Giesbrecht, 1889)	SCP	4,6,8
	Candacia truncata (Dana, 1849)	GC, SCP, MPT, MAP	1,2,3,4,6,8,10,14,15,17,18,19,20,21,22,25
	Candacia varicans (Giesbrecht, 1892)	GC, SCP-MPT	1,2,4,8
Centropagidae	*Centropages abdominalis* Sato, 1913	GC, SCP, MPT	1,7,13
	Centropages bradyi Wheeler, 1901	SCP	1,2,3,4,6,8
	Centroages calaninus (Dana, 1849)	GC, SCP	1,3,4,7,8,11,15,25
	Centropages elongatus Giesbrecht, 1896*	GC, SCP-MPT	1,4,6,8,9,10,11,16,25
	Centropages furcatus (Dana, 1849)*	GC, SCP, MPT, MAP	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,24,25
	Centropages gracilis (Dana, 1849)*	GC, SCP, MPT, MAP	1,3,4,6,8,10,11,16,18,19,22,25
	Centropages longicornis Mori, 1932	GC, SCP	1,3,7,25
	Centropages violaceus (Claus, 1863)	SCP	4,8
Clausocalanidae	*Clausocalanus arcuicornis* (Dana, 1849)	GC, SCP, MAP	1,3,7,10,11,12,14,22,25
	Clausocalanus farrani (Sewell, 1929)	GC, MPT	1,10,18,19,25
	Clausocalanus furcatus (Brady, 1883)*	GC, SCP, MPT, MAP	1,3,4,10,12,14,15,16,17,18,19,22,25
	Clausocalanus jobei Frost & Fleminger, 1968*	GC, SCP, MPT	1,3,15,16,17,18,19
	Clausocalanus mastigophorus (Claus, 1863)	GC, MPT	1,10,14,18,19,25
	Clausocalanus minor (Sewell, 1929)	MPT	18,19,21

	Clausocalanus parapergens Frost & Fleminger, 1968	GC	1,10,25
	Clausocalanus pergens Farran, 1936	GC	25
	Ctenocalanus longicornis Mori, 1937	SCP-MPT	1
	Ctenocalanus vanus Giesbrecht, 1888	GC, SCP	1,3
	Microcalanus pygmaeus (Sars G.O., 1903)	SCP	3
	Pseudocalanus major (Sars G.O., 1900)	SCP	3
Eucalanidae	*Eucalanus attenuatus* (Danam 1849)	SCP, MAP	2,4,5,6,8,22
	Eucalanus californicus Jhonson M.W., 1938*	GC, SCP	1,2,3,5,6,8,16
	Eucalanus elongatus elongatus (Dana, 1848)*	GC, SCP-MPT	1,3,4,8,16
	Eucalanus hyalinus (Claus, 1866)*	GC, SCP, MPT	1,4,6,8,16
	Eucalanus inermis Giesbrecht, 1893	MPT, MAP	18,19,22
	Paraeucalanus inermis Giesbrecht, 1892*	MPT	1,16
	Paraeucalanus sewelli (Fleminger, 1973)*	GC, SCP, MPT	1,3,7,9,10,11,14,16,18,19,20,25
	Rhincalanus cornutus (Dana, 1849)	GC, MAP	1,22
	Rhincalanus nasutus Giesbrecht, 1888*	GC, SCP, MPT, MAP	1,2,3,4,5,6,7,8,9,10,12,14,16,18,19,22,25
	Rhincalanus rostrifrons (Dana, 1849)	GC, MPT	14,18,19
	Subeucalanus crassus (Giesbrecht, 1888)	SCP, MPT	1,2,3,4,6,8,18,19,21
	Subeucalanus mucronatus (Giesbrecht, 1888)	GC, SCP, MPT	3,4,8,10,11,12,15,17,18,20,25
	Subeucalanus pileatus (Giesbrecht, 1888)	GC, SCP, MPT, MAP	1,4,6,8,10,15,18,20,22,25
	Subeucalanus subcrassus (Giesbrecht, 1888)*	GC, SCP, MPT, MAP	1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17,18,19,20,21,22
	Subeucalanus subtenuis (Giesbrecht, 1888)*	GC, SCP, MPT, MAP	1,4,61,6,7,8,9,11,12,13,14,15,16,21,22,25
Euchaetidae	*Euchaeta acuta* Giesbrecht, 1893*	GC	1,4,6,8,14,16
	Euchaeta concinna Dana, 1849	SCP	4,8
	Euchaeta indica Wolfenden, 1906*	GC, SCP, MPT	1,2,3,4,6,7,8,9,10,11,12,14,15,16,17,18,19,20,21,25
	Euchaeta longicornis Giesbrecht, 1888	GC, SCP, MPT, MAP	1,2,3,4,5,6,7,8,9,10,12,14,15,17,18,19,20,21,22,25
	Euchaeta magniloba (Park, 1978)	MPT	18,19
	Euchaeta marina (Prestandrea, 1833)*	GC, SCP, MPT, MAP	1,2,3,5,7,10,11,13,15,16,22
	Euchaeta marinella Bradford, 1974	SCP-MPT	1
	Euchaeta media Giesbretch, 1888*	GC, SCP	1,3,4,6,7,8,10,12,14,16,25
	Euchaeta plana Mori, 1937*	GC	1,14,16
	Euchaeta pubera Sars G.O., 1907	MAP	22
	Euchaeta rimana (Bradford, 1974)	GC, SCP, MPT	1,4,6,8,9,14,17,18,19,20,21,25
	Euchaeta spinosa Giesbrecht, 1892	GC	1,4,8
	Euchaeta tenuis Esterly, 1906	GC, SCP	4,8,14
	Paraeuchaeta aequatorialis Tanaka, 1958	SCP-MPT	1
	Paraeuchaeta birostrata Brodsky, 1950	GC	14
	Paraeuchaeta bisinuata (Sars G.O., 1907)	SCP-MPT	1
	Paraeuchaeta californica (Esterly, 1906)	GC, SCP-MPT	1
	Paraeuchaeta copleyae Park, 1993*	GC	1
	Paraeuchaeta elongata (Esterly, 1913)	SCP	4,6,8
	Paraeuchaeta flava (Giesbrecht, 1888)	SCP	2
	Paraeuchaeta grandiremis (Giesbrecht, 1888)	GC, SCP-MPT	1

	Paraeuchaeta malayensis Sewell, 1929	SCP-MPT		1
	Paraeuchaeta mexicana Park, 1995*?*	GC		1
	Paraeuchaeta scopaeorhina Park, 1993	GC, SCP-MPT		1
	Paraeuchaeta sesquipedalis Park, 1993	GC, SCP-MPT		1
	Paraeuchaeta tonsa (Giesbrecht, 1895)	SCP-MPT		1
	Paraeuchaeta triloba Park, 1993	GC		1
Heterorhabidae	*Disseta palumbii* Giesbrecht, 1889*	GC	TALUD	
	Disseta scopularis (Brady, 1883)*	GC, MPT	TALUD	
	Heterorhabdus clausi (Giesbrecht, 1888)	GC, SCP	1,4,8	
	Heterorhabdus papilliger (Claus, 1863)*	GC, SCP, MAP	1,3,4,6,8,9,14,16,22,25	
	Heterorhabdus spinifrons (Claus, 1863)	GC, SCP	3,4,8	
	Heterorhabdus tanneri (Giesbrecht, 1895)	SCP-MPT	1,4,6,8	
	Heterostylites longicornis (Giesbrecht, 1889)	GC, SCP	1,3,4,6,8	
	Heterostylites major (Dahl F., 1984)*	GC	TALUD	
	Mesorhabdus angustus Sars G.O., 1907*	GC	TALUD	
	Parahererorhabdus compactus (Sars G.O., 1900)*	GC	TALUD	
Lucicutiidae	*Lucicutia bicornuta* Wolfenden, 1905*	GC, MPT	TALUD	
	Lucicutia flavicornis (Claus, 1863)*	GC, SCP, MAP	1,3,4,6,7,8,10,12,14,16,20,22,25	
	Lucicutia gaussae (Grice, 1963)	MPT	18,19	
	Lucicutia gemina (Farran, 1926)	MAP	1,22	
	Lucicutia grandis (Giesbrecht, 1895)	SCP-MPT		1
	Lucicutia hulsemannae Markhaseva & Ferrari, 2005*	GC, MPT	TALUD	
	Lucicutia ovalis (Giesbrecht, 1895)	SCP		3
	Lucicutia pacifica Brodsky, 1950*	GC, MPT	1,16,20	
Megacalanidae	*Megalacanus frosti* Bradford-Grieve, Blanco-Bercial & Boxshall, 2017*	GC, MPT	TALUD	
Metridinidae	*Gaussia princeps* (Scott T., 1894)	SCP	1,3,5	
	Metridia brevicauda Giesbrecht, 1889*	GC, SCP-MPT		1
	Metridia curticauda Giesbrecht, 1889	SCP-MPT, GC		1
	Metridia pacifica Brodsky, 1950	SCP	1,3,4,6,8,20	
	Metridia prínceps Giesbrecht, 1889*	GC, SCP, MPT	1,4,5,8,12,14	
	Pleuromamma abdominalis abdominalis (Lubbock, 1856)*	GC, SCP, MPT, MAP	1,2,3,4,5,6,8,9,12,14,16,18,20,22	
	Pleuromamma borealis Dahl F., 1893*	GC, SCP, MPT	1,4,6,8,16	
	Pleuromamma gracilis gracilis Claus, 1863*	GC, SCP, MPT, MAP	1,3,4,5,6,8,9,10,12,14,16,18,19,22,25	
	Pleuromamma johnsoni (Ferrari & Saltzman, 1948)	MPT	18,19,21	
	Pleuromamma piseki (Farran, 1929)	SCP, MPT	4,6,8,18,19,21	
	Pleuromamma quadrangulata (Dahl, 1893)	GC, SCP-MPT	1,2,4,6,8,25	
	Pleuromamma robusta (Dahl F., 1893)	GC		11
	Pleuromamma xiphias (Giesbrecht, 1889)	GC, SCP	3,4,6,8,14	
Nullosetigeridae	*Nullosetigera auctiseta* Soh, Ohtsuka, Imabayashi & Suh, 1999*	GC	TALUD	
	Nullosetigera bidentata (Brady, 1883)	GC, SCP-MPT		1
	Nullosetigera mutica (Sars G.O., 1907)*	MPT	TALUD	
Paracalanidae	*Acrocalanus andersoni* (Bowman, 1958)	GC, MPT	1,10,18,19,21,25	

	Acrocalanus gibber Giesbrecht, 1888	GC, SCP	3,11,15,17,21,25
	Acrocalanus gracilis Giesbrecht, 1888	GC, SCP, MPT	1,3,5,7,11,12,14,15,18,19
	Acrocalanus inermis Sewell, 1912	GC, SCP-MPT	1
	Acrocalanus longicornis Giesbrecht, 1888	GC, SCP, MAP	1,3,4,6,8,10,12,21,22,24,25
	Acrocalanus monachus Giesbrecht, 1888	GC, SCP	1,3,10,25
	Bestiolina sarae Dorado-Roncancio & Gaviria, 2019 in: Dorado-Roncancio, Gaviria, Bernal-De La Torre & Ahrens, 2019?	GC	25
	Calocalanus contractus Farran, 1926	GC, SCP-MPT	3
	Calocalanus pavo (Dana, 1849)	GC, SCP, MPT, MAP	3,4,6,7,8,10,11,15,17,18,19,20,22,25
	Calocalanus pavoninus (Farran, 1936)	GC, SCP	3
	Calocalanus plumulosus (Claus, 1863)	GC, SCP, MPT, MAP	3,10,18,19,22,25
	Calocalanus styliremis (Giesbrecht, 1888)	GC, SCP	3,4,8,10,20,25
	Calocalanus tenuis Farran, 1926	GC	10,25
	Mecynocera clausi Thompson I.C., 1888	GC, SCP, MPT	1,3,4,6,8,20,25
	Paracalanus aculeatus Giesbrecht, 1888*	GC, SCP, MPT	1,3,7,10,16,17,18,19,20,25
	Paracalanus denudatus Sewell, 1929	GC	1
	Paracalanus indicus Wolfenden, 1905	GC	25
	Paracalanus parvus parvus (Claus, 1863)*	GC, SCP, MPT, MAP	1,2,3,4,5,6,7,8,10,13,15,16,17,18,20,22,25
	Parvocalanus crassirostris Dahl, 1894	GC, SCP	3,25
Phaenidae	*Cephalophanes tectus* (Esterly, 1911)	SCP-MPT	1
	Cephalophanes Sars G.O., 1907 und. sp.*	MPT	TALUD
	Phaenna spinifera Claus, 1863*	GC, SCP	1,3,4,5,6,8,12,14,16
	Scopalatum smithae (Grice, 1962)	SCP	4,8
	Xanthocalanus Farran, 1905 und. sp*.	GC	TALUD
Pontellidae	*Calanopia eliptica* (Dana, 1849)	GC	14,15,25
	Calanopia minor Scott A., 1902	GC, MPT	14,17,18,21
	Labidocera acuta (Dana, 1849)*	GC, SCP, MPT, MAP	1,3,4,5,6,7,8,10,11,12,14,15,16,17,18,19,20,22,23,25
	Labidocera acutifrons (Dana, 1849)*	GC, SCP	1,2,3,4,5,6,7,8,10,11,14,15,16,25
	Labidocera darwinii Lubbock, 1853	GC, MPT, MAP	1,20,23,24
	Labidocera detruncata (Dana, 1849)*	GC, MPT, MAP	1,11,13,14,15,16,18,19,22,25
	Labidocera diandra Fleminger, 1967	GC, SCP, MPT	1,3,10,12,13,15,17,18,19,25
	Labidocera euchaeta Giesbrecht, 1888	SCP, MPT	1,6,8
	Labidocera johnsoni Fleminger, 1964*	GC, SCP	1,3,13,16,25
	Labidocera jollae Esterly, 1906*	GC, SCP	1,3,4,7,8,13,16,25
	Labidocera kolpos Fleminger, 1967*	GC	1,13,16
	Labidocera minuta Giesbrecht, 1888	GC, SCP	1,3,5,13
	Labidocera neri (Krøyer, 1849)	SCP, MPT	1
	Labidocera trispinosa Esterly, 1905*	GC, SCP	1,2,3,4,5,7,8,13,14,15,25
	Pontella agassizi Giesbrecht, 1895*	GC, MPT	1,11,14,16,18,19,23,25
	Pontella armata Dana, 1849	SCP, MPT	1
	Pontella danae Giesbrecht, 1889*	GC	16
	Pontella fera Dana, 1849*	GC, SCP	1,3,7,16,25
	Pontella princeps Dana, 1849	SCP	3
	Pontella securifer Brady, 1883	GC, SCP, MPT	1,25

	Pontella spinicauda Mori, 1937	SCP-MPT	1
	Pontella spinipes Giesbrecht, 1889	GC, SCP-MPT	1
	Pontella tenuiremis Giesbrecht, 1889	MAP	23
	Pontellina plumata (Dana, 1849)*	GC, SCP, MPT, MAP	1,3,4,5,6,7,8,10,11,14,15,16,18,19,20,22,23,25
	Pontellina sobrina Fleminger & Hulsemann, 1974	GC, MPT	18,19
	Pontellopsis armata (Giesbrecht, 1889)*	GC, SCP	7,12,16,25
	Pontellopsis brevis (Giesbrecht, 1889)*	GC, SCP	3,4,8,16
	Pontellopsis lubbockii (Giesbrecht, 1889)	GC, MPT	1,18,19
	Pontellopsis occidentalis Esterly, 1906*	GC, SCP, MPT	1,3,4,5,8,10,11,13,16,25
	Pontellopsis perspicax (Dana, 1852)	GC, SCP, MPT	3,7,14,18,19,25
	Pontellopsis regalis (Dana, 1849)*	GC, SCP, MPT, MAP	1,3,4,8,10,11,16,18,19,20,22,25
	Pontellopsis tenuicauda (Giesbrecht, 1889)	GC, SCP	1,3,25
	Pontellopsis villosa Brady, 1883	SCP-MPT	1
	Pontellopsis yamadae Mori, 1937*	GC, SCP	1,3,5,14,16
Pseudocalanidae	*Pseudocalanus elongatus* (Brady, 1865)	GC	1,12
Pseudodiaptomidae	*Pseudodiaptomus culebrensis* Marsh, 1913	MPT, MAP	1,18,19,20,24
	Pseudodiaptomus euryhalinus Johnson M.W., 1939	GC	1,13,25
	Pseudodiaptomus wrighti Johnson, 1964	GC, SCP, MPT	1,3,7,11,13,18,20,25
Scolecithricidae	*Amallothrix elephas* (Esterly, 1913)	SCP-MPT	1
	Amallothrix mollis (Esterly, 1913)	SCP-MPT	1
	Amallothrix tenuiserrata (Giesbrecht, 1893)	MAP	1,22
	Lophothrix frontalis Giesbrecht, 1895*	GC, SCP	3,4,5,6,8
	Pseudoamallothrix emarginata (Farran, 1905)	SCP-MPT	1
	Pseudoamallothrix inornata (Esterly, 1906)*	GC, MPT	TALUD
	Pseudoamallothrix ovata (Farran, 1905)	SCP	4,6,8
	Racovitzanus pacificus (Esterly, 1905)	SCP-MPT	1
	Scaphocalanus affinis (Sars G.O., 1905)*	GC	TALUD
	Scaphocalanus curtus (Farran, 1926)	GC, SCP	1,3
	Scaphocalanus echinatus (Farran, 1905)	GC	Literature
	Scaphocalanus elongatus Scott A., 1909	GC	14
	Scaphocalanus magnus (Scott, 1909)	SCP-MPT	1,4,8
	Scolecithricella abyssalis Giesbrecht, 1888)*	GC, MPT, MAP	1,4,6,8,16,18,19,21,22
	Scolecithricella dentata (Giesbrecht, 1893)	SCP	4,6,7,8,20
	Scolecithricella marginata (Giesbrecht, 1888)	MPT, MAP	1,18,19,21,22
	Scolecithricella nicobarica (Sewell, 1929)*	GC, MPT	1,16,18,19
	Scolecithrix bradyi Giesbrecht, 1888*	GC, SCP, MPT, MAP	3,4,5,6,7,8,9,12,16,17,18,19,21,22
	Scolecithrix danae (Lubbock, 1856)*	GC, SCP, MPT, MAP	2,3,4,5,6,7,9,10,11,12,14,15,16,18,19,20,22,25
	Scolecithrix longirostris Esterly, 1913	SCP, MPT	1
	Scolecithrix obscura Esterly, 1913	SCP, MPT	1
	Scolecitrichopsis ctenopus (Giesbrecht, 1888)*	GC, SCP, MPT, MAP	1,3,7,16,18,19,21,22
	Scottocalanus helenae (Lubbock, 1856)	SCP	4,8
	Scottocalanus securifrons (Scott T., 1894)	SCP	4,8
	Scottocalanus sedatus Farran, 1936	SCP	4,8

Spinocalanidae	*Isaacsicalanus paucisetus* Fleminger, 1983	GC	1
	Mimocalanus heronae Damkaer, 1975	SCP	1
	Spinocalanus abyssalis Giesbrecht, 1888	MAP	1,22
Temoridae	*Eurytemora affinis affinis* (Poppe, 1880)	GC, SCP-MPT	1
	Temora discaudata Giesbrecht, 1889*	GC, SCP, MPT, MAP	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,25
	Temora turbinata (Dana, 1849)	GC, SCP-MPT	1
	Temoropia mayumbaensis Scott T., 1894*	GC, SCP	1,3,16
Tortanidae	*Tortanus* (*Boreotortanus*) *discaudatus* (Thompson I.C. & Scott A.) In Herdman, Thompson & Scott, 1897)	SCP	4,8
Clausidiidae	*Hyphalion captans* Humes, 1987	GC	1
	Sapphirella tropica Wolfenden, 1906*	GC	1,7,16
Corycaeidae	*Agetus flaccus* (Giesbrecht, 1891)	GC, SCP, MPT, MAP	1,2,3,4,6,8,10,18,20,22,25
	*Agetus limbatus (*Brady, 1883)	GC, SCP	4,6,8,10,25
	Agetus typicus (Krøyer, 1849)	GC, SCP	3,25
	Corycaeus affinis McMurrich, 1916	GC, SCP	3,12,13,25
	Corycaeus clausi Dahl F., 1894	GC	1,4,6,8,10,25
	Corycaeus crassiusculus, Dana 1849*	GC, SCP	1,3,4,8,15,16,25
	Corycaeus obtusus Dana, 1849	GC	1
	Corycaeus speciosus Dana, 1849*	GC, SCP, MPT, MAP	1,2,3,4,5,6,7,8,10,11,12,15,16,17,18,20,22,25
	Ditrichocorycaeus affinis (McMurrich, 1916)	GC, SCP-MPT	1
	Ditrichocorycaeys amazonicus (Dahl F., 1894)	GC, SCP	3,4,5,6,8,10,20,25
	Ditrichocorycaeus americanus (Wilson M.S., 1949)	SCP	4,8
	Ditrichocorycaeys andrewsi (Farran, 1911)	GC, SCP	1,3,7,10,11,17,25
	Ditrichocorycaeus anglicus (Lubbock, 1857)	GC, SCP, MAP	1,4,6,8,24,25
	Ditrichocorycaeus brehmi (Steuer, 1910)	GC, SCP-MPT	1
	Ditrichocorycaeus dubius (Farran, 1911)	GC, SCP, MPT	1,10
	Farranula carinata (Giesbrecht, 1891)	GC	10,25
	Farranula gibbula (Giesbrecht, 1891)	SCP	1,3,4,7,8,11,25
	*Farranula gracilis (*Dana, 1849)	GC, SCP	4,8,10,25
	Farranula rostrata (Claus, 1863)	GC	1,10,25
	Monocorycaeus robustus (Giesbrecht, 1891)	SCP, MAP	1,3,4,7,8,12,22
	Onychocorycaeus agilis (Dana, 1848)	SCP	3,4,8,10,25
	Onychocorycaeus catus (Dahl F., 1894)*	SCP, GC	3,10,11,12,15,16,17,25
	Onychocorycaeus giesbrechti (Dahl F., 1894)	SCP	4,8
	Onychocorycaeus latus (Dana, 1849)*	GC, SCP-MPT	1,3,4,7,8,10,12,16,25
	Onychocorycaeus ovalis (Claus, 1863)	GC, SCP, MPT	1,3,10,18,20,25
	Onychocorycaeus pacificus (Dahl F., 1894)	GC, SCP	1,3,4,8,10,24,25
	Onychocorycaeus pumilus (Dahl M., 1912)	GC	10,25
	Urocorycaeus furcifer (Claus, 1863)	SCP	3,4,6,8
	Urocorycaeus lautus (Dana, 1849)*	GC, SCP-MPT	1,3,4,7,8,10,11,16,25
	Urocorycaeus longistylis (Dana, 1848)	SCP	1,3,4,8
Erebonasteridae	*Erebonaster protentipes* Humes, 1987	GC	1
	Ergasilus versicolor Wilsonn C.B., 1911	MAP	24

	Laitmatobius crinitus Humes, 1987	GC	1
Incertae sedis	*Pachos puctatum* (Claus, 1863)*	GC, SCP, MAP	1,4,5,8,16,22
	Pachos dentatum (Mori, 1932)	MPT	1,18,25
Lubbockidae	*Lubbockia aculeata* Giesbrecht, 1891*	GC, SCP	1,3,4,8,16
	Lubbockia squillimana Claus, 1863*	GC, SCP	1,3,4,8,16,25
Oithonidae	*Dioithona oculata* (Farran, 1913)	SCP	4,8,20
	Oithona alvarezi Lindberg, 1955	SCP-MPT	1
	Oithona attenuata Farran, 1913	SCP-MPT	1,3,4,8,20
	Oithona atlantica Farran, 1908*	GC	16
	Oithona decipiens Farran, 1913	GC, SCP-MPT	1,3,25
	Oithona fallax Farran, 1913	GC, SCP, MPT, MAP	1,2,5,12,18,22,25
	Oithona nana Giesbrecht, 1892	GC, SCP, MPT, MAP	1,3,10,15,24,25
	Oithona parvula (Farran, 1908)	SCP-MPT	1
	Oithona plumifera Baird, 1843	GC, SCP, MPT, MAP	1,2,3,4,5,6,7,8,10,11,12,15,17,18,20,22,25
	Oithona rigida Giesbrecht, 1896	GC, SCP	1,3,7,12,25
	Oithona robusta Giesbrecht, 1891	GC, SCP, MPT, MAP	1,2,10,18,20,22,25
	Oithona setigera setigera (Dana, 1849)*	GC, SCP, MPT	1,3,6,8,10,12,16,18,25
	Oithona similis Claus, 1866*	GC, SCP	1,3,4,7,8,11,16,25
	Oithona tenuis Rosendorn, 1917	GC, SCP	1,3,4,7,8,10,11,25
Oncaeidae	*Conaea rapax* Giesbrecht, 1891	SCP	4,8
	Triconia conifera (Giesbrecht, 1891)	GC, SCP	1,3,4,7,8,10,11,12,25
	Triconia dentipes (Giesbrecht, 1891)	SCP	4,8
	Oncaea media Giesbrecht, 1891*	GC, SCP, MAP	1,3,4,7,8,10,16,20,22,25
	Oncaea mediterranea (Claus, 1863)	GC, SCP, MPT	4,6,8,10,20,25
	Oncaea venusta Philippi, 1843*	GC, SCP, MPT, MAP	1,3,4,5,7,8,10,11,12,13,15,16,17,18,20,22,25
	Oncaea minuta Giesbrecht, 1892	GC	1
	Oncaea praeclara Humes, 1988	GC	1
Sapphirinidae	*Copilia longistylis* Mori, 1932	GC, SCP	1,3,4,8,11,25
	Copilia mirabilis Dana, 1852*	GC, SCP, MPT, MAP	1,3,4,5,6,8,10,11,12,15,16,17,18,20,22,25
	Copilia quadrata Dana, 1849*	GC, SCP	1,3,4,6,8,11,16,20,25
	Copilia vitrea (Haeckel, 1864)	SCP. MAP	1,4,8,22
	Sapphirina angusta Dana, 1849*	GC, SCP	1,3,4,5,6,8,15,16,20,25
	Sapphirina auronitens Claus, 1863	GC, MAP	10,22,25
	Sapphirina darwinii Haeckel, 1864*	GC, SCP, MPT, MAP	1,3,4,8,16,18,22
	Sapphirina gastrica Giesbrecht, 1891*	GC, SCP	1,3,4,6,8,11,15,16,17,20,25
	Sapphirina gemma Dana, 1849*	GC, SCP, MPT	3,4,5,6,8,10,15,16,17,18,25
	Sapphirina intestinata Giesbrecht, 1891	GC, SCP	4,8,25
	Sapphirina iris Dana, 1849*	GC	16
	Sapphirina metallina Dana, 1849*	GC, SCP, MPT, MAP	1,3,4,5,8,15,16,18,21,22
	Sapphirina nigromaculata Claus, 1863	GC, SCP, MPT, MAP	1,3,4,5,6,8,10,18,20,22,25
	Sapphirina opalina Dana, 1849*	GC, SCP-MPT	1,4,8,16,25
	Sapphirina ovatolanceolata Dana, 1849	GC	10,25

	Sapphirina scarlata Giesbrecht, 1892	GC, SCP	3,4,8,10,12,15,17,20,25
	Sapphirina stellata Brady, 1891*	GC, SCP	4,6,8,16,25
	Vettoria parva (Farran, 1936)	SCP	3
Miraciidae	*Macrosetella gracilis* (Dana, 1848)	GC, SCP, MAP	1,3,10,15,20,22,25
Ectinosomatidae	*Microsetella rosea* (Dana, 1847)*	GC, SCP, MAP	1,3,4,8,16,20,22,25
	Microsetella norvegica (Boeck, 1865)	GC, SCP, MPT, MAP	1,3,12,13,18,20,22,25
Peltidiidae	*Clytemnestra rostrata* (Brady, 1883)	GC, SCP	1,3,4,7,8,10,25
	Clytemnestra scutellata Dana, 1847*	GC, SCP	1,3,10,16,17,25
Tachidiidae	*Euterpina acutifrons* (Dana, 1847)*	GC, SCP, MPT MAP	1,3,5,7,10,13,16,17,18,20,22,24,25
Monstrillidae	*Cymbasoma californiense* Suárez-Morales & Palomares-Garcia, 1999	GC	3,7,25
	Monstrilla bitumida Suárez-Morales & Palomares-García, 1995	GC	1
	Monstrilla gibbosa Suárez-Morales & Palomares-García, 1995	GC, SCP	3,25
	Monstrilla Dana, 1849 und. sp.	GC	TALUD
	Monstrilla leucopis Sars, 1921*	GC	16
	Monstrilla spinosa Park, 1967	SCP-MPT	1
Pontoeciellidae	*Pontoeciella abyssicola* (Scott T., 1893)*	GC	1,16
Rataniidae	*Ratania flava* Giesbrecht, 1893*	GC, SCP	1,3,16

8.4.2. *Distribution of pelagic copepod communities*

The most similar provinces in terms of species composition, according to the CLUSTER results, were the SCP and the GC, both in a single subgroup. The MPT conformed a sister subgroup to the SCP-GC group (within a similitude of 50%), while the MAP province conformed an independent subgroup (Fig. 2). Based on the family-level composition, the most similar provinces were again the GC and the SCP, both together in a subgroup that also includes the MPT (within a distance of 30 units). The MAP is placed again as an independent subgroup (Fig. 3). In both analyses, the conformation of the subgroups is supported by the SIMPROF tests.

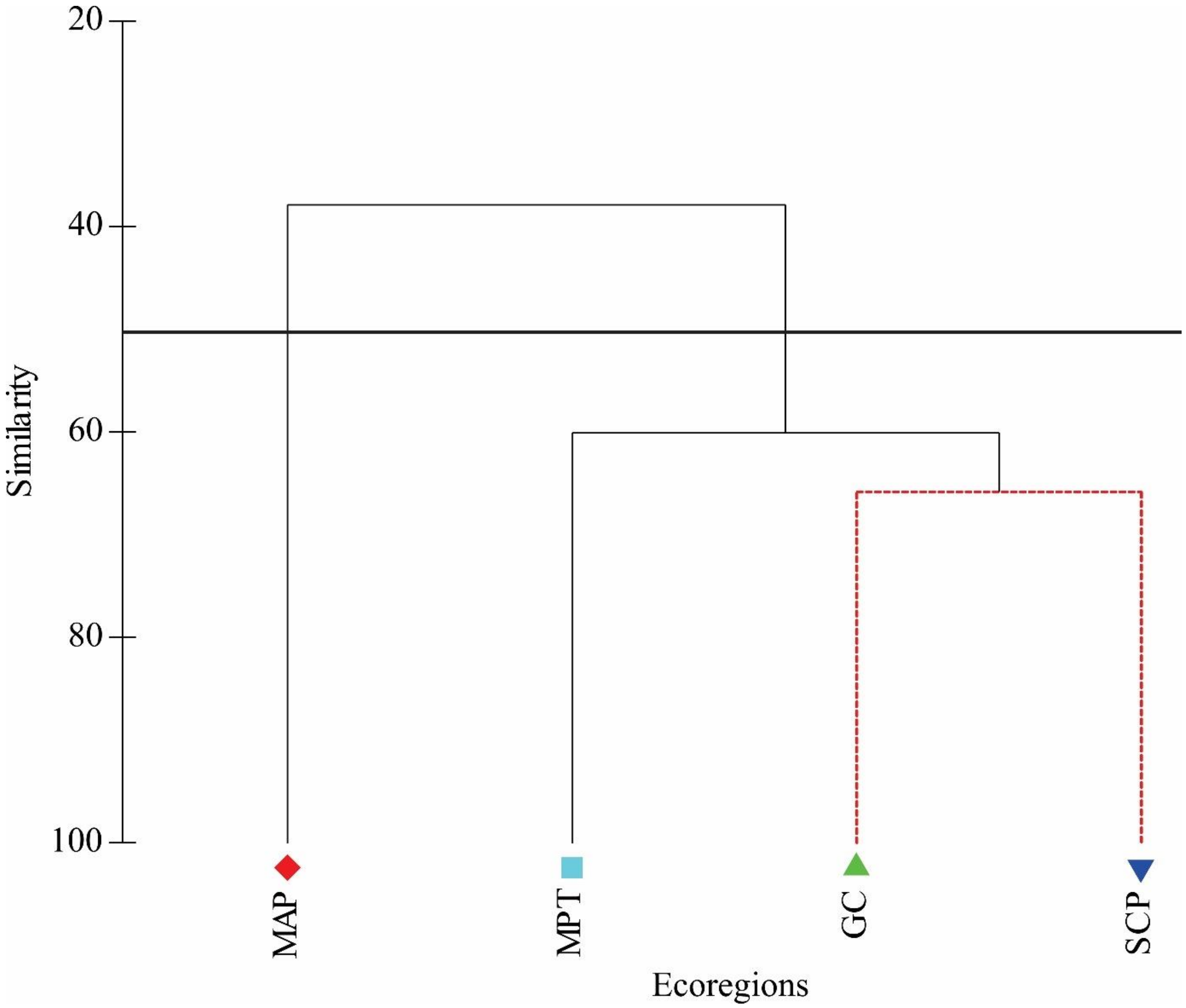

Figure 2. Similarity calculated among the four ecoregions of the Mexican Pacific based on the copepod species-level composition. MAP, Middle American Pacific; GC, Gulf of California; SCP, Southern Californian Pacific; MPT, Mexican-Pacific Transition. Units are expressed as Sørensen Similitude Index. Line placed at 50% similarity.

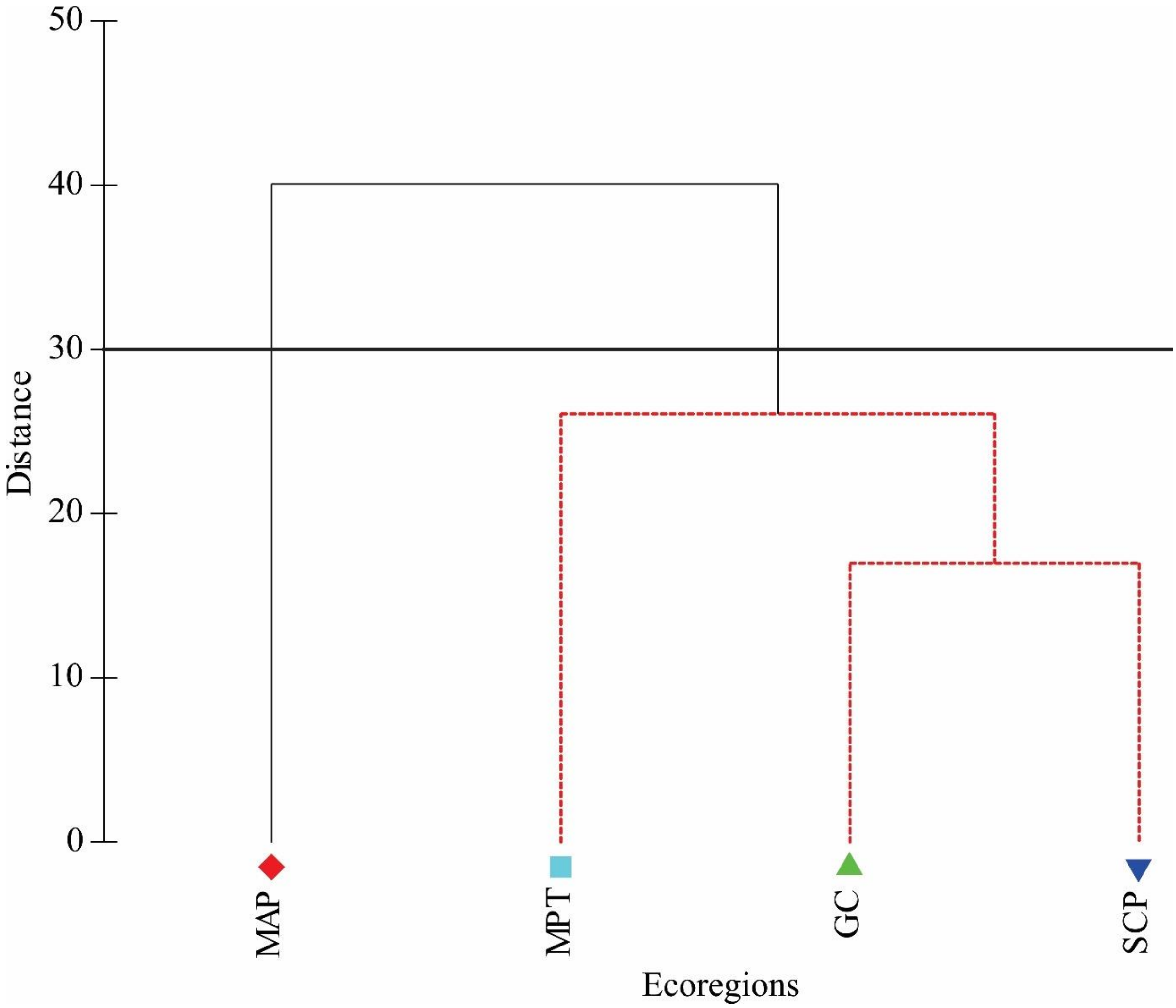

Figure 3. Similarity calculated among the four ecoregions of the Mexican Pacific based on the copepod family-level composition. MAP, Middle American Pacific; GC, Gulf of California; SCP, Southern Californian Pacific; MPT, Mexican-Pacific Transition. Units are expressed as Sørensen Similitude Index. Line placed at a distance of 30 units.

8.5. *Discussion*

8.5.1. *Richness and composition of the pelagic copepod fauna*

Recent contributions about the Copepoda in the Mexican Pacific have provided a clear picture of how epipelagic copepod communities are constituted, as well as what their latitudinal and vertical distribution is. The list of 382 species represents an important increase since the updated checklist of Suárez-Morales and Gasca (1998). If only pelagic, neritic or semi-parasitic species in the contribution of Suárez-Morales and Gasca (1998) are included, the total increase of records after this survey is of around 90%. If benthonic and parasitic species are added to the final list, the total results in around 680 species, although this list still present lack of records for other copepod orders, as Mormonilloida or Platycopioida. Calanoida, as expected, was clearly the richest order. It has to be noted that several species could only be identified at genus level, leaving the possibility of more species to be added.

Calanoids were usually the dominant group in our samples, especially in the TALUD samples, when more than 90% of the total copepod abundance corresponded to calanoids. In epipelagic samples, calanoids were still dominant, and accounted for between 60 and 80% of the total copepod abundance. In the new checklist, 289 species were calanoids and the rest corresponded to the orders Cyclopoida (79 species), Harpacticoida (6 species), Monstrilloida (6 species), and Siphonostomatoida (2 species).

The families Aetideidae, Corycaeidae, Euchaetidae, Oithonidae, Paracalanidae, Pseudocalanidae, Pseudodiaptomidae, and Spinocalanidae were relatively poorly represented in our samples, considering their total richness in the Mexican Pacific; some genera, such as *Paraeuchaeta* Scott A., 1909, *Acrocalanus* Giesbrecht, 1888 or *Calocalanus* Giesbrecht, 1888 were particularly poorly represented. This is probably related to the seasonal and annual change in the copepod communities, the spatial zonation, the shift in the environmental gradients, and the diel vertical migrations of certain species (see Palomares-García et al. 2013; Beltrán-Castro et al. 2020; González 2020). Also, the nets with a large mesh size (2 mm) used during the TALUD cruises could have led to underestimation of the abundances of small species below the oxygen minimum zone. Typically, during an annual survey in the Mexican Pacific, the expectations are to find between 30 and 80 copepod species (e.g., Palomares-García et al. 2013; Cruz-Hernández et al. 2019; Beltrán-Castro et al. 2020, Velázquez-Ornelas and Hendrickx 2023). The analysis of 124 samples during this study resulted in the identification of 132 species, thus the sampling effort was actually acceptable. Comparatively, the study of Jiménez-Pérez and Lavaniegos (2004) in the northern SCP from 1997 to 1999 resulted in 169 recorded species, based on the analysis of as many as 342 samples. These results enforce the need for additional sampling effort aimed at exploring a wider vertical range in search of the true copepod richness along the ETP and other regions of the world.

8.5.2. *Distribution pattern of pelagic copepods*

Although the GC species composition was found to be more than 50% similar to the fauna occurring in the SCP and the MPT ecoregions, the copepod community of the GC is still unique. Epipelagic species (e.g., species of *Acartia*, *Centropages*, *Calanus*, *Corycaeus*, *Haloptilus*, *Labidocera*, *Nannocalanus*, *Oithona*, *Oncaea*, *Paraeucalanus*, and *Subeucalanus*) have been observed to show a clear latitudinal pattern, and communities in the NGC, the CGC-SGC, and the EGC presents differences in the composition, particularly during the cold season (Velázquez-Ornelas and Hendrickx 2023). If deep-water (from surface to depth > 500 m) samples are considered, the copepod community varies between the GC and the MPT, especially for the dominance of some vertical migrators, such as *Eucalanus hyalinus* (dominant in the MPT samples), *Rhincalanus nasutus* or *Paraeucalanus sewelli* (dominant in the GC samples). Among the deep-water species, five species were recorded only for the MPT: *Arietellus* sp., *Centraugaptilus macrodus*, *Cephalophanes* sp., *Nullosetigera mutica* and *Sarsarietellus* sp. On the other hand, 17 species were recorded only in the Gulf of California, including *Arietellus setosus*, *Augaptilus cornutus*, *Euaugaptilus nodifrons*, *Mesorhabdus angustus*, and *Temorites elongata*. *Paraeuchaeta copleyae* is considered to be an endemic species in the Gulf (Park 1993) and it was collected only in the GC during this survey. *Paraheterorhabdus compactus* was the most widespread species to be recorded only in the GC; it has not been previously recorded for the MPT.

The MAP ecoregion was the area with the lowest species richness. Reasons for this might be a combination of two factors, namely the lack of intensive long-term sampling and the fact that it is a much smaller region. However, species richness in this province as calculated in our work (79 species) is not very different when compared with the copepod richness observed in adjacent countries in the 0 to ca. 200 m depth fringe. Suárez-Morales and Gasca (1989) included 41 species for Costa Rica, while Jerez-Guerrero et al. (2017) included a list of 52 species for Pacific Colombia. In other contributions, Jerez-Guerrero et al. (2020, 2022) reported 73 species for western Colombia. Samples collected during the CEEMEX cruises, also in neritic water, in the MAP ecoregion (e.g., Gulf of Tehuantepec) did not provided new records.

Neritic species belonging to the genera *Acartia*, *Centropages*, *Pseudodiaptomus*, *Oithona*, and *Oncaea* were much less frequent in our samples than oceanic species, i.e., species of *Candacia*, *Euchirella*, *Labidocera*, *Eucalanus*, and *Rhincalanus*. Some contributions, as those of Fernández-Álamo et al. (2000), Álvarez-Silva et al. (2003) or Kozak et al. (2014a) presents larger proportions of neritic species due to their sampling areas. The zoogeographic affinities for the copepods in the Gulf of California, as described by Jiménez-Pérez and Lara-Lara (1988), is mostly tropical (69%) and partly equatorial (17%)

and temperate (14%). These numbers should vary for the western coast of the California Peninsula, which is under a greater influence of temperate waters, and for the Mexican eastern tropical Pacific, where a greater influence of warm equatorial waters prevails. This is also true for deep-water species; most of these are tropically or sub tropically distributed, with only a 10% of non-tropical species.

Although given the greater similitude observed between the SCP and the GC at the species and family-level composition, the GC remains as an independent province of the Mexican Pacific if based on the differences in the dominance of certain species. Both at species and family-level there are no significant differences between the SCP and the GC, as depicted in the contribution of Spalding et al. (2007). However, no analysis shows enough similitude between the GC and the MPT in order to consider both areas as belonging to the same province, as depicted in the contribution of Spalding et al. (2012). It is necessary to increase the sampling efforts to bring up a clear picture of how the copepod communities are actually distributed in the ETP, including additional sampling of the epipelagic and mesopelagic fringes, combined with an increase of sampling in the bathypelagic and abyssopelagic vertical zones. These results enforce the idea that, even if several copepod species are actually cosmopolitan due to the lack of physical barriers, the overall composition of the copepod community is sensitive to even small changes among the different water masses, making them a good indicator for changes at different scales.

Additionally, when compared to the area covered by neritic and oceanic waters of western Mexico, the species richness and composition of copepods in the vicinity of the oceanic islands of the Mexican Pacific reveals both lower numbers of species and differences in the dominant taxa, being mostly small neritic species (e.g., Gómez-Gutiérrez et al. 2014). There is still a lack of information for most oceanic islands in the Exclusive Economic Zone of Mexico, but similar dominance of neritic species has been observed around the Gorgona Island, Colombia (Jerez-Guerrero et al. 2020). Larger pelagic species occur in temperate northern or southern regions, e.g., in the vicinity of Vancouver Island and Easter Island (Gardner and Szabo 1982; Medellín-Mora et al. 2021).

8.6. *Conclusions*

The number of pelagic copepod species recorded for the Mexican pacific is now of 382. This number is 90% larger than the last updated checklist for this study area. Part of the reasons for this increase is the addition of 25 deep-water species, collected during the TAUD cruises and observed in some contributions. The richest families were, in descendent order, Pontellidae, with 34 species, Corycaeidae and Aetideidae, both with 30 species. 25 deep-water species can be considered as new records for the Mexican Pacific: of these, 5 species were not identified at species level, but presents several differences in relation to described species recorded in the study area. The SCP and the MPT are the most similar provinces if analyzed at species-level, but the SCP and the GC are more similar if analyzed at family-level. The MAP province is different than the rest of the Mexican Pacific, both based on the present results and on published research, most probably due to the lack of sampling effort at large depths. The zoogeographic affinities of the copepod communities in the Mexican Pacific are mostly tropical, both for epipelagic and deep-water species. Additional contributions must be performed in order to describe the real range of distribution, both vertical and horizontal, of the more than 500 species recorded in the eastern Pacific.

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IX. DISCUSIÓN

9.1. *Los copépodos pelágicos del golfo de California*

Pese a que los copépodos son, en realidad, uno de los grupos de invertebrados más ampliamente estudiados, aún existen preguntas acerca de sus patrones de distribución, su diversidad, su fisiología o su comportamiento. Particularmente, los copépodos calanoides son el grupo de copépodos mejor conocido, tanto en agua dulce como en sistemas marinos, y estos son también el grupo dominante en la comunidad de copépodos. Algunos de los cuestionamientos fundamentales que aún existen sobre las comunidades de copépodos del Pacífico mexicano son, por ejemplo, ¿Cuál es el número total de especies tanto en sistemas continentales como marinos? ¿Qué tan marcada es la variación entre las comunidades de la zona fótica con respecto a las comunidades de aguas profundas? ¿Es el cambio estacional en la composición de especies similar a lo que se ha reportado en otras latitudes? Entre otras.

El primer capítulo de esta tesis aborda el uso de métodos estadísticos multivariados para el análisis integral de las distintas variables que influyeron en la composición de las comunidades de copépodos del golfo de California durante 1985, tales como la dominancia de algunas especies en relación con las variables ambientales o la relación entre la productividad primaria con la diversidad y la estructura funcional de las comunidades de copépodos. Estos métodos son más eficientes si el trabajo de identificación es adecuado, ya que de otro modo no es posible evaluar de manera sensible el carácter indicativo de ciertas especies, además de que esto limita la representatividad de los datos. El alto número de especies para un solo ciclo anual fue considerablemente alto en relación a contribuciones previas para el golfo de California (Jiménez-Pérez y Lara-Lara 1988; Lavaniegos-Espejo y Lara-Lara 1990; Gómez-Gutiérrez y Hernández-Trujillo 1994; Palomares-García et al. 2013; Cruz-Hernández et al. 2018; Beltrán-Castro et al. 2020). La composición de especies reportada en este capítulo fue muy similar a la reportada en el trabajo más similar a este por Jiménez-Pérez y Lara-Lara (1988), con pocas adiciones al trabajo de Palomares-García et al. (1988), aunque en el presente estudio las especies dominantes fueron distintas.

El patrón latitudinal de la distribución de los copépodos epipelágicos en el golfo de California se ha estudiado en trabajos previos (Jiménez-Pérez y Lara-Lara 1988; Lavaniegos-Espejo y Lara-Lara 1990; Palomares-García et al. 2013). Gran parte de los resultados obtenidos en esas contribuciones coinciden con los hallazgos hechos por Velázquez-Ornelas y Hendrickx (2023) (capítulo VI). En las contribuciones más similares (Jiménez-Pérez y

Lara-Lara 1988; Lavaniegos-Espejo y Lara-Lara 1990; Palomares-García et al. 2013) se trabajó únicamente con material de las zonas centro y sur del golfo, por lo que la zona norte no pudo ser comparada con otros trabajos. En este trabajo se determinó que la comunidad de copépodos de la zona norte es distinta al resto del golfo, no solo en términos de composición y diversidad, sino también en la estructura funcional de la comunidad observada a través de los intervalos de tamaño de las especies, pues la comunidad de la zona norte presenta una clara dominancia de especies grandes (herbívoros filtradores, principalmente), mientras que las especies son cada vez más pequeñas (depredadores y filtradores selectivos, principalmente) conforme se muestrea hacia la entrada del golfo.

Las comunidades de copépodos en el golfo son sensiblemente distintas según la época del año y las características de las masas de agua, dando lugar a cambios a nivel de riqueza y diversidad asociados con la salinidad y con la estructura funcional de la comunidad de fitoplancton. La comunidad de copépodos de la época fría presenta dominancia, en general, de especies de mayor tamaño y con hábitos alimenticios filtradores, mientras los copépodos observados durante la época cálida tienden a ser especies más pequeñas y, en general, con hábitos depredadores o semi parásitos. La variación la abundancia, la composición y la estructura funcional de la comunidad de los copépodos es, ante la evidencia, fuertemente correlacionada con el cambio estacional en la temperatura, además de la variación de la radiación solar. Esto ha sido previamente observado tanto en el golfo como en otras áreas (Palomares-García et al. 2013; Spinelli et al. 2016).

9.2. *Los copépodos de las campañas TALUD*

Uno de los principales problemas sobre el conocimiento de los copépodos en el Pacífico mexicano ha sido, históricamente, la poca disponibilidad de material recolectado a profundidades más allá de la zona fótica, una problemática previamente mencionada. Las campañas TALUD tuvieron como uno de sus objetivos el muestrear gran parte del Pacífico mexicano más allá de la zona fótica: muestras de hasta 1600 metros de profundidad presentan una oportunidad para complementar el estudio de la fauna copepodológica de México. En el capítulo VIIa se logró determinar una comunidad de copépodos bastante distinta a lo observado en la zona fótica; 36 de las 85 especies de copépodos registradas a partir de este material pueden ser consideradas de aguas profundas debido, principalmente, a tres factores: su distribución vertical está descrita en la literatura, estas no aparecen en muestreos tomados a menos de 200 m de profundidad, y también presentan adaptaciones visibles para habitar estos ambientes. Se observó que algunas de estas especies presentan una distribución muy amplia, desde el golfo de California central hasta el Pacífico transicional mexicano. La migración vertical de estas especies está potencialmente limitada por la amplia ZMO, presente en la mayor parte del Pacífico mexicano.

La ZMO afecta la distribución vertical de la mayoría de las especies del zooplancton, y en su núcleo suelen encontrarse muy bajos niveles de biomasa (Vidhya et al. 2022). Las tasas de respiración de los copépodos se ven principalmente influenciadas principalmente por la temperatura y por la biomasa de cada individuo, con una correlación inversa entre la masa y la tasa de respiración (Teuber et al. 2013). Los copépodos de aguas profundas observados durante este trabajo son, en general, especies de gran tamaño, lo que implicaría teóricamente una menor demanda de oxígeno y, por ende, explicaría el por qué son las especies más comunes en arrastres tomados a través o por debajo de la ZMO. Las especies de la zona mesopelágica son, en muchos casos, capaces de realizar migraciones verticales diarias relacionadas con la tasa de depredación y la disponibilidad de alimento; los géneros *Pleuromamma*, *Metridia*, *Rhincalanus* o *Euchirella* son algunos ejemplos de copépodos asociados con eventos de surgencia (Fernandez de Puelles et al. 2023). Estos géneros fueron considerablemente abundantes en las muestras de las campañas TALUD, aunque también se encontraron en gran abundancia en las muestras de las campañas CORTES y SIPCO.

Las especies que no pudieron ser identificadas deberán ser abordadas en trabajos posteriores; *Xanthocalanus* sp. y *Cephalophanes* sp. son, muy probablemente, taxones no descritos. Esto sobre la base de las diferencias observadas en la ornamentación de los apéndices natatorios. No se descarta la posibilidad de que *Sarsarietellus* sp.*,* *Arietellus* sp. e *Incertae sedis* cf. Scolecithricidae sean también taxones indescritos. Las familias Phaennidae y Scolecithricidae presentan pocos caracteres que permitan diferenciarlas entre sí, lo que indica la necesidad de trabajar de manera más profunda, y con herramientas adicionales a la morfología, que permitan asignar de manera más robusta a los géneros que pertenecen a cada familia.

La zonación que se observó para el golfo de California a partir del material de las campañas TALUD fue distinta a lo observado a partir de las campañas CORTES; las zonas CGC y SGC fueron nuevamente muy similares, pero la zona EGC fue distinta a ambas zonas y, en parte, similar a la composición del PCM. Pese a que los datos de las campañas TALUD presentan alta incertidumbre para los análisis multivariados (ver capítulo V), el patrón de distribución espacial fue relativamente claro. La zona EGC, además de ser distinta de las otras zonas en términos de composición, fue la zona en la que se observaron valores más altos de diversidad y equitatividad. Esto puede relacionarse con el hecho de que la zona EGC representa la transición entre las masas de agua del golfo de California y el resto del Pacífico mexicano. Los gradientes ambientales, particularmente de temperatura, juegan un papel fundamental en la distribución espacial de los copépodos en diferentes escalas (González et al. 2020).

9.3. Los copépodos del Pacífico mexicano

El conocimiento de la diversidad y distribución de los copépodos del Pacífico mexicano procede de contribuciones realizadas desde principios del siglo XX, y se ha mantenido en incremento desde entonces. A pesar de las limitantes para el estudio de los copépodos en México (ver capítulo I), la lista de especies pelágicas registradas en el Pacífico mexicano es considerablemente alta, solo después del número de registros para el Pacífico oriental, el océano Índico y el Atlántico tropical (Razouls et al. 2024). Entre los puntos de oportunidad para incrementar el conocimiento de los copépodos marinos de México está el estudio de la ecología y sistemática de especies marinas bentónicas, especies de aguas profundas, especies asociadas a sistemas subterráneos y también de especies parásitas. Desde el trabajo de Suárez-Morales y Gasca (1998) se han realizado numerosas contribuciones al conocimiento de los copépodos epipelágicos en el Pacífico mexicano, pero muy poco se ha hecho con respecto a las comunidades de copépodos en aguas profundas. De las más de 330 especies conocidas hasta el día de hoy en el área de estudio, el porcentaje de especies registradas en aguas profundas es considerablemente bajo: menos de un 5% del total se han registrado en aguas a profundidades mayores que 250 m. A partir del material recolectado durante las campañas TALUD se incrementó la lista a 36 especies de calanoides de aguas profundas que habitan en el Pacífico mexicano, muchas de estas ampliamente distribuidas.

La lista total de especies para el Pacífico mexicano alcanza, por el momento, alrededor de 680 especies si se consideran los registros de especies bentónicas y parásitas. Este es aún un número conservador, debido a que usualmente se hipotetiza una riqueza mayor tanto de harpacticoides como de especies parásitas, debido a los escasos muestreos dirigidos a estos grupos a nivel mundial en comparación con el estudio de otros grupos de copépodos. En cuanto a especies pelágicas, es difícil que el número se incremente de forma considerable debido al gran número de contribuciones que se han hecho sobre esta área, aunque es evidente que la riqueza de especies de aguas profundas todavía no se conoce del todo. El uso de redes de micronecton permite realizar arrastres de manera eficiente a gran profundidad, pero la luz de malla tan grande (2 mm) podría haber excluido a algunas especies. Sin embargo, como se discutió en el capítulo XVIII, es probable que la mayoría de especies en estas profundidades presenten tamaños considerables en función del déficit de oxígeno, lo que significaría que la representatividad del muestreo fue de hecho muy buena.

El uso de ecorregiones como referencia para el análisis de las comunidades de copépodos fue adecuado, con una mayor resolución que el propuesto por Spalding (2012). Sobre la base de lo discutido en el capítulo VI, la comunidad de copépodos es sumamente sensible a la variación entre las distintas masas de agua, incluso a microescala. Es muy probable que el potencial como indicador de la comunidad de copépodos sea en el futuro cercano de gran utilidad para estudiar fenómenos relacionados al cambio climático, pues gracias a los análisis multivariados esta permite detectar desde eventos locales de surgencia hasta los efectos de eventos macro-escala como es el fenómeno ENSO.

X. CONCLUSIONES

La revisión de 124 muestras recolectadas durante 21 cruceros en el golfo de California resultó en una riqueza de copépodos en 1982 (año Niño) y 1985 de 79 especies, con una composición dominada principalmente por *Aetideus armatus*, *Calanus pacificus*, *Clausocalanus jobei*, *Nannocalanus minor*, *Pleuromamma gracilis* y *Rhincalanus nasutus*. El cambio en la riqueza y la diversidad ecológica se asoció principalmente con la salinidad y las características de la comunidad de fitoplancton, mientras que el cambio en la composición y la abundancia se asoció principalmente con la temperatura. Las masas de agua frías, más saladas y más productivas favorecieron la dominancia de especies más grandes, de hábitos filtradores, mientras que las aguas más cálidas, menos saladas y menos productivas favorecieron la dominancia de especies más pequeñas y de hábitos depredadores. Se determinó que el golfo de California presenta una estructura latitudinal en las comunidades de copépodos en invierno, pero en verano esta no es muy evidente. En ambas épocas se observó una estructura meridional en el sur y la entrada del golfo, reflejada en la temperatura del agua y la composición de especies. La composición y la abundancia observadas coinciden con lo observado en contribuciones similares; la riqueza fue relativamente alta para un solo ciclo anual.

La comunidad de copépodos pelágicos observada en muestras recolectadas a más de 500 m en el golfo de California durante 21 campañas oceanográficas (124 muestras) fue considerablemente distinta: de las 85 especies recolectadas en las campañas TALUD, 36 se pueden considerar como especies de aguas profundas. De estas, 25 especies representan nuevos registros para el Pacífico mexicano y 27 especies son nuevos registros para el golfo de California. Las especies de aguas profundas dominantes en términos de frecuencia y abundancia fueron: *Euaugaptilus angustus*, *Lucicutia hulsemannae*, *Megacalanus frosti*, *Paraheterorhabdus compactus*, *Pseudhaloptilus pacificus* y *Pseudochirella obtusa*. El patrón de distribución espacial de la composición a nivel de familia fue ligeramente distinto con respecto a la composición a nivel de especie, observándose que la zona EGC fue siempre distinta del golfo de California. El patrón de distribución espacial de la comunidad epipelágica fue distinta a la de la comunidad meso-batipelágica: la zona EGC es distinta del centro y sur del golfo de California en el caso de la comunidad meso-batipelágica, no así en la comunidad epipelágica. Cinco especies de los géneros *Arietellus*, (?) *Archescolecithrix*, *Cephalophanes*, *Sarsarietellus* y *Xanthocalanus* son, probablemente, taxones indescritos por presentar una combinación de caracteres morfológicos únicos y distintos de las especies conocidas.

Sobre la base de estos hallazgos, además de la revisión de literatura reciente, la lista de especies para el Pacífico mexicano se actualiza con un incremento del 90% comparativamente con el trabajo pionero de Suárez-Morales y Gasca (1998). Concluimos que el número de especies para cada zona del área de estudio incremento de manera significativa y se ubica actualmente en: 269 especies para la zona GC, 272 para la zona SCP, 184 para la zona MPT y 80 para la zona MAP. El número total de especies para el Pacífico mexicano es de 382 especies, incluidos los 25 nuevos registros obtenidos en este trabajo. Se determinó que el golfo de California es muy similar al Pacífico sudcaliforniano en términos de composición, aunque las diferencias en las especies dominantes y las abundancias de otras especies permiten distinguirla como una ecorregión única. El Pacífico americano intermedio fue muy distinto en términos de riqueza, probablemente por la reducida área que ocupa y por el menor número de trabajos que se han realizado en esa zona. La estimación actual del número total de especies de copépodos marinos en el Pacífico mexicano, incluyendo los Calanoida, Cyclopoida, Harpacticoida, Monstrilloida y Siphonostomatoida excede las 680 especies. Este número debería aumentar de manera significativa en las próximas décadas debido a los continuos esfuerzos de los especialistas mexicanos. No se conocen registros en el Pacífico mexicano de los órdenes Canuelloida, Mormonilloida o Platycopioida, lo cual abre las puertas a la investigación enfocada en el hallazgo de ejemplares de estos órdenes.

XI. REFERENCIAS

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