

Taxonomic revision of the Mexican *Eucyclops* (Copepoda: Cyclopoida) with comments on the biogeography of the genus

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ABSTRACT

Based on the examination of specimens deposited in different national and international biological collections, we reviewed the ca. 800 records of the genus *Eucyclops* in Mexico and compared them with the type material of presumed widespread species. Resulting from our taxonomical analysis, in this contribution we recognise 17 species dwelling in Mexico. Complementary upgraded descriptions of eight species emphasising newly introduced taxonomic characters are also presented from the examination of Mexican specimens. These species include *E. elegans*, *E. prionophorus*, *E. festivus*, *E. leptacanthus*, *E. torresphilipi*, *E. chihuahuensis*, *E. cuatrocieneegas* and the recently described *E. tziscao* and *E. angeli*. In addition, the use of upgraded descriptive standards involving new morphological characters allowed the discovery of six new species that are described in this work: *E. alekseevi* sp. nov., *E. wixarica* sp. nov., *E. defayae* sp. nov., *E. mittmanni* sp. nov., *E. estherae* sp. nov. and *E. ishidae* sp. nov. Most of these species were previously recorded in Mexico under different names. The occurrence of *E. pectinifer*, *E. elegans*, *E. prionophorus* and *E. leptacanthus* in Mexico is herein confirmed. We propose the ornamentation patterns of the fourth swimming legs (i.e. basipodite, coxal plates) as reliable additional characters to recognise closely related species of *Eucyclops*. The importance of the antennal basis ornamentation in the taxonomy of the genus is supported by our data. We evaluated the taxonomic value of 113 morphometric and binary characters using statistical methods; results of this analysis showed that morphometric characters alone overlap and thus have a limited value to distinguish species of *Eucyclops*. We include comments on *E. serrulatus* s. str. in order to provide a complete comparison frame among members of the *serrulatus*-species complex, but we did not find the strict form in the samples examined. A key to the Mexican species of the genus is also provided.

ARTICLE HISTORY

Received 4 November 2014
Accepted 4 June 2015
Online 3 August 2015

KEYWORDS

serrulatus-complex;
freshwater copepods;
taxonomy; diversity;
morphometrics

Introduction

Until recently the systematics of the free-living Cyclopidae was based on a limited number of morphological characters, some of which have been proved to be highly variable and related to environmental factors (Dahms and Fernando 1997; Rocha 1998;

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Karaytug 1999). Another problem that is common among species of the family Cyclopidae is the notion of cosmopolitanism. According to Boxshall and Defaye (2008), the nineteenth-century species concepts were largely established and applied by European natural historians who tended to record species from around the world under European names, assuming that these species are naturally cosmopolitan. The second half of the twentieth century brought revisionary studies with the exploration of new characters and improved taxonomic resolution; numerous species complexes were recognised among the freshwater cyclopid copepods. The evaluation of more characters in the definition of species of copepods in the last three decades has led to the clarification of their taxonomy (Karaytug 1999; Boxshall and Halsey 2004; Dussart and Defaye 2006). Currently, the diversity of some cyclopid genera is being rediscovered and described, including *Paracyclops* (Karaytug 1999), *Mesocyclops* (Van de Velde 1984; Suárez-Morales and Gutiérrez-Aguirre 2001; Ueda and Reid 2003; Hołyńska 2006) and *Acanthocyclops* (Dodson 1994; Mirabdullayeb and Defaye 2002, 2004; Dodson et al. 2003; Miracle et al. 2013).

Among the Cyclopidae, the subfamily Eucyclopinæ is the one with deeper taxonomic problems. It contains approximately 185 species belonging to 10 genera; the genus *Eucyclops* is the most diversified Eucyclopine genus and it includes 110 nominal species and subspecies (Dussart and Defaye 2006; Alekseev and Defaye 2011; Gutiérrez-Aguirre et al. 2013). Due to its diversification, *Eucyclops* is probably the most taxonomically challenging group among the freshwater Copepoda; it contains several problematic taxa and some species groups with a high intraspecific variability.

The genus is currently divided into three subgenera: *Eucyclops* s. str. containing most of the known species, *Stygocyclops* Plesa, 1971 with only one known species, and *Isocyclops* Kiefer, 1957b which includes only two species, both endemic to Lake Tanganyika (Dussart and Defaye 2001, 2006; Suárez-Morales 2004; Mercado-Salas et al. 2012). *Eucyclops* has a very wide geographic distribution in tropical, temperate and cold latitudes of all continents, and inhabits all kind of aquatic habitats (Reid 2001; Suárez-Morales 2004). Some species, such as *Eucyclops elegans*, have been recorded in man-modified environments like reservoirs, water pipes and pooled water in tyres. Because of this tolerance to extreme conditions, it has been proposed that some species of *Eucyclops* might be used as a potential biological control of mosquito larvae (Reid and Marten 1995; Reid 2001). Furthermore, some *Eucyclops* (not identified at the species level) can be intermediate hosts of nematode parasites of fish, mammals and even humans. Some species of the parasitic *Gnathostoma* have been observed in *Eucyclops* from Mexico, where more than 8000 cases of human gnathostomiasis have been reported (Lamothe-Argumedo et al. 2001; García-Márquez 2005).

The primary characters used in the current taxonomy of the genus were proposed and implemented by Reid (1985), Morton (1990), Dussart and Defaye (2001), Suárez-Morales (2004) and, more recently, by Alekseev et al. (2006) and Alekseev and Defaye (2011). These characters include: (1) the presence and features of the fifth leg segment, armed with one inner spine and two setae; (2) antennules 12-segmented in females and 16-segmented in males; (3) the presence and coverage of spinules along the outer margin of the caudal rami; (4) the presence of hair-like setae on the outer margin of the fifth pedigerous somite; and (5) a spine formula of swimming legs being 3443. In

many cases, these characters have been insufficient to distinguish closely related species in the genus, a situation that has favoured a complex taxonomic history that includes many species or records that remain under an uncertain status (Collado et al. 1984; Reid 1985; Ishida 1997; Suárez-Morales 2004).

Ishida (1997, 2001, 2002, 2003), Alekseev et al. (2006), Alekseev (2008, 2010) and Alekseev and Defaye (2011) pioneered interesting attempts to solve the taxonomic problems in the genus. Ishida's works focused on the species complex 'serrulatus-like species' and 'speratus-like species' from Japan. Alekseev and collaborators emphasised the study of the 'serrulatus-group'. These authors incorporated new characters such as the antennal ornamentation patterns, the ornamentation of mouthparts, the patterns of body pores and even the ornamentation of the coxal plates, the basipods and coxopods of the fourth swimming leg. Overall, some problems have been solved, but new characters remain to be explored in order to strengthen the taxonomy of the genus.

In the Americas, there are more than 800 records of the genus that have been assigned to 31 nominal species. Approximately 300 of these records are related to taxonomically conflictive taxa (i.e. *E. serrulatus*, *E. agilis*, *E. speratus*). These records should be reviewed and eventually reassigned to American forms or, alternatively, confirm the presence of European species in this continent. Currently, Mexico is the country with the most records of *Eucyclops* (460) in the Americas, which currently involve 18 species: *E. agilis* (synonym of *E. serrulatus*), *E. bondi*, *E. breviramatus*, *E. chihuahuensis*, *E. conrowae*, *E. cuatrocieneegas*, *E. delachauxi*, *E. elegans*, *E. festivus*, *E. leptacanthus*, *E. pectinifer*, *E. prionophorus*, *E. pseudoensifer*, *E. serrulatus* (possibly *E. pectinifer*), *E. speratus* (*E. elegans* in the Americas), *E. torresphilipi* and the recently described *E. tziscao* and *E. angeli* (Juday 1915; Pearse and Wilson 1938; Osorio-Tafall 1943; Comita 1950; Lindberg 1955; Suárez-Morales et al. 1985; Zamudio-Valdéz 1991; Zanatta-Juárez 1995; Dodson and Silva-Briano 1996; Grimaldo-Ortega et al. 1998; Suárez-Morales and Reid 1998; Gutiérrez-Aguirre 1999; Álvarez-Silva and Gómez-Aguirre 2000; Elías-Gutiérrez 2000; Fiers et al. 2000; Rodríguez-Almaráz 2000; Suárez-Morales 2004; Elías-Gutiérrez et al. 2008; Jiménez-Trejo and Vásquez-Vargas 2008; Mercado-Salas 2009; Suárez-Morales and Walsh 2009; Gutiérrez-Aguirre et al. 2013). Based on the complexity of the genus and the lack of revisionary efforts in Mexico and in the Neotropical region as well, Suárez-Morales (2004), Suárez-Morales and Walsh (2009) and Gutiérrez-Aguirre et al. (2013) argued that the Mexican diversity of the genus could be underestimated. According to observations from Grimaldo-Ortega et al. (1998), Elías-Gutiérrez (2000), Rodríguez-Almaráz (2000), Suárez-Morales (2004), Suárez-Morales and Walsh (2009), Mercado-Salas (2009) and Gutiérrez-Aguirre et al. (2013), the morphology of the Mexican specimens shows some variations with respect to original descriptions and records. These variations suggest that undescribed species have been recorded over time under the names of 'common', 'widespread' or 'cosmopolitan' species. These observations highlight the importance of performing a complete morphological study of the species and records from Mexican water bodies including the re-examination and redescription of type material and the revision of voucher specimens supporting Mexican records in national or international collections. This process is expected to allow a re-evaluation of the variability among Mexican populations by using new characters that could aid us to achieve an accurate morphological delimitation of the Mexican species and allow

reliable taxonomical identifications. The goal of this survey is to provide the bases of a new taxonomical approach to identify species of *Eucyclops*. This will contribute to (1) solving the taxonomy and diversity of the genus in Mexico, (2) assessing and clarifying the real distributional patterns of the species and (3) marking an upgraded standard in the description model in the taxonomy of the genus in the Americas.

Methods

In order to have a complete overview of the taxonomic status of the Mexican material, we examined type and non-type specimens deposited in different collections: Staatliches Museum für Naturkunde, Karlsruhe (*E. delachauxi*, *E. prionophorus*, *E. bondi*, *E. leptachantus* and specimens of *E. elegans*); Muséum National d'Histoire Naturelle, Paris (*E. pseudoensifer*); National Museum of Natural History Smithsonian Institution in Washington, DC (*E. conrowae* and specimens of *E. elegans*); and El Colegio de la Frontera Sur (*E. torresphilipi*, *E. cuatrocieneegas*, *E. chihuahuensis*, *E. tziscao*, *E. angeli*). The redescriptions of species and additional comparative comments on specimens from the first three collections can be consulted in Mercado-Salas and Suárez-Morales (2014a, 2014b). Taxonomic and morphological remarks on the Mexican type specimens deposited at El Colegio de la Frontera Sur are included in this work. A thorough search was performed to locate the collections where Mexican material is deposited; the two main collections where Mexican specimens are deposited are: (1) the National Museum of Natural History Smithsonian Institution, which holds a number of records from the states of Quintana Roo and Nuevo Leon; and (2) El Colegio de la Frontera Sur, which holds the most important collection of *Eucyclops* (and copepods in general) from Mexico, including records from 10 states: Aguascalientes, Chihuahua, Chiapas, Coahuila, Durango, San Luis Potosi, State of Mexico, Tabasco, Quintana Roo and Zacatecas. From only these two collections we reviewed more than 300 specimens. Additional biological samples from Baja California, Baja California Sur, Oaxaca, Coahuila and Sinaloa deposited at the Centro de Investigaciones del Noreste (CIBNOR) and samples from the states of Queretaro, Veracruz and Oaxaca held at the FES-Iztacala Universidad Nacional Autónoma de México (UNAM), Mexico City, were also examined, aiming to expand the geographic coverage of this survey.

All specimens from ECOSUR, CIBNOR and UNAM were dissected and appendages mounted in glycerin for taxonomic analysis. For each slide/specimen examined, a sheet with morphometric measurements was filled in to have a detailed record of the morphological variation of each species. The appendage and body morphology, measurements and micropatterns analysed in each specimen followed Einsle (1985), Karaytug (1999), Alekseev et al. (2006) and Alekseev and Defaye (2011), all with slight modifications (see Figure 1).

The following morphological characters (with abbreviations) were examined and evaluated in most of the studied material.

In females:

- (1) Antennule (A1): number of segments and elements present on each segment, size of spine on sixth segment and structure of hyaline membrane on three distalmost segments (Figure 1A, B);

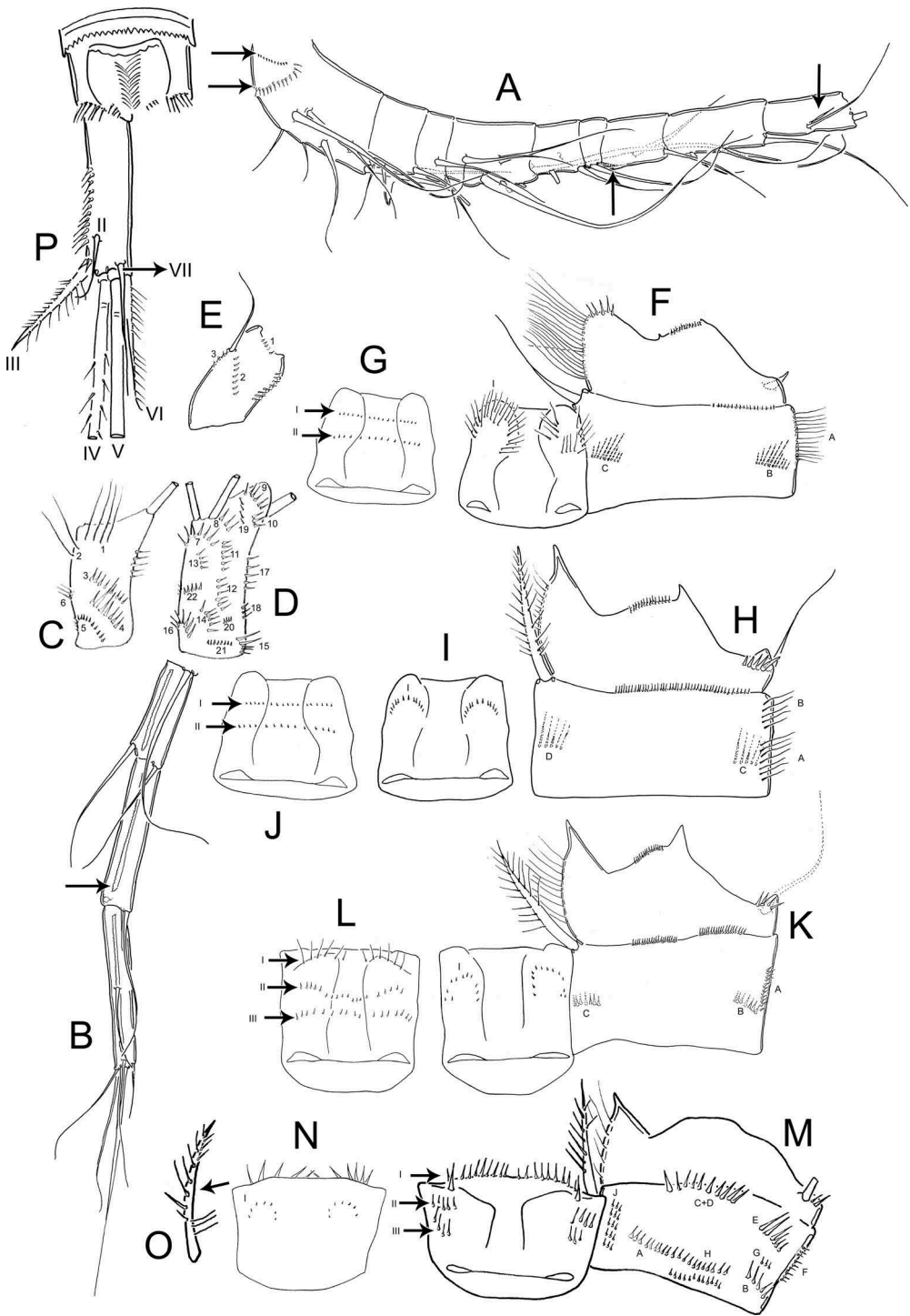


Figure 1. Morphological characters reviewed in the Mexican *Eucyclops*. (A) Antennule segments 1–9; (B) antennule segments 10–12; (C) antenna basis, frontal; (D) antenna basis, caudal; (E) Enp1 antenna; (F) coxa, basis and intercoxal sclerite P1, frontal; (G) intercoxal sclerite P1 (caudal); (H) coxa and basis P2, frontal; (I) intercoxal sclerite P2, frontal; (J) intercoxal sclerite P2, caudal; (K) coxa, basis and intercoxal sclerite P3, frontal; (L) intercoxal sclerite, caudal; (M) coxa and intercoxal sclerite P4, caudal; (N) intercoxal sclerite P4, frontal; (O) coxal spine P4; (P) caudal ramus and anal operculum.

- (2) Antenna (A2): spinulation micropatterns on frontal and caudal sides of basipodite (Figure 1C, D), modified from Alekseev et al. (2006) and Alekseev and Defaye (2011); micropatterns on Enp1 (Endopodite; Figure 1E), number of setae on Enp 1–3;
- (3) Swimming legs 1–4 (P1–P4): spine formula of distal segments of exopodites (Exp). For P1, size of basipodal spine and relative lengths of distal segment of Enp and apical spine; for Enp3 P4, relative length, width and size of apical spines, insertion of lateral seta and ornamentation of coxal spine (Figure 1O); for P1–P4, micropatterns on caudal side of coxopodite, micropatterns on frontal and caudal surfaces of intercoxal sclerites, and number of modified setae in Enp and Exp (see Figure 1F–N);
- (4) Leg 5 (P5): relative length of inner spine, segment and two setae;
- (5) Genital double somite (GDS): shape of seminal receptacle;
- (6) Anal somite: shape of anal operculum;
- (7) Caudal rami: length/width ratio; percentage of spinule coverage of outer margin and size of spinules; length ratio of caudal setae. Caudal setae labeled as follows: II – anterolateral (lateral) caudal seta; III – posterolateral (outermost) caudal seta; IV – outer terminal (terminal median external) caudal seta; V – inner terminal (terminal median internal) caudal seta; VI – terminal accessory (innermost) caudal seta; VII – dorsal seta; nomenclature follows Huys and Boxshall (1991), Dussart and Defaye (1995) and Alekseev and Defaye (2011) (Figure 1P).

In males:

- (1) Antennule (A1): number of segments and number of elements present on each segment, following Karaytug and Boxshall (1999);
- (2) Antenna (A2): micropatterns on frontal and caudal sides of basipodite, as in females;
- (3) Fourth leg (P4): for Enp3, relative length, width and size of apical spines, relative percentage of lateral seta insertion and ornamentation of coxal spine; micropatterns of caudal side of coxopodite, micropatterns of frontal and caudal sides of intercoxal sclerites and number of modified seta in Enp and Exp (as in females);
- (4) Legs 5 and 6 (P5, P6): relative length of inner spine, segment and setae of both legs and relative length of spine of P6 relative to urosomites;
- (5) Caudal rami: length/width ratio; percentage of outer margin cover with spinules and size of spinules; length ratio of the caudal setae. Caudal setae nomenclature as in female.

Drawings of dissected specimens were prepared using an Olympus-BX53 microscope equipped with a camera lucida at a magnification of 1000 \times . Type specimens were deposited in the collection of Zooplankton held at El Colegio de la Frontera Sur (ECOSUR), Chetumal, Mexico (ECO-CH-Z).

For those species of which several specimens were available, one or two individuals were prepared for scanning electron microscopy (SEM) examination. This analysis was performed with a JEOL LV-5900 microscope at facilities of the Universidad Aut3noma de Aguascalientes, Mexico. The SEM processing included dehydration in progressively higher ethanol concentrations (60, 70, 80, 96, 100%), drying and gold coating following standard methods.

In order to provide a general evaluation of the characters measured as a tool to separate the species examined in this survey, we used different statistical methods.

These included boxplot graphics for morphometrical characters, correlation between morphometric values, and a cluster analysis (Euclidean distances-similitude). These were performed with the aid of the R-Development Core Team (2008) software. The matrix data used in these analyses included 113 characters (morphometric and binaries). Characters were codified as follows:

- (1) TB (total body length): value in millimeters.
- (2) SR (seminal receptacle): 0 – *serrulatus*-complex; 1 – with sinuous sac.
- (3) AO (anal operculum): 0 – rounded and smooth; 1 – rounded and serrate.
- (4) L/WCR (length/width caudal ramus): value.
- (5) VII/CR (dorsal seta VII/length of caudal ramus): value.
- (6) VII/III (dorsal seta VII/outermost caudal seta III): value.
- (7) VI/III (innermost caudal seta VI/outermost caudal seta III): value.
- (8) INII (insertion of lateral seta II – % of caudal ramus length): value.
- (9) A1S6 (length of spine on sixth segment of antennule): 0 – not reaching medial margin of seventh segment; 1 – reaching or exceeding medial margin of seventh segment.
- (10) N1 (row N1 – antenna): 0 – hairs; 1 – spinules.
- (11) N2 (row N2 – antenna): 0 – absent; 1 – present.
- (12) N2-O (row N2 – antenna ornamentation): 0 – hairs; 1 – spinules.
- (13) N3 (row N3 – antenna): 0 – absent; 1 – present.
- (14) N4 (row N4 – antenna): 0 – absent; 1 – present.
- (15) N5 (row N5 – antenna): 0 – absent; 1 – present.
- (16) N6 (row N6 – antenna): 0 – absent; 1 – present.
- (17) N7 (row N7 – antenna): 0 – absent; 1 – present.
- (18) N8 (row N8 – antenna): 0 – absent; 1 – present.
- (19) N9–10 (row N9–10 – antenna): 0 – fused; 1 – separated.
- (20) N9 (row N9 – antenna): 0 – absent; 1 – present.
- (21) N10 (row N10 – antenna): 0 – absent; 1 – present.
- (22) N11 (row N11 – antenna): 0 – absent; 1 – present.
- (23) N12 (row N12 – antenna): 0 – absent; 1 – present.
- (24) N13 (row N13 – antenna): 0 – absent; 1 – present.
- (25) N14 (row N14 – antenna): 0 – absent; 1 – present.
- (26) N15 (row N15 – antenna): 0 – absent; 1 – present.
- (27) N16 (row N16 – antenna): 0 – absent; 1 – present.
- (28) N17 (row N17 – antenna): 0 – absent; 1 – present.
- (29) N18 (row N18 – antenna): 0 – absent; 1 – present.
- (30) N19 (row N19 – antenna): 0 – absent; 1 – present.
- (31) N20 (row N20 – antenna): 0 – absent; 1 – present.
- (32) N21 (row N21 – antenna): 0 – absent; 1 – present.
- (33) N22 (row N22 – antenna): 0 – absent; 1 – present.
- (34) B1 (row B1 – Enp1 antenna): 0 – absent; 1 – present.
- (35) B2 (row B2 – Enp1 antenna): 0 – absent; 1 – present.
- (36) B3 (row B3 – Enp1 antenna): 0 – absent; 1 – present
- (37) P1F (row I frontal surface of intercoxal sclerite P1): 0 – absent; 1 – present.
- (38) P1F-O (row I frontal surface of intercoxal sclerite P1 – ornamentation): 0 – hairs; 1 – hair-spinules; 2 – spinules.

- (39) P1CRI (row I caudal surface of intercoxal sclerite P1): 0 – absent; 1 – present.
- (40) P1CRI-O (row I caudal surface of intercoxal sclerite P1 – ornamentation): 0 – hairs; 1 – spinules.
- (41) P1CRII (row III caudal surface of intercoxal sclerite P1): 0 – absent; 1 – present.
- (42) P1CRII-O (row II caudal surface of intercoxal sclerite P1): 0 – hairs; 1 – hair-spinules; 2 – spinules.
- (43) P1A (row A coxa P1): 0 – absent; 1 – present.
- (44) P1B (row B coxa P1 – ornamentation): 0 – hair-spinules; 1 – spinules.
- (45) P1BN (row B coxa P1 – number): 0 – one row; 1 – more than one row.
- (46) P1C (row C coxa P1): 0 – absent; 1 – present.
- (47) P1B/E (length basipodal spine/total length of Enp): value.
- (48) P1L/W (length/width Enp3 P1): value.
- (49) P1S/E (length apical spine/length Enp3 P1): value.
- (50) P2F (row I frontal surface of intercoxal sclerite P2): 0 – absent; 1 – present.
- (51) P2F-O (row I frontal surface of intercoxal sclerite P2 – ornamentation): 0 – hairs; 1 – hair-spinules; 2 – spinules.
- (52) P2CRI (row I caudal surface of intercoxal sclerite P2): 0 – absent; 1 – present.
- (53) P2CRI-O (row I caudal surface of intercoxal sclerite P2 – ornamentation): 0 – hairs; 1 – spinules.
- (54) P2CRII (row III caudal surface of intercoxal sclerite P2): 0 – absent; 1 – present.
- (55) P2CRII-O (row II caudal surface of intercoxal sclerite P2 – ornamentation): 0 – hairs; 1 – spinules.
- (56) P2A (row A coxa P2): 0 – absent; 1 – present.
- (57) P2B (row B coxa P2): 0 – absent; 1 – present.
- (58) P2B-O (row B coxa P2 – ornamentation): 0 – absent; 1 – present.
- (59) P2C (row C coxa P2): 0 – absent; 1 – present.
- (60) P2C-O (row C coxa P2 – ornamentation): 0 – hair-spinules; 1 – spinules.
- (61) P2CN (row C coxa P2 – number): 0 – one row; 1 – more than one row.
- (62) P2D (row D coxa P2): 0 – absent; 1 – present.
- (63) P2D-O (row D coxa P2 – ornamentation): 0 – hairs; 1 – spinules.
- (64) P2L/W (length/width Enp3 P1): value.
- (65) P2S/L (length apical spine/length Enp3 P1): value.
- (66) P3F (row I frontal surface of intercoxal sclerite P3): 0 – absent; 1 – present.
- (67) P3F-O (row I frontal surface of intercoxal sclerite P3 – ornamentation): 0 – hairs; 1 – hair-spinules; 2 – spinules.
- (68) P3CRI (row I caudal surface of intercoxal sclerite P3): 0 – absent; 1 – present.
- (69) P3CRI – C (row I caudal surface of intercoxal sclerite P3 – shape): 0 – continuous; 1 – with gap in the middle section.
- (70) P3CRI-O (row II caudal surface of intercoxal sclerite P3 – ornamentation): 0 – hairs; 1 – hair-spinules, 2 – spinules.
- (71) P3CRII (row II caudal surface of intercoxal sclerite P3): 0 – absent; 1 – present.
- (72) P3CRII-C (row II caudal surface of intercoxal sclerite P3 – shape): 0 – continuous; 1 – with gap in the middle section.
- (73) P3CRII-O (row II frontal surface of intercoxal sclerite P3 – ornamentation): 0 – hairs; 1 – hair-spinules; 2 – spinules.
- (74) P3CRIII (row III caudal surface of intercoxal sclerite P3): 0 – absent; 1 – present.

- (75) P3CRIII-C (row III caudal surface of intercoxal sclerite P3 – shape): 0 – continuous; 1 – with gap in the middle section.
- (76) P3CRIII-O (row III frontal surface of intercoxal sclerite P3 – ornamentation): 0 – hairs; 1 – hair–spinules; 2 – spinules.
- (77) P3L/W (length/width Enp3 P3): value.
- (78) P3S/L (length apical spine/length Enp3 P3): value.
- (79) P4F (row I frontal surface of intercoxal sclerite P4): 0 – absent; 1 – present.
- (80) P4F-O (row I frontal surface of intercoxal sclerite P4 – ornamentation): 0 – hairs; 1 – hair–spinules; 2 – spinules.
- (81) P4CRI (row I caudal surface of intercoxal sclerite P4): 0 – absent; 1 – present.
- (82) P4CRI-O (row I caudal surface of intercoxal sclerite P4 – ornamentation): 0 – hairs; 1 – spinules.
- (83) P4CRI-S (row I caudal surface of intercoxal sclerite P4 – size): 0 – short spinules; 1 – long spinules.
- (84) P4CRI-C (row I caudal surface of intercoxal sclerite P4 – shape): 0 – continuous; 1 – with gap in the middle section.
- (85) P4CRII (row II caudal surface of intercoxal sclerite P4): 0 – absent; 1 – present.
- (86) P4CRII-C (row II caudal surface of intercoxal sclerite P4 – shape): 0 – continuous; 1 – with gap in the middle section.
- (87) P4CRII-L (row II caudal surface of intercoxal sclerite P4 – position): 0 – outer margins; 1 – along sclerite.
- (88) P4CRII-O (row II frontal surface of intercoxal sclerite P4 – ornamentation): 0 – hairs; 1 – hair–spinules; 2 – spinules.
- (89) P4CRIII (row III caudal surface of intercoxal sclerite P4): 0 – absent; 1 – present.
- (90) P4CRIII-C (row III caudal surface of intercoxal sclerite P4 – shape): 0 – continuous; 1 – with gap at middle section.
- (91) P4CRIII-L (row III caudal surface of intercoxal sclerite P4 – position): 0 – outer margins; 1 – along sclerite.
- (92) P4CRIII-O (row III frontal surface of intercoxal sclerite P4 – ornamentation): 0 – hairs; 1 – hair–spinules; 2 – spinules.
- (93) P4A (row A coxa P4): 0 – absent; 1 – present.
- (94) P4B (row B coxa P4): 0 – absent; 1 – present.
- (95) P4C+D (row C+D coxa P4): 0 – absent; 1 – present.
- (96) P4E (row E coxa P4): 0 – absent; 1 – present.
- (97) P4F (row F coxa P4): 0 – absent; 1 – present.
- (98) P4G (row G coxa P4): 0 – absent; 1 – present.
- (99) P4H (row H coxa P4): 0 – absent; 1 – present.
- (100) P4J (row J coxa P4): 0 – absent; 1 – present.
- (101) P4J-O (row J coxa P4 – shape): 0 – in group; 1 – divided in rows.
- (102) P4L/W (length/width Enp3 P4): value.
- (103) P4I/L (length inner spine/length Enp3 P4): value.
- (104) P4O/L (length outer spine/length Enp3 P4): value.
- (105) P4I/O (length inner spine/length outer spine P4): value.
- (106) P4L (insertion of lateral seta): value.
- (107) P2MS (modified setae P2): 0 – absent; 1 – present.
- (108) P3MS (modified setae P3): 0 – absent; 1 – present.

- (109) P4MS (modified setae P4): 0 – absent; 1 – present.
(110) P5L/W (length/width seg P5): value.
(111) P5M/O (length medial seta/length outer seta P5): value.
(112) P5M/S (length medial seta/inner spine P5): value.
(113) P5S/L (length inner spine/length seg P5): value.

Results

Order **CYCLOPIDA** Rafinesque, 1815

Family **CYCLOPIDAE** Rafinesque, 1815

Subfamily **EUCYCLOPINAE** Kiefer, 1927

Genus ***Eucyclops*** Claus, 1893

Shared characters among species

Females. Prosome widest at end of cephalosome and second pediger. Urosome five-segmented, slightly elongated. First urosomal somite with long setules on lateral margin. Posterior margin of anal somite with row of spinules; anal somite as long as preanal somite. Inner margin of caudal rami naked. Terminal setae of caudal ramus plumose. Antennules 12-segmented with finely denticulated hyaline membrane on segments 10–12. Third swimming leg with small spinules along insertion of basipodite (frontal surface).

Males. More slender than female, with urosome six-segmented. Antennules 16-segmented in examined species.

Eucyclops elegans (Herrick, 1884)
(Figures 2–8)

Description

Female. Habitus as in Figure 5A. Average length excluding caudal setae = 1061 μm . Whole body (caudal rami included) ornamented with small pits (see Figure 2A, 5). Prosome representing 58% of total body length, symmetrical in dorsal view. Prosomal fringes finely serrate in dorsal view (Figure 5B). Urosomal fringes strongly serrate. Genital double somite symmetrical (Figure 5D), representing 10% of total body length; proximal third of genital double somite expanded laterally. Seminal receptacle with rounded lateral arms on posterior margin, typical of the *serrulatus*-complex. Anal operculum slightly rounded, weakly serrate (Figure 5F). Length/width of caudal rami = 7.0; inner margin of caudal ramus naked; outer margin with strong spinules covering 60% with respect to the total length of ramus. Dorsal seta (VII) 0.4 times as long as caudal ramus and 0.7 times as long as outermost caudal seta (III). Length ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.2. Lateral caudal seta (II) inserted at 70% of ramus.

Antennule (Figures 2B–C, 6A–B). Tip reaching posterior margin of fourth pediger, antennules ornamented with pits. Armature per segment as follows: 1(8s), 2(4s), 3(2s),

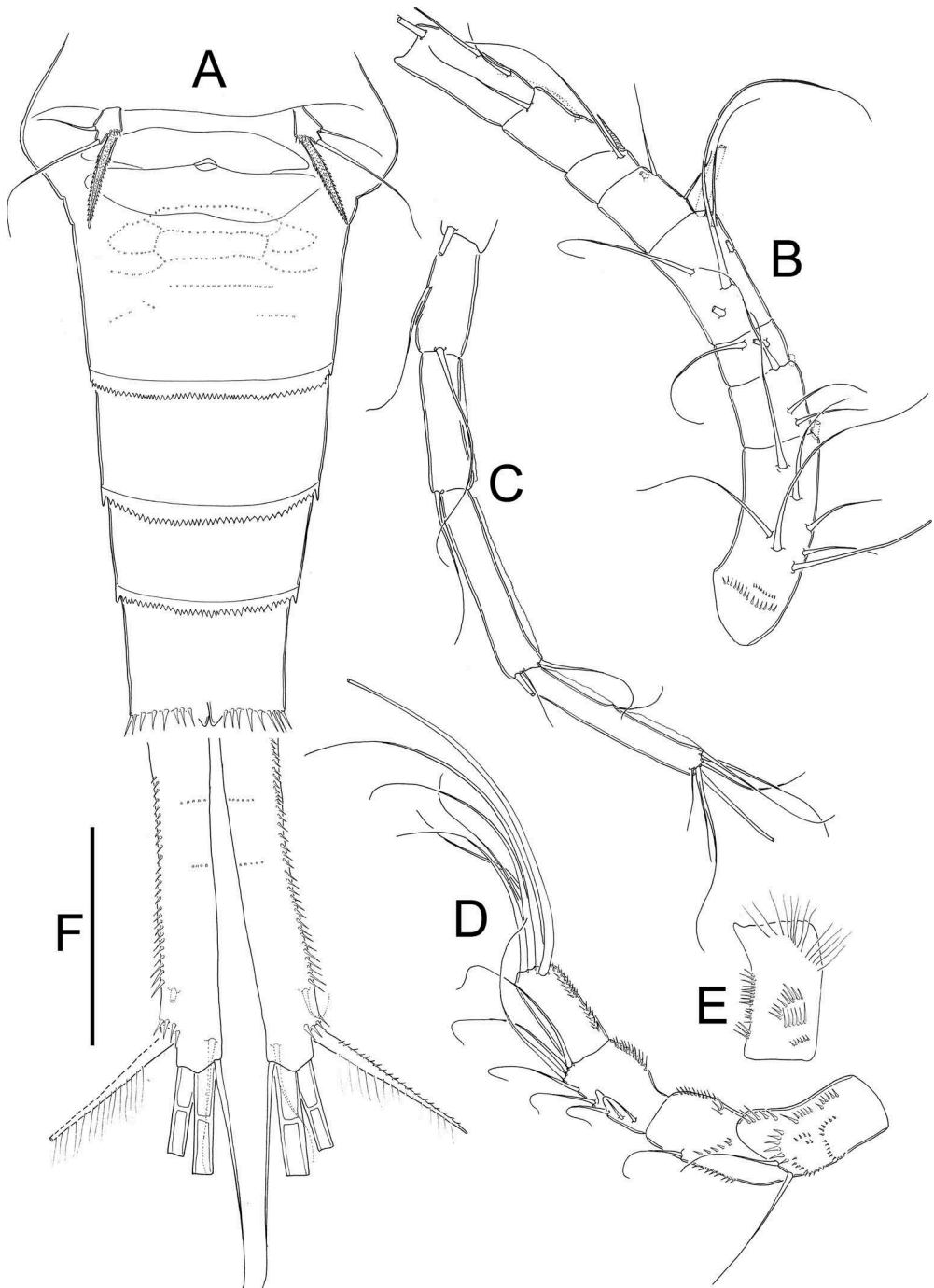


Figure 2. *Eucyclops elegans* (Herrick, 1884). Adult female. (A) Urosome, ventral; (B) antennule segments 1–8; (C) antennule segments 9–12; (D) antenna, caudal; (E) antenna basis, frontal; (F) Scale bar = 100 μm .

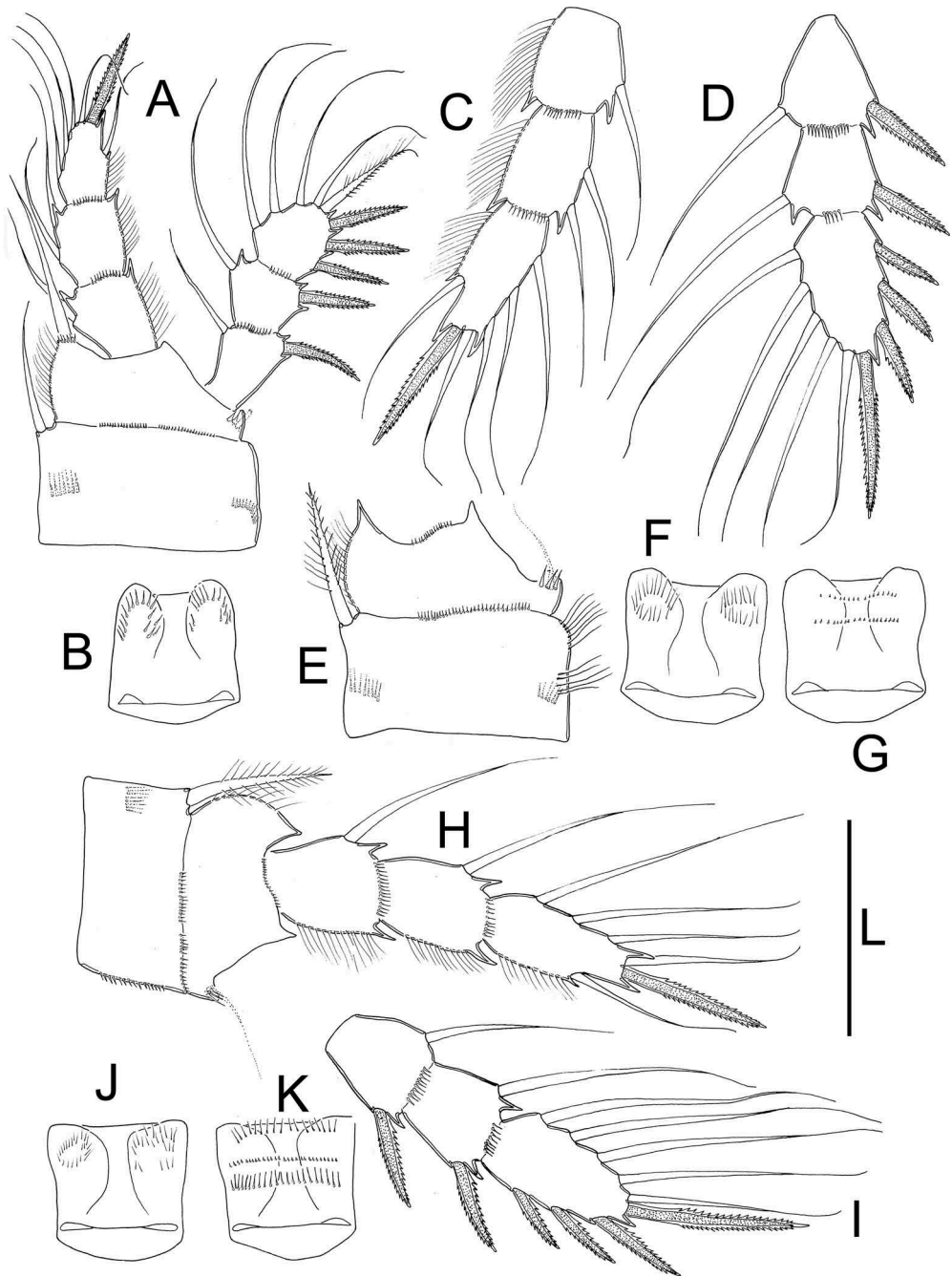


Figure 3. *Eucyclops elegans* (Herrick, 1884). Adult female. (A) P1; (B) intercoxal sclerite P1, frontal; (C) endopod P2; (D) exopod P2; (E) coxa and basis P2, frontal; (F) intercoxal sclerite P2, frontal; (G) intercoxal sclerite P2, caudal; (H) coxa, basis and endopod P3, frontal; (I) exopod P3; (J) intercoxal sclerite P3, frontal; (K) intercoxal sclerite P3, caudal; (L) Scale bar = 100 μ m.

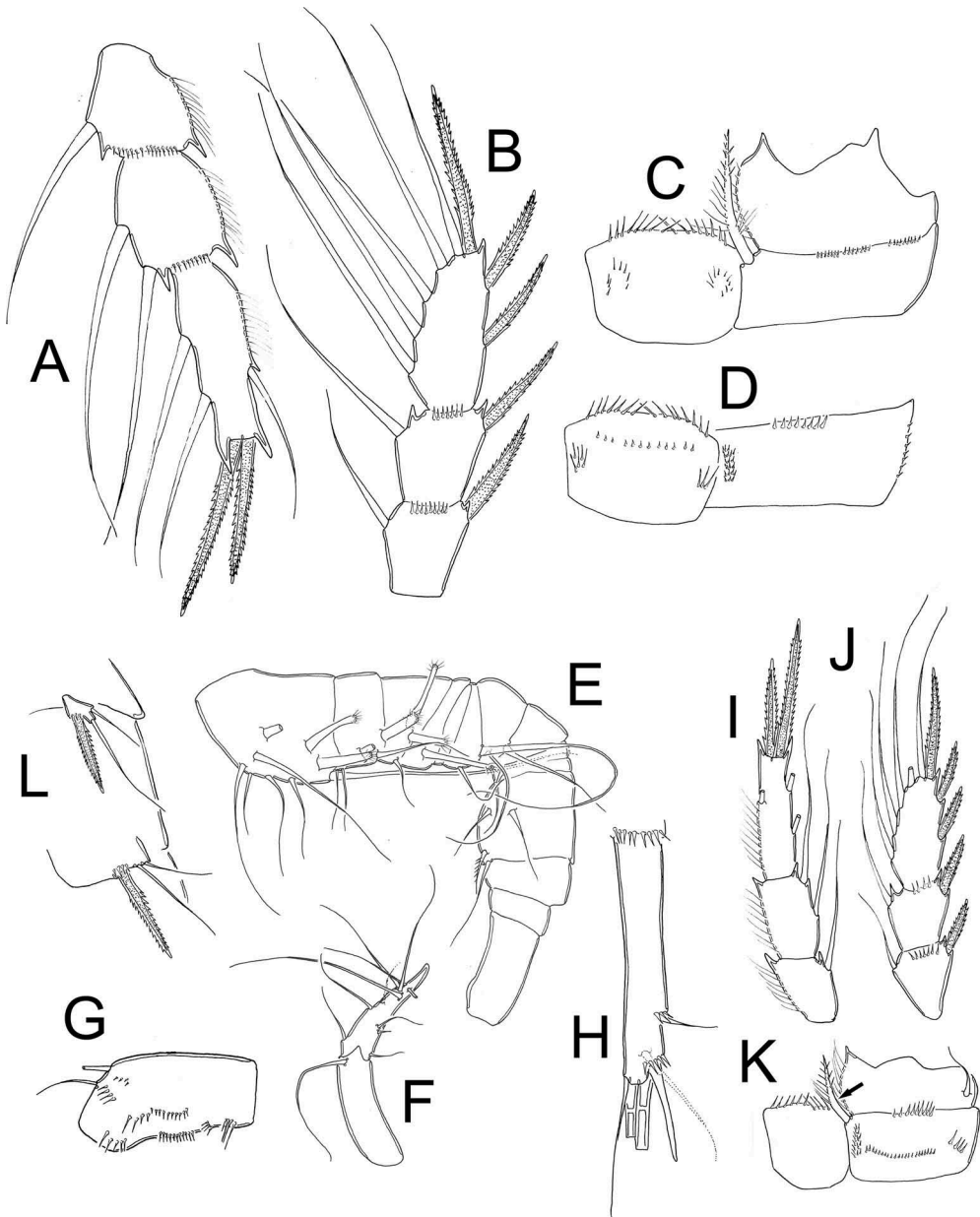


Figure 4. *Eucyclops elegans* (Herrick, 1884). A–D, adult female; E–L, adult male. (A) Endopod P4; (B) exopod P4; (C) coxa, basis and intercoxal sclerite, frontal; (D) coxa, basis and intercoxal sclerite, caudal; (E) antennule segments 1–13; (F) antennule segments 14–15; (G) basis antenna, caudal; (H) caudal ramus; (I) endopod P4; (J) exopod P4; (K) coxa, basis and intercoxal sclerite P4, caudal; (L) P5 and P6.

4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(8s). Two transverse rows of spinules on first segment, first one with minute spinules, second row with stronger, longer spinules. Spine on sixth segment not reaching medial margin of seventh segment.

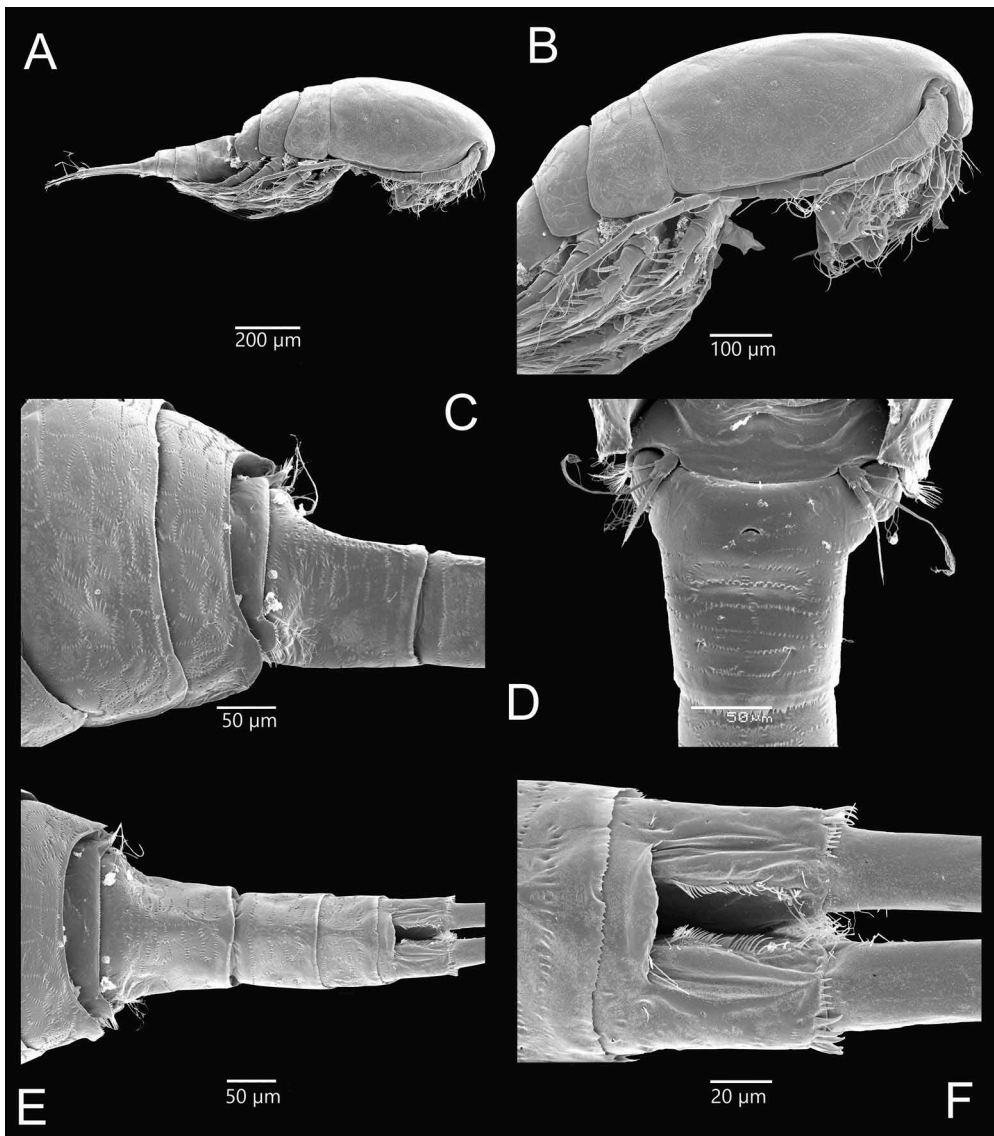


Figure 5. *Eucyclops elegans* (Herrick, 1884). Adult female. (A) Habitus, lateral; (B) prosome, lateral; (C) cuticular patterns, dorsal; (D) genital somite and P5, ventral; (E) urosome, dorsal; (F) anal operculum, dorsal.

Antenna (Figures 2D–E, 6E–F; 7A). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface: N1+N2(XVI), N3(9), N4(8), N5(5), N15(5), N17(16), N18(5) and on caudal surface: N7(7), N8(5), N9+10(7), N11(9), N12(12), N13(6), N16(14), 22(14). Caudal surface of Enp1 with B2(6) and B3(8).

Leg 1 (Figures 3A–B, 7B–C). Frontal surface of intercoxal sclerite with row I bearing spinules in semicircular pattern on each side, caudal surface with row I continuous

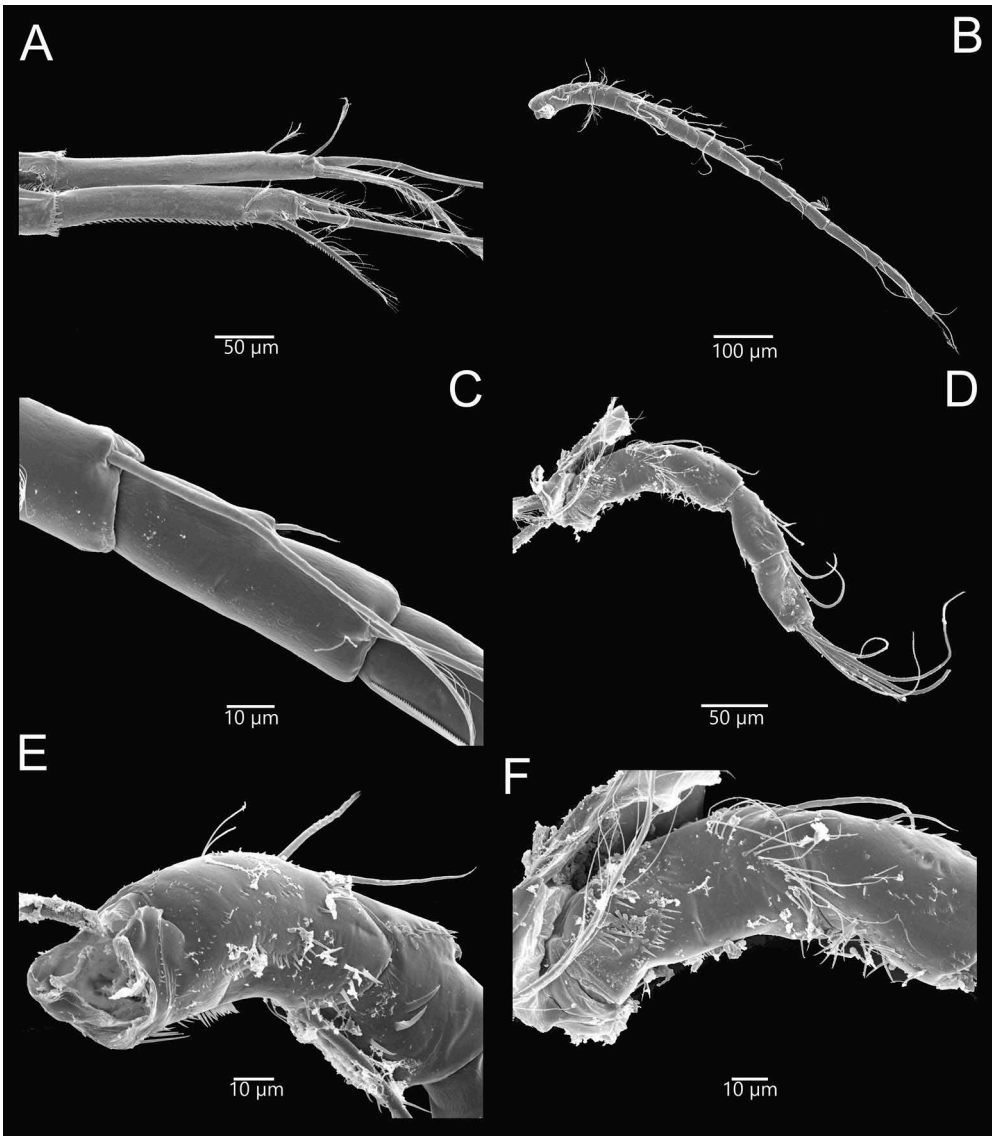


Figure 6. *Eucyclops elegans* (Herrick, 1884). Adult female. (A) Caudal rami; (B) antennule; (C) antennule segment 9; (D) antenna; (E) antenna basis, caudal; (F) antenna basis, frontal.

bearing 14 minute spinules. Row II continuous, armed with 23 minute spinules. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal spine) reaching middle margin of Enp3, 0.7 times as long as Enp. Length/width ratio of Enp3 = 1.6, apical spine of Enp3 being 1.3 times as long as Enp3.

Leg 2 (Figures 3C–G, 7D–E). Frontal surface of intercoxal sclerite with row I with hairs arranged in circular pattern; caudal surface with rows I and II continuous, row I with 16 minute spinules and row II with minute spinules. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal

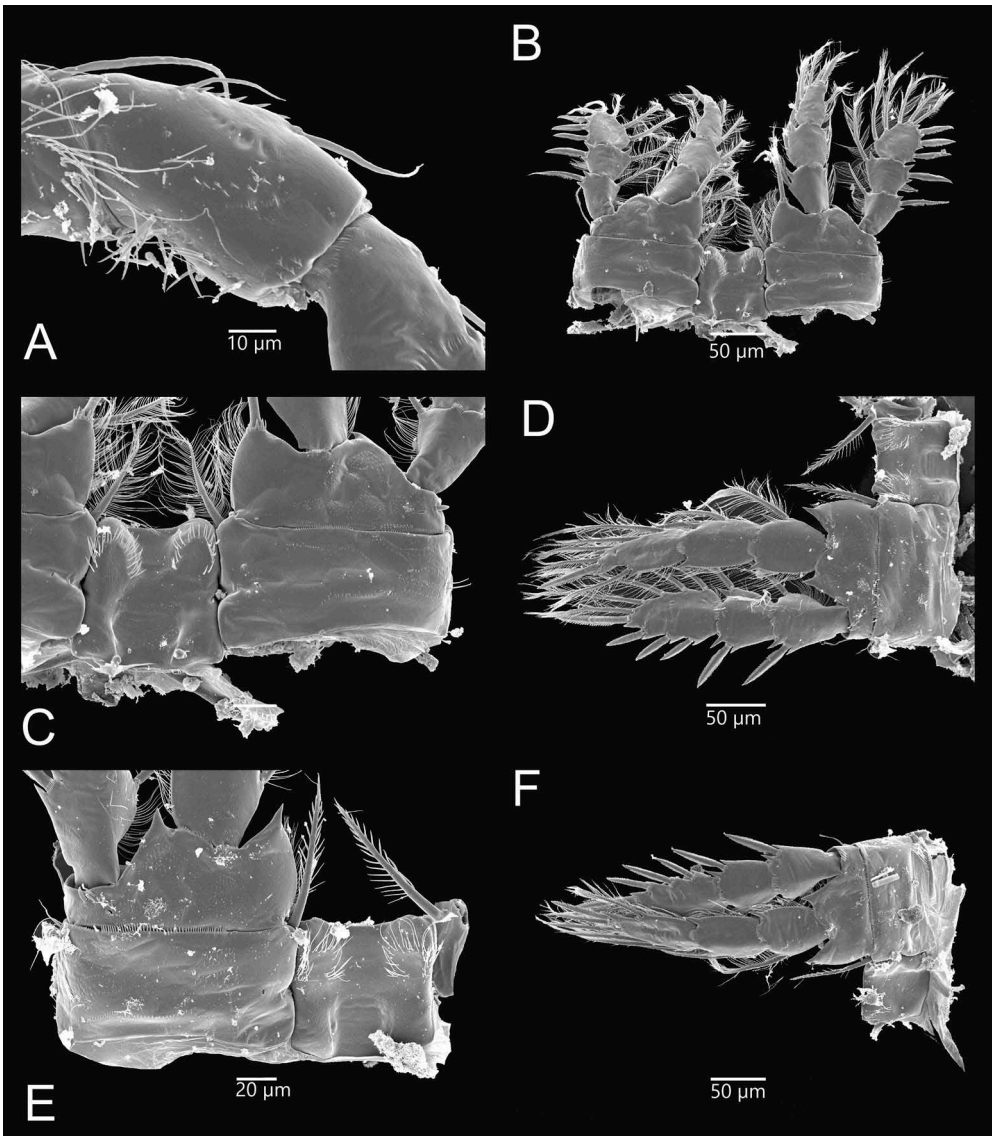


Figure 7. *Eucyclops elegans* (Herrick, 1884). Adult female. (A) Enp 1 antenna, frontal; (B) P1, frontal; (C) coxa, basis and intercoxal plate P1, frontal; (D) P2, frontal; (E) coxa, basis and intercoxal sclerite P2, frontal; (F) P3, frontal.

surface with spinule formula A-B-C-D. Length/width ratio of Enp3 = 2.1, apical spine of Enp3 being 1.1 times as long as Enp3. No modified setae present.

Leg 3 (Figures 3H-K, 7F, 8A). Frontal surface of intercoxal sclerite with row I formed by hair-like elements arranged in circular pattern on each side caudal surface with row I bearing slender spinules, row II continuous with 28 minute spinules and row III with 21 strong spinules. Distal margin with two rounded, chitinised projections. Coxa with strong, biserially setulated inner coxal seta, ornamented basally with long hair-like

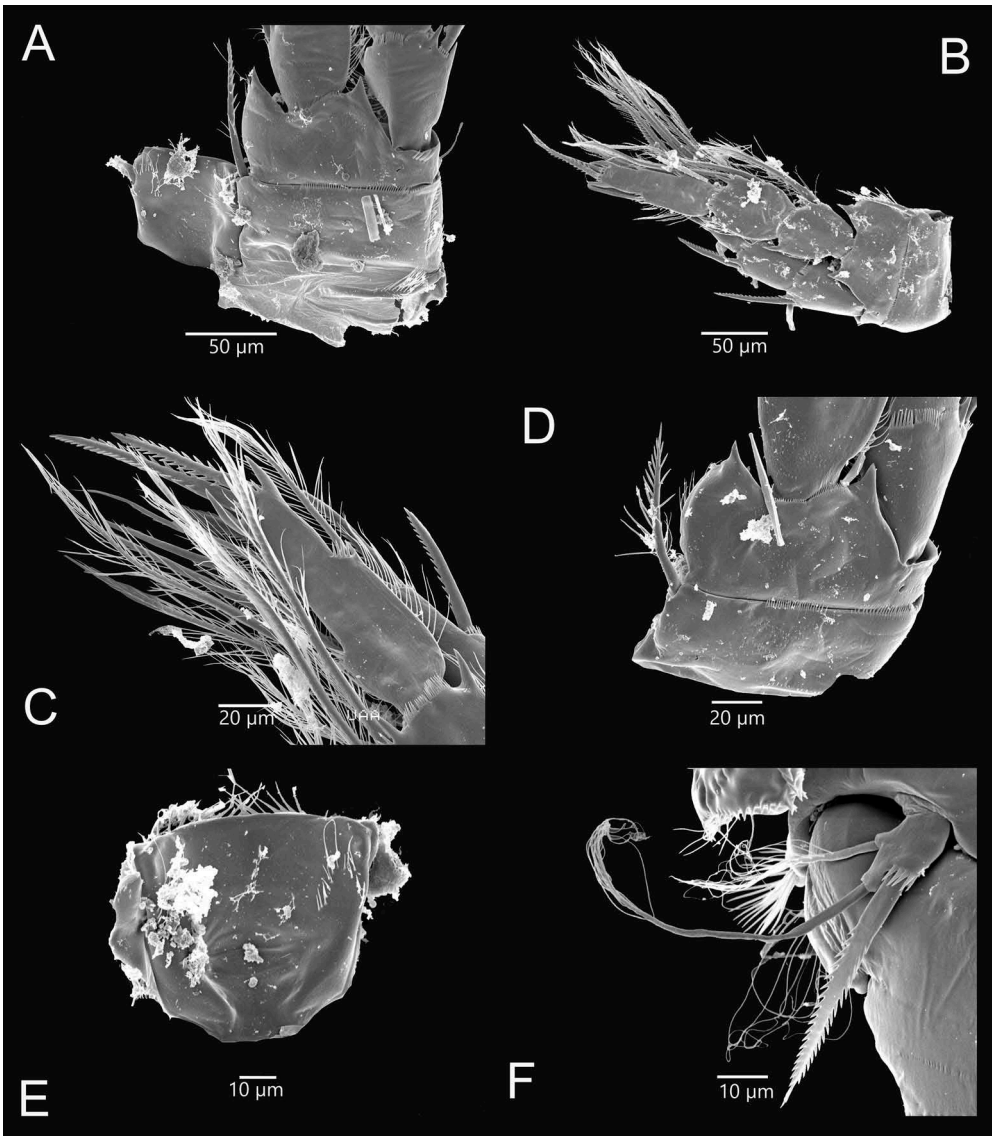


Figure 8. *Eucyclops elegans* (Herrick, 1884). Adult female. (A) Coxa, basis and intercoxal sclerite P3, frontal; (B) P4, frontal; (C) Enp3 P4; (D) coxa and basis P4, frontal; (E) intercoxal sclerite P4, frontal; (F) P5.

elements and distally with strong spinules along both margins. Caudal coxal surface with spinules formula A-C. Length/width ratio of Enp = 2.6, apical spine of Enp3 being 1.1 times as long as Enp3. No modified setae present.

Leg 4 (Figures 4A–D, 8B–E). Distal margin of sclerite with two low, rounded, chitinised projections. Frontal surface with row I bearing small, slender spinules arranged in circular pattern, caudal surface of intercoxal sclerite with row I bearing strong, small spinules, row II with small spinules at middle section and row III with strong, slightly

longer spinules close to outer margins. Frontal surface of coxa with row of small spinules at insertion of basipod (Bsp). Inner coxal spine with heterogeneous ornamentation; inner margin with proximal row of long hairs, distal section with strong spinules. Outer margin with three distal spinules and proximal hair-like elements, gap in middle margin. Spinule formula of caudal surface of coxa: A-C + D-G-H-J. Length/width ratio Enp3 = 3.5, length ratio inner spine of Enp3/length Enp3 = 0.9; length ratio outer spine of Enp3/length Enp3 = 0.7; length ratio inner/outer spines Enp3 = 1.3. Lateral seta of Enp3 inserted at 62% of segment. No modified setae in Enp and Exp.

Leg 5 (Figure 8F). Free segment subrectangular, 1.9 times longer than wide, bearing strong inner spine and two setae; medial seta 1.7 times longer than outer seta and 1.4 times longer than inner spine. Inner spine 2.6 times longer than segment.

Male. Prosome symmetrical in dorsal view. Urosome slightly elongated, urosomal fringes strongly serrate. Caudal ramus smooth along both inner and outer margins, except for strong spinules at insertion of lateral seta. Length/width ratio of caudal ramus = 6.1, dorsal seta (VII) 0.5 times as long as caudal ramus and 1.2 times as long as outermost caudal seta (III). Innermost caudal seta (VI)/outermost caudal seta (III) ratio = 1.1. Lateral caudal seta (II) inserted at 71% of ramus length.

Antennule (Figure 4E–F). Armature as follows: 1(6s+3ms), 2(4s+1ms), 3(1+2ms), 4(1ms), 5(0), 6(2s), 7(3s), 8(0), 9(1s), 10(4s), 11(0), 12(0), 13(0), 14(1), 15(9s+1sp).

Antenna (Figure 4G). Basis with spinule groups on frontal surface: N1(VI), N2(V), N3(6), N4(7), N5(11), N15(4), N17(11), N18(4) and on caudal surface: N7(4), N8(4), N9+10(5), N11(4), N12(10).

Legs 1–4. Enp and Exp of all swimming legs three-segmented, armed as in females.

Leg 5 (Figure 4L). Free segment subrectangular, 1.8 times longer than wide, bearing inner spine and two setae; medial seta longer than outer seta (about 1.8 times) and inner spine (1.3 times).

Leg 6 (Figure 4L). Represented by small, low plate adjacent to lateral margin of genital somite armed with strong inner spine and two unequal setae. Inner spine reaching medial margin of third urosomite, as long as medial seta and 1.6 times longer than outer seta. Small, strong spinules present at insertion of inner spine.

Remarks. *Eucyclops elegans* was recently assigned as a member of the *serrulatus*-group by Mercado-Salas and Suárez-Morales (2014b) following the diagnostic characters established by Alekseev and Defaye (2011) to distinguish species of this group. The inclusion of *E. elegans* in the *serrulatus*-group precludes the idea of a synonymy with *E. speratus* and supports Reid and Marten's (1995) assumption that American records of *E. speratus* should be assigned to *E. elegans* after an analysis of more material. It is important to consider that we observed differences between specimens of *E. elegans* from North and South America; the latter population could refer to another species (see Mercado-Salas

and Suárez-Morales 2014b). We described a new species closely related to *E. elegans* (see remarks of *E. mittmanni* sp. nov.) from Mexico that must be considered in the identification of material related to *E. elegans*. *Eucyclops elegans* can be distinguished from *E. serrulatus* by the ornamentation of the frontal surface of the antennary basis: group N18, N1 and N2 are fused and row 22 is present on the caudal surface. Both species share rows N3, N4, N5, N15 and N17 on the frontal surface. The caudal surface of the antennary basis has some additional differences between these two species: row N8 is absent in *E. serrulatus* and sometimes N16 is absent too, but in *E. elegans* both rows are always present. The sixth leg of males of *E. elegans* is remarkably different from that of *E. serrulatus*, *E. speratus*, *E. neumani titicacae*, and most of the American species of the genus: it bears a small but strong inner spine which barely reaches the medial margin of the third urosomite, while in the rest of the species this spine is clearly longer than both the medial and outer setae and reaches at least the posterior margin of the third urosomite. Furthermore, the proportions of the P6 setae and spine should be considered important in separating the populations examined; together with the antennule ornamentations, this character was useful to distinguish species.

Other American *Eucyclops* with long caudal rami are *E. neumani* s. str. and *E. neumani titicacae*, both differing from *E. elegans* because the caudal ramus only bears spinules in the area adjacent to the lateral caudal seta (II). Among other characters, the former subspecies (*E. neumani* s. str.) differs from *E. elegans*, *E. serrulatus* and *E. neumani titicacae* in details of the antennary ornamentation, with group N1 formed by spinules and not hair-like elements. *Eucyclops neumani titicacae* also differs from *E. elegans* and *E. serrulatus* in its unique ornamentation pattern of the intercoxal plate of P4 (see Figure 13 Kiefer 1957a; Fuentes and Suárez-Morales 2014).

***Eucyclops prionophorus* Kiefer, 1931b** (Figures 9–13)

Description

Female. Habitus as in Figure 11A. Average length excluding caudal setae = 688 μ m. Prosome representing 58% of total body length, symmetrical in dorsal view. Prosomal fringes finely serrate in dorsal view. Urosomal fringes strongly serrate. Genital double somite symmetrical (Figures 9A, 11B), representing 11.3% of total body length; proximal third of genital somite expanded laterally. Seminal receptacle with rounded lateral arms, posterior margin with sinuous sac (Figure 9A). Anal operculum slightly rounded, smooth (Figure 9B). Length/width of caudal rami = 3.9; inner margin of caudal ramus naked; outer margin with strong spinules covering 55% with respect to the total length of ramus. Dorsal seta (VII) 0.5 times as long as caudal ramus and 0.9 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.1. Lateral caudal seta (II) inserted at 74% of caudal ramus.

Antennule (Figures 9C, 11E–F). Tip reaching posterior margin of fourth pediger, antennules ornamented with pits. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(8s). Two transversal rows of spinules on first segment, first with strong spinules of different sizes

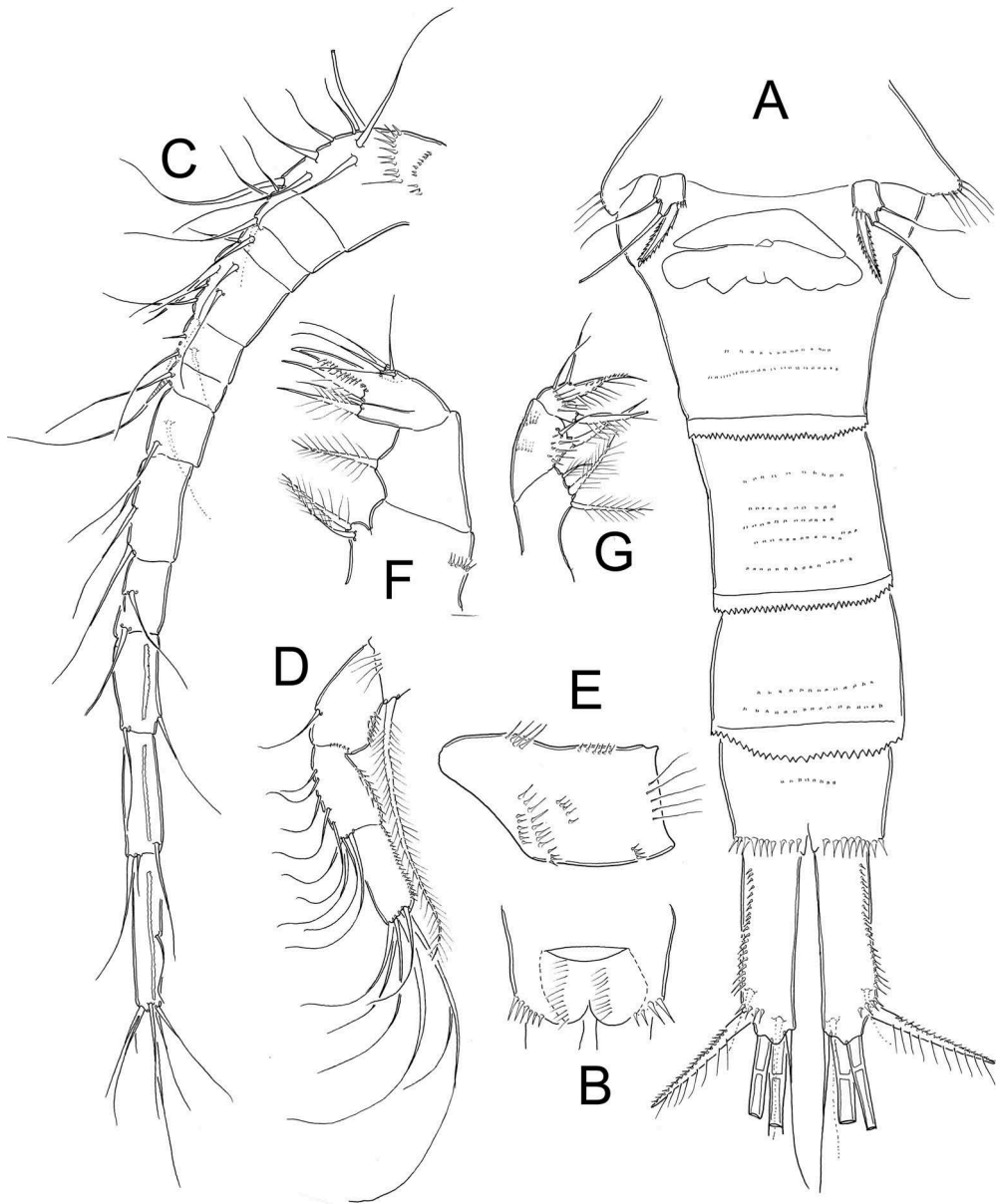


Figure 9. *Eucyclops prionophorus* Kiefer, 1931a. Adult female. (A) Urosome, ventral; (B) anal operculum, dorsal; (C) antennule; (D) Enp1–3 antenna; (E) antennal basis, frontal; (F) maxilla; (G) maxilliped.

and second row with minute spinules. Spine on sixth segment not reaching medial margin of seventh segment.

Antenna (Figures 9D–E, 12A–B). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface: N1(IV), N2(4), N3(5), N4(12), N5(6), N15(4), N17(5), N18(5) and on caudal surface: N7(13), N8(5),

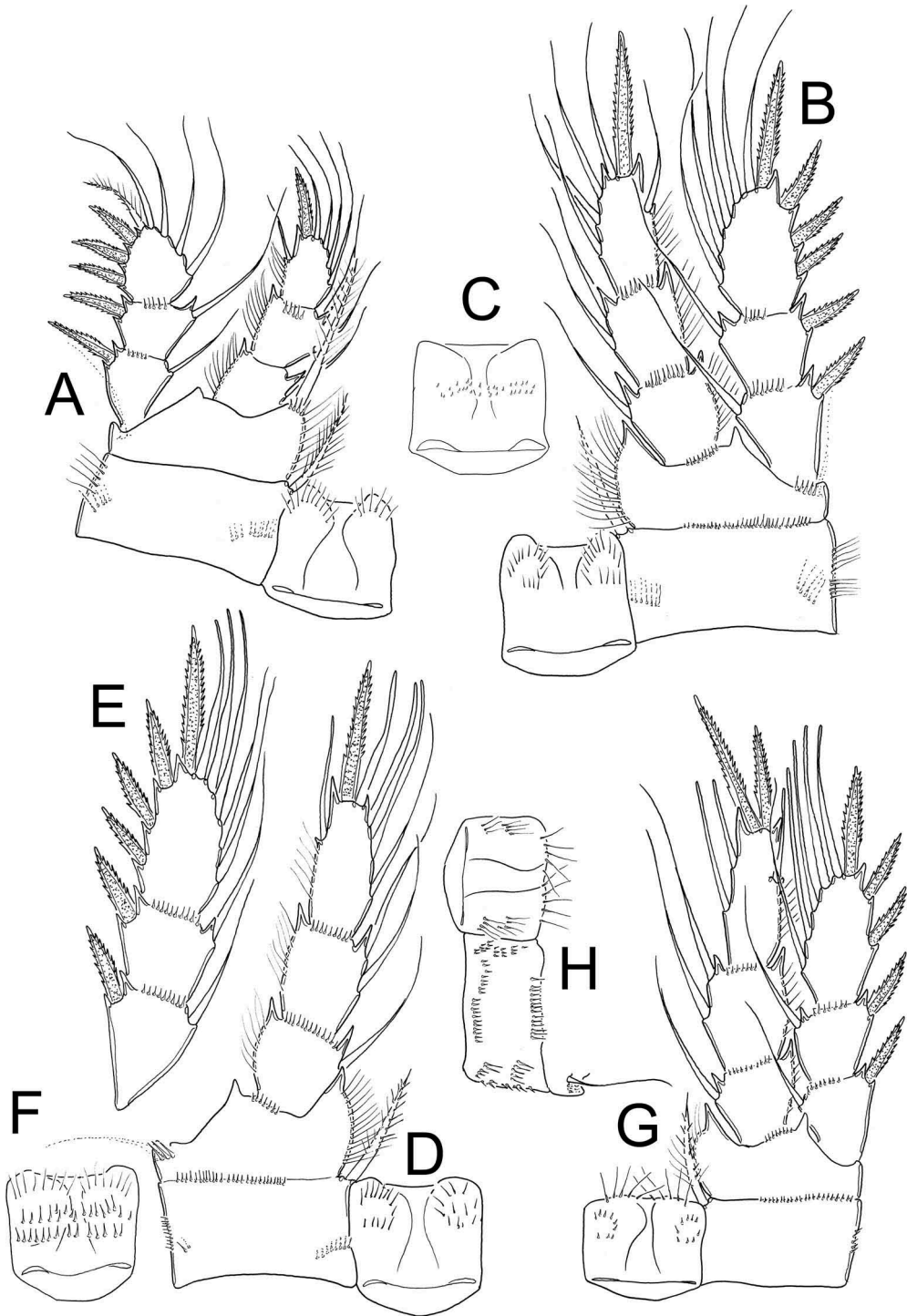


Figure 10. *Eucyclops prionophorus* Kiefer, 1931a. Adult female. (A) P1, frontal; (B) P2, frontal; (C) intercoxal sclerite P2, caudal; (D) P3, frontal; (E) exopod P3; (F) intercoxal sclerite P3, caudal; (G) P4, frontal; (H) coxa and intercoxal sclerite P4, caudal.

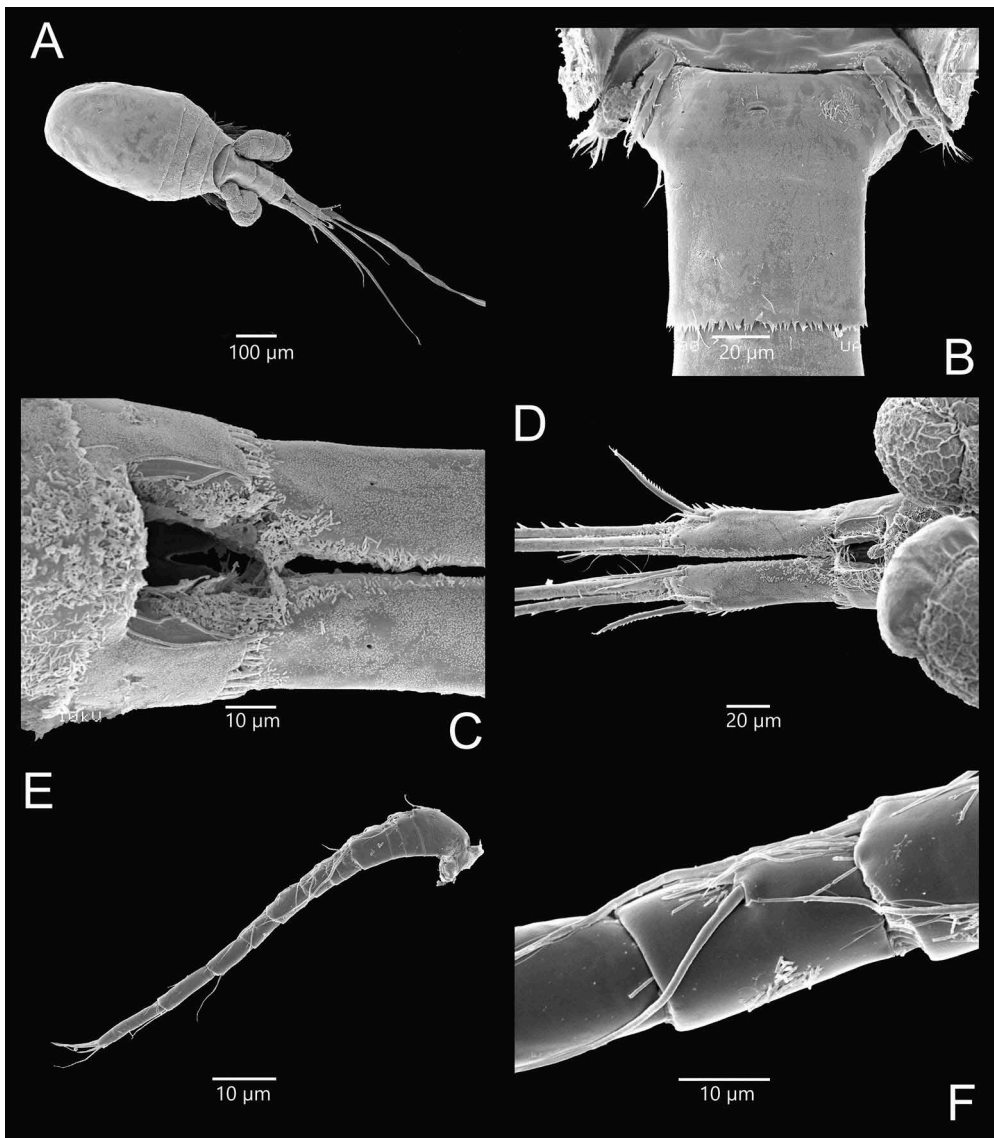


Figure 11. *Eucyclops prionophorus* Kiefer, 1931a. Adult female. (A) Habitus, dorsal; (B) genital somite, ventral; (C) anal operculum, dorsal; (D) caudal rami, dorsal; (E) antennule; (F) antennule segment 9.

N9 + 10(6), N11(7), N12(6), N14(4), N16(7), N22(11). Frontal surface of Enp1 with B1(9) and caudal surface with B2(8).

Leg 1 (Figures 10A, 12D–E). Frontal surface of intercoxal sclerite with row of hair-like elements arranged in a semicircular pattern on each side, caudal surface with row I bearing 10 minute spinules and row II with 24 minute spinules. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal

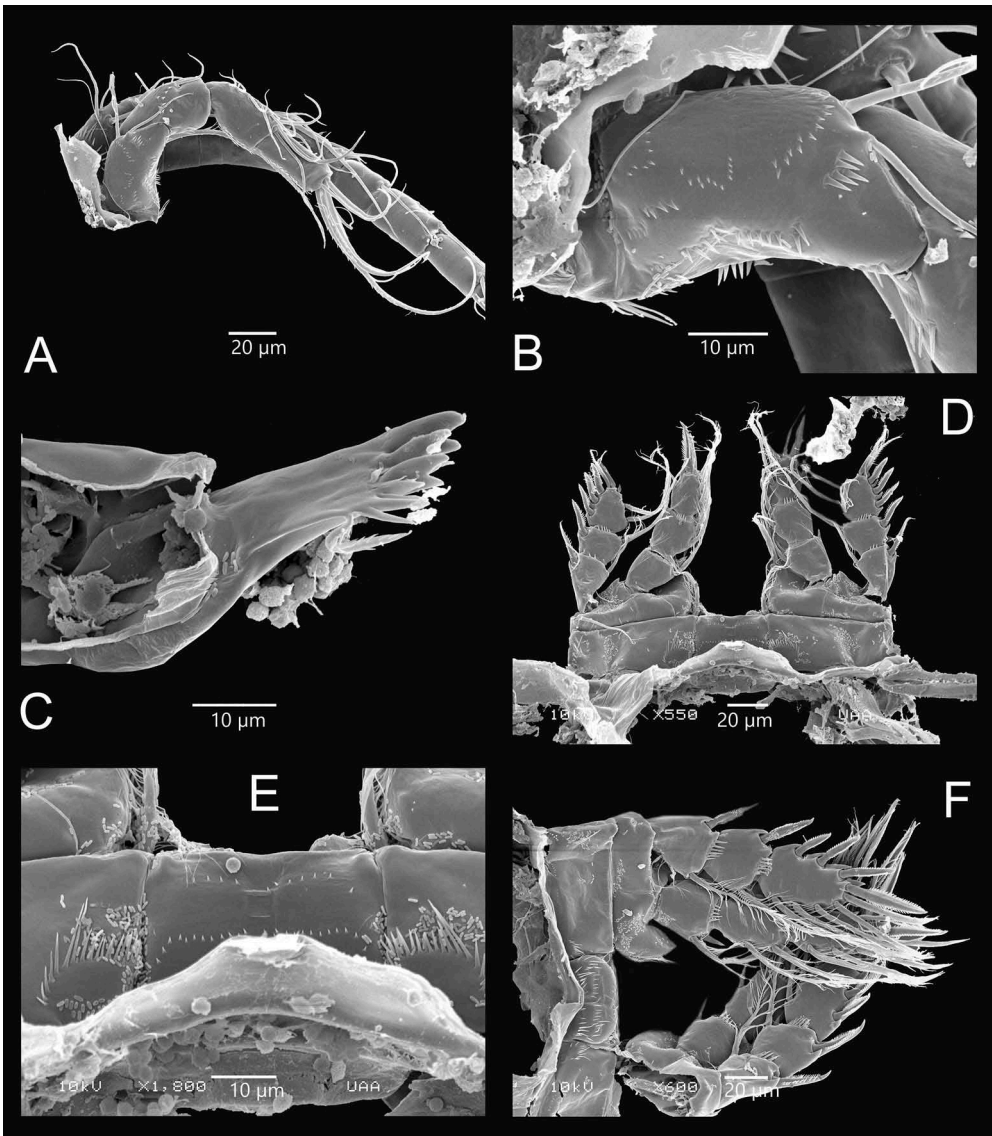


Figure 12. *Eucyclops prionophorus* Kiefer, 1931a. Adult female. (A) Antenna, caudal; (B) antennal basis, caudal; (C) mandible; (D) P1, caudal; (E) intercoxal sclerite P1, caudal; (F) P3, caudal.

spine) reaching middle margin of Enp3, 0.8 times as long as Enp. Length/width ratio Enp3 = 1.6, apical spine of Enp3 as long as Enp3 (1.0).

Leg 2 (Figure 10B–C). Frontal surface of intercoxal sclerite with row I bearing hair-like spinules arranged in a circular pattern; caudal surface with rows I and II close to each other, forming a group in a position where group II is usually found, with minute spinules. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula A-B-C-D.

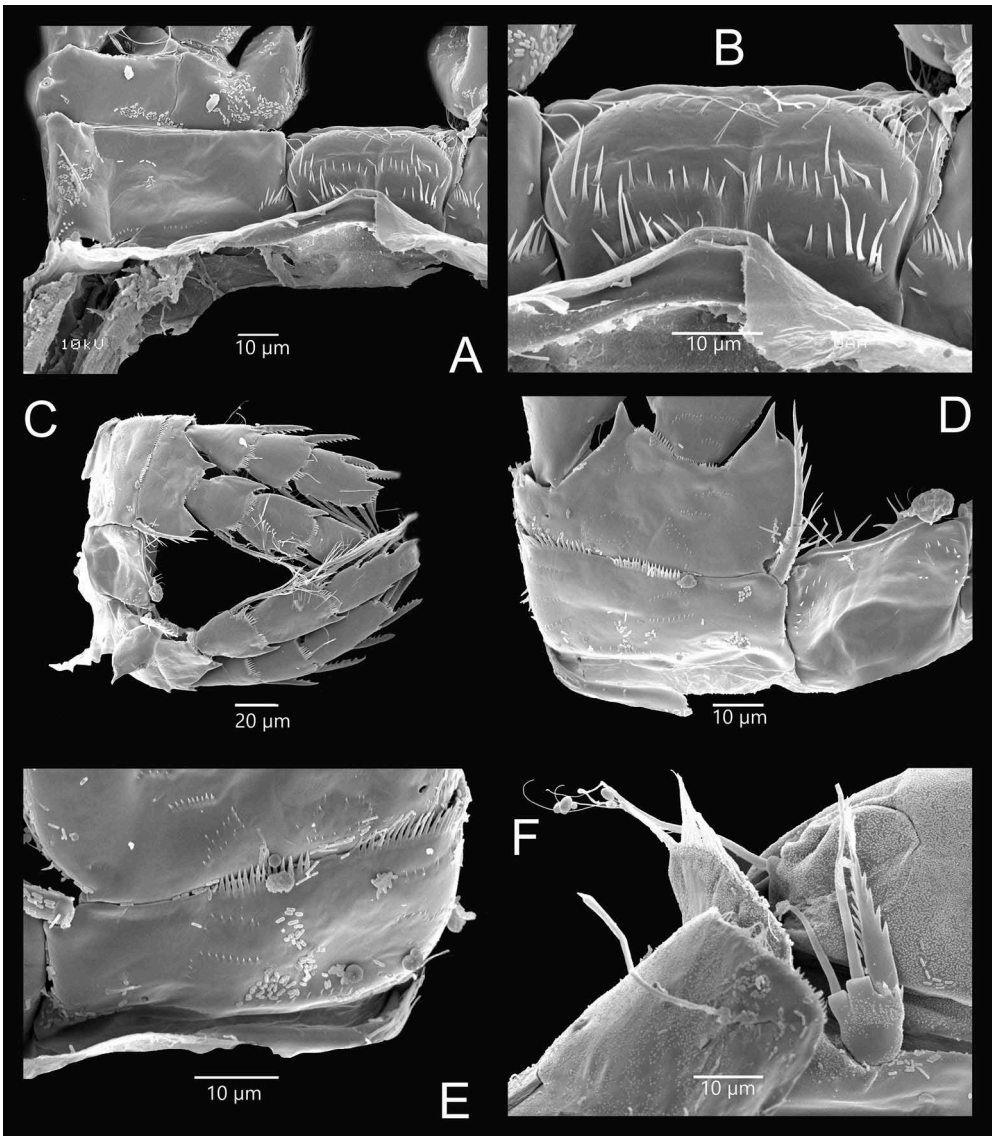


Figure 13. *Eucyclops prionophorus* Kiefer, 1931a. Adult female. (A) Coxa, basis and intercoxal sclerite P3, caudal; (B) intercoxal sclerite P3, caudal; (C) P4; (D) coxa, basis and intercoxal sclerite P4, frontal; (E) coxa P4, frontal; (F) P5.

Length/width ratio of Enp3 = 2.4, apical spine of Enp3 1.2 times as long as Enp3. No modified setae present.

Leg 3 (Figures 10D–F, 12F, 13A–B). Frontal surface of intercoxal sclerite ornamented with hair-like spinules arranged in circular pattern on each side; caudal surface with row I bearing long hair-like elements (small gap in the middle), row II continuous, bearing 25 strong spinules, those near outer margins longer than medial ones. Row III continuous, with 15 strong spinules, spinules on outer margins longer than medial ones. Distal

margin with two rounded, chitinised projections. Coxa with strong, biserially setulated inner coxal seta ornamented with long hairs proximally and with strong spinules distally along both margins. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp = 2.4, apical spine of Enp3 as long as Enp3. Modified setae present in both Exp and Enp.

Leg 4 (Figures 10G–H, 13C–E). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface of sclerite with row I bearing small spinules arranged in circular pattern, caudal surface of intercoxal sclerite with row I bearing long, strong spinules, row II with long slender spinules near outer margins and row III with long, slender spinules. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; proximal inner margin with long hairs and distal section with strong spinules. Outer margin with one distal spinule and proximal section with hairs, gap in middle margin. Spinule formula on the caudal surface of coxa: A-B-C + D-E-F-H-J. Length/width ratio Enp3 = 2.6, length ratio inner spine of Enp3/ Enp3 = 1.1; length ratio outer spine of Enp3/length Enp3 = 0.8; length ratio inner/outer spines Enp3 = 1.4. Lateral seta of Enp3 inserted at 66% of segment. Modified setae in Enp and Exp.

Leg 5 (Figures 9A, 13F). Free segment subrectangular, 1.5 times longer than wide, bearing one strong inner spine and two setae; medial seta 1.4 times longer than outer seta and 1.6 times longer than inner spine. Inner spine 1.9 times longer than segment.

Male. Not found.

Remarks. In Kiefer's (1931a) original description, the ornamentation of the outer margin of the caudal rami, with spinules increasing in size distally, and the remarkably strong spine of the fifth leg were advanced as the main characteristics to distinguish this species. Both characters were found in the Mexican specimens identified as *E. prionophorus*. This species was studied by Einsle (1992) based on type material and additional records deposited in Kiefer's collection and recently also by Mercado-Salas and Suárez-Morales (2014b). This species differs from its congeners by the possession of a dorsal caudal seta shorter than both the innermost and outermost caudal setae, a P1 basipodal seta reaching the middle margin of Enp3, and the modified setae of Exp of P3 and P4, which are heavily chitinised and distally blunt. This species differs from *E. bondi* and *E. conrowae* by its possession of a relatively smaller caudal dorsal seta and in the ornamentation of the fourth coxal plate, in which row I is represented by long and strong spinules, whereas it is formed by small and stronger spinules in the other two species. There are additional differences in rows I and II; in the former two species these rows are always continuous, with short and strong spinules, but in *E. prionophorus* both rows are present only adjacent to the outer margins and are represented by long hair-like spinules. As stated by Alekseev and Defaye (2011), *E. prionophorus* belongs to the *serrulatus*-group, a notion that we are able to support with the additional data on the ornamentation of the antennal basis. In addition, we observed that in some of the Mexican specimens the seminal receptacle differs from that observed in specimens from Kiefer's collection but also from those depicted by Einsle (1992) and Mercado-Salas and

Suárez-Morales (2014a). These specimens have a typical seminal receptacle of the *serrulatus*-group, but in some Mexican specimens the posterior margin has a sinuous sac. Another difference between the Mexican *E. prionophorus* and the type material was the length/width proportion of Enp3 of all swimming legs, which is slightly longer in the Mexican material. *Eucyclops prionophorus* can be easily distinguished from *E. serrulatus* by the possession of small spinules on row N2 on the frontal surface of the antennal basis and also by the presence of rows N18 (frontal surface), N10, N16 and N22 (caudal surface), absent in *E. serrulatus*. It differs from *E. pectinifer* by the absence of N6 and the presence of N22 (absent in *E. pectinifer*); both species share the absence of N13 and the presence of row N1. Spinules of row N12 have the same size in *E. prionophorus* while some spinules are clearly longer than the others in *E. pectinifer*. The ornamentation patterns of the caudal surface of the intercoxal sclerites of *E. prionophorus* differ from those of both *E. pectinifer* and *E. serrulatus*. In P1, rows I and II of *E. prionophorus* bear minute spinules whereas row I is absent and row II bears long hair-spinules in the other two species. In P2 of *E. prionophorus* rows I and II has minute spinules and both are closer to each other than in other related species. In *E. serrulatus* and *E. pectinifer* row I is absent and row II is, as in P1, formed by long spinules. The caudal surface of the intercoxal sclerite of P3 has some additional differences among these three species. In *E. pectinifer* row I bears long hairs and a gap at the middle margin, row II and III are continuous and armed with long hair-spinules; in *E. serrulatus* row I bears long hair spinules and a gap in the middle margin as well, row II is continuous, with small spinules, row III bears long, strong spinules only in the outer margins (gap in middle section); and in *E. prionophorus* row I bears long hairs with a small gap at middle margin, row II is continuous and bears strong spinules, those adjacent to the outer margins are longer than those in the middle, and row III is continuous, with strong spinules, while the spinules on the outer margins are longer. The fourth leg sclerite ornamentation differs among these species: in *E. pectinifer* and *E. serrulatus* row I bears remarkably long spinules while in *E. prionophorus* these spinules are long but shorter than in the other species, rows II and III fit well in the variation pattern described by Alekseev et al. (2006) and Alekseev and Defaye (2011) for *E. serrulatus* and *E. pectinifer*. In *E. prionophorus* row F is present in the coxal surface, like in *E. pectinifer*, but this row is absent in *E. serrulatus*.

***Eucyclops festivus* Lindberg, 1955**
(Figures 14–21)

Description

Female. Habitus as in Figure 16A. Average body length excluding caudal setae = 866 μm . Body surface (including caudal rami) ornamented with small pits. Prosome representing 59% of total body length. Prosomal fringes serrate dorsally. Urosomal fringes strongly serrate. Genital double somite symmetrical (Figure 16B), representing 10.8% of total body length; proximal third of genital double somite slightly expanded laterally. Seminal receptacle with rounded lateral arms on posterior margin, typical of the *serrulatus*-complex. Length/width of caudal rami = 4.6; inner margin of caudal ramus smooth; outer margin with strong spinules covering 61% with respect to the total length of ramus. Dorsal seta (VII) 0.5 times as long as caudal

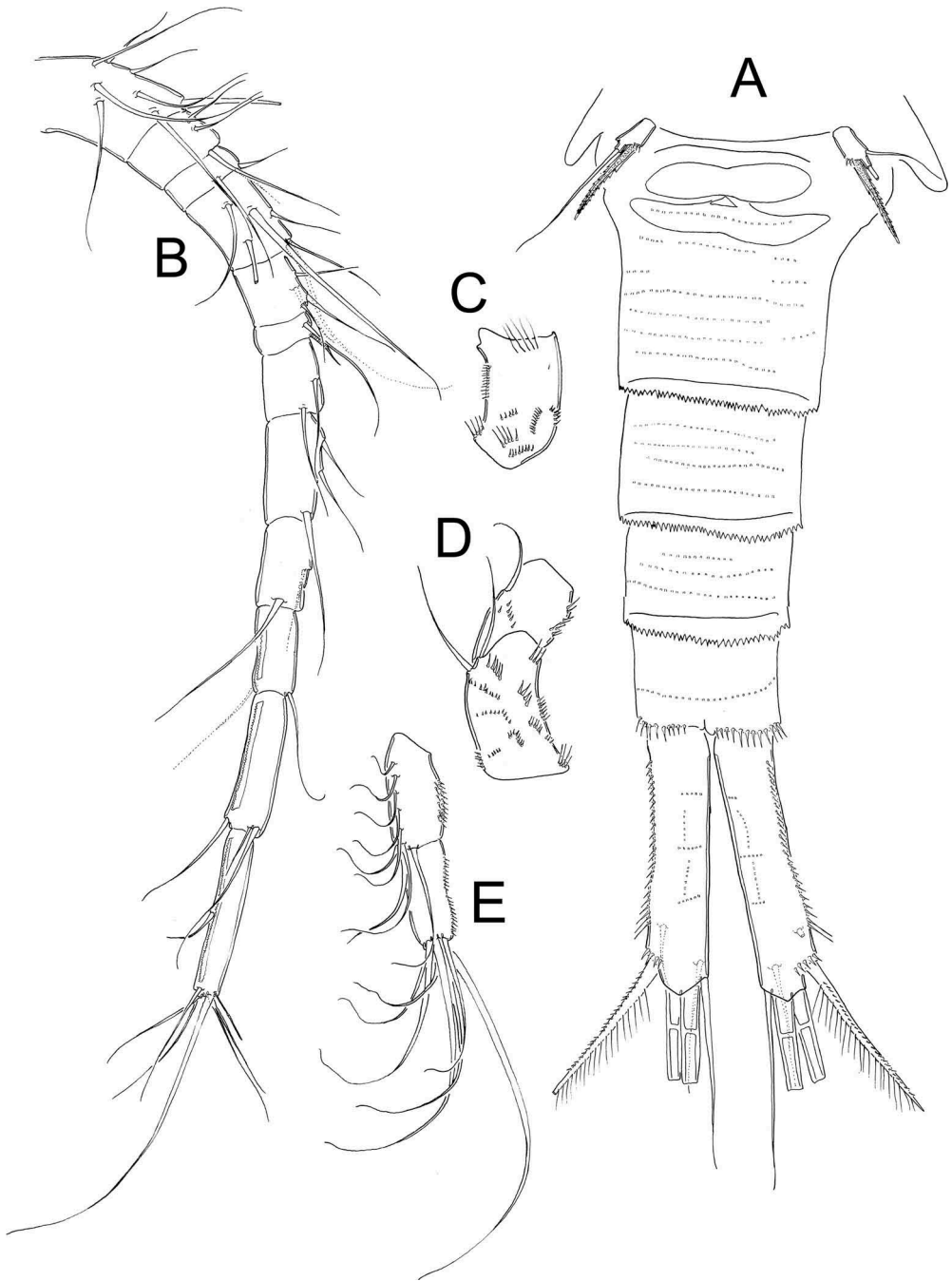


Figure 14. *Eucyclops festivus* Lindberg, 1955. Adult female. (A) Urosome, ventral; (B) antennule; (C) antennal basis, frontal; (D) basis and Enp1 antenna, caudal, (E) Enp2 and Enp3 antenna.

ramus and 0.6 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.0. Lateral caudal seta (II) inserted at 74% of caudal ramus.

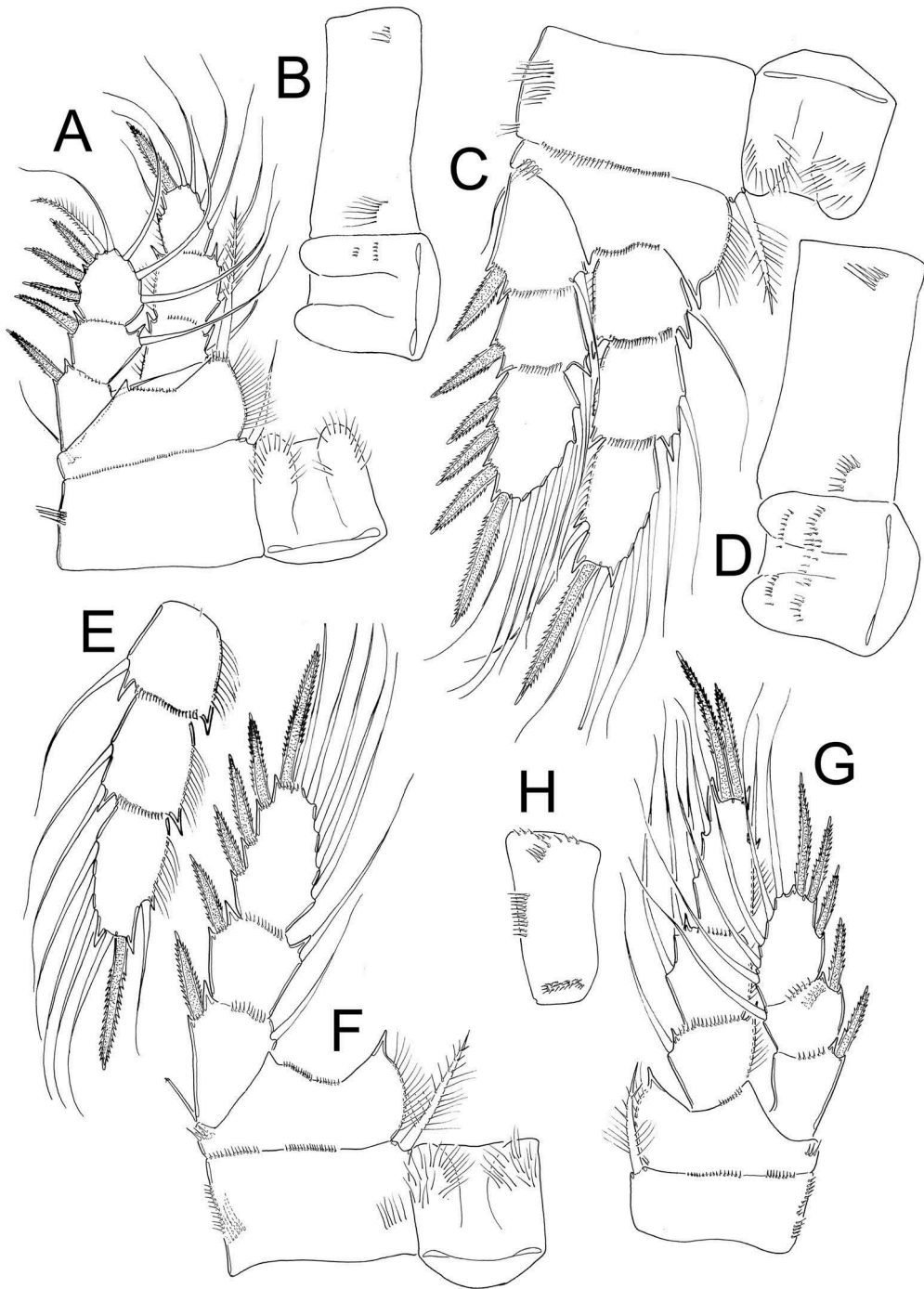


Figure 15. *Eucyclops festivus* Lindberg, 1955. Adult female. (A) P1, frontal; (B) coxa and intercoxal sclerite P1, caudal; (C) P2, frontal; (D) coxa and intercoxal sclerite P2, caudal; (E) endopod P3; (F) coxa, basis, intercoxal sclerite and exopodite P3, frontal; (G) P4, frontal; (H) coxaP4, caudal.

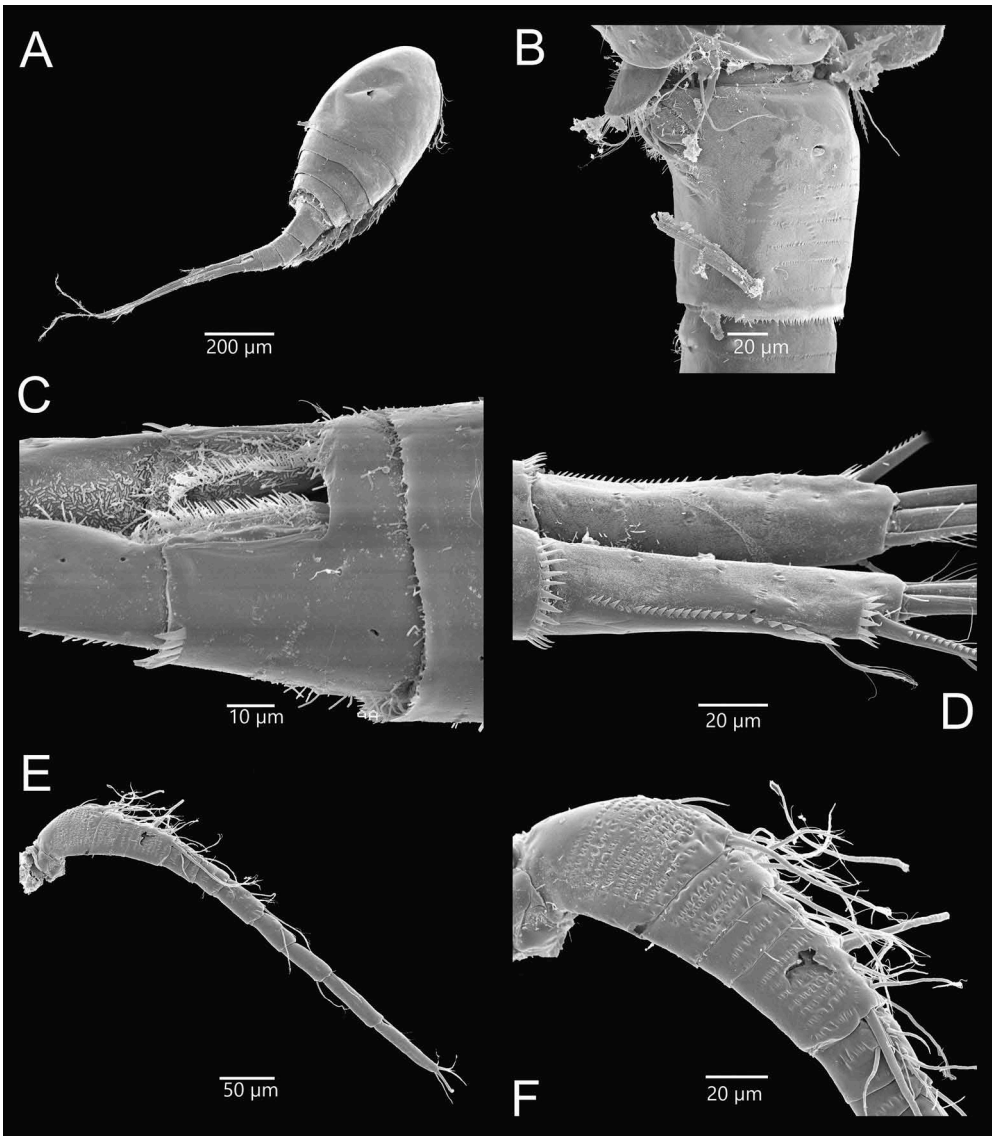


Figure 16. *Eucyclops festivus* Lindberg, 1955. Adult female. (A) Habitus, dorsal; (B) genital somite, ventral; (C) anal operculum, dorsal; (D) caudal rami, ventral; (E) antennule; (F) antennule segments 1–5.

Antennule (Figures 14B, 16E–F, 17A). Tip reaching second pediger, antennules ornamented with pits. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(7s+1ae). Transverse rows of spinules on first segment not observed. Spine on sixth segment reaching midlength of seventh antennular segment.

Antenna (Figures 14C–D, 17B–D). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface:

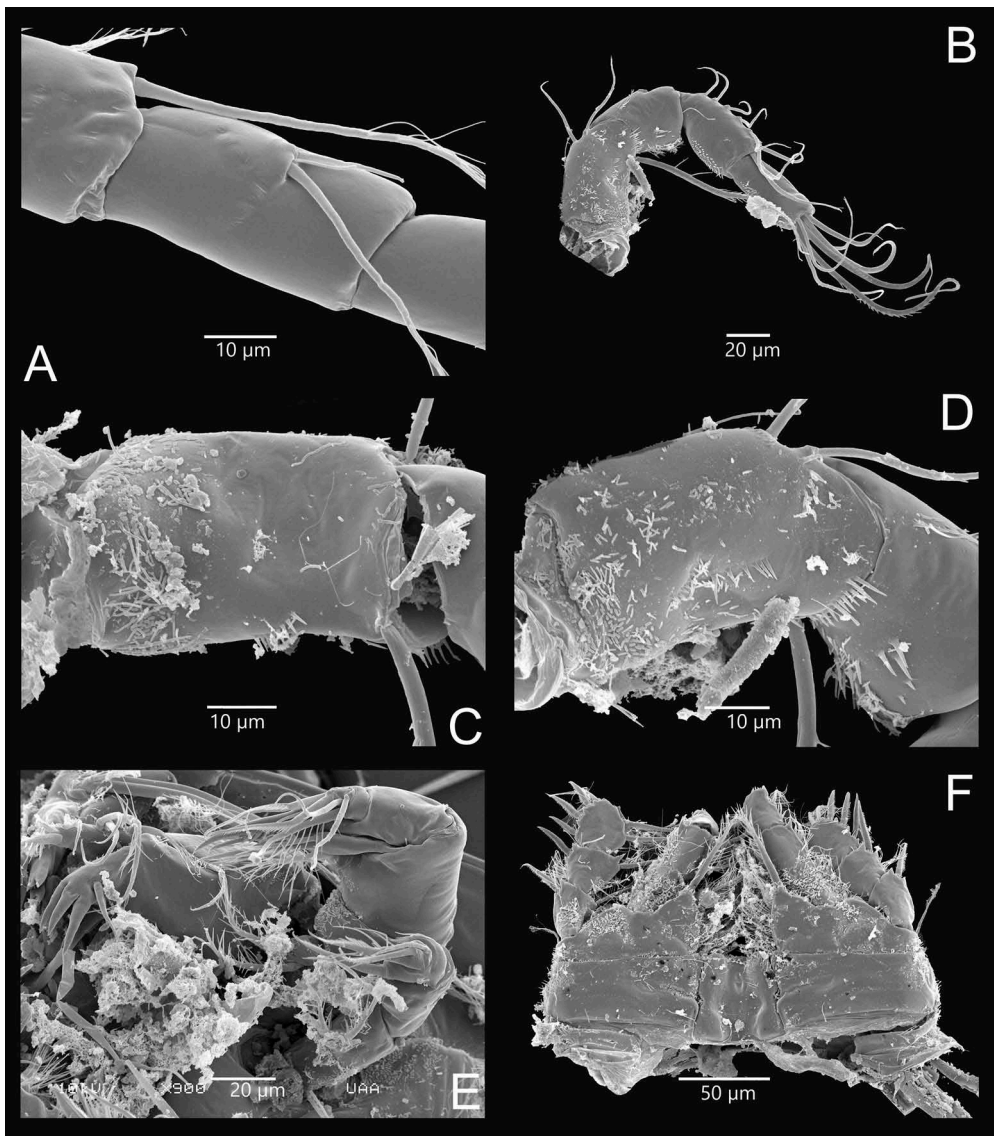


Figure 17. *Eucyclops festivus* Lindberg, 1955. Adult female. (A) Antennule segment 9; (B) antenna, caudal; (C) antennal basis, frontal; (D) antennal basis, caudal; (E) maxillule, maxilla and maxiliped, (F) P1, frontal.

N1(V), N2(3), N3(5), N4(5), N5(8), N6(10), N15(4), N17 (12), N18(3) and on caudal surface: N7(4), N8(5), N9 + 10(8), N11(4), N12(6), N13(5), N14(8), N16(5), N22(10). Caudal surface of first Enp with B2 (5).

Leg 1 (Figures 15A–B, 17F). Frontal surface of intercoxal sclerite with row I armed with hair-like elements arranged in semicircular pattern, caudal surface with rows I and II bearing minute spinules. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal spine) reaching middle margin of

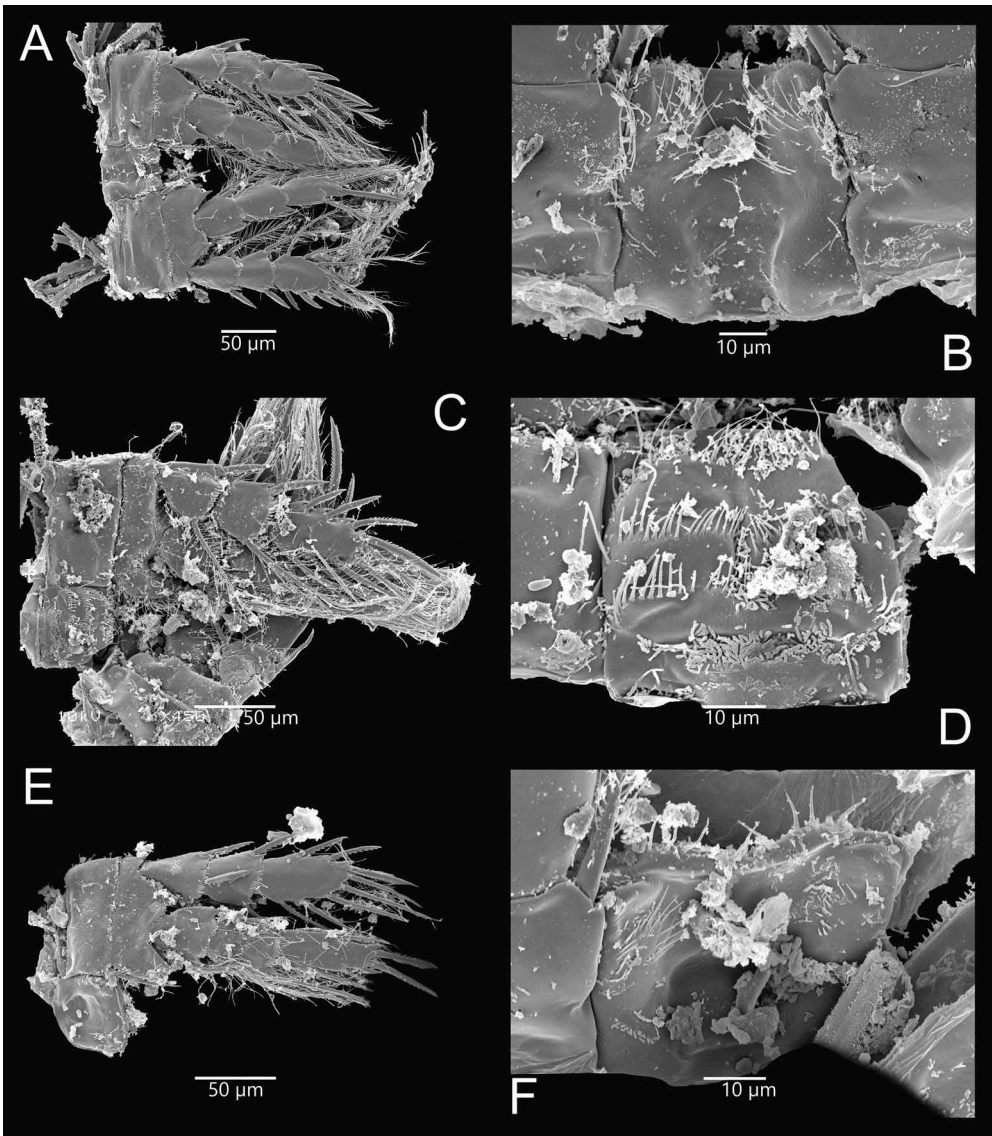


Figure 18. *Eucyclops festivus* Lindberg, 1955. Adult female. (A) P2, frontal; (B) intercoxal sclerite P2, frontal; (C) P3, caudal; (D) intercoxal sclerite P3, caudal; (E) P4, frontal; (F) intercoxal sclerite P4, frontal.

Enp3, 0.8 times as long as Enp. Length/width ratio Enp3 = 1.4, apical spine of Enp3 being 1.2 times as long as Enp3.

Leg 2 (Figures 15C–D, 18A–B). Frontal surface of intercoxal sclerite with row I bearing hair-like elements arranged in a circular pattern; caudal surface with row I discontinuous, bearing 7–9 small spinules on each side, row II continuous with 24–30 small spinules. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula A-B-C-D.

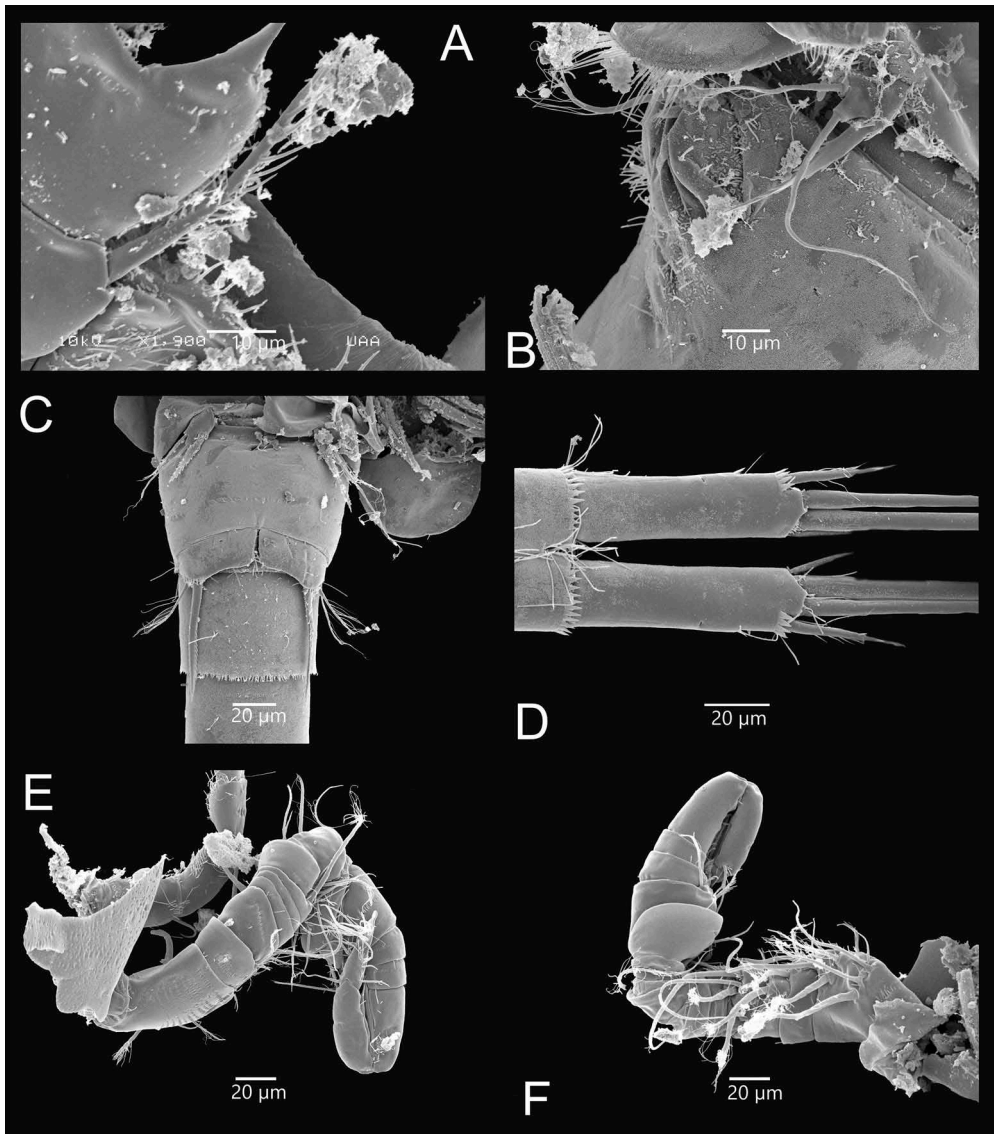


Figure 19. *Eucyclops festivus* Lindberg, 1955. Adult female, A–B; adult male, C–F. (A) Coxal spine P4; (B) P5; (C) P5 and P6; (D) caudal rami, ventral; (E) antennae; (F) antennule.

Length/width ratio of Enp3 = 2, apical spine of Enp3 1.2 times as long as Enp3. No modified setae present.

Leg 3 (Figures 15E–F, 18C–D). Frontal surface of intercoxal sclerite armed with group of long hairs on each side; caudal surface with row I bearing long hairs and with a small gap in the middle, row II continuous bearing 30–32 small spinules and row III continuous bearing 32–37 spinules. Distal margin with two rounded, chitinised projections. Coxa with strong, biserially setulated inner coxal seta, basally with long hairs and distally with

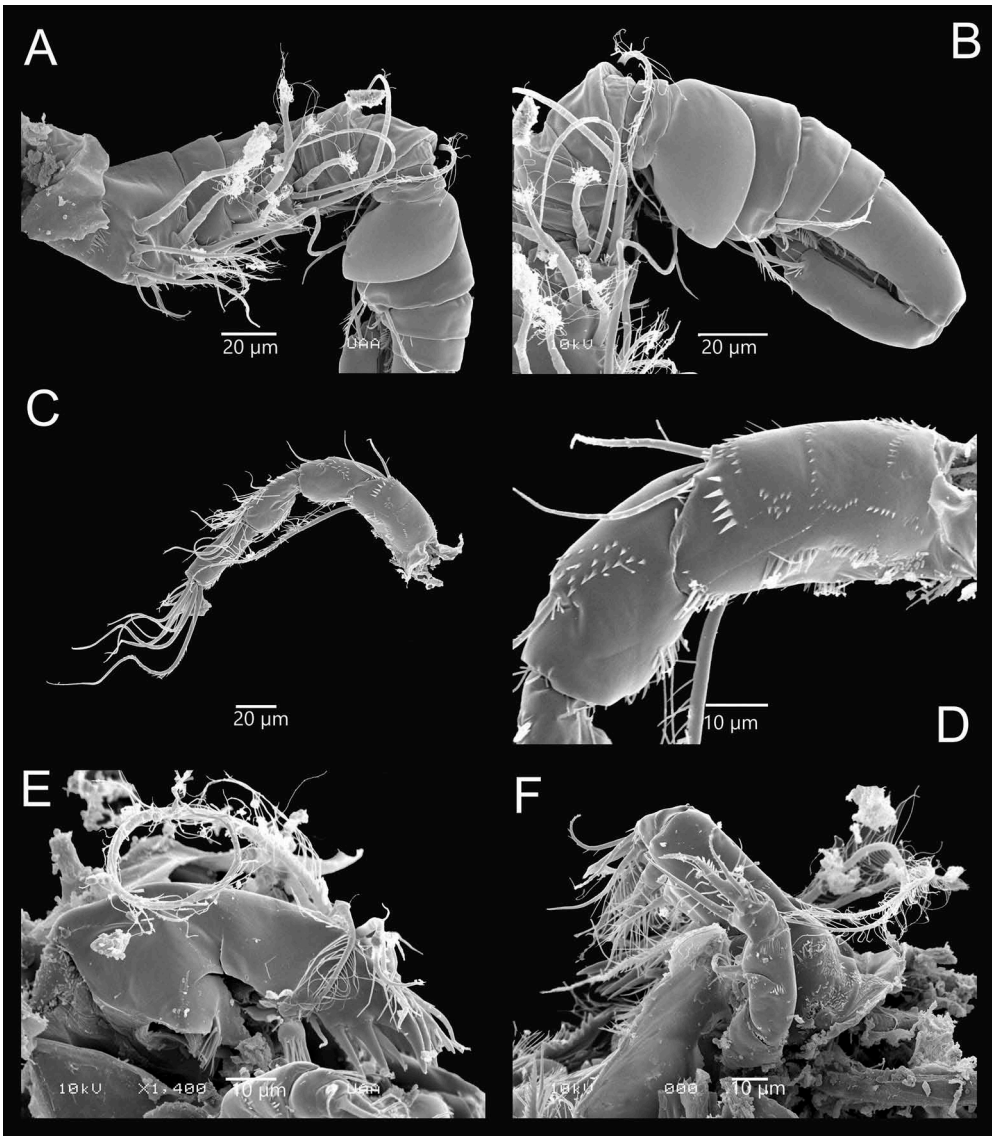


Figure 20. *Eucyclops festivus* Lindberg, 1955. Adult male. (A) Antennule; (B) antennule; (C) antenna, caudal; (D) basis and Enp1 antenna, caudal; (E) maxillule; (F) maxilla and maxilliped.

strong spinules along both margins. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp3 = 1.9, apical spine of Enp3 as long as segment (Enp3). No modified setae present.

Leg 4 (Figures 15G–H, 18F, 19A). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface of sclerite with row I bearing long slender spinules arranged in a semicircular pattern on both sides of surface. Caudal surface of intercoxal sclerite with row I with seven strong spinules on each side and with

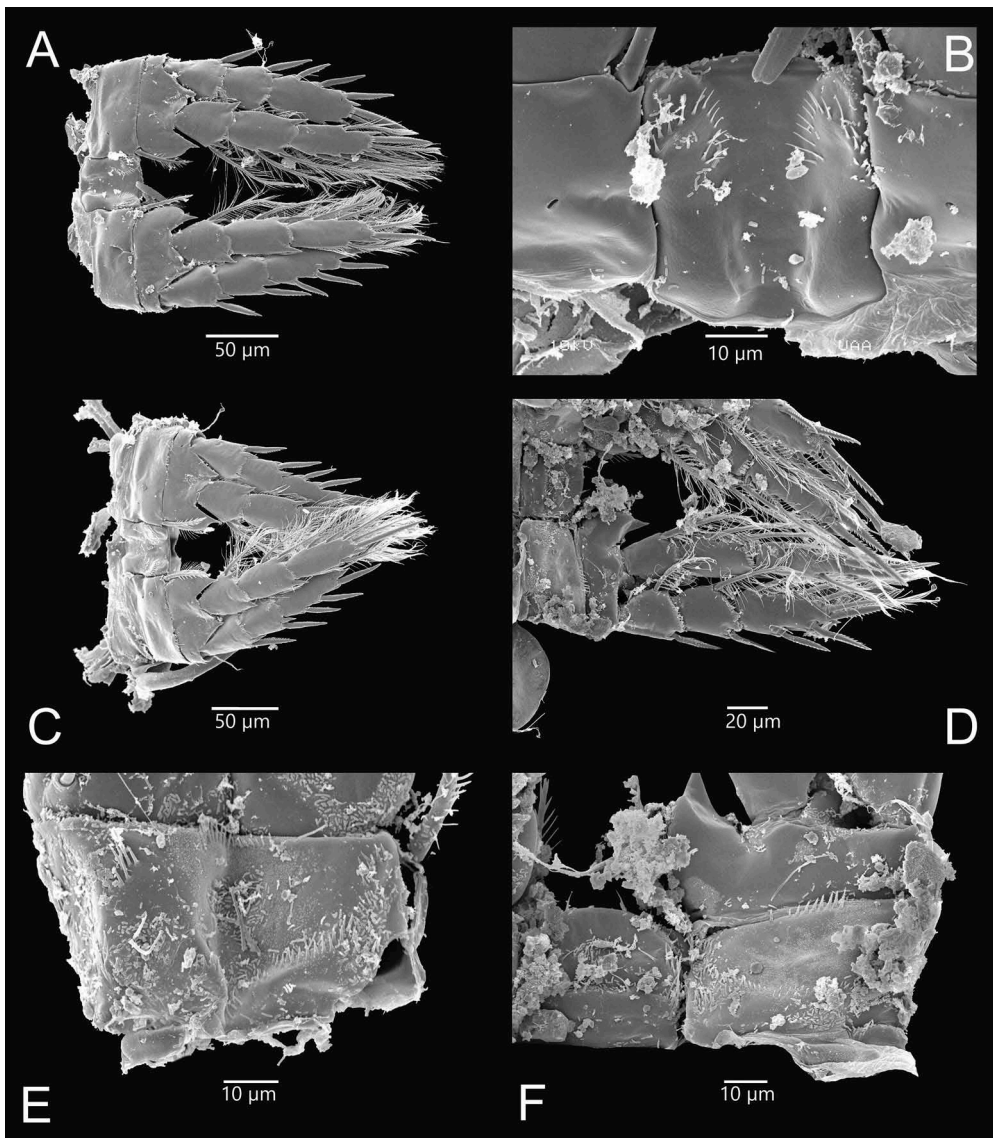


Figure 21. *Eucyclops festivus* Lindberg, 1955. Adult male. (A) P2, frontal; (B) intercoxal sclerite P2, frontal; (C) P3, frontal; (D) P4, caudal; (E) coxa P4, caudal; (F) coxa and intercoxal sclerite P4, caudal.

a small gap in the middle margin; row II continuous, with strong spinules, outer margins bearing more spinules than medial margin; and row III divided into three sections, two on outer margins with strong and long spinules and medial margin with 3–4 long spinules. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; inner margin with long hairs on proximal section and strong spinules distally; outer edge with one distal spinule and proximal hair-like elements, gap in the middle margin. Length/width ratio Enp3 = 2.5, length ratio inner spine of Enp3/length Enp3 = 1.2; length ratio outer spine of Enp3/

length Enp3 = 0.9; proportion inner/outer spines Enp3 = 1.3. Lateral seta of Enp3 inserted at 68% of segment. No modified setae in Enp and Exp.

Leg 5 (Figure 19B). Free segment subrectangular, 2.1 times longer than wide, bearing one strong inner spine and two setae; medial seta 1.8 times longer than outer seta and 1.6 times longer than inner spine. Inner spine twice longer than segment.

Remarks. As mentioned by Gutiérrez-Aguirre et al. (2013), *E. festivus* has been recorded in north and central Mexico and recently also from a pond in the state of Chiapas in southeast Mexico. This species appears to be related to *E. estherae* sp. nov. and *E. wixarica* sp. nov., both described herein. Differences among these species are presented in the remarks sections of *E. wixarica* sp. nov. and *E. estherae* sp. nov.

***Eucyclops leptacanthus* Kiefer, 1956**
(Figures 22–26)

Description

Female. Average length excluding caudal setae = 792 μm . Prosome representing 63% of total body length, prosome symmetrical in dorsal view. Prosomal fringes finely serrate in dorsal view. Urosomal fringes strongly serrate, urosomites ornamented with pits (see Figure 22A); posterior margin of anal somite with row of spinules. Genital double somite symmetrical (Figure 24A), representing 11% of total body length; proximal third of genital double somite expanded laterally. Seminal receptacle with rounded lateral arms on posterior margin, typical of the *serrulatus*-complex. Anal operculum slightly rounded, serrate (Figure 22B). Length/width of caudal rami = 3.7; inner margin of caudal ramus smooth; outer margin with strong spinules covering 60% with respect to the total length of ramus. Dorsal seta (VII) 0.7 times as long as caudal ramus and as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.3. Lateral caudal seta (II) inserted at 71% of caudal ramus.

Antennule (Figures 22C–D, 24D–F). Tip reaching posterior margin of third pediger, antennules ornamented with pits. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(8s). Two transverse rows of spinules on first segment, first row with long, strong spinules and adjacent second row with minute spinules. Spine on sixth segment reaching midlength of seventh segment.

Antenna (Figures 22E–F, 25A–C). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface: N1(5), N2(3), N3(3), N4(8), N5(5), N15(4), N17(5), N18(3) and on caudal surface: N7(4), N8(4), N9 + 10(6), N11(5), N12(6), N13(3) N14(4), N22(6). Caudal surface of Enp1 with B2(6) and B3(3).

Leg 1 (Figures 23A–C, 25D). Frontal surface of intercoxal sclerite with row I bearing hair-like spinules arranged in semicircular pattern; caudal surface with row II continuous, bearing 21 minute but strong spinules, row I absent. Inner coxal seta biserially setulated,

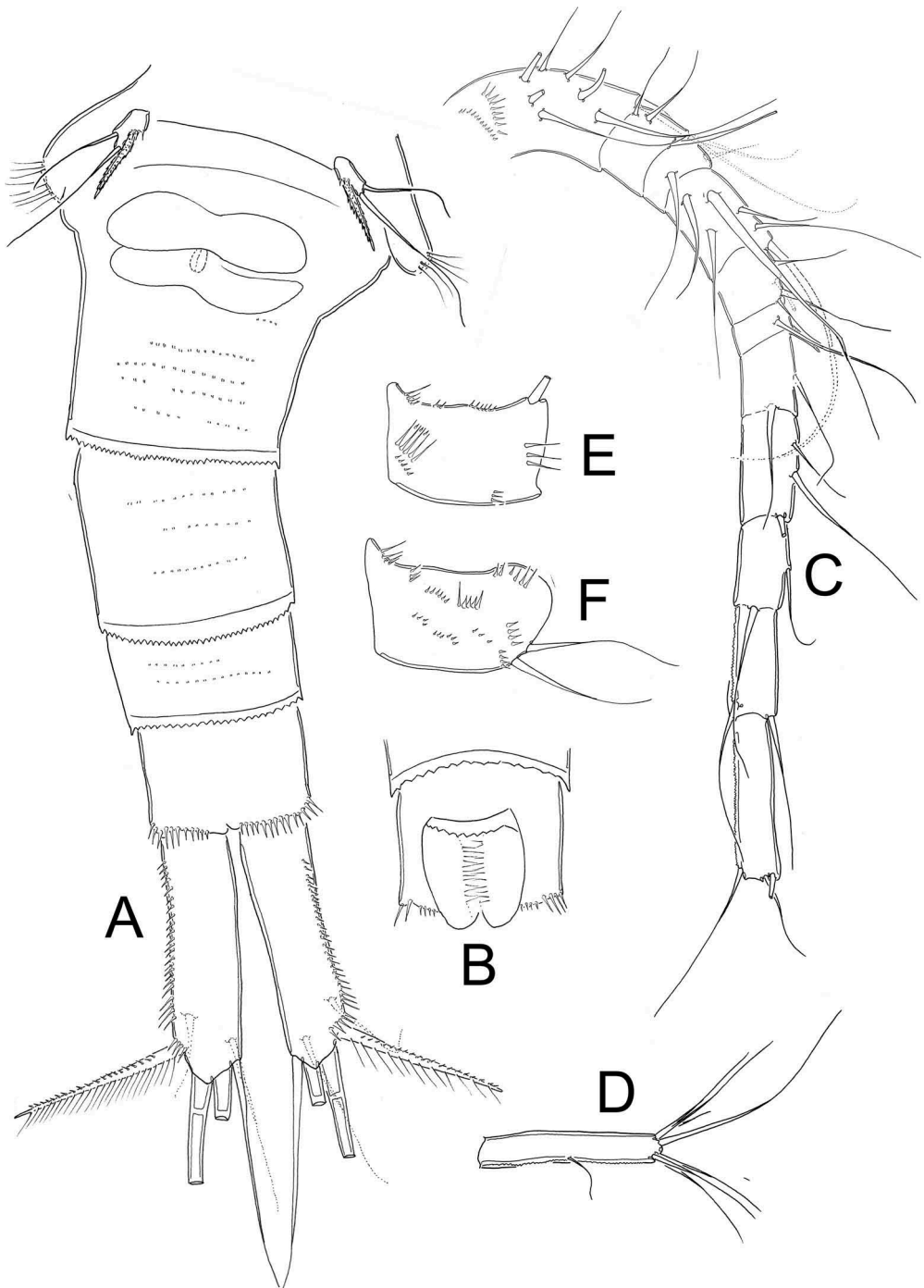


Figure 22. *Eucyclops leptacanthus* Kiefer, 1956. Adult female. (A) Urosome, ventral; (B) anal operculum, dorsal; (C) antennule, segments 1–11; (D) antennule, segment 12; (E) antennal basis, frontal; (F) antennal basis, caudal.

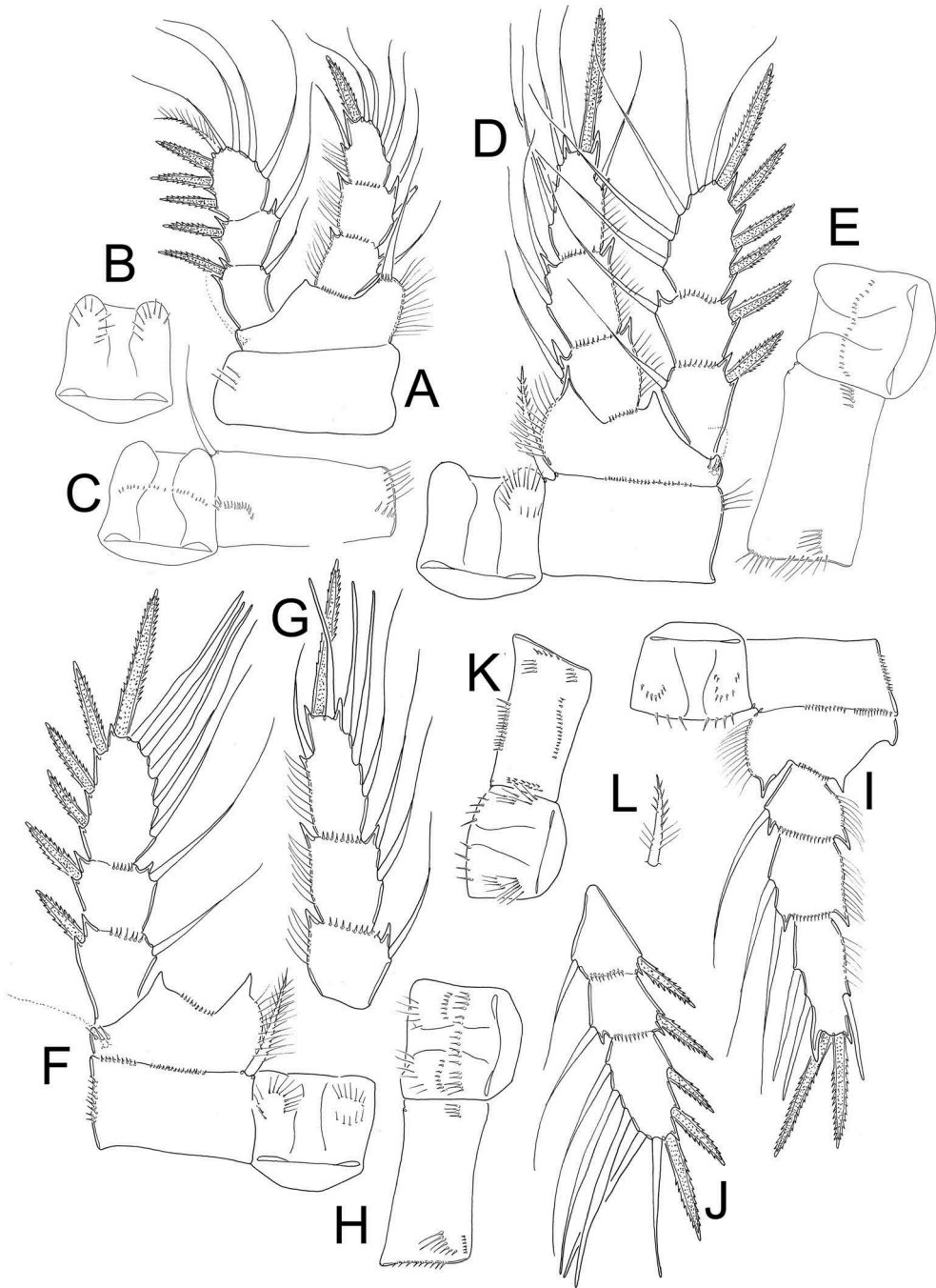


Figure 23. *Eucyclops leptacanthus* Kiefer, 1956. Adult female. (A) P1, frontal; (B) intercoxal sclerite P1, frontal; (C) coxa and intercoxal sclerite P1, caudal; (D) P2, frontal; (E) coxa and intercoxal sclerite P2; caudal; (F) P3, frontal; (G) endopod P3; (H) coxa and intercoxal sclerite P3, caudal; (I) P4, frontal; (J) exopod P4; (K) coxa and intercoxal sclerite P4, caudal; (L) coxal spine P4.

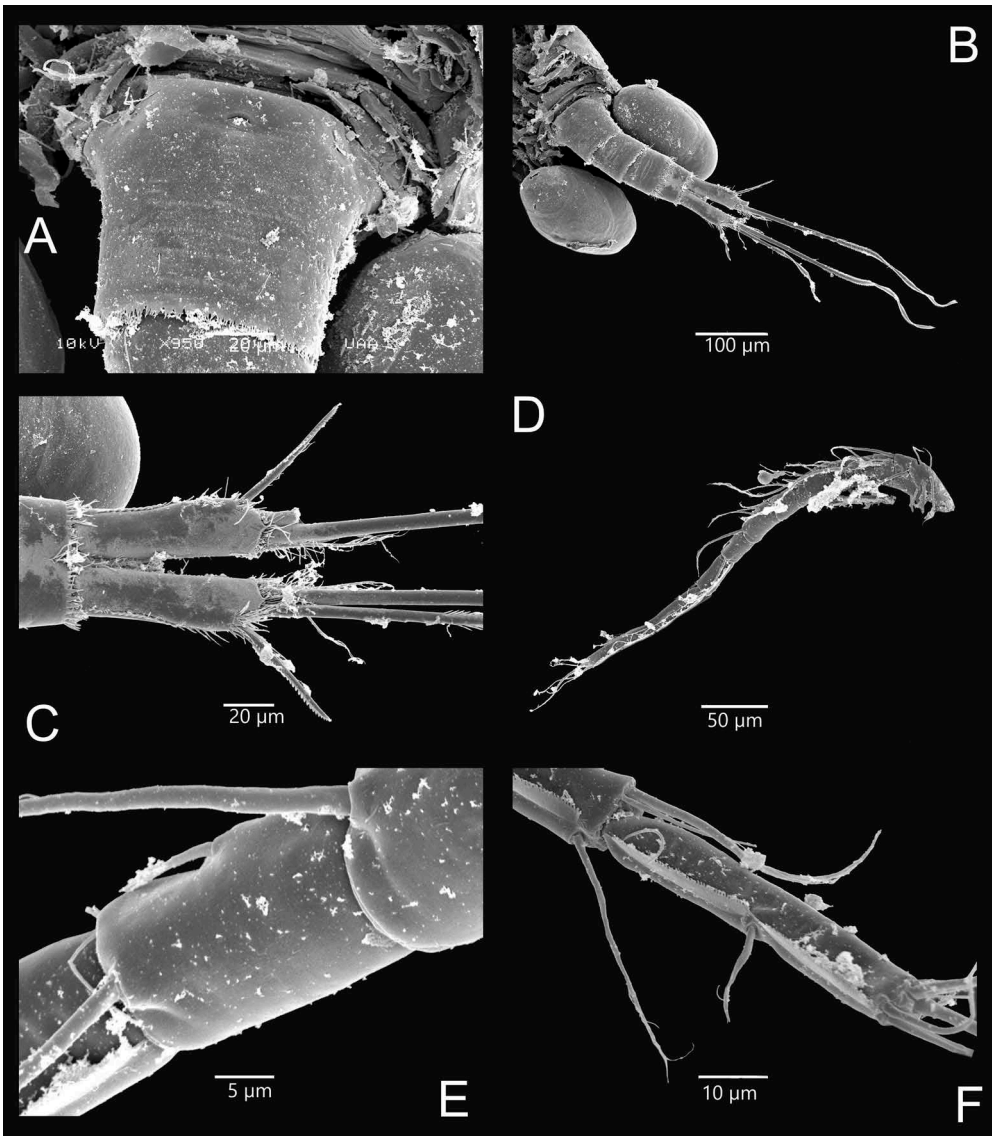


Figure 24. *Eucyclops leptacanthus* Kiefer, 1956. Adult female. (A) Genital somite, ventral; (B) urosome, ventral; (C) caudal rami, ventral; (D) antennule; (E) antennule segment 9; (F) antennule segment 12.

caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal spine) reaching middle margin of Enp3, 0.8 times as long as Enp. Length/width ratio Enp3 = 1.6, apical spine of Enp3 being 1.1 times as long as Enp3.

Leg 2 (Figure 23D–E, 25E). Frontal surface of intercoxal sclerite with row I bearing long hair-like elements arranged in circular pattern; caudal surface with row II continuous, with 20 minute spinules, row I absent. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface

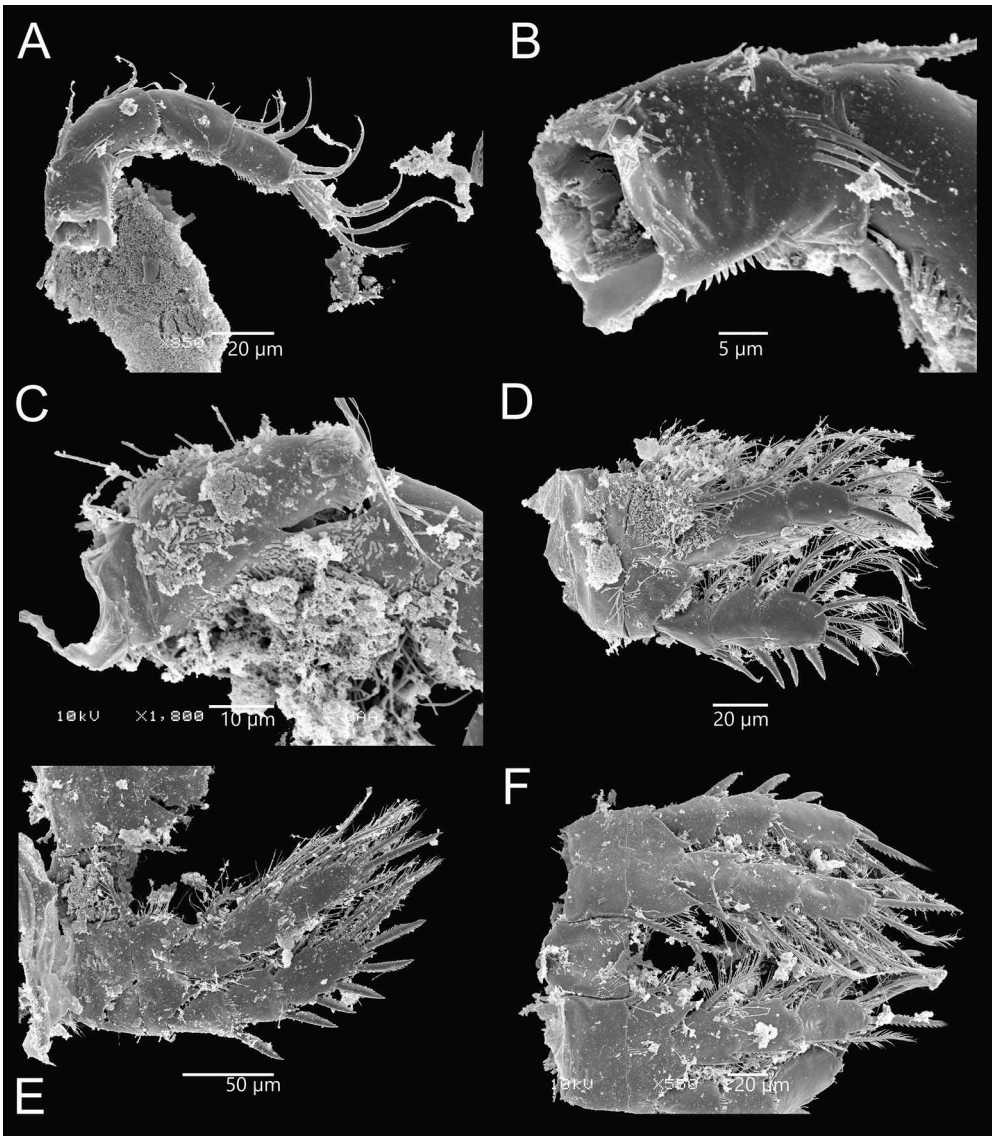


Figure 25. *Eucyclops leptacanthus* Kiefer, 1956. Adult female. (A) Antenna, frontal; (B) antennal basis, frontal; (C) antennal basis, caudal; (D) P1, frontal; (E) P2, frontal; (F) P3, frontal.

with spinule formula = A-B-C-D. Length/width ratio of Enp3 = 2.1, apical spine of Enp3 being 1.4 times as long as Enp3. No modified setae present.

Leg 3 (Figures 23F–H, 25F, 26A). Frontal surface of intercoxal sclerite armed with hair-spinules arranged in a circle on each side; caudal surface with row I bearing hair-like elements, row II divided in two groups, each one with eight minute spinules (gap in middle); row III continuous, with 18 strong spinules, spinules adjacent to outer margins being longer. Distal margin with two rounded, chitinised projections. Coxa with strong,

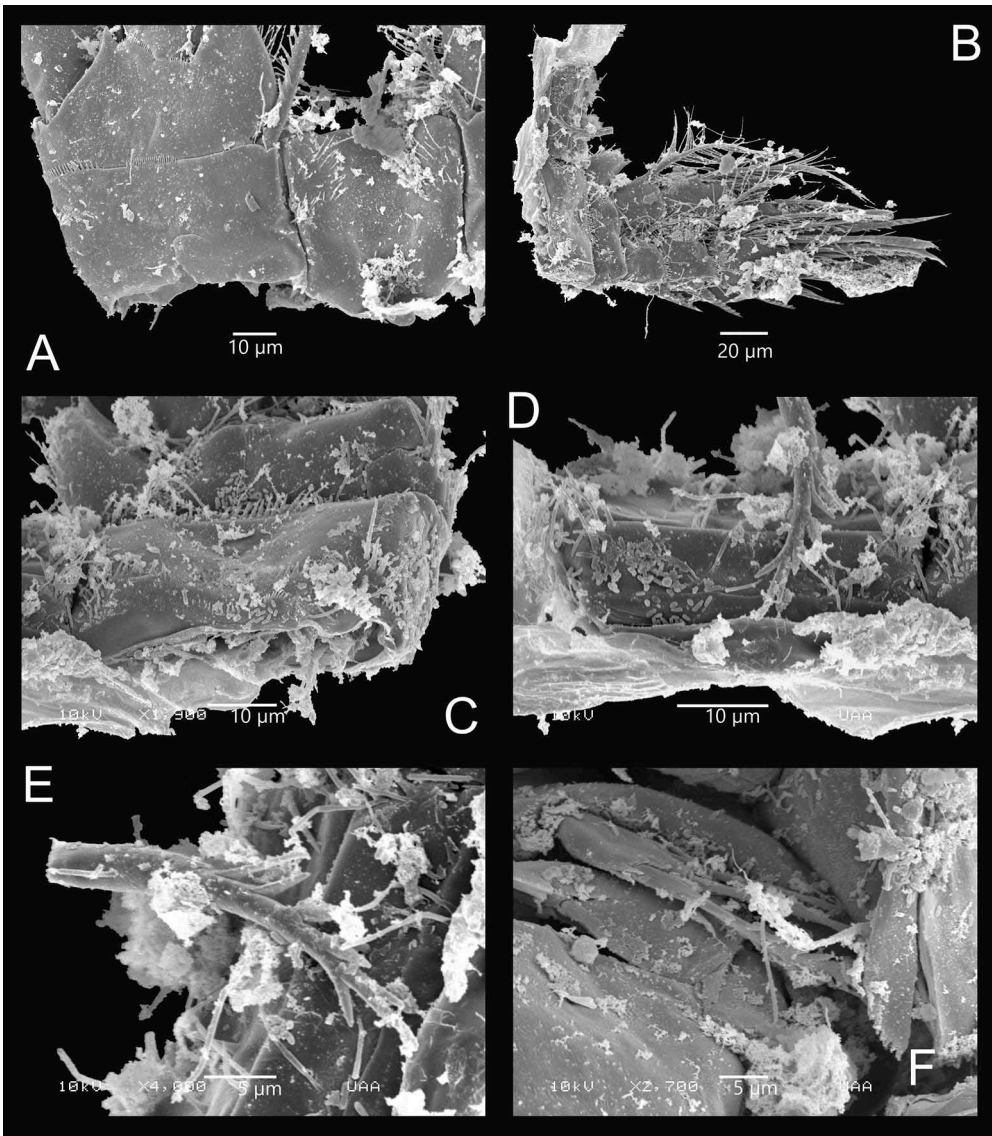


Figure 26. *Eucyclops leptacanthus* Kiefer, 1956. Adult female. (A) Coxa, basis and intercoxal sclerite P3, frontal; (B) P4, caudal; (C) coxa P4, caudal; (D) intercoxal sclerite P4, caudal; (E) coxal spine P4; (F) P5.

biseriately setulated inner coxal seta, with long hair-like elements on proximal section and with strong spinules distally. Caudal coxal surface with spinule formula = A-B-C, group B with two rows. Length/width ratio of Enp = 2.3, apical spine of Enp3 being 1.3 times as long as Enp3. Modified setae present in both, Enp and Exp.

Leg 4 (Figures 231–L, 26B–E). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface of sclerite with row I bearing small, strong spinules arranged in semicircular pattern. Caudal surface of intercoxal sclerite

with row I bearing strong small spinules, row II with strong spinules adjacent to outer margins and row III with strong, long hair-like spinules adjacent to outer margins. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; proximal inner margin with long hairs; distal section with strong spinules, outer margin with three distal spinules and with hairs on proximal section, gap in middle margin. Spinule formula on the caudal surface = A-B-C + D-E-F-G-J. Length/width ratio Enp3 = 2.7, length ratio inner spine of Enp3/length Enp3 = 1.1; length ratio outer spine of Enp3/length Enp3 = 0.9; proportion inner/outer spines Enp3 = 1.2. Lateral seta of Enp3 inserted at 61% of segment. Modified setae in Enp and Exp.

Leg 5 (Figure 26F). Free segment subrectangular, 1.9 times longer than wide, bearing one slender inner spine and two setae; medial seta 1.7 times longer than outer seta and 2.3 times longer than inner spine. Inner spine 1.7 times longer than segment.

Male. Not found.

Remarks. Based on our observations, we herein assign *E. leptacanthus* as a member of the *serrulatus*-group. A distinguishing character of this species is the presence of long hair-like spinules on N1, while this row possesses long hairs in all the other members of the group. We identified our specimens from Mexico as *E. leptacanthus* because it has the main morphologic and morphometric characters found in the holotype from Kiefer's collection. This species is characterised by a long innermost caudal seta (VI) which is 1.3 times longer than the outermost caudal seta (III), long setae in the four swimming legs and a slender P5 spine. Among its congeners, *E. leptacanthus* can be easily distinguished from *E. bondi* by the possession of a shorter dorsal seta and a completely different ornamentation of the P4 intercoxal sclerite. *Eucyclops leptacanthus* resembles *E. prionophorus*, *E. serrulatus* and *E. pectinifer* but shows significant differences with respect to these species. In *E. leptacanthus* row N1 of the antennal Bsp has long hair-spinules, while in *E. prionophorus*, *E. serrulatus* and *E. pectinifer* this row bears long hair-like elements. In addition, N6 is absent in *E. leptacanthus* as it is in *E. prionophorus* and *E. serrulatus*, but it is present in *E. pectinifer*. The caudal surface of the antennal Bsp of *E. leptacanthus* resembles both *E. prionophorus* and *E. pectinifer* in the presence of row N18, but differs from both species by the unique presence of N13. The caudal surface of the coxal sclerite of the four swimming legs differs among these species as well. In P1 *E. leptacanthus* shares with *E. serrulatus* and *E. pectinifer* the absence of row I but differs from both species in its possession of a row II with minute spinules; it has long hairs in the other species and in *E. prionophorus* row I is always present. In P2, *E. leptacanthus* shares the absence of row I with *E. serrulatus* and *E. pectinifer* but differs in having row II with minute spinules vs long spinules in the other two species. Also, *E. prionophorus* differs by possessing a row I armed with minute spinules. The caudal surface of the P3 intercoxal sclerite is similar in the three species, but row II of *E. leptacanthus* is discontinuous, thus differing from the continuous pattern observed in *E. prionophorus*, *E. serrulatus* and *E. pectinifer*. The ornamentation pattern of the caudal surface of the P4 sclerite is similar in all species; in *E. leptacanthus* it has small but strong spinules on row I, whereas this row bears long spinules in the other species.

***Eucyclops torresphilipi* Suárez-Morales, 2004**
(Figure 27)

Description

Female. Average length excluding caudal setae = 680 μm . Prosome representing 66% of total body length, symmetrical in dorsal view. Prosomal fringes finely serrate in dorsal view. Urosomal fringes strongly serrate; posterior margin of anal somite with row of spinules. Genital double somite symmetrical, representing 16.5% of total body length; proximal third of genital double somite expanded laterally. Seminal receptacle with rounded, lateral arms on posterior margin, typical of the *serrulatus*-complex but posterior lobe slightly expanded. Anal operculum slightly rounded and smooth, with a small gap in the middle margin (Figure 27A). Length/width of caudal rami = 4.1; inner margin of caudal ramus smooth; strong spinules covering 47% with respect to the total length of ramus. Dorsal seta (VII) 0.7 times as long as caudal ramus, and 1.0 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.6. Lateral caudal seta (II) inserted at 77% of total length of caudal ramus.

Antennule. Tip reaching middle margin of second pediger, antennules ornamented with pits. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(7s+1ae). One transverse row of spinules on first segment. Spine on sixth segment not reaching medial margin of seventh antennular segment.

Antenna (Figure 27B). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface: N1(V), N2(2), N3(3), N4(9), N5(6), N6(3), N15(3), N17(6), N18(3).

Leg 1 (Figure 27C–D). Frontal surface of intercoxal sclerite with row hair-spinules arranged in semicircular pattern on each side, caudal surface with row II bearing spinules, row I absent. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal spine) not reaching midlength of Enp3, 0.6 times as long as Enp. Length/width ratio Enp3 = 1.5, apical spine of Enp3 being 1.2 times as long as Enp3.

Leg 2 (Figure 27E–F). Frontal surface of intercoxal sclerite with row I bearing hairs arranged in semicircular pattern; caudal surface lacking row I, row II continuous, with 21 strong spinules. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C-D. Length/width ratio of Enp3 = 2.0, apical spine of Enp3 1.2 times as long as Enp3. No modified setae present.

Leg 3 (Figure 27G–H). Frontal surface of intercoxal sclerite with hairs-spinules arranged in circular pattern on each side; caudal surface with row I bearing long hairs (gap at middle section), row II with 24 strong spinules, divided into two sections arranged in semicircular pattern; row III continuous, with 19 strong spinules. Distal margin with two rounded, chitinised projections. Coxa with strong biserially setulated

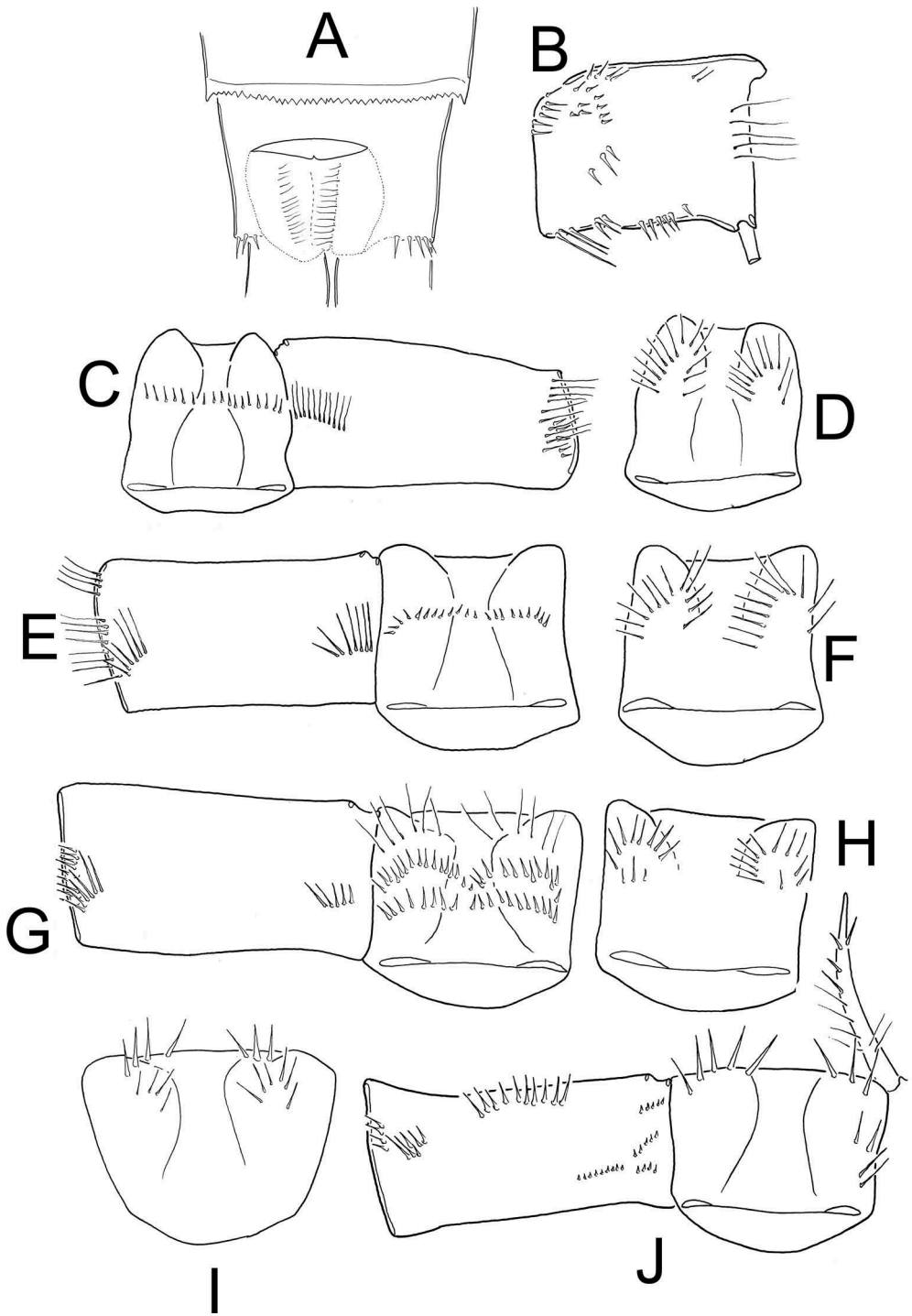


Figure 27. *Eucyclops torresphilipi* Suárez-Morales, 2004. Adult female. (A) Anal operculum, dorsal; (B) antennal basis, frontal; (C) coxa and intercoxal sclerite P1, frontal; (D) intercoxal sclerite P1, frontal; (E) coxa and intercoxal sclerite P2, caudal; (F) intercoxal sclerite P2, frontal; (G) coxa and intercoxal sclerite P3, caudal; (H) intercoxal sclerite P3, frontal; (I) intercoxal sclerite P4, frontal; (J) coxa, intercoxal sclerite and coxal spine P4, caudal.

inner coxal seta, proximal section with long hairs; distal section with strong spinules long both margins. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp = 2.3, apical spine of Enp3 being 1.0 times as long as Enp3. No modified setae present.

Leg 4 (Figure 271–J). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface of sclerite with row I bearing small hair–spinules arranged in a semicircular pattern, caudal surface with row I bearing long, strong spinules, row II with spinules close to outer margins of sclerite; row III with strong and slightly longer spinules close to outer margins. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; proximal inner margin with long hairs; distal margin with strong spinules; outer margin with one distal spinule, proximal section with setules, gap in middle margin. Spinule formula on caudal surface = C + D-G-H-J. Length/width ratio Enp3 = 2.1, length ratio inner spine of Enp3/length Enp3 = 1.2; length ratio outer spine of Enp3/length Enp3 = 0.8; length ratio inner/outer spines Enp3 = 1.5. Lateral seta of Enp3 inserted at 70% of segment. No modified setae in Enp and Exp.

Leg 5. Free segment subrectangular, 1.6 times longer than wide; bearing one strong inner spine and two setae; medial seta 1.6 times longer than outer seta and 1.6 times longer than inner spine. Inner spine twice longer than segment.

Male. Length range excluding caudal setae = 652 μm . Prosome symmetrical in dorsal view, representing 67% of total body length. Urosome six-segmented, slightly elongated, urosomal fringes strongly serrate. Caudal ramus smooth along both inner and outer margins, with strong spinules at insertion of lateral seta.

Antennule. Armature as follows: 1(6s+3ms), 2(4s+1ms), 3(1+2ms), 4(1ms), 5(0), 6(2s), 7(3s), 8(0), 9(1s), 10(4s), 11(0), 12(0), 13(0), 14(1), 15(9s+1sp).

Antenna. Basis ornamented on frontal surface: N1(VI), N2(V), N3(6), N4(7), N5(11), N15(4), N17(11), N18(4) and on caudal surface: N7(4), N8(4), N9+10(5), N11(4), N12(10).

Legs 1–4. End and Exp of all swimming legs three-segmented and armed as in female.

Leg 5. Free segment subrectangular, 1.7 times longer than wide, bearing one inner spine and two setae; medial seta longer than outer seta (about 1.6 times) and inner spine (1.5 times). Inner spine 1.5 times longer than segment.

Remarks. As stated by Suárez-Morales (2004), *E. torresphilipi* resembles the South American species *E. leptacanthus* and *E. delachauxi* because they share a particularly slender inner P5 spine and relatively short caudal rami. The morphometric values obtained from our analysis of *E. leptacanthus* and *E. torresphilipi* revealed that there are no significant differences between these species, but the ornamentation of the swimming legs and the antennae provide useful characters to distinguish them. In the P1 coxa of *E. torresphilipi* row C bears long hair–spinules whereas this row has small but

strong spinules in *E. leptacanthus*. In the P2 coxa small differences were found: row D of *E. torresphilipi* bears long hair-spinules but in *E. leptacanthus* this row has strong and long spinules which are also fewer than in *E. torresphilipi*. In P3 differences in the caudal surface of the intercoxal sclerite are remarkable; in *E. leptacanthus* row I bears long hairs while in *E. torresphilipi* this row is armed with long hair-spinules. In both species row II is divided in two sections, each close to the outer margin, but in *E. leptacanthus* it has small but strong spinules whereas in *E. torresphilipi* this row covers all the medial surface of the intercoxal sclerite and bears strong and slightly longer spinules. In both species row III has long spinules along the sclerite.

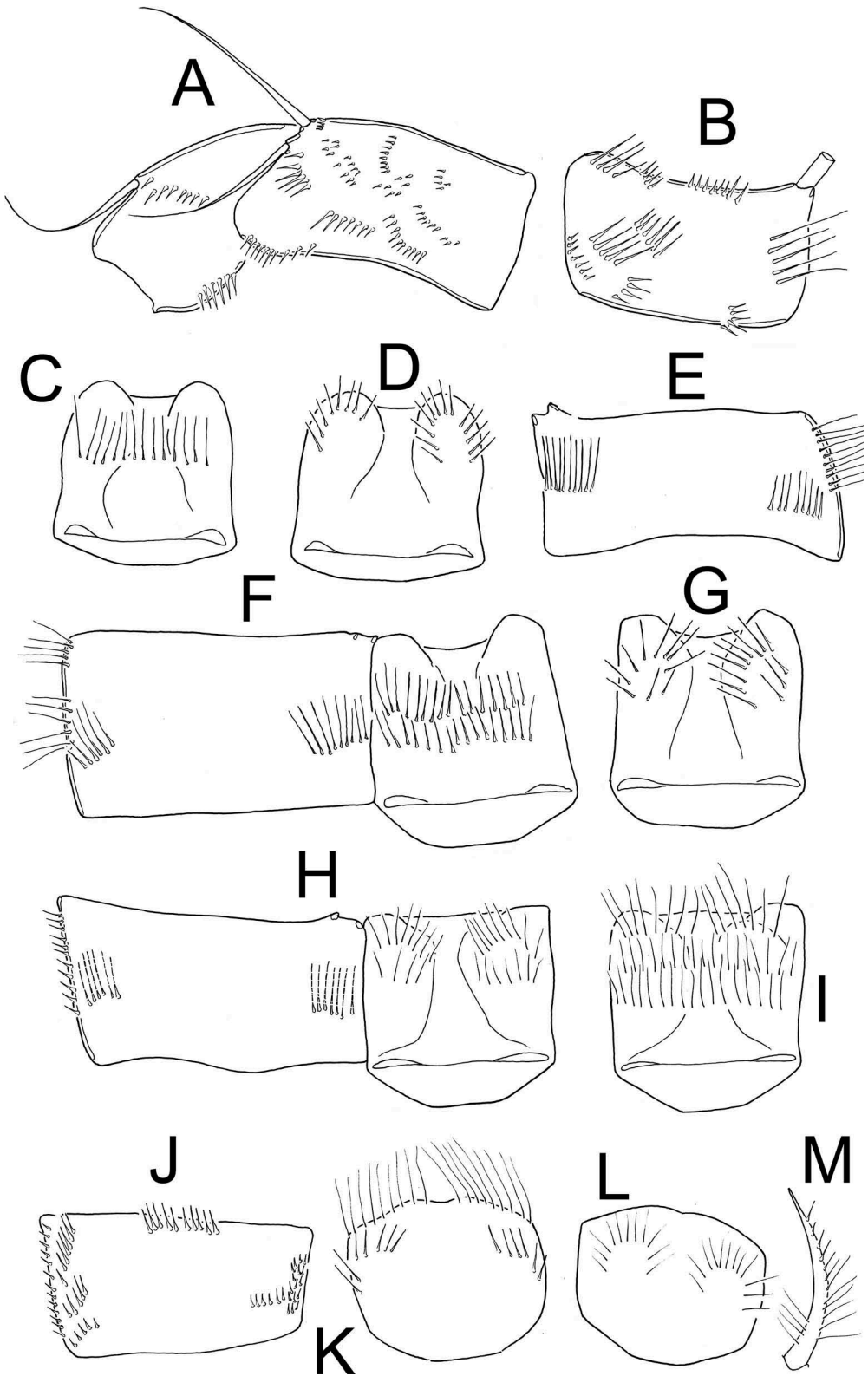
Eucyclops prionophorus is another species that seems to be closely related to *E. torresphilipi* but can be easily distinguished because of its possession of row I on the caudal surface of P1 and P2 intercoxal sclerites; this row is absent in *E. torresphilipi*. One of the main characteristics of *E. torresphilipi* is the coxal ornamentation of the fourth swimming leg which is remarkably reduced when compared with that known in other congeners like *E. delachauxi*, *E. leptacanthus*, *E. prionophorus*, *E. pectinifer* and *E. bondi*. In *E. torresphilipi* row A is not present as it is in all the other mentioned species, but also *E. torresphilipi* presents a unique pattern in row J which is divided into three rows bearing minute spinules. This pattern is similar to that present in *E. albuferensis* from Spain (Alekseev 2008), with the difference that in *E. albuferensis* the groups of spinules are not clearly separated as they are in *E. torresphilipi*. Another distinctive feature of *E. torresphilipi* is the shape of its anal operculum; in the Mexican *Eucyclops* we found two general types: (1) rounded and smooth and (2) rounded and serrate (*E. elegans*, *E. tziscao* and *E. defayae* sp. nov.); *E. torresphilipi* is the only species whose anal operculum is smooth and rounded but has a small gap in its middle section. This character is known only in *E. neumani* s. str., a South American species and otherwise clearly different to *E. torresphilipi* because of the ornamentation of the caudal rami, the length/width of the caudal ramus, and the body size, among other characters.

Eucyclops delachauxi and *E. torresphilipi* share a short caudal ramus and a particularly long lateral seta in Enp3 P4 as compared to other species of *Eucyclops*. In these two species this seta reaches or exceeds the apical margin of the outer spine, while in the rest of the species the seta does not reach beyond the midlength of the outer spine. A character that separates these two species is the ornamentation of the outer margin of the caudal ramus; in *E. torresphilipi* (as in most of species of the genus) spinules cover $\frac{3}{4}$ of the total length of the ramus, while in *E. delachauxi* the serra is reduced – it covers only 20–30% of the outer margin.

Eucyclops chihuahuensis Suárez-Morales and Walsh, 2009
(Figure 28)

Description

Female. Average length excluding caudal setae = 640 μm . Prosome representing 59% of total body length, symmetrical in dorsal view. Urosomal fringes strongly serrate; posterior margin of anal somite with row of spinules. Genital double somite symmetrical, representing 11% of total body length; anterior third of genital double somite expanded laterally. Seminal receptacle with rounded lateral arms on posterior margin, typical of



the *serrulatus*-complex. Anal operculum smooth, rounded. Length/width of caudal rami = 4.5; inner margin of caudal ramus naked; outer margin with strong spinules covering 63% with respect to the total length of ramus. Dorsal seta (VII) 0.4 times as long as caudal ramus and 0.8 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.3. Lateral caudal seta (II) inserted at 76% of caudal ramus.

Antennule. Tip reaching midlength of third pediger. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(2s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(2s+1ae), 12(7s+1ae). Two transverse rows of spinules on first segment, first row with strong spinules and adjacent second row with minute spinules. Spine on sixth segment reaching midlength of seventh segment.

Antenna (Figure 28A–B). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface: N1(5), N2(5), N3(6), N4(5), N5(7), N15(4), N17(8), N18(4); on caudal surface: N7(4), N8(6), N9(7), N10(3), N11(7), N12(10), N13(13) N14(6), N20(10), N22(15). Caudal surface of Enp1 with B2(8).

Leg 1 (Figure 28C–E). Frontal surface of intercoxal sclerite with row I bearing long spinules arranged in semicircular pattern on each side, caudal surface with row II bearing long hair-spinules, row I absent. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal spine) not reaching midlength of Enp3, 0.6 times as long as Enp. Length/width ratio Enp3 = 1.5, apical spine of Enp3 being 1.1 times as long as Enp3.

Leg 2 (Figure 28F–G). Frontal surface of intercoxal sclerite with row I armed with hairs arranged in circular pattern; caudal surface with rows I and II continuous, both bearing long hair-spinules. Distal margin of intercoxal sclerite with two rounded chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C-D. Length/width ratio of Enp3 = 1.9, apical spine of Enp3 1.3 times as long as Enp3. No modified setae present.

Leg 3 (Figure 28H–I). Frontal surface of intercoxal sclerite armed with hairs arranged in circular pattern on each side; caudal surface with row I bearing long hairs (gap at middle section), rows II and III continuous, bearing long hairs. Distal margin with two rounded, chitinised projections. Coxa with strong biserially setulated inner coxal seta, proximal section with long hairs; distal section with strong spinules along both margins. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp = 2.0, apical spine of Enp3 being 1.2 times as long as Enp3. No modified setae present.

Figure 28. *Eucyclops chihuahuensis* Suárez-Morales and Walsh, 2009. Adult female. (A) Basis and Enp1 antenna, caudal; (B) antennal basis, frontal; (C) intercoxal sclerite P1, caudal; (D) intercoxal sclerite P1, frontal; (E) coxa P1, caudal; (F) coxa and intercoxal sclerite P2, caudal; (G) intercoxal sclerite P2, frontal; (H) coxa and intercoxal sclerite P3, frontal; (I) intercoxal sclerite P3, caudal; (J) coxa P4, caudal; (K) intercoxal sclerite P4, caudal; (L) intercoxal sclerite P4, frontal; (M) coxal spine P4.

Leg 4 (Figure 28J–M). Distal margin with two low, rounded, chitinised projections. Frontal surface of intercoxal sclerite with row I bearing long hairs arranged in semicircular pattern, caudal surface of intercoxal sclerite with row I bearing long hairs, row II with long hair–spinules on outer margins and row III with long hair–spinules on outer margins. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; inner margin with long setules proximally and with strong spinules distally, outer margin with setules along proximal section and distally naked. Spinule formula on caudal surface = A-B-C + D-E-F-G-J. Length/width ratio Enp3 = 2.5, length ratio inner spine of Enp3/length Enp3 = 1.1; length ratio outer spine of Enp3/length Enp3 = 0.9; length ratio inner/outer spines Enp3 = 1.3. Lateral seta of Enp3 inserted at 68% of segment. No modified setae in Enp and Exp.

Leg 5. Free segment subrectangular, 1.5 times longer than wide, bearing one strong inner spine and two setae; medial seta 2.8 times longer than outer seta, twice as long as inner spine. Inner spine 2.2 times longer than segment.

Male. Unknown.

Remarks. When this species was described (Suárez-Morales and Walsh 2009), it was related and compared to *E. pseudoensifer*; however, even when the general shape and main proportions are similar to *E. pseudoensifer*, our analysis revealed that they belong to different groups. *Eucyclops pseudoensifer* was redescribed by Suárez-Morales and Walsh (2009) and new morphological data consulted in Dussart Collection (pers. obs. Mercado-Salas, 2012), mainly in reference to the ornamentation patterns of the swimming legs and antennal basis. *Eucyclops pseudoensifer* is not a member of the *serrulatus*-group because of the lack of N1 and N2 in the antennal basis while both rows N1 and N2 are present in *E. chihuahuensis*, the former bearing long hair–spinules and N2 with small but strong spinules. This character places this species in the *serrulatus*-group. It appears to be more closely related to *E. pectinifer* and *E. serrulatus* than to its South American congeners *E. pseudoensifer* and *E. leptacanthus*. This species can be easily separated from *E. serrulatus* and *E. pectinifer* by the presence of a more complex ornamentation pattern in both the caudal and frontal surfaces of the antennal basis. *Eucyclops serrulatus* lacks rows N8, N9, N13, N18 and N22 which are present in *E. chihuahuensis*, and *E. pectinifer* lacks rows N13, N20 and N22 which are present in *E. chihuahuensis*. The three above-mentioned species share a caudal surface of the P1 coxal sclerite with row I absent and row II bearing long hair–spinules, but differ in the intercoxal ornamentation of P2. In *E. pectinifer* and *E. serrulatus* row I on the caudal surface is absent while in *E. chihuahuensis* it is present and has long hair–spinules; the three species share a row II bearing long hair–spinules. *Eucyclops chihuahuensis* also differs from *E. serrulatus* and *E. pectinifer* in the ornamentation of the P3 intercoxal sclerite. In the first species all rows are armed with long hairs, while in the other two species these rows bear hair–spinules and strong spinules. The P4 intercoxal sclerite also differs among these three species: in *E. serrulatus* and *E. pectinifer* row I has long and strong spinules whereas *E. chihuahuensis* has long hairs. The coxal surface of *E. chihuahuensis* can be distinguished from that of *E. serrulatus* by the presence of row F, and from both *E. serrulatus* and *E. pectinifer* by the absence of

row H. Based on the comparative analysis of these characters, we presume that previous records of *E. pseudoensifer* in Mexico could be assignable to *E. chihuahuensis*.

***Eucyclops cuatrocieneegas* Suárez-Morales and Walsh, 2009**
(Figures 29–30)

Description

Female. Average length excluding caudal setae = 818 μm . Body elongate, prosome representing 63% of total body length, symmetrical in dorsal view. Urosome representing 37% of body length, urosomal fringes strongly serrate. Genital somite (Figure 29A)

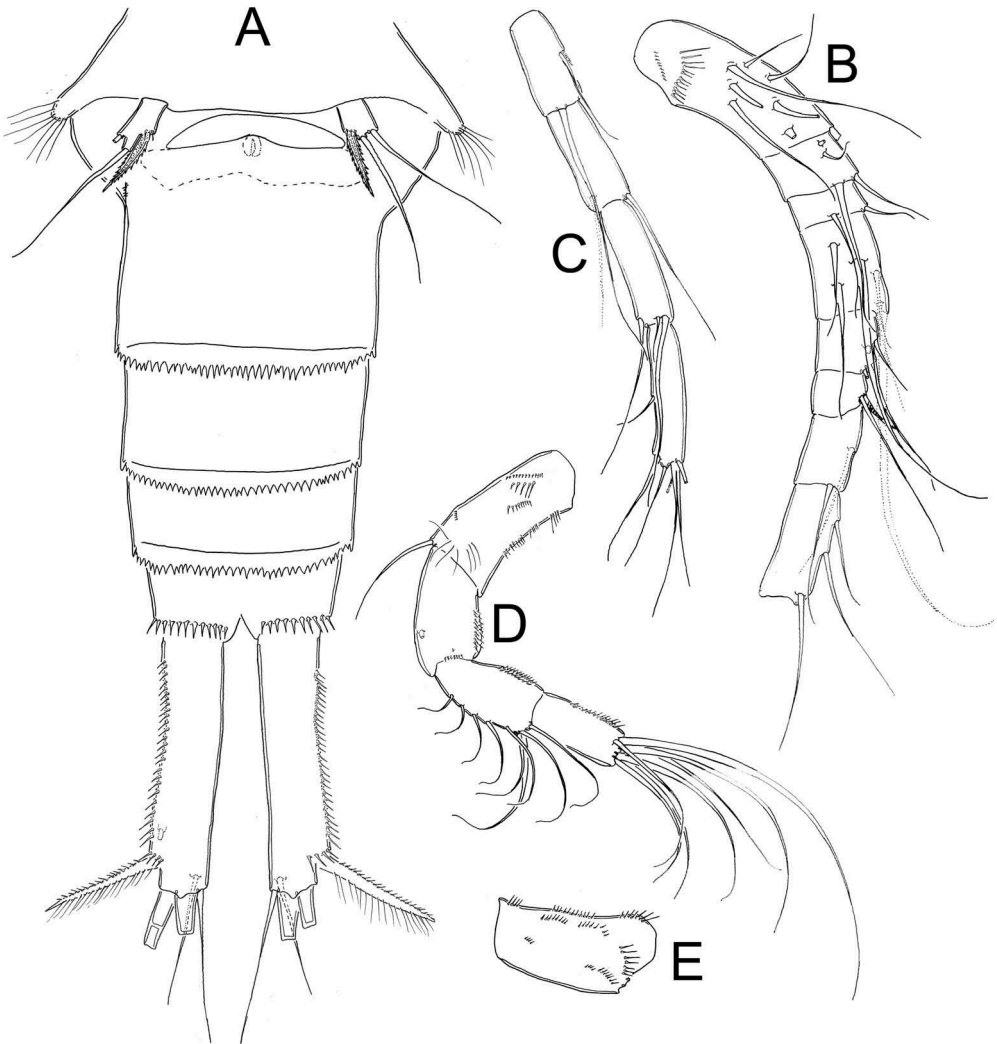


Figure 29. *Eucyclops cuatrocieneegas* Suárez-Morales and Walsh, 2009. Adult female. (A) Urosome, ventral; (B) antennule, segment 1–8; (C) antennule, segment 9–12; (D) antenna, frontal; (E) antennal basis, caudal.

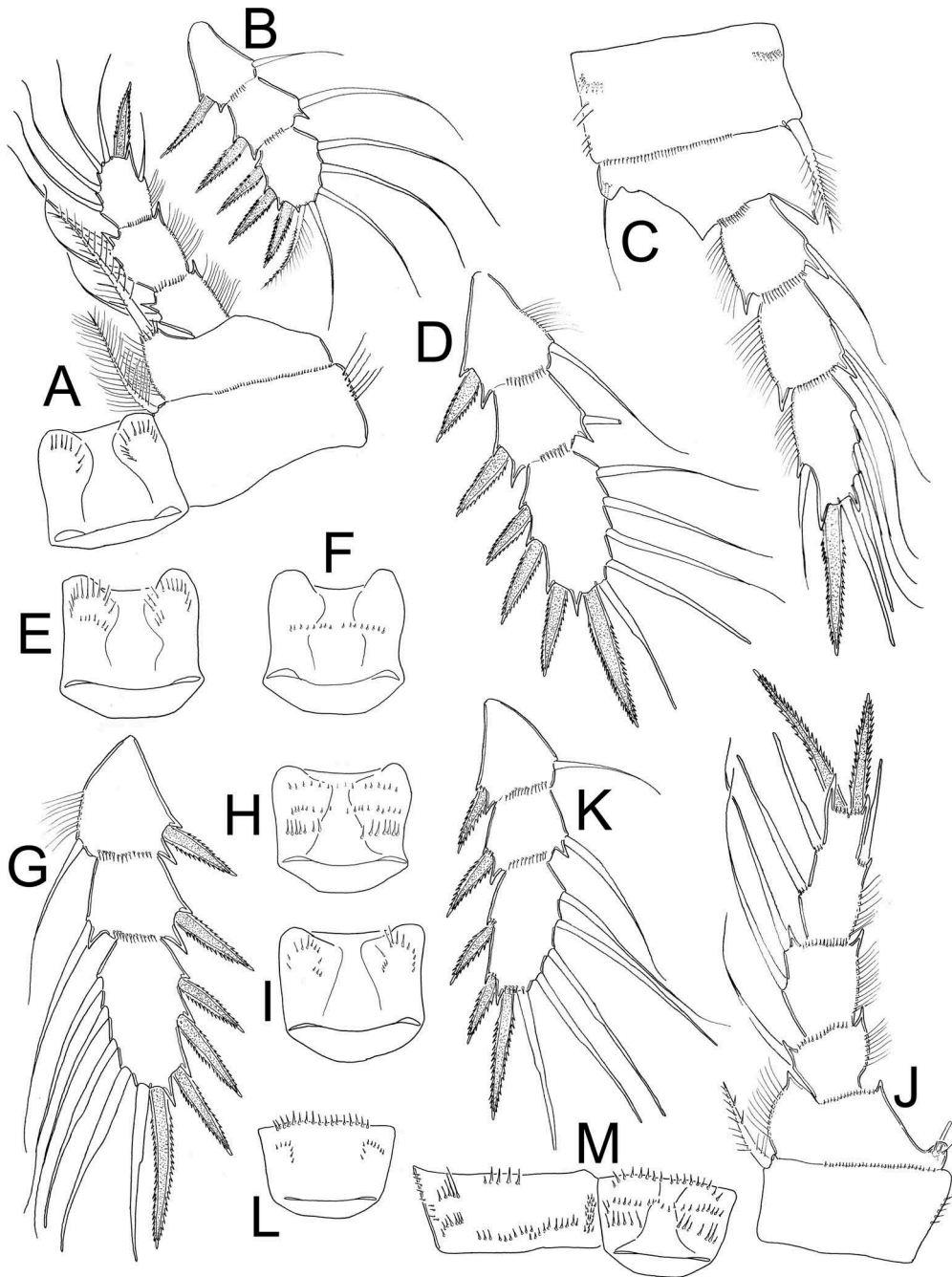


Figure 30. *Eucyclops cuatrocienegas* Suárez-Morales and Walsh, 2009. Adult female. (A) P1, frontal; (B) exopod P1; (C) P2, caudal; (D) exopod P2; (E) intercoxal sclerite P2, frontal; (F) intercoxal sclerite P2, caudal; (G) exopod P3; (H) intercoxal sclerite P3, caudal; (I) intercoxal sclerite P3, frontal; (J) P4, frontal; (K) exopod P4; (L) intercoxal sclerite P4, frontal; (M) coxa and intercoxal sclerite P4, caudal.

symmetrical, representing 13.9% of total body length; proximal third of genital double somite expanded laterally. Seminal receptacle with rounded lateral arms on posterior margin. Length/width ratio of caudal rami = 3.7; inner margin of caudal ramus naked, outer margin with strong spines covering 65% with respect to the total length of ramus. Dorsal seta (VII) relatively short: 0.4 times the length of caudal ramus, and 1.1 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/ outermost caudal seta (III) = 1.3. Lateral caudal seta (II) inserted at 68% of total length of caudal ramus.

Antennule (Figure 29B–C). Tip reaching distal margin of cephalothorax. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(7s+1ae). Two rows of spinules on first segment, basal row bearing minute spinules, second row with longer and stronger spinules than those in basal row. Spine on sixth segment reaching midlength of seventh antennular segment.

Antenna (Figure 29D–E). Coxa (unarmed), basis (2s + Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface: N1(VII), N2 (5), N3(9), N4(5), N5(13), N17(8), N18(5); on caudal surface: N7(7), N8(7), N9+10 (7), N11(8), N12(8), N13(4), N14(4), N15(4). Caudal surface of Enp1 with B1(7).

Leg 1 (Figure 30A–B). Frontal surface of intercoxal sclerite with row I bearing strong spinules arranged in semicircular pattern on each side; caudal surface smooth, distal margin with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal spine) reaching middle margin of Enp3, 0.8 times as long as Enp. Length/width ratio of Enp3 = 1.4, apical spine of Enp3 being 1.1 times as long as Enp3.

Leg 2 (Figure 30C–F). Frontal surface of intercoxal sclerite with row I bearing small, strong spinules arranged in a semicircular pattern on each side; caudal surface with row II continuous, with 16 minute spinules, distal margin with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C-D. Small spinules along insertion of basipodite. Length/width ratio of Enp 3 = 2.0, apical spine of Enp3 being 1.2 times as long as Enp3. Modified setae present in Enp and Exp.

Leg 3 (Figure 30G–I). Frontal surface of intercoxal with row I bearing spinules arranged in semi-circular pattern on each side, proximal spinules longer than the others; caudal surface with row I bearing 13 minute spinules (small gap in the middle), row II continuous, bearing 18 minute spinules; row III with 14 strong, long spinules, with gap in the middle (seven spinules on each side). Distal margin with two rounded projections. Coxa with strong biserially setulated coxal seta, both margins with long setules along proximal section and strong spinules along distal section. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp3 = 2.2, apical spine of Enp3 being 1.1 times as long as Enp 3. Modified setae in Enp and Exp.

Leg 4 (Figure 30J–M). Distal margin with two low, rounded, chitinised projections. Frontal surface of intercoxal sclerite with row I bearing minute spinules in semi-circular

pattern on each side; caudal surface of intercoxal sclerite with row I bearing nine strong but small spinules on each side, with small gap, row II continuous, bearing 22 spinules, outer spinules slightly longer than inner ones; row III with seven spinules on each side, with wide gap. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; proximal inner margin with long hairs, distal margin with spinules; outer margin with two distal spinules, proximal section with three hairs, gap in middle margin. Caudal coxal surface with spinule formula = A-B-C + D-E-F-H-J. Length/width ratio Enp3 P4 = 2.5; length ratio inner spine of Enp3 P4/length Enp3 P4 = 1.3; length ratio outer spine of Enp3 P4/length Enp3 P4 = 0.9; proportion inner/outer spine Enp3 = 1.4. Lateral seta of Enp3 inserted at 61% of segment. Modified setae in Enp and Exp.

Leg 5. Free segment subrectangular, 2.2 times longer than wide, bearing one inner spine and two setae; medial and outer setae equal in length. Setae 2.1 times longer than inner spine. Inner spine 1.3 times as long as segment.

Remarks. *Eucyclops cuatrocieneegas* was recognised as a new species by Suárez-Morales and Walsh (2009) based on the peculiarity of its fifth leg, which, diverging from most of its congeners, has a remarkably short inner spine and an outer seta as long as the medial seta. *Eucyclops siolii* Herbst, 1962 resembles *E. cuatrocieneegas* because of the general shape and armature of the fifth leg, but in *E. siolii* the outer seta is clearly shorter than the medial seta, and it also has a shorter caudal ramus (2.5 times longer than wide) than that of *E. cuatrocieneegas* (3.7–3.9). It is noteworthy to consider that *E. siolii* has been recorded only from the Brazilian Amazon. Among the species known from Mexico, only *E. pectinifer* has a fifth leg resembling that of *E. cuatrocieneegas*. These species can be easily distinguished by the length of the outer and medial setae of the fifth leg; in *E. cuatrocieneegas* these setae are equally long, while in *E. pectinifer* the medial seta is always longer than the outer seta (about 1.3 times). These two species also share a relatively weak ornamentation of the antennal basis caudal surface when compared with species like *E. prionophorus*, *E. leptacanthus* and *E. chihuahuensis*, bearing rows N20 and N22. *Eucyclops cuatrocieneegas* differs from *E. pectinifer* by the presence of N13, the absence of N6, N16 and the fusion of N9+N10. Many differences were found in the caudal surfaces of intercoxal sclerites of the two species; *E. cuatrocieneegas* is the only species distributed in Mexico with a completely naked caudal surface of P1, while in the rest of the species row II is always present and row I is present only in *E. elegans*, *E. prionophorus*, *E. tziscao*, *E. festivus*, *E. mittmanni* sp. nov. and *E. wixarica* sp. nov. The ornamentation of the caudal surface of the P2 intercoxal sclerite differs between *E. cuatrocieneegas* and *E. pectinifer*: in the former species this row bears minute spinules (as in *E. leptacanthus*) while in *E. pectinifer* the row has long hair-spinules. Another distinctive character of *E. cuatrocieneegas* is the ornamentation of the caudal surface of the P3 sclerite; most of the species distributed in Mexico have long hairs or hair-spinules in row I, but in *E. cuatrocieneegas* this row bears small but strong spinules, a character shared only with *E. mittmanni* sp. nov. and *E. defayae* sp. nov., both of which differ from *E. cuatrocieneegas* in the ornamentation of the antennal basis, with row N2 (frontal) bearing long hairs as in *E. serrulatus*, but in *E. cuatrocieneegas* this row has short spinules as in *E. pectinifer*.

Eucyclops tzisca Mercado-Salas 2013
(Figures 31–33 and Gutiérrez-Aguirre et al. 2013)

Description

Female. Average length excluding caudal setae = 620 μm . Prosome representing 61% of total body length, symmetrical in dorsal view. Urosomal fringes strongly serrate. Genital double-somite symmetrical (Figure 31A), carrying paired egg sacs. Seminal receptacle with rounded, lateral arms on posterior margin typical of the *serrulatus*-complex. Anal somite with hair-seta in anal opening, anal operculum serrate. Length/width of caudal ramus = 4.0; inner margin of caudal ramus naked; outer margin with strong spinules covering 40% with respect to the total length of ramus. Dorsal seta (VII) short: 0.65 times the length of caudal ramus, and 1.1 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.2. Lateral caudal seta (II) inserted at 71% of caudal ramus.

Antennule (Figure 31C–F). Tip reaching from middle to distal margin of third pediger. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6 (1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(8s). Two transverse rows of spinules on first segment, first row with strong long spinules, second row with minute spinules. Spine on sixth segment reaching midlength of seventh segment.

Antenna (Figures 32A). Coxa (unarmed), basis (2s +Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface: N1 (IV), N2 (5), N3(5), N4(6), N5(12), N15(4), N17(10); on caudal surface: N8(4), N9+10(5), N11(5), N12(5). Caudal surface of Enp 1 with B3(4).

Leg 1 (Figure 32C–D). Frontal surface of intercoxal sclerite with row I bearing spinules arranged in semicircular pattern on each side; caudal surface with row I bearing 17 minute spinules and row II with 14 minute spinules, distal margin with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal spine) reaching middle margin of Enp3, 0.8 times as long as Enp. Length/width ratio Enp3 = 1.0, apical spine of Enp3 being 1.4 times as long as Enp3.

Leg 2 (Figure 32E–F). Frontal surface of intercoxal sclerite with row I bearing minute spinules arranged in semicircular pattern; caudal surface with row II continuous, with 20 minute spinules. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C-D. Length/width ratio of Enp3 = 1.9, apical spine of Enp3 1.0 times as long as Enp3. No modified setae present.

Leg 3 (Figure 33A–B). Frontal surface of intercoxal sclerite with row I armed with minute spinules arranged in semi-circle on each side; caudal surface with row I bearing long hair-like spinules (small gap in middle section), rows II and III continuous, with minute spinules. Distal margin with two low, rounded projections. Coxa with strong, biserially setulated inner coxal seta, basally with long hairs and distally with strong

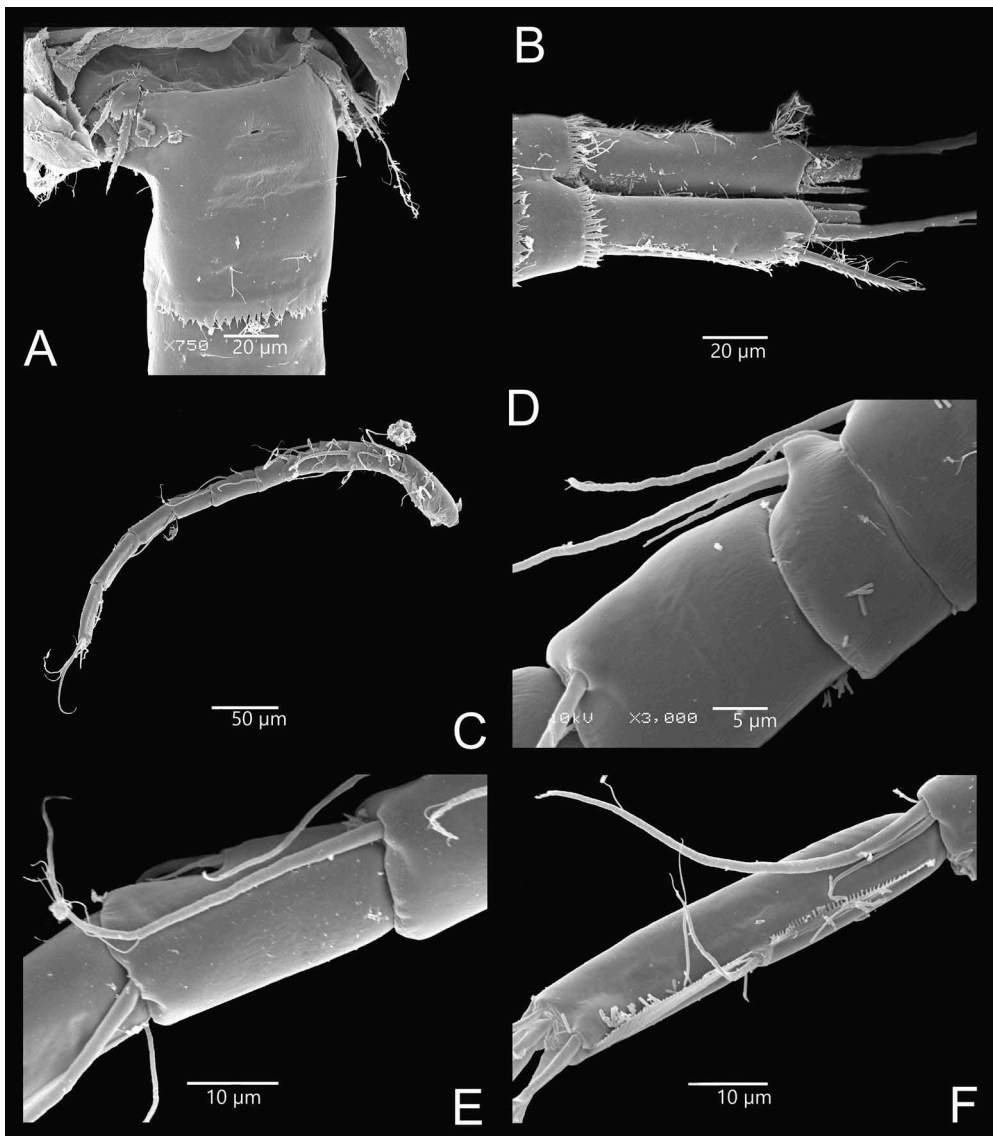


Figure 31. *Eucyclops tziscaoi* Mercado-Salas, 2013. Adult female. (A) Genital somite, ventral; (B) caudal rami, ventral; (C) antennule; (D) antennule segment 6; (E) antennule segment 9; (F) antennule segment 12.

spinules along both margins. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp = 2.2, apical spine of Enp3 being 1.2 times as long as Enp3. Modified setae present in both Enp and Exp.

Leg 4 (Figure 33C–E). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface of intercoxal sclerite with row I bearing minute spinules arranged in semicircular pattern; caudal surface of sclerite with row I bearing strong spinules on each side and small gap, row II with small spinules divided into three

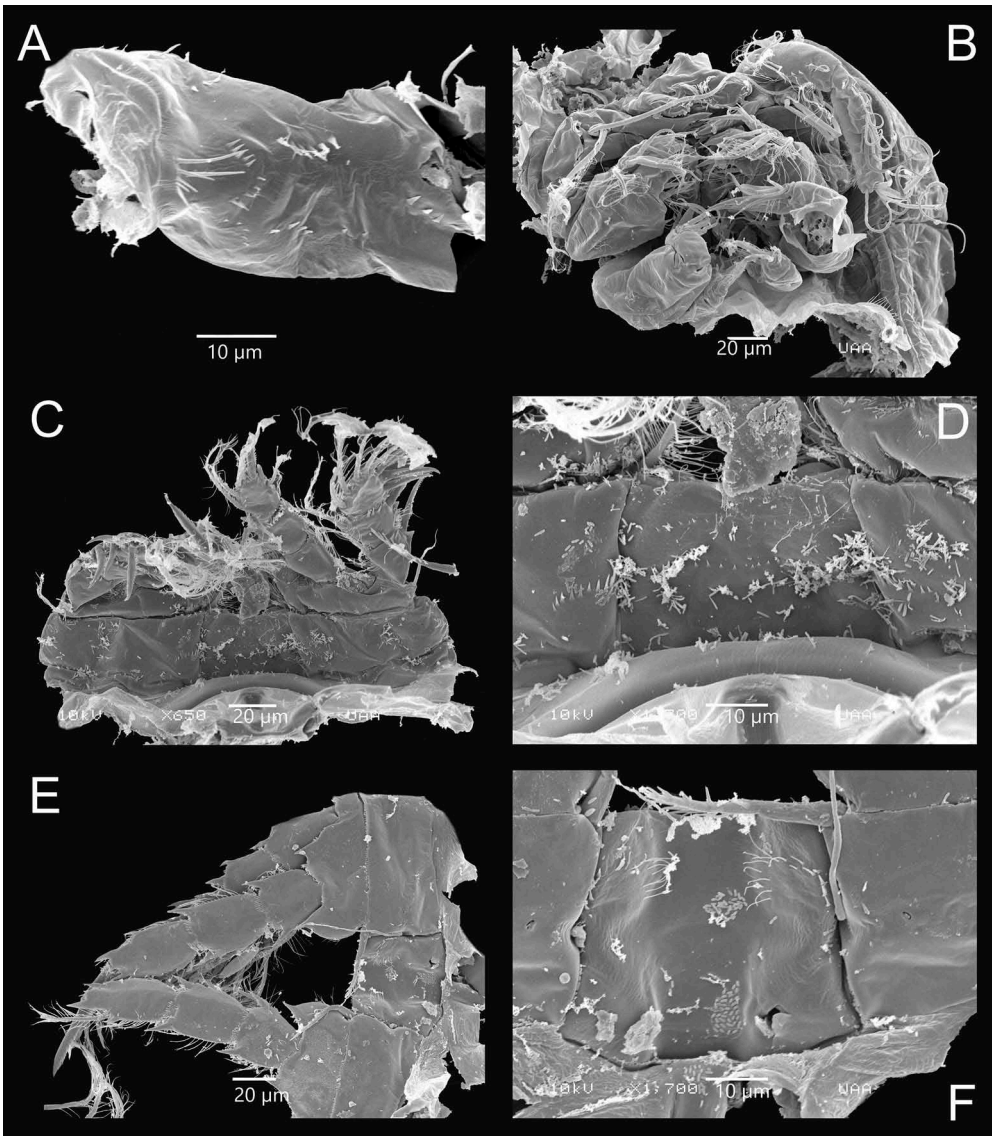


Figure 32. *Eucyclops tzisca* Mercado-Salas, 2013. Adult female. (A) Antennal basis; (B) mouthparts; (C) P1, caudal; (D) intercoxal sclerite P1, caudal; (E) P2, frontal; (F) intercoxal sclerite P2, frontal.

sections, with small gap between them and row III divided into three sections, first section with five long spinules, middle section with six small, strong spinules, and third section with five long spinules. Inner coxal spine with heteronomous setulation: proximally with long hair-like setules, distally with spinule-like setules; outer edge of coxal spine with three spinule-like setules distally, naked proximally. Caudal surface of coxa with spinule groups A-C + D-E-F-H-J. Length/width ratio Enp3 = 3.0; length ratio inner spine/ length Enp3 = 0.70; length ratio outer spine Enp3/length Enp3 = 1.0; proportion inner/outer spines Enp3 = 1.4. Lateral seta of Enp3 inserted at 66% of segment. Modified setae on Enp3 and Exp3.

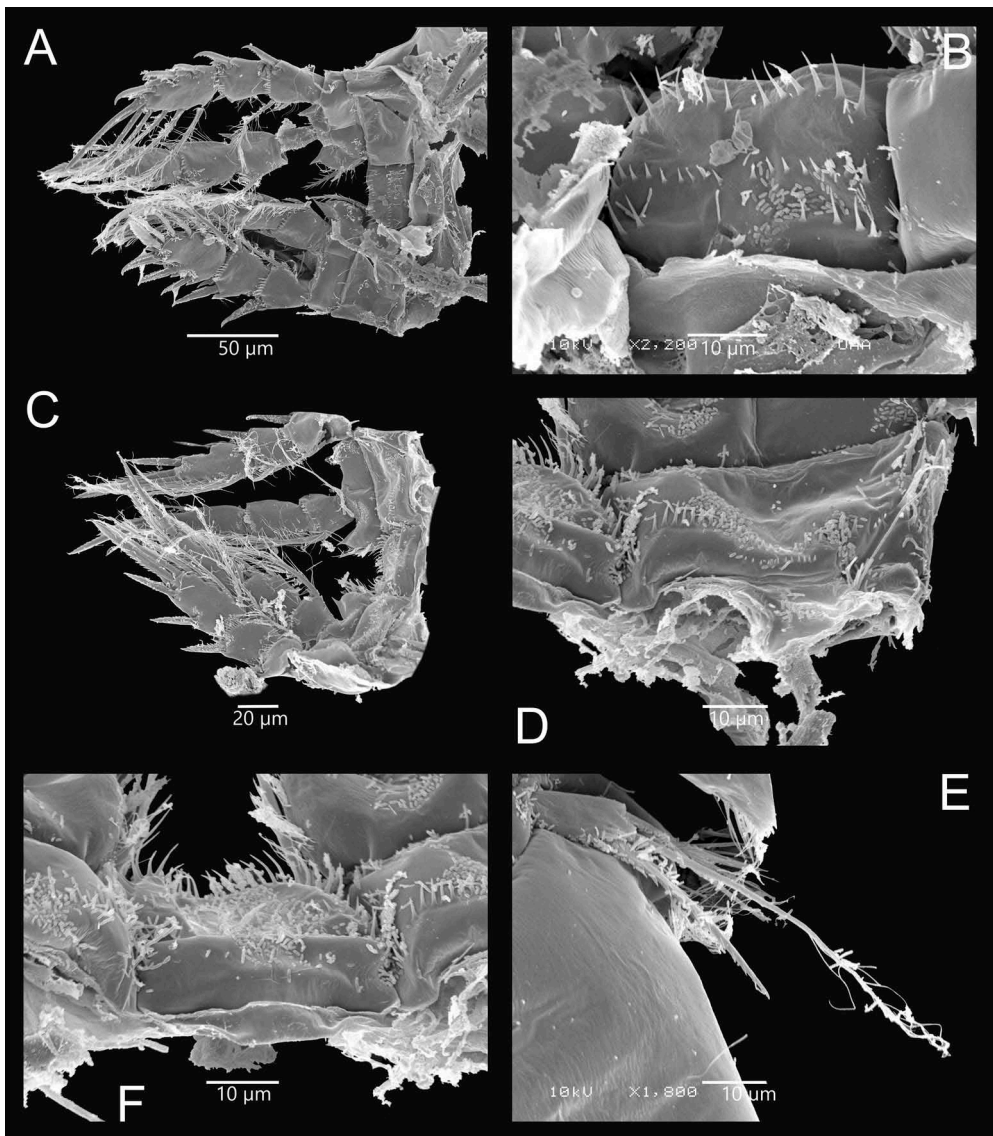


Figure 33. *Eucyclops tziscaoi* Mercado-Salas, 2013. Adult female. (A) P3, caudal; (B) intercoxal sclerite P3, caudal; (C) P4, caudal; (D) coxa P4, caudal; (E) intercoxal sclerite P4, caudal; (F) P5.

Leg 5 (Figure 33F). Free segment subrectangular, 2.1 times longer than wide, bearing one inner spine and two setae; medial seta about 1.3 times longer than outer seta and 1.8 times longer than inner spine. Inner spine 1.7 times as long as segment.

Male. Body length excluding caudal setae = 509 µm. Prosome symmetrical in dorsal view, representing 65% of total body length. Urosome relatively short, representing 35% of total body length. Anal operculum slightly rounded, smooth. Caudal ramus 3.5 times longer than wide; medial margin naked, strong spinules at insertion of lateral caudal seta (II) and outermost terminal caudal seta (III). Dorsal seta (VII) short, 0.35 times as long as

caudal ramus, and 0.75 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.6. Lateral caudal seta (II) inserted at 70% of caudal ramus. All terminal caudal setae plumose.

Antennule. Armature per segment as follows: 1(7s+2ms); 2(3s+1ms); 3(1s+2ms); 4(1s+1ms+1ae); 5(0); 6(2s); 7(1s); 8(1s); 9(0); 10(3s); 11(2s); 12(0); 13(0); 14(0); 15(3s); 16(8s).

Antenna. Coxa (unarmed), basis (2s+1 seta representing Exp) plus three-segmented Enp (first to third Enp with 1, 8, and 7 setae, respectively). Basis ornamented with: N1 (four hair-setae), N2 (four small spinules), N3, N4, N5, N15, and N17 on frontal surface (Figure 4E); and N9+N10, and N12 on caudal surface.

Legs 1–4. Endopods and exopods of all swimming legs three-segmented; P1–P3 armed as in females.

Leg 4. Coxa, Bsp, and intercoxal sclerite as in female, except for distal row of spinules of intercoxal sclerite, which has nine spinules, all longer and more slender than in female. Enp3 P4 being 2.6 times as long as width; inner spines 1.2 times as long as outer spine, and 1.2 times as long as segment. No modified setae on fourth leg. Lateral seta of Enp3 P4 inserted at 64.7% of segment length, lateral seta reaching midlength of outer spine.

Leg 5. Free segment subrectangular, 1.5 times longer than wide, bearing one inner spine and two setae: outer seta about 1.3 times longer than medial seta and 1.3 times longer than inner spine. Inner spine 1.8 times as long as segment.

Leg 6. Represented by small, low plate near lateral margin of genital somite with one strong and long inner spine and two unequal setae. Inner spine reaching distal margin of fourth urosomite. Inner spine about 2.3 times longer than median seta and about 1.6 longer than outer seta.

Remarks. This species, recently described in Gutiérrez-Aguirre et al. (2013), closely resembles *Eucyclops bondi*. Morphometric values are similar but the lack of data on the ornamentation of the antennal basis of *E. bondi* did not allow a complete comparison. Other characters that are useful to separate these species include the length of the lateral seta on Enp3 P4, which in *E. bondi* exceeds half the length of the outer apical spine and is not modified, while in *E. tziscao* the same seta is shorter, not reaching half the length of the outer apical spine, and it is modified as a strong, heavily sclerotised blunt seta. The male secondary characters have been deemed useful in the separation of species among the Eucyclopinæ. Since its original description by Kiefer (1931a), one of the main characteristics of *E. bondi* (and constantly ignored thereafter in the identification of the species) is the sixth leg of the male, which bears a very small inner spine; it does not reach the posterior margin of the third urosomite and it is smaller than the outer seta and as long as the medial seta. The opposite pattern is present in males of *E. tziscao*, in which the inner spine is 1.5 times longer than the outer seta and 2.5 longer than the medial seta.

Another species that resembles *E. tziscao* is *E. pectinifer*, but strong differences clearly separate these taxa. Among the differences advanced by Gutiérrez-Aguirre et al. (2013) to distinguish these two species, the ornamentation of the anal operculum (smooth in *E. pectinifer*, serrate in *E. tziscao*) is one of the strongest. A serrate operculum is shared also with *E. elegans* and *E. defayae* sp. nov. The ornamentation of the antennal basis is simple in both species, but differs mainly by the presence of N18 on the caudal surface and N7, N13 and N14 on the frontal surface of *E. pectinifer*; these rows are absent in *E. tziscao*. The ornamentation of the intercoxal sclerites also differs between these two species: *E. tziscao* is the only species distributed in Mexico in which the sclerite spinules of row I of P1 (frontal surface) are remarkably small, while in the rest of the species these spinules (or in some cases hairs) are always long, conspicuous elements. On the caudal surface of the same P1 sclerite, row I bears minute spinules in *E. tziscao* but is absent in *E. pectinifer*. Row II is present in both species but in *E. pectinifer* it bears long hairs and in *E. tziscao* it has small spinules. Row I of the P4 intercoxal sclerite has some additional differences; in *E. pectinifer* this row bears long spinules vs strong and short spinules in *E. tziscao*. Another species resembling *E. tziscao* by the presence of modified setae on P3 and P4 and similar length/width proportions of the caudal ramus is *E. conrowae*. However, they are easily distinguished because *E. conrowae* is not a member of the *serrulatus*-group – it lacks groups N1 and N2 on the frontal surface of the antennal basis – whereas in *E. tziscao* both groups are present in all the specimens examined (Gutiérrez-Aguirre et al. 2013)

***Eucyclops angeli* Gutiérrez-Aguirre and Cervantes-Martínez, 2013**
(see figures in Gutiérrez-Aguirre et al. 2013)

Description

Female. Average length excluding caudal setae = 600 μm . Representing 58% of total body length, symmetrical in dorsal view. Prosomal fringes serrate dorsally; fourth pediger with long, lateral, hair-like setae. First urosomite with long spinules on lateral margin; urosomal fringes strongly serrate. Posterior margin of anal somite with large spinules on ventral and dorsal surfaces, except for the medial section. Genital double somite symmetrical, lateral arms of proximal part of seminal receptacle rounded; distal section forming sinuous sac. Anal somite subequal in length to preanal somite, with hair-like setae adjacent to anal pore. Length/width of caudal ramus = 2.1; inner margin of caudal ramus naked, strong spines covering 62% with respect to the total length of ramus. Dorsal seta (VII) 0.8 times as long as caudal ramus, and 1.1 times as long as outermost terminal caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.5. Lateral caudal seta (II) inserted at 71.6% of caudal ramus.

Antennule. Tip reaching between middle and distal margin of second pediger. Armature per segment as follows: 1(8s); 2(4s); 3(2s); 4(6s); 5(4s); 6(1s+1sp); 7(2s); 8(3s); 9(2s+1ae); 10(2s); 11(2s+1ae); 12(7s+1ae). Row of spinules on first segment: inner spinules shorter than outer spinules. Long spine on sixth segment, reaching distal 1/3 of seventh antennular segment.

Antenna. Coxa (unarmed), basis (2s+1s representing Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface: N1(4), N2(3), N3(4), N4(7), N5(11), N15(3), N17(6); on caudal surface: N7(5), N8(5), N10(5), N11(6), N12(6), N13(11), N16(4), N18(2).

Leg 1. Frontal surface of intercoxal sclerite with row I bearing long spinules arranged in semicircular pattern, caudal surface with row II bearing 21 small, strong spinules, row I absent. Inner coxal seta biserially setulated, caudal surface with spinule formula = A-C. Inner basal seta (basipodal spine) reaching beyond apical margin of Enp3, 0.9 times as long as Enp. Length/width ratio Enp3 = 1.4, apical spine of Enp3 being 1.3 times as long as Enp3.

Leg 2. Frontal surface of intercoxal sclerite with row I bearing long hair-spinules arranged in circular pattern; caudal surface with row I divided in two groups of 10 minute spinules on each side; row II continuous, armed with 10 minute spinules. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C-D. Length/width ratio Enp3 = 1.6, apical spine of Enp3 being 1.4 times as long as Enp3. No modified setae observed.

Leg 3. Frontal surface of intercoxal sclerite with row I bearing hair-spinules arranged in circular pattern on each side; caudal surface with row I bearing long hairs (small gap in middle section), row II continuous, bearing long hair-spinules; row III discontinuous, with long hair-spinules (small gap in middle section). Distal margin with two rounded, chitinised projections. Coxa with strong, biserially setulated inner coxal seta, basally with long hairs and distally with strong spinules along both margins. Caudal coxal surface with spinule formula = A-B-C. Modified setae in both Enp and Exp.

Leg 4. Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface with row I bearing long spinules arranged in circular pattern (on each side), caudal surface of sclerite with row I bearing seven long denticles (gap in middle section), rows II and III with long hair-spinules on outer margins. Frontal coxal surface with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; basally, inner margin with long hairs; distally, with strong spinules. Outer distal margin naked, proximal section setulated. Spinule formula on caudal surface of coxa = A-B-C + D-E-F-G-H-J. Length/width ratio Enp3 = 1.8; length ratio inner spine of Enp3/length Enp3 = 1.3; length ratio outer spine of Enp3/length Enp3 = 0.9; length ratio inner/outer spines Enp3 = 1.3. Lateral seta of Enp3 inserted at 68% of segment. Modified setae present in both, Enp and Exp.

Leg 5. Free segment 1.4 times longer than wide, bearing one inner spine and two setae; medial seta 2.0 times longer than outer seta and 1.3 times longer than inner spine. Inner spine twice as long as segment.

Male. Body length excluding caudal setae = 540–580 μm ($n = 4$); average body length = $552.9 \pm 15.56 \mu\text{m}$. Prosome symmetrical in dorsal view, representing 60–63% of total

body length. Urosome relatively elongated; lateral margin of first urosomite naked; posterior margin of anal somite with continuous (dorsally and ventrally) row of spinules. Anal region armed with two parallel rows of hair-like setae; anal operculum slightly rounded, smooth. Caudal ramus 2.3 times longer than wide; medial margin of caudal ramus naked, strong spines at insertion of lateral caudal seta. Dorsal seta (VII) 0.9 times as long as caudal ramus and 1.2 times as long as outermost caudal seta (III). Innermost caudal seta (VI)/outermost caudal seta (III) ratio = 1.8. Lateral caudal seta (II) inserted at 75% of ramus length.

Antennule. Armature per segment as follows: 1(6s+2ms+1ae); 2(3s+1ms); 3(1s+1ms); 4(1s+1ms+1ae); 5(2s+1ms); 6(1s+1ae); 7(1s); 8(2s); 9(2s); 10(2s); 11(1s); 12(1s); 13(3s); 14(0s); 15(1s); 16(9s). Row of spinules on first segment, inner spinules shorter than outer spines.

Antenna. As in female except for absence of groups N7, N13 and N16 on caudal surface of antennal Bsp. Basis ornamented with: N1 (IV), N2 (II) N3, N4, N5, and N17 on frontal surface.

Leg 5. Free segment 1.6 times longer than wide, bearing three elements; outer seta slightly longer than in female (subequal in length to inner spine). Inner spine 1.8 times as long as segment.

Leg 6. Represented by small, low plate adjacent to lateral margin of genital somite, armed with one inner spine, 1.87 times longer than median seta, and 0.6 times longer than outer seta. Inner spine of sixth leg reaching distal margin of fourth urosomite.

Remarks. *Eucyclops angeli* is easily distinguishable from the other species of *Eucyclops* distributed in Mexico because of its remarkably short caudal rami and the unique ornamentation on the P4 coxa. There are other species in the Americas that share with *E. angeli* short caudal rami such as *E. breviramatus* and *E. siolii*, but these species are restricted to South America. As mentioned by Gutiérrez-Aguirre et al. (2013), Löffler's description of *E. breviramatus* did not include the new, currently used characters, but some other characters are useful to distinguish them. The length/width ratio of Enp3 P4 differs between these species; in *E. angeli* the ratio range is 1.8–2.0 while in *E. breviramatus* the segment is shorter (1.4–1.5). Another character that could be useful to separate these species is the armature of the male sixth leg; in *E. angeli* the inner spine is almost twice as long as the medial and outer setae, while in *E. breviramatus* the inner spine is clearly shorter, only 1.2 times longer than both the outer and medial setae. *Eucyclops angeli* can be distinguished from *E. siolii* by the shape and size of P5; in both species the medial seta is longer than the outer seta and the inner spine but in *E. siolii* the inner spine is remarkably short, being as long as or slightly shorter than the segment. Other species resembling *E. angeli* but from other geographic regions are the recently described *E. albuferensis* from Spain (Alekseev 2008), *E. dumonti* Alekseev, 2000 distributed in Mongolia (and not belonging to the *serrulatus*-group; Alekseev 2000; Alekseev and Defaye 2011) and *E. echinatus* Kiefer, 1926 with a distribution restricted

to Africa (Angola, Democratic Republic of Congo, Ivory Coast, Kenya, and Madagascar; Dussart and Defaye 2006).

***Eucyclops alekseevi* sp. nov.** Mercado-Salas and Suárez-Morales
(Figures 34–39)

Material examined

Holotype. Adult ♂ specimen dissected, mounted in glycerin, slides sealed with Entellan (ECO-CH-Z-04640).

Allotype. Adult ♂, dissected, mounted in glycerin, slides sealed with Entellan (ECO-CH-Z-04641).

Paratypes. Five adult ♀♀, undissected, ethanol-preserved (90%) (ECO-CH-Z-04642). Samples from type locality collected 1 March 1991 by Marcelo Silva-Briano.

Type locality

Río Juchipila, Juchipila, Zacatecas, Mexico (21°24′37.59″ N, 103°06′57.90″ W). 1250 m above sea level (asl).

Etymology

This species is warmly dedicated to Dr. Victor R. Alekseev for his valuable contributions to the knowledge of the genus *Eucyclops* worldwide.

Description

Female. Average length excluding caudal setae = 705 µm. Prosome representing 55% of total body length, symmetrical in dorsal view. Prosomal fringes finely serrate in dorsal view. Urosomal fringes strongly serrate. Genital double somite symmetrical (Figure 36B), representing 11% of total body length; widest proximally, tapering towards distal edge. Seminal receptacle with rounded lateral arms; posterior margin with sinuous sac (Figure 34A). Anal operculum slightly rounded, smooth (Figure 34B). Length/width of caudal ramus = 3.5; inner margin of caudal ramus naked; strong spinules covering 60% with respect to the total length of ramus. Dorsal seta (VII) 0.5 times as long as caudal ramus, 0.8 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.3. Lateral caudal seta (II) inserted at 73% of caudal ramus.

Antennule (Figures 34C, 36D–F). Tip reaching posterior margin of the fourth pediger. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(8s). Two transverse rows of spinules on first segment, the first with strong spinules and the second below, with minute spinules. Spine on sixth segment not reaching medial margin of seventh antennular segment.

Antenna (Figures 34E–G, 37A–D). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s respectively). Basis with rows of spinules on frontal surface: N1(V),

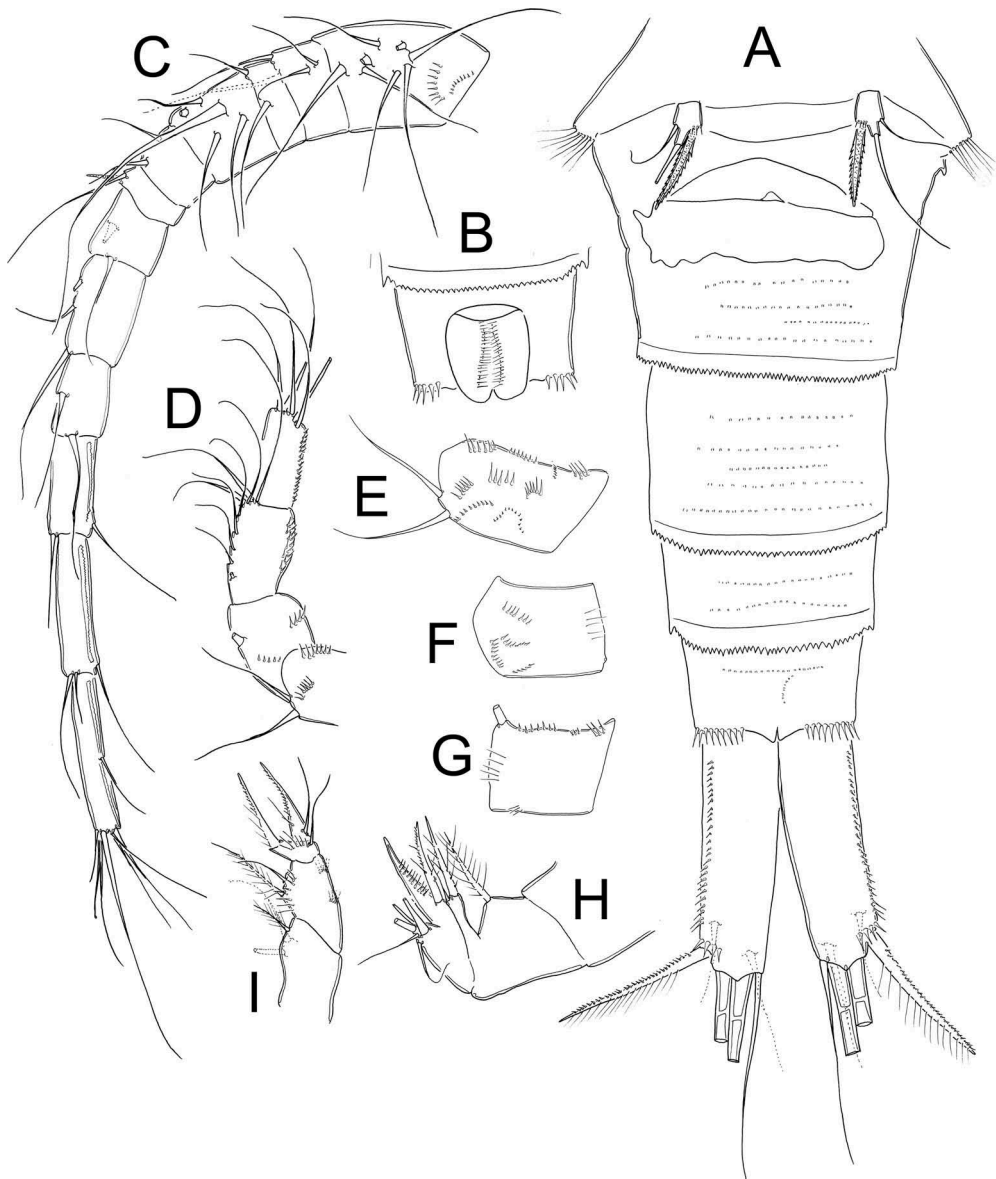


Figure 34. *Eucyclops alekseevi* sp. nov. Adult female. (A) Urosome, ventral; (B) anal operculum, dorsal; (C) antennule; (D) Enp1–3 antenna; (E) antennal basis, caudal; (F) antennal basis, frontal; (G) antennal basis, frontal; (H) maxilla; (I) maxilliped.

N2(III), N3(6), N4(7), N5(8), N6(4), N15(4), N17(7), N18(6); on caudal surface: N7(10), N8(6), N9+10(8), N11(5), N12(7), 22(13); caudal surface of Enp1 with B2(6).

Leg 1 (Figures 35A, 37F, 38A–B). Frontal surface of intercoxal sclerite with a row of strong spinules arranged in a semicircular pattern on each side, caudal surface with row II continuous, bearing 22 minute spinules, row I absent. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal

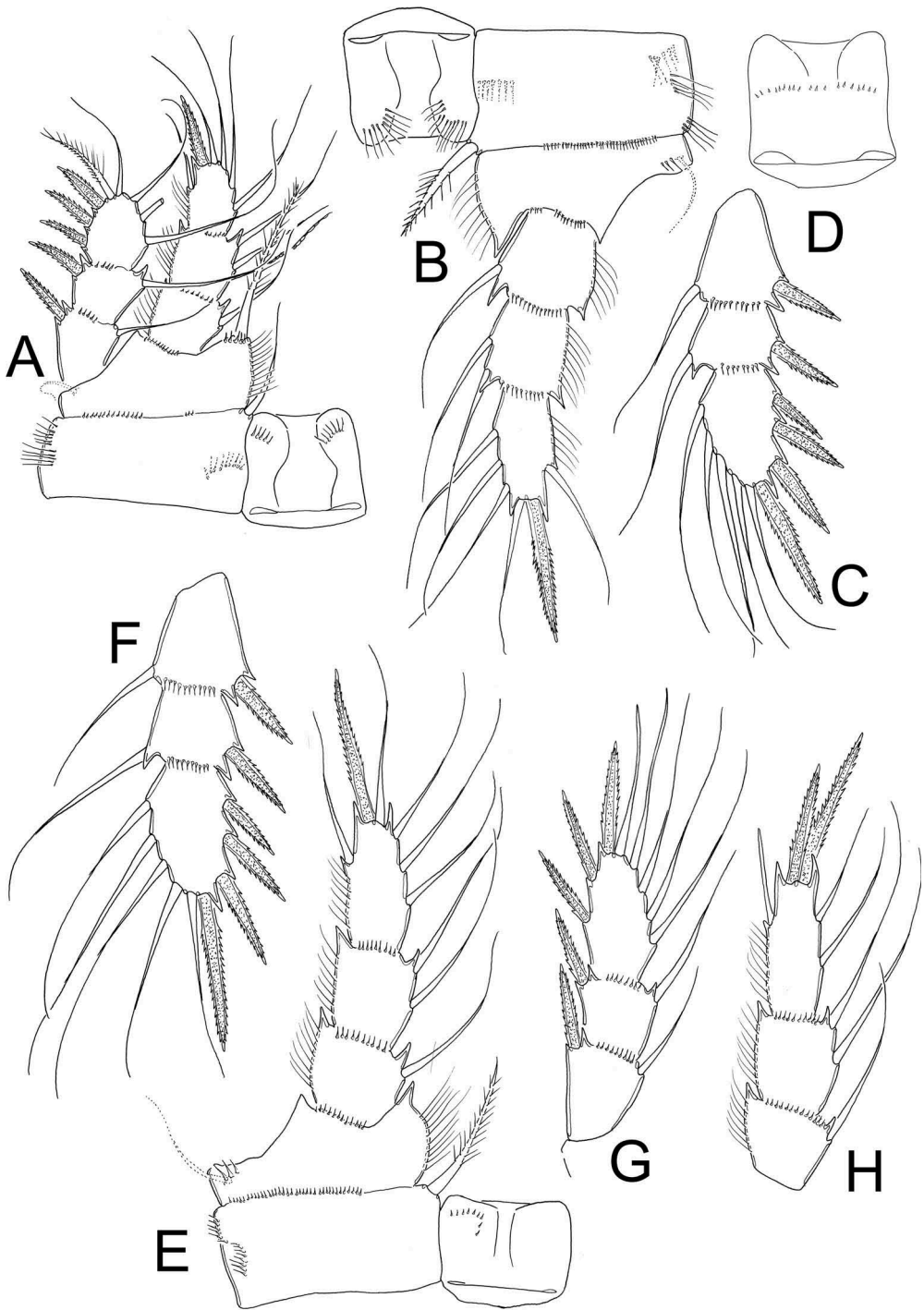


Figure 35. *Eucyclops alekseevi* sp. nov. Adult female. (A) P1, frontal; (B) P2, frontal; (C) exopod P2; (D) intercoxal sclerite P2, caudal; (E) P3, frontal; (F) exopod P3; (G) exopod P4; (H) endopod P4.

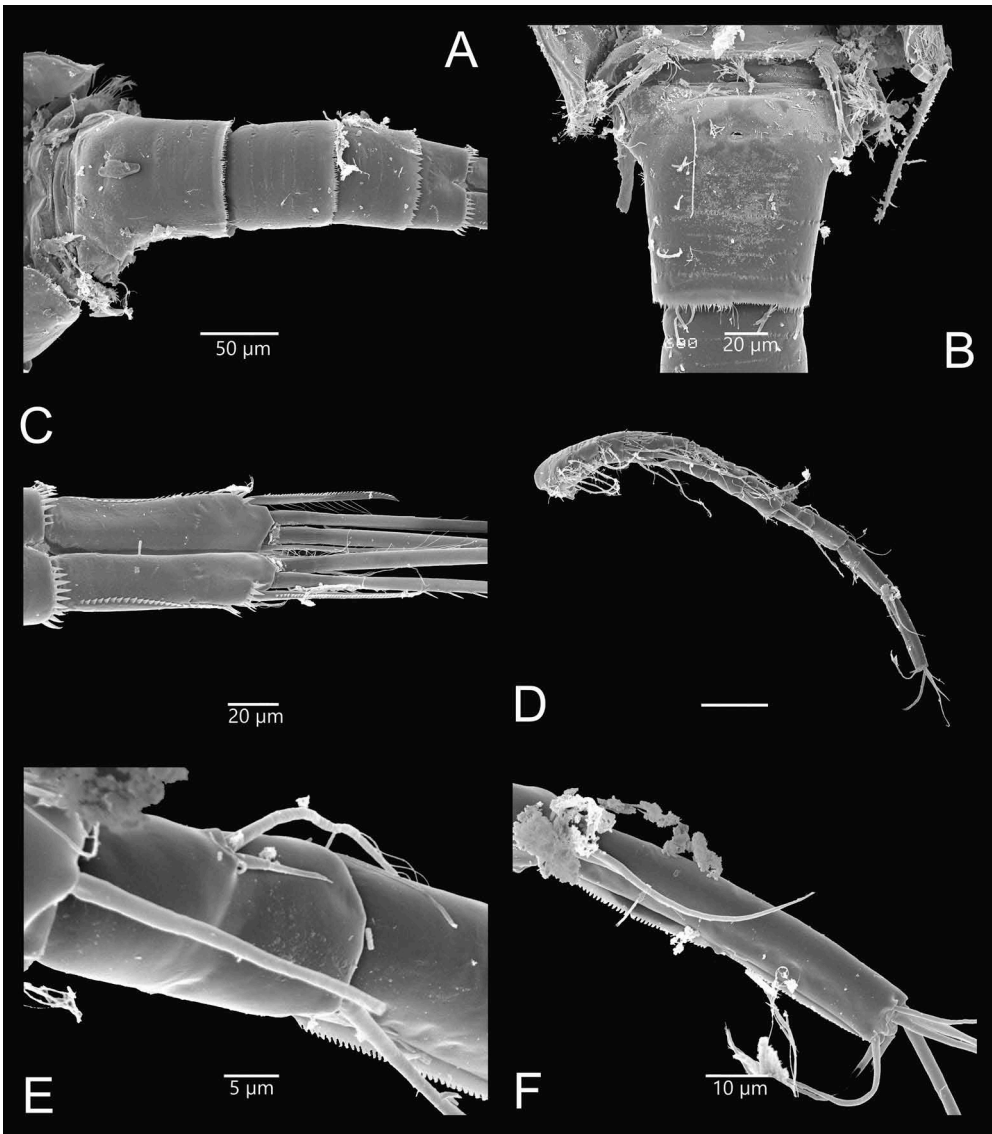


Figure 36. *Eucyclops alekseevi* sp. nov. Adult female. (A) Urosome, ventral; (B) genital somite, ventral; (C) caudal rami, ventral; (D) antennule; (E) antennule segment 9; (F) antennule segment 12.

spine) reaching beyond midlength of Enp3, 0.9 times as long as Enp. Length/width ratio Enp3 = 1.5, apical spine of Enp3 being 1.1 times as long as Enp3.

Leg 2 (Figure 35B–D, 38C–D). Frontal surface of intercoxal sclerite with row I bearing long hair-spinules arranged in a semicircular pattern; caudal surface with row II continuous, bearing 17 small spinules, row I absent. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C-D. Length/width ratio of Enp3 = 2.0, apical spine of Enp3 1.4 times as long as Enp3. No modified setae present.

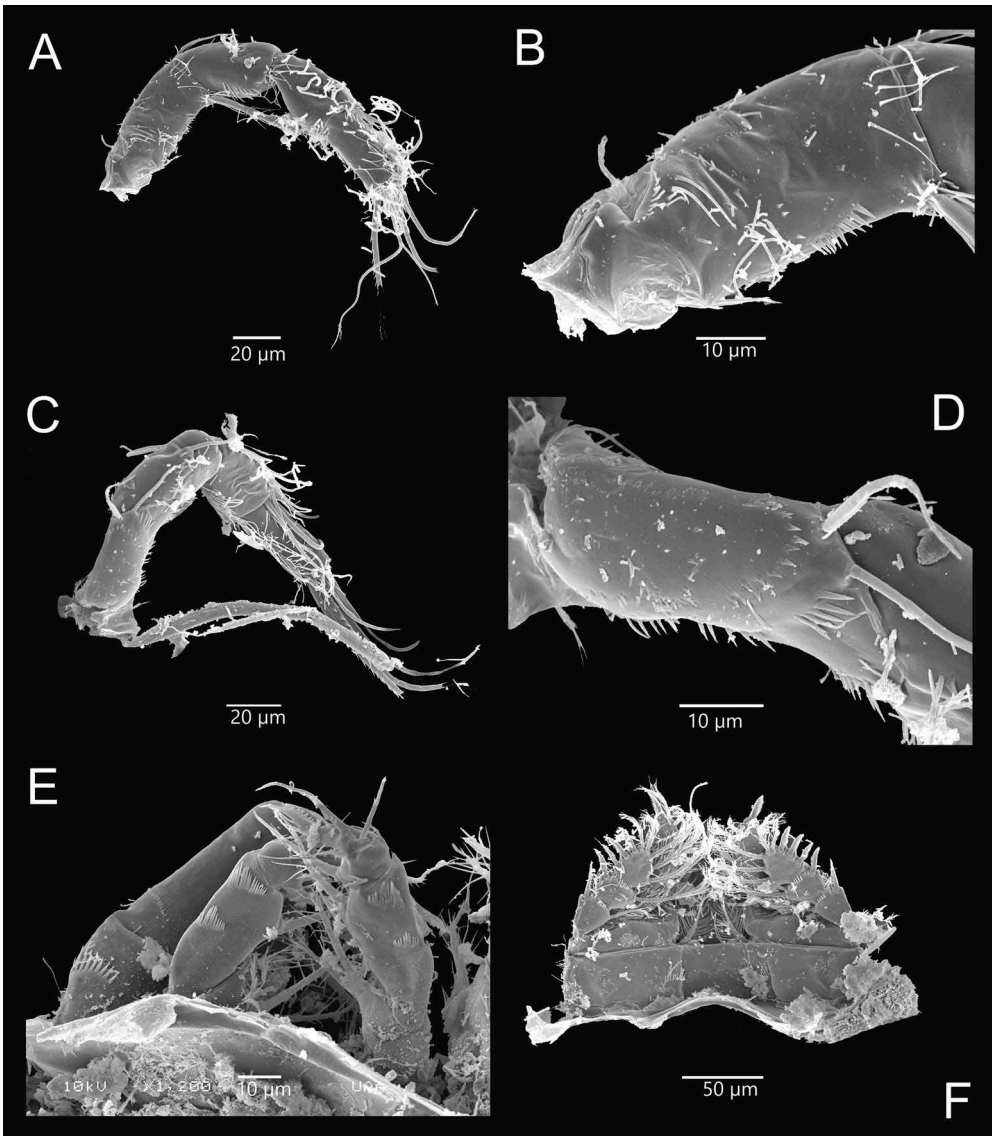


Figure 37. *Eucyclops alekseevi* sp. nov. Adult female. (A) Antenna, frontal; (B) antennal basis, frontal; (C) antenna, caudal; (D) antennal basis, caudal; (E) maxilliped; (F) P1, caudal.

Leg 3 (Figures 35E–F, 38E–F, 39A–B). Frontal surface of intercoxal sclerite with small spinules arranged in semicircular pattern on each side. Caudal surface with row I bearing slender hair-spinules, row II continuous, with 28 strong spinules and row III continuous, with 26 long, strong spinules. Distal margin with two rounded, chitinised projections. Coxa with strong, biserially setulated inner coxal seta, basally with long hairs and distally with strong spinules along both margins. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp = 2.1, apical spine of Enp3 1.2 times as long as Enp3. No modified setae present.

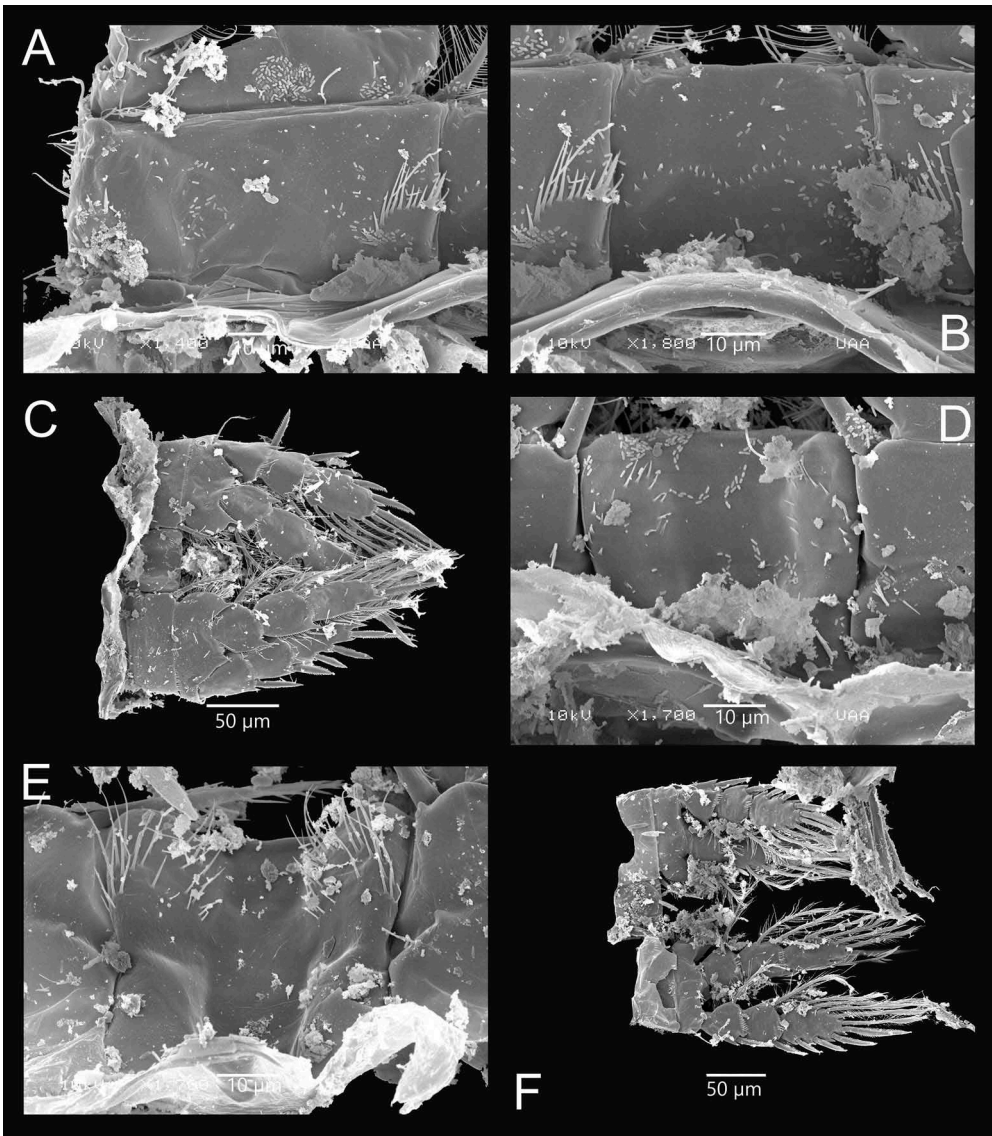


Figure 38. *Eucyclops alekseevi* sp. nov. Adult female. (A) Coxa P1, caudal; (B) intercoxal sclerite P1, caudal; (C) P2, frontal; (D) intercoxal sclerite P2, frontal; (E) intercoxal sclerite P3, frontal; (F) P3, frontal.

Leg 4 (Figures 35G–H, 39C–E). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface of sclerite with row I bearing small spinules arranged in a semicircular pattern, caudal surface with row I bearing long, strong spinules (gap in the middle margin), row II with strong spinules on each side of sclerite and row III with long, strong spinules on outer margins. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; proximal inner margin with long hairs, distal margin with strong spinules, outer margin with three spinules on distal surface and proximally smooth. Spinule

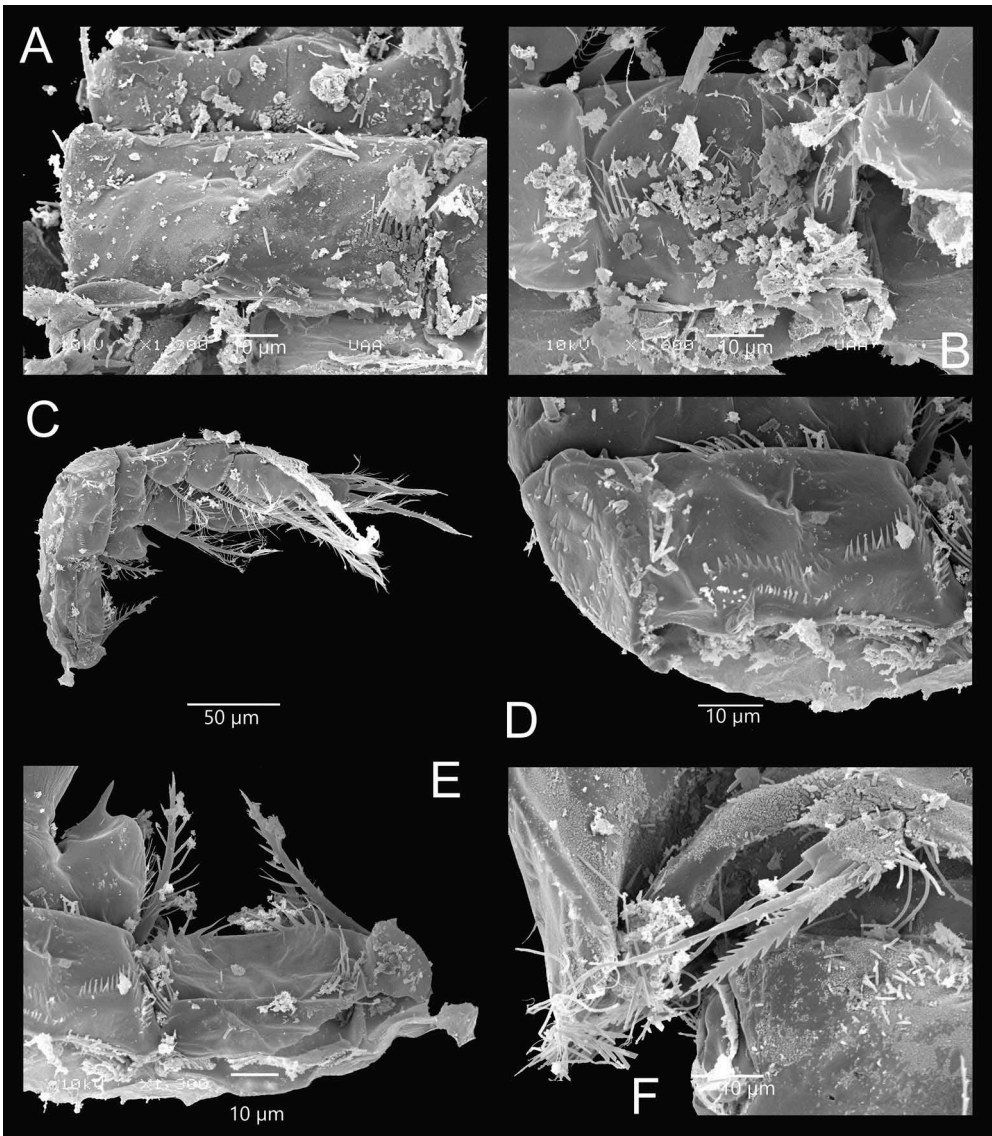


Figure 39. *Eucyclops alekseevi* sp. nov. Adult female. (A) Coxa P3, caudal; (B) intercoxal sclerite P3, caudal; (C) P4, caudal; (D) coxa P4, caudal; (E) intercoxal sclerite, caudal; (F) P5.

formula on caudal surface = A-B-C + D-E-F-H-J. Length/width ratio Enp3 = 2.6, length ratio inner spine of Enp3/length Enp3 = 1.2; length ratio outer spine of Enp3/length Enp3 = 0.9; proportion inner/outer spines Enp3 = 1.4. Lateral setae of Enp3 inserted at 67% of segment. Modified setae in Enp and Exp.

Leg 5 (Figure 39F). Free segment subrectangular, 1.5 times longer than wide, bearing one strong inner spine and two setae; medial seta 1.5 times longer than outer seta and 1.8 times longer than inner spine. Inner spine 2.0 times longer than segment.

Male. Prosome symmetrical in dorsal view. Urosome slightly elongated. Caudal ramus smooth along both inner and outer margins, except for strong spinules at insertion of lateral seta. Length/width ratio of caudal ramus = 2.7, dorsal seta (VII) 0.8 times as long as caudal ramus and 1.3 times as long as outermost caudal seta (III). Innermost caudal seta (VI)/outermost caudal seta (III) ratio = 2.2. Lateral caudal seta (II) inserted at 72% of ramus length.

Antennule. Armature as follows: 1(5s+2ms), 2(2s+1ms), 3(1s+1ms), 4(1s+1ms), 5(1s+2ms), 6(2s), 7(0), 8(0), 9(0), 10 (2s), 11(1sp+1s), 12(0), 13(0), 14(0), 15(3s), 16(7s).

Antenna. Basis with spinule groups on frontal surface: N1(IV), N2(2), N3(4), N4(5), N5(4), N15 (3), N17(6), N18(4) and on caudal surface: N7(10), N8(5), N9+N10 (6), N11(5), N12(6), N22(8).

Legs 1–4. Enp and Exp of all swimming legs three-segmented, armed as in females.

Leg 5. Free segment subrectangular, 1.7 times longer than wide, bearing inner spine and two setae; medial seta longer than outer seta (about 1.3 times) and inner spine (1.3 times). Inner spine as long as outer seta.

Leg 6. Represented by small, low plate adjacent to lateral margin of genital somite, armed with one strong inner spine and two unequal setae. Inner spine reaching medial margin of fourth urosomite, inner spine 1.8 times longer than medial seta and 1.5 times longer than outer seta. Small, strong spinules present at insertion of inner spine.

Remarks. *Eucyclops alekseevi* sp. nov. belongs to the *serrulatus*-group because it has the diagnostic characters established by Alekseev and Defaye (2011) to recognise members of this group: (1) longitudinal row of spinules along most of the outer margin of caudal ramus and without hair-like setae or denticles on dorsal or ventral surfaces; (2) antennules 12-segmented, with smooth membrane along three distal segments; (3) frontal side of antennal basipodite with groups N1 and N2 (both with long hairs or spinules); (4) coxopodite of P4 with strong inner spine; and (5) fifth leg with a wide, strong inner spine. *Eucyclops alekseevi* sp. nov. resembles other American species such as *E. pectinifer*, *E. prionophorus* and *E. estherae* sp. nov. (the last two species share a sinuous sac on the posterior lobe of the seminal receptacle). *Eucyclops alekseevi* sp. nov. can be distinguished from *E. pectinifer* because it has a different length/width ratio of the caudal ramus (3.5 in the new species vs 5.0 in *E. pectinifer*). In addition, in *E. alekseevi* sp. nov. the outermost caudal seta (III) is 1.3 times longer than the innermost caudal seta (VI), while both setae are equally long in *E. pectinifer*. More differences are found in the caudal ornamentation of the antennal basis: in *E. pectinifer* rows N9 and N10 are separated, but they are fused in *E. alekseevi* sp. nov. Also, row N22 is present in the new species and absent in *E. pectinifer*, which in turn has rows N14 and N16, both absent in *E. alekseevi* sp. nov. The frontal surface ornamentation of P1 sclerite in *E. pectinifer* has row I with long hair-spinules while in the new species this row bears small, strong spinules. Both species share the absence of row I on the caudal surface of P1 but differ in the armature of row II: in *E. pectinifer* it has long hair-like elements and in *E. alekseevi*

sp. nov. it has minute spinules along the medial margin. The same pattern is found in P2: in *E. pectinifer* row I of the frontal surface has long hair-like spinules, row I of the caudal surface is absent and row II bears long hair-like elements, while in *E. alekseevi* sp. nov. row I of the frontal surface bears small and strong spinules and row II bears minute spinules. The ornamentation of the P3 intercoxal sclerite differs between these species: in the new species row II of the caudal surface is armed with spinules as well as row III, while in *E. pectinifer* both rows have long hair-spinules. The P4 sclerite differs between these species: in *E. alekseevi* sp. nov. the frontal surface has row I with minute spinules and in the caudal surface rows II and III bear long spinules on the outer margins of sclerite. The pattern is different in *E. pectinifer*; in the frontal surface row I bears long hair-spinules and in the caudal surface rows II and III bear spinules only along the medial margin of the sclerite. The proportion of length/width of Enp3 P4 in *E. pectinifer* is about 3.4 times, while this value is 2.6 in *E. alekseevi* sp. nov. Also, the inner spine/length of segment of P5 ratio is 1.1 in *E. pectinifer* and 2.0 in *E. alekseevi* sp. nov. The other species resembling *E. alekseevi* sp. nov. is *E. prionophorus*, mainly in having the same length/width ratio of the caudal ramus and the presence of a sinuous sac in posterior lobe of seminal receptacle. These species can be separated by the ornamentation of the antennal basis; group N6 is absent in *E. prionophorus* but present in the new species, and groups N14 and N16 are absent in *E. alekseevi* sp. nov. but present in *E. prionophorus*. Other differences include the presence of row I on the caudal surface of the intercoxal sclerite of P1 and P2 in *E. prionophorus*, while both rows are absent in the new species. Discussion about differences between *E. alekseevi* sp. nov. and *E. estherae* sp. nov. are included in the remarks of the latter species.

***Eucyclops wixarica* sp. nov.** Mercado-Salas and Suárez-Morales
(Figures 40–47)

Material examined

Holotype. Adult ♀ specimen dissected, mounted in glycerin sealed with Entellan (ECO-CH-Z-04633).

Allotype. Adult ♂, dissected, mounted in glycerin sealed with Entellan (ECO-CH-Z-04634).

Paratypes. Ten adult ♀♀ undissected ethanol-preserved (90%) (ECO-CH-Z-04635). Samples from type locality collected 15 October 2006 by Marcelo Silva-Briano and Nancy F. Mercado-Salas.

Type locality

San Francisco Pond, San Francisco, San Luis Potosí, Mexico (22°03'13.8" N; 99°50'50.3" W).

Etymology

This species is warmly dedicated to one of the most important indigenous ethnic groups from Mexico, the Wixaricas or Huicholes. One of their main ceremonial sites is located in the state of San Luis Potosí, where the type specimens were collected.

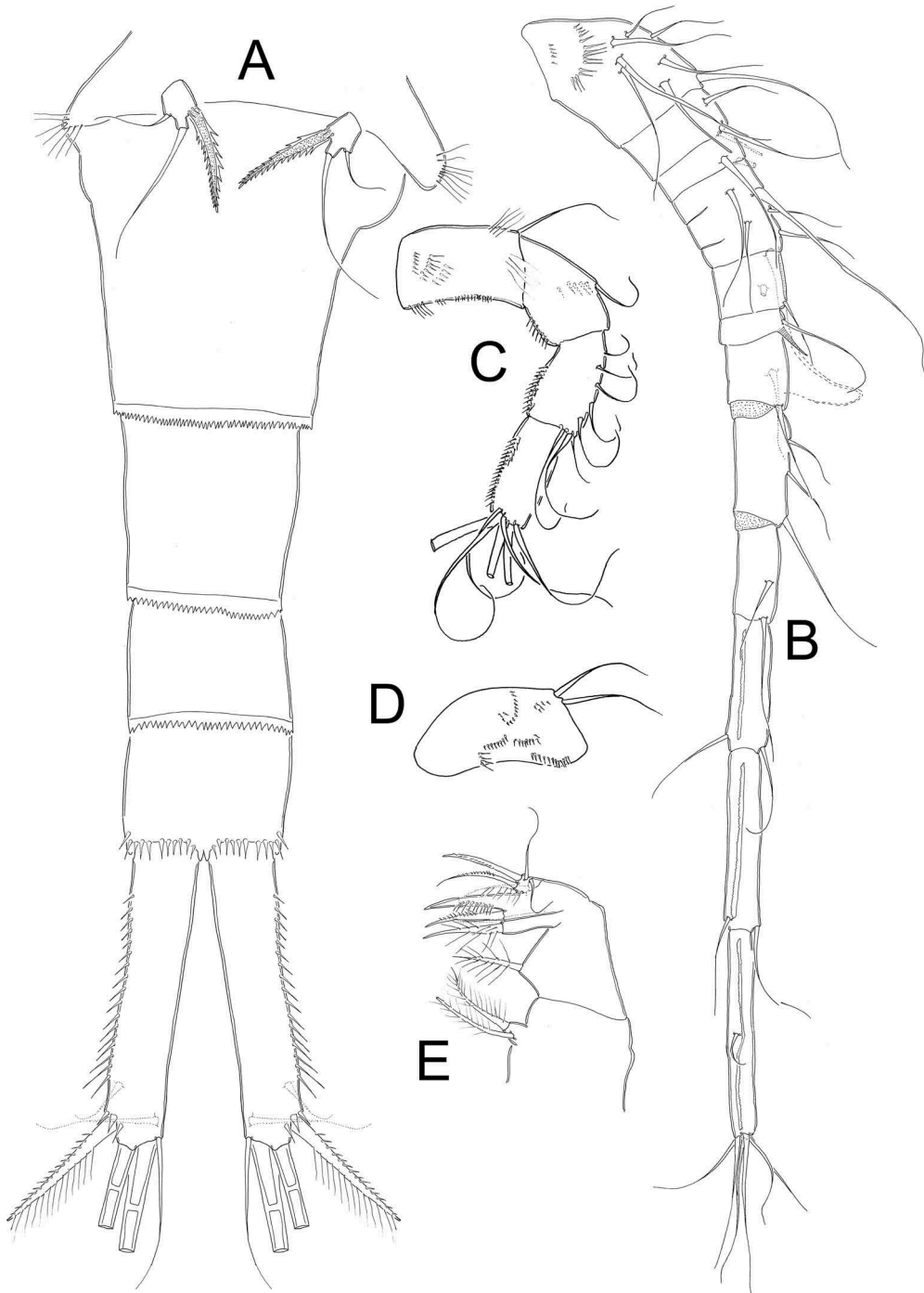


Figure 40. *Eucyclops wixarica* sp. nov. Adult female. (A) Urosome, ventral; (B) antennule; (C) antenna, frontal; (D) antennal basis, caudal; (E) maxilla.

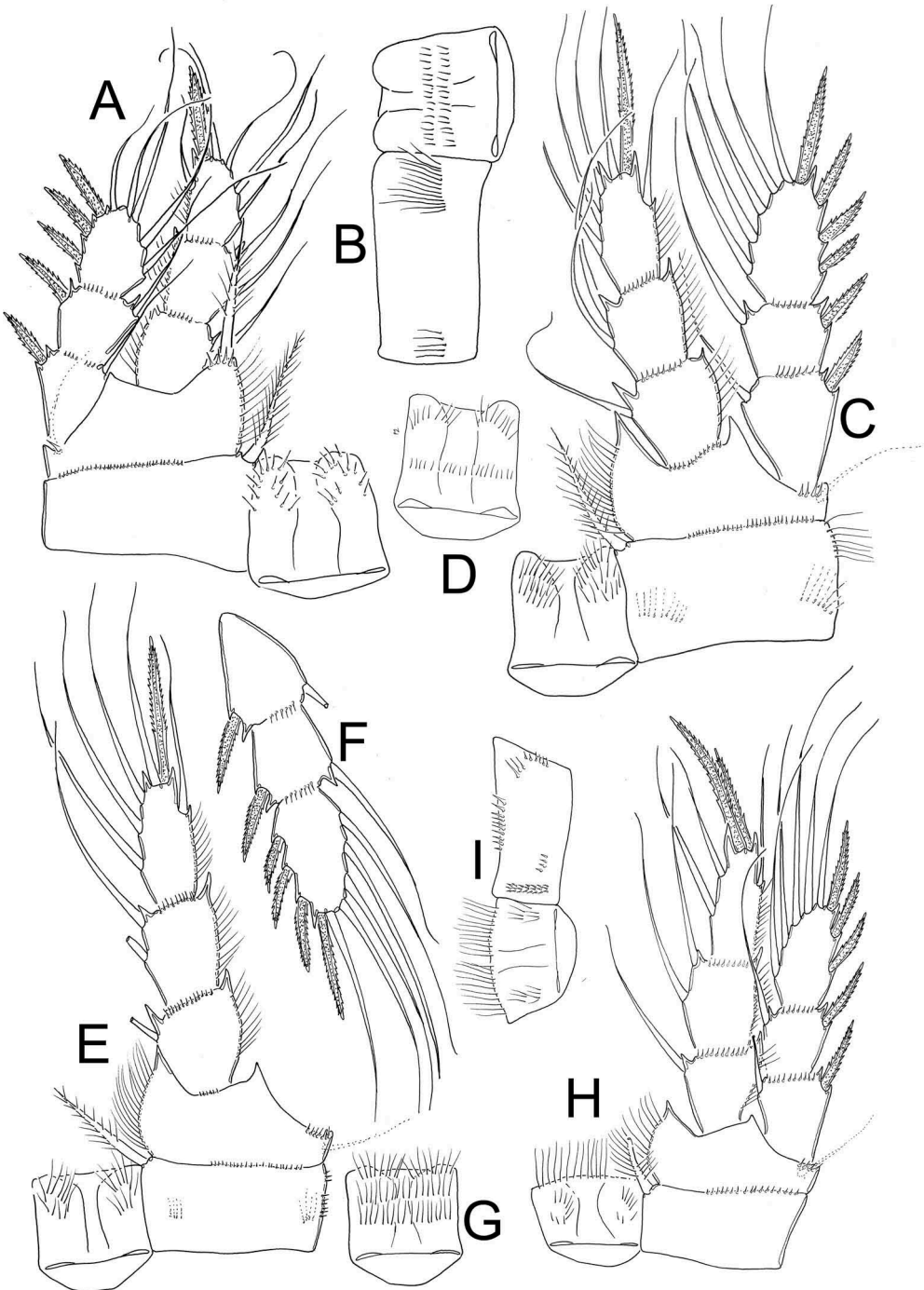


Figure 41. *Eucyclops wixarica* sp. nov. Adult female. (A) P1, frontal; (B) coxa and intercoxal sclerite P1, caudal; (C) P2, frontal; (D) intercoxal sclerite, caudal; (E) P3, frontal; (F) exopod P3; (G) intercoxal sclerite P3, caudal; (H) P4, frontal; (I) coxa and intercoxal sclerite P4, caudal.

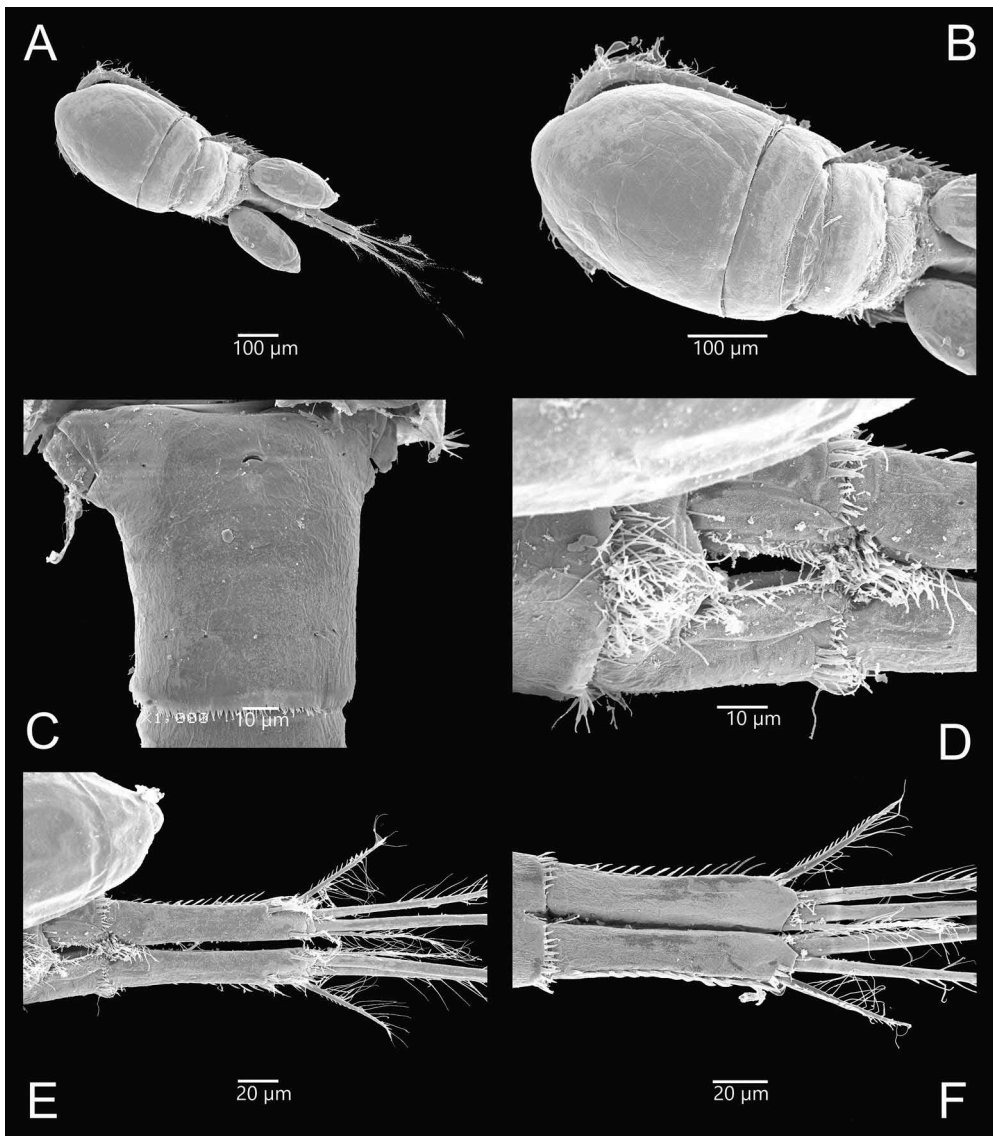


Figure 42. *Eucyclops wixarica* sp. nov. Adult female. (A) Habitus, dorsal; (B) prosome, dorsal; (C) genital somite, ventral; (D) anal operculum, dorsal; (E) anal somite and caudal rami; (F) caudal rami, dorsal.

Distribution

Bordo San Francisco, San Luis Potosí, Mexico.

Description

Female. Habitus as in Figure 42A. Average length excluding caudal setae = 850 µm. Prosome representing 62% of total body length, symmetrical in dorsal view. Prosomal fringes finely serrate in dorsal view (Figure 42B). Urosomal fringes strongly serrate. Genital double somite symmetrical (Figure 42C), representing 10% of total body length;

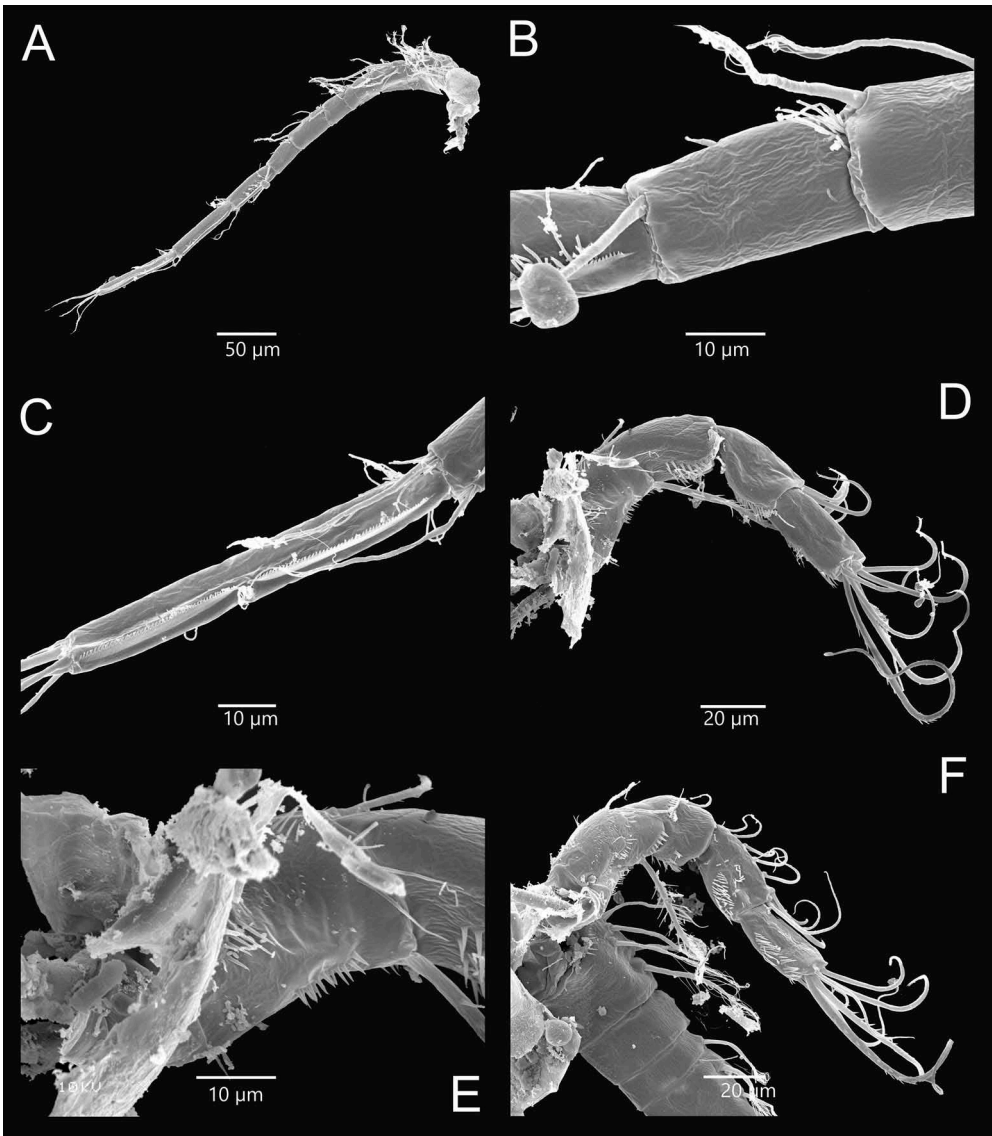


Figure 43. *Eucyclops wixarica* sp. nov. Adult female. (A) Antennule; (B) antennule segment 9; (C) antennule segment 12; (D) antenna, frontal; (E) antennal basis, frontal; (F) antenna, caudal.

anterior third of genital double somite expanded. Seminal receptacle with rounded lateral arms on posterior margin, typical of the *serrulatus*-complex. Anal operculum slightly rounded, smooth (Figure 42D). Length/width of caudal ramus = 5.1; inner margin of caudal ramus naked; strong spinules covering 61% with respect to the total length of ramus. Dorsal seta (VII) 0.4 times as long as caudal ramus and 0.9 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 0.9. Lateral caudal seta (II) inserted at 77% of caudal ramus.

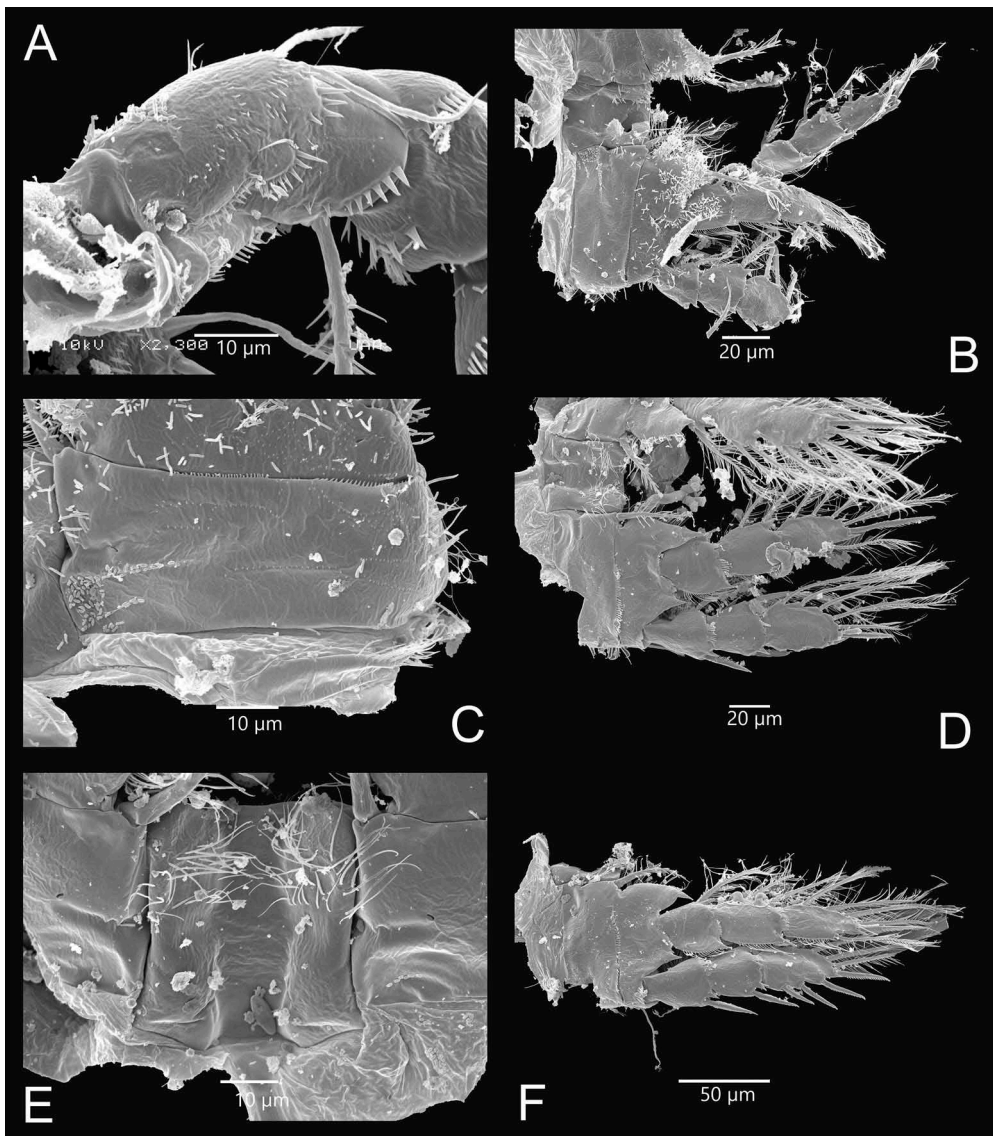


Figure 44. *Eucyclops wixarica* sp. nov. Adult female. (A) Antennal basis, caudal; (B) P1, frontal; (C) coxa P1, frontal; (D) P2, frontal; (E) intercoxal basipodite, frontal; (F) P3, frontal.

Antennule (Figures 40B, 43A–C). Tip reaching posterior margin of cephalosome. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(2s+1ae), 12(8s). Two transverse rows of spinules on first segment, first row with strong spinules (outer spinules slightly smaller than medial one), adjacent second row with minute spinules. Spine on sixth segment reaching midlength of seventh antennular segment.

Antenna (Figures 40C–D, 43D–F, 44A). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface:

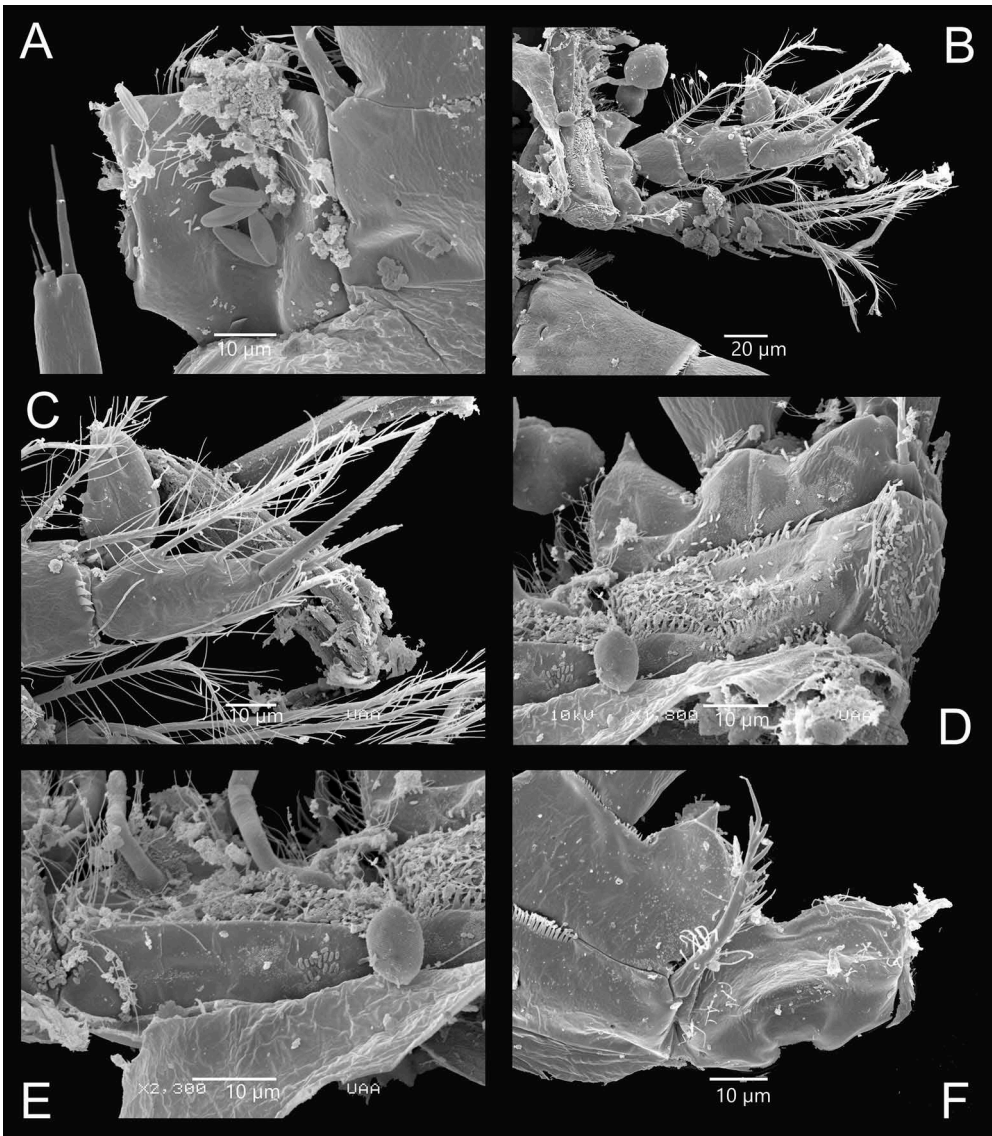


Figure 45. *Eucyclops wixarica* sp. nov. Adult female. (A) Intercoxal sclerite P3, frontal; (B) P4, caudal; (C) Enp3 P4; (D) coxa and basipodite P4, caudal; (E) intercoxal sclerite P4, caudal; (F) coxal spine.

N1(IV), N2(IV), N3(6), N4(7), N5(6), N15(4), N17(14), N18(3); on caudal surface: N7(16), N8(5), N9(6), 10(3), N11(9), N12(9), N13(12) N14(7), N16(11). Caudal surface of Enp1 with B2(5).

Leg 1 (Figures 41A–B, 44B–C). Frontal surface of intercoxal sclerite with a row of strong spinules arranged in a semicircular pattern on each side; caudal surface with row I continuous, bearing 18 short hair spinules; row II continuous, with 17 short hair spinules. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C.

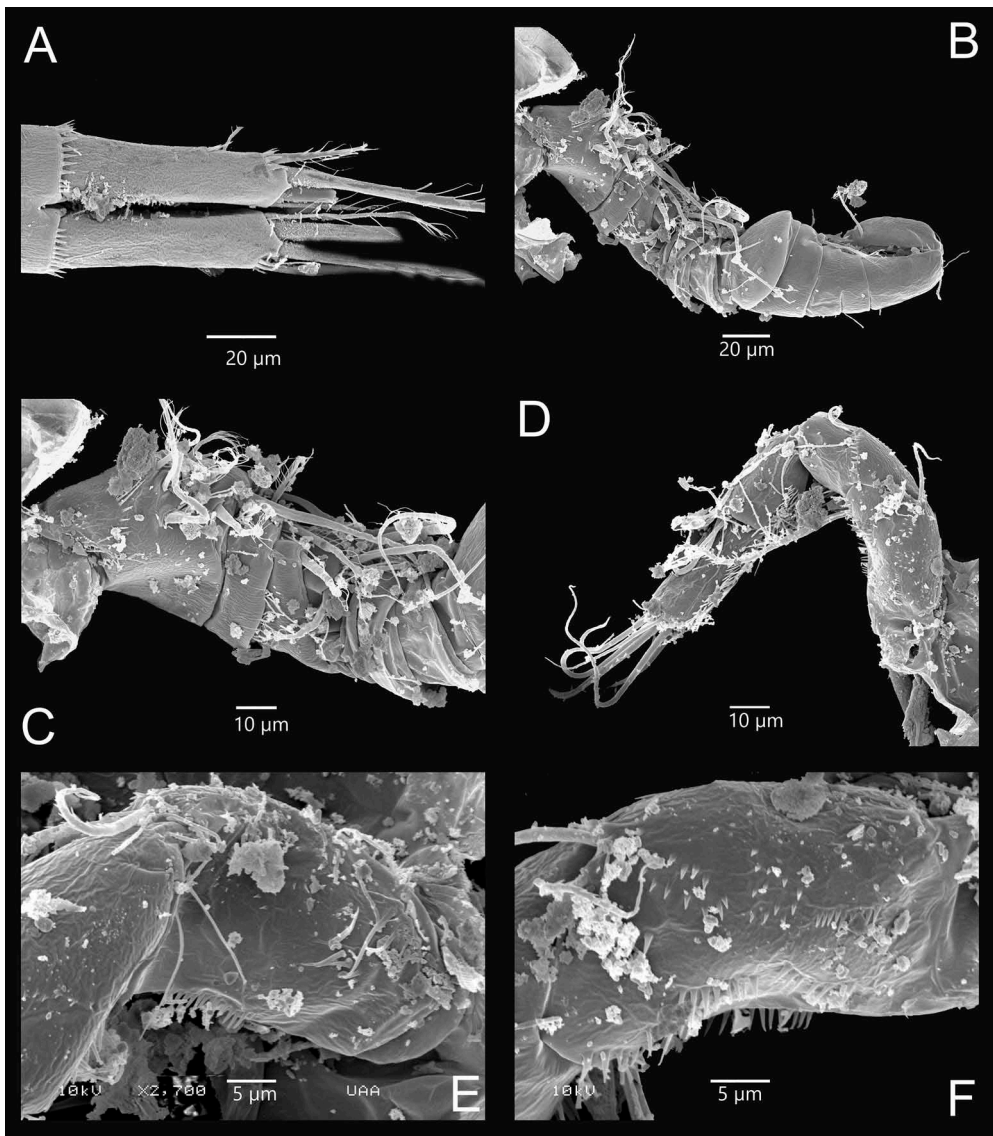


Figure 46. *Eucyclops wixarica* sp. nov. Adult male. (A) Caudal rami; (B) antennule; (C) antennule; (D) antenna, caudal; (E) antennal basis, frontal; (F) antennal basis, caudal.

Inner basal seta (basipodal spine) not reaching midlength of Enp3, 0.6 times as long as Enp. Length/width ratio Enp3 = 1.6, apical spine of Enp3 being 1.1 times as long as Enp3.

Leg 2 (Figures 41C–D, 44D–E). Frontal surface of intercoxal sclerite with row I bearing hairs arranged in circular pattern; caudal surface with row I divided into two groups bearing long hairs and arranged in a semicircular pattern on each side and close to the posterior margin. Row II continuous, with small hairs. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal

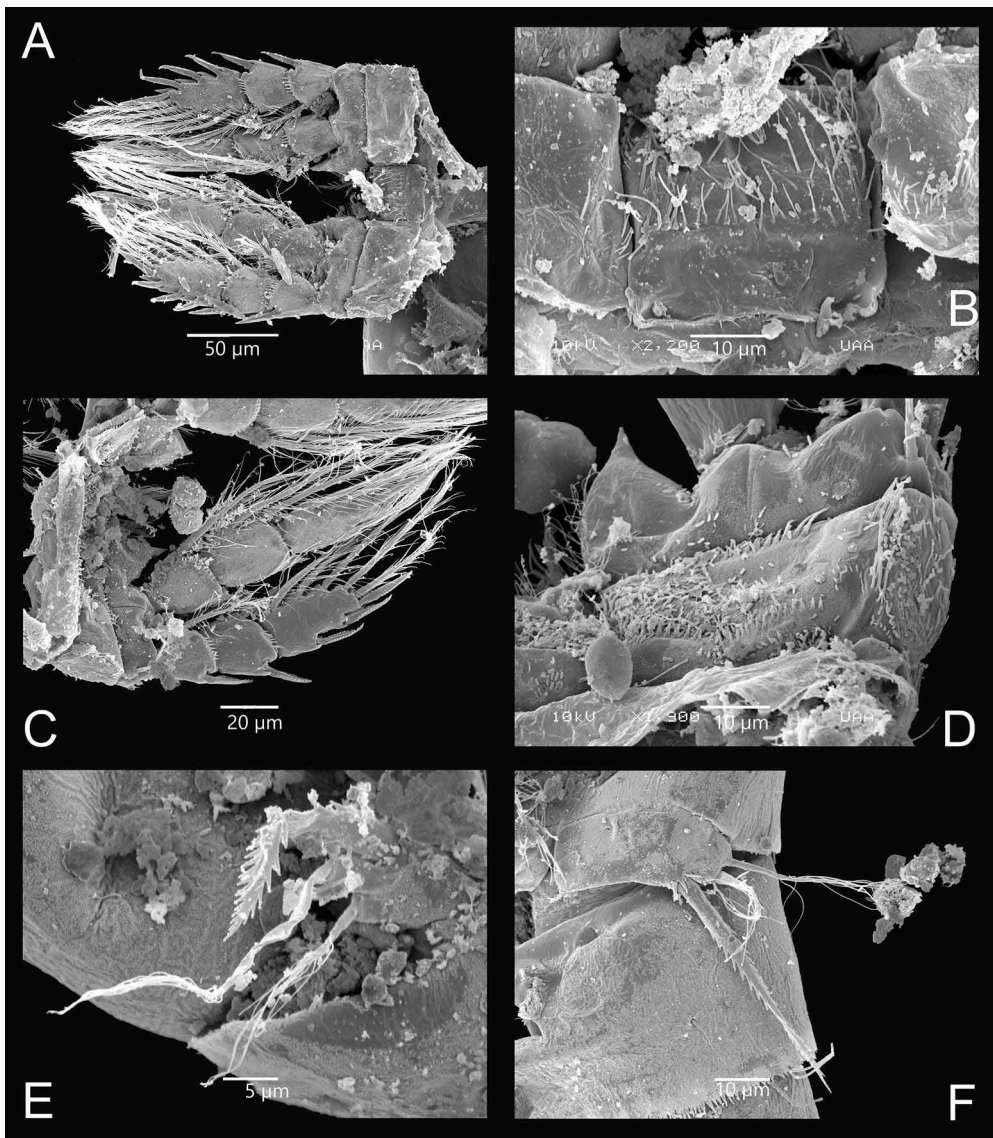


Figure 47. *Eucyclops wixarica* sp. nov. Adult male. (A) P3, caudal; (B) intercoxal sclerite P3, caudal; (C) P4, caudal; (D) coxa and basis P4, caudal; (E) P5; (F) P6.

coxa surface with spinule formula = A-B-C-D. Length/width ratio of Enp3 = 2.0, apical spine of Enp3 being 1.4 times as long as Enp3. No modified setae present.

Leg 3 (Figures 41E–G, 44F, 45A). Frontal surface of intercoxal sclerite with hairs arranged in circular pattern on each side; caudal surface with row I bearing long hairs (gap in the middle section), rows II and III continuous, bearing long hairs. Distal margin with two rounded, chitinised projections. Coxa with strong, biserially setulated inner coxal seta, proximally with long hairs and distally with strong spinules along both

margins. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp = 2.2, apical spine of Enp3 being 1.2 times as long as Enp3. No modified setae present.

Leg 4 (Figures 41H–I, 45B–F). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface of sclerite with row I bearing long hairs arranged in circle, caudal surface of intercoxal sclerite with row I bearing very long hairs, row II with long hairs on outer margins; row III with long hairs close to outer margins. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; inner margin with long hairs on proximal section and with strong spinules distally; outer margin with one distal spinule and setulated along proximal section, gap in middle margin. Spinule formula on caudal surface = A-B-C + D-E-F-H-J. Length/width ratio Enp3 = 2.5, length ratio inner spine of Enp3/length Enp3 = 1.3; length ratio outer spine of Enp3/length Enp3 = 0.9; length ratio inner/outer spines Enp3 = 1.5. Lateral seta of Enp3 inserted at 65% of segment. No modified setae in Enp and Exp.

Leg 5. Free segment subrectangular, 1.4 times longer than wide, bearing one strong inner spine and two setae; medial seta 2.4 times longer than outer seta and 1.5 times longer than inner spine. Inner spine 2.6 times longer than segment.

Male. Urosome slightly elongated, urosomal fringes serrated. Caudal ramus smooth along both inner and outer margins, only with strong spinules at insertion of lateral seta. Length/width ratio of caudal ramus = 3.8, dorsal seta (VII) 0.5 times as long as caudal ramus and 0.9 times as long as outermost caudal seta (III). Innermost caudal seta (VI)/outermost caudal seta (III) ratio = 1.8. Lateral caudal seta (II) inserted at 71% of caudal ramus length.

Antennule (Figure 43A). Armature as follows: 1(5s+4ms), 2(4s), 3(1s+1ms), 4(1ms) 5(1ms), 6(1s) 7(1s), 8(1s), 9(0), 10(3s), 11(1s), 12(1sp+1s), 13(0), 14(0), 15(3s), 16(8s).

Legs 1–4. Enp and Exp of all swimming legs three-segmented, armed as in females.

Leg 5 (Figure 43B). Free segment subrectangular, 1.5 times longer than wide, bearing inner spine and two setae; medial seta longer than outer seta (about 2.8 times) and inner spine (1.5 times).

Leg 6 (Figure 43B). Represented by small, low plate adjacent to lateral margin of genital somite armed with strong inner spine and two unequal setae. Inner spine reaching posterior margin of third urosomite, inner spine 1.5 times longer than medial seta and 1.6 longer than outer seta. Strong spinules at insertion of inner spine.

Remarks. *Eucyclops wixarica* sp. nov. can be easily distinguished from most of its congeners distributed in the Americas by the presence of long hair-like elements on the frontal surface of the antennal basipodite; this character is shared with the American *E. elegans*, *E. defayae* sp. nov. and *E. mittmanni* sp. nov., and also with some other

members of the *serrulatus*-group such as *E. serrulatus* s. str., *E. romaniensis*, *E. albuferensis*, *E. miracleae*, *E. agioides roseus*, *E. pacificus* and *E. vandouwei*; these species are known from Europe, Africa and Asia (Ishida 2000; Dussart and Defaye 2006; Alekseev 2008, 2010; Alekseev and Defaye 2011). *Eucyclops wixarica* sp. nov. differs from *E. elegans* and *E. mittmanni* sp. nov. because of its total body length. The two latter species are – together with *E. neumani* s. str. and *E. titicacae* – the largest *Eucyclops* in the Americas; their size is > 1050 µm, whereas *E. wixarica* sp. nov. is clearly a smaller species (810 µm). Also, the new species can be distinguished from those species by the length/width ratio of the caudal ramus; it is about 5.1 in the new species vs more than 6.0 in both *E. elegans* and *E. mittmanni* sp. nov. The ornamentation of the antennal basis is more complex in *E. elegans* and *E. mittmanni* sp. nov. than in *E. wixarica* sp. nov. In addition, the caudal surface of the P3 and P4 coxal plates differs among these species. In *E. wixarica* all rows of both P3 and P4 are long hairs, whereas some rows with spinules are present in the other species. *Eucyclops wixarica* sp. nov. seems to be closely related to *E. serrulatus* because of the presence of long hairs on row N2 of the antennal basis and the similar length/width ratio of the caudal ramus (about 5.0 in both species), and also in most morphometric values. These species can be separated by a combination of characters. Row N6 is absent in *E. wixarica* sp. nov. and is present in *E. serrulatus*. The new species shows a more complex ornamentation on the caudal surface of the antennal Bsp; it has rows N8, N10, N13, N16 and N18, all of them absent in *E. serrulatus*. The ornamentation of the caudal surface of P2 intercoxal sclerite diverges in these species; in *E. wixarica* sp. nov. row I is present but it is absent in *E. serrulatus*. Also, the P3 and P4 sclerites have rows with strong spinules in *E. serrulatus*, thus differing from *E. wixarica* sp. nov., in which all rows bear long hair-like elements. The P4 coxa of *E. wixarica* sp. nov. has row F; this row is absent in *E. serrulatus*.

***Eucyclops defayee* sp. nov.** Mercado-Salas and Suárez-Morales
(Figures 48–54)

Material examined

Holotype. Adult ♀ specimen dissected, mounted in glycerin, slides sealed with Entellan (ECO-CH-Z-05110).

Allotype. Adult ♂, dissected, mounted in glycerin, slides sealed with Entellan (ECO-CH-Z-05111).

Paratypes. Five adult ♀♀ undissected, ethanol-preserved (90%) (ECO-CH-Z-05112). Samples from type locality collected 12 March 1992 by Marcelo Silva-Briano.

Type locality

Pond at Villa Juárez, Asientos, Aguascalientes, Mexico.

Etymology

This species is warmly dedicated to Dr. Danielle Defaye (Museum National d'Histoire Naturelle, Paris) for her many contributions to the knowledge of the taxonomy and

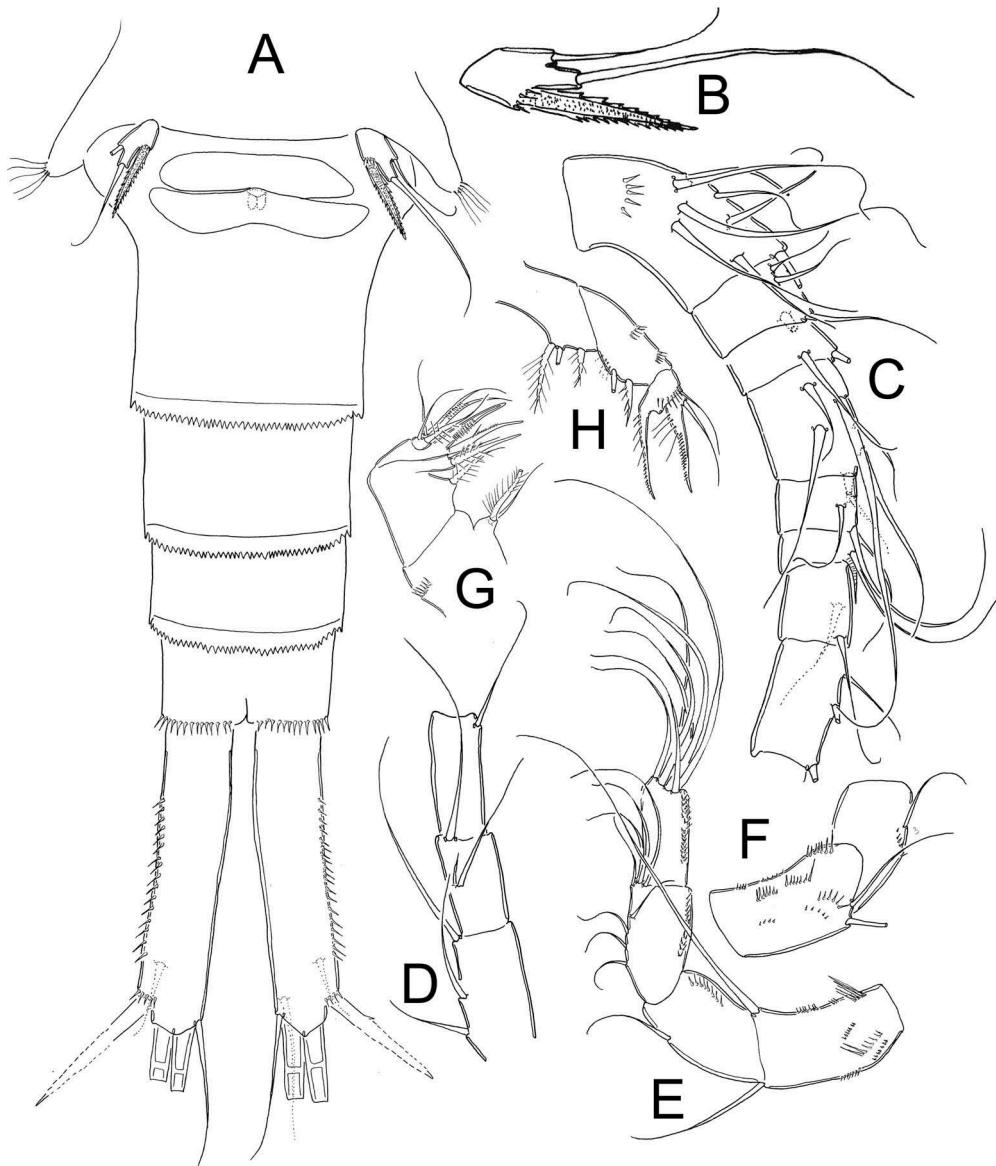


Figure 48. *Eucyclops defaye* sp. nov. Adult female. (A) Urosome, ventral; (B) P5; (C) antennule, segments 1–8; (D) antennule, segments 8–10; (E) antenna, frontal; (F) basis and Enp1 antenna; (G) maxilla; (H) maxilliped.

systematics of freshwater copepods, and also for all her kind help and advice during the development of this work.

Distribution

Central and Northern part of Mexico (Aguascalientes, Zacatecas, San Luis Potosí).

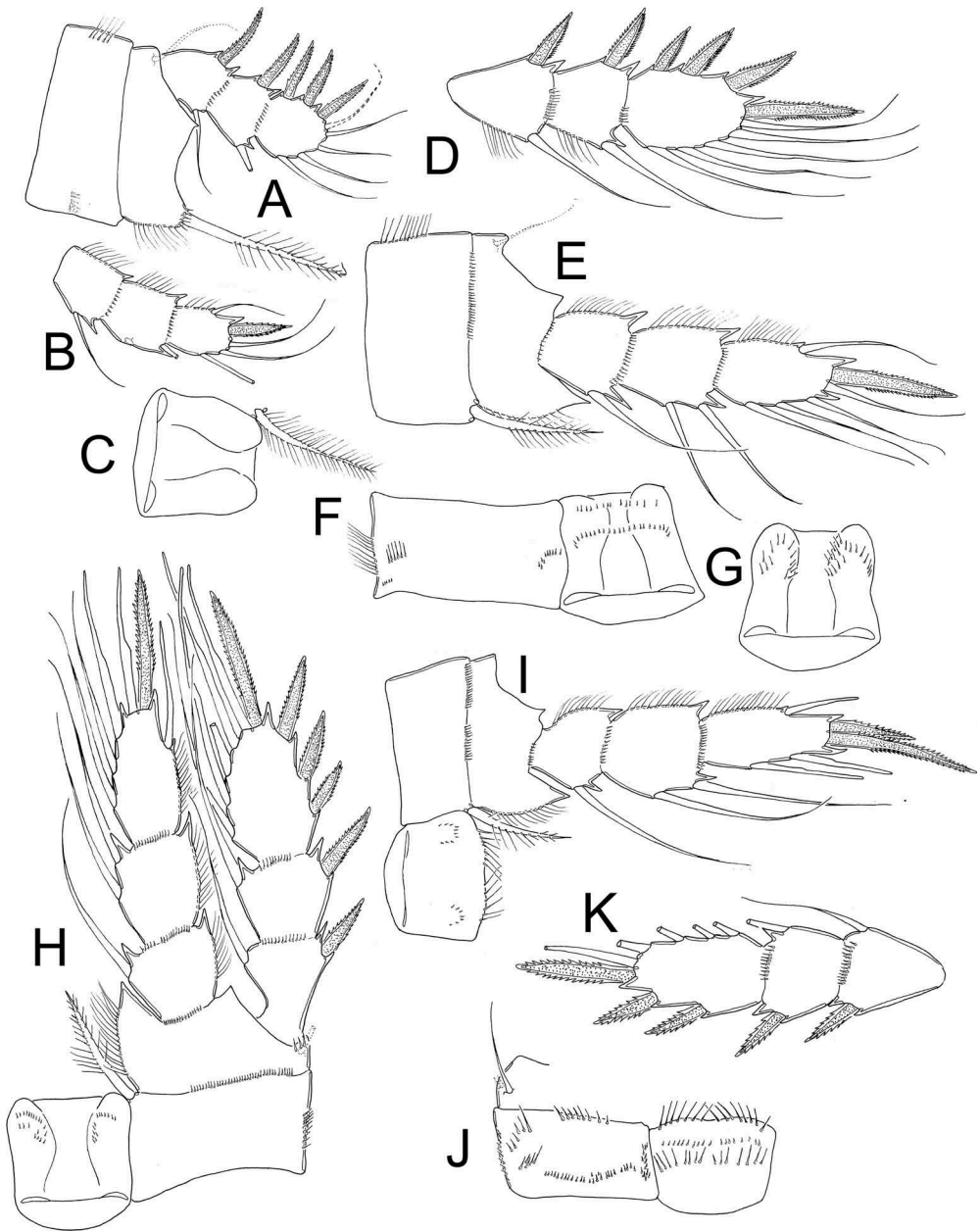


Figure 49. *Eucyclops defaye* sp. nov. Adult female. (A) P1, frontal; (B) exopod P1, (C) intercoxal sclerite P1, caudal; (D) exopod P2; (E) coxa, basis and endopod P2, frontal; (F) coxa and intercoxal sclerite P2, caudal; (G) intercoxal sclerite P2, frontal. (H) P3, frontal; (I) coxa, basis and endopod P4, frontal; (J) coxa and intercoxal sclerite P4, caudal; (K) exopod P4.

Description

Female. Habitus as in [Figure 50A](#). Average length excluding caudal setae = 800 μm . Prosome representing 55% of total body length, symmetrical in dorsal view. Prosomal fringes finely serrate in dorsal view. Urosomal fringes strongly serrate. Genital double

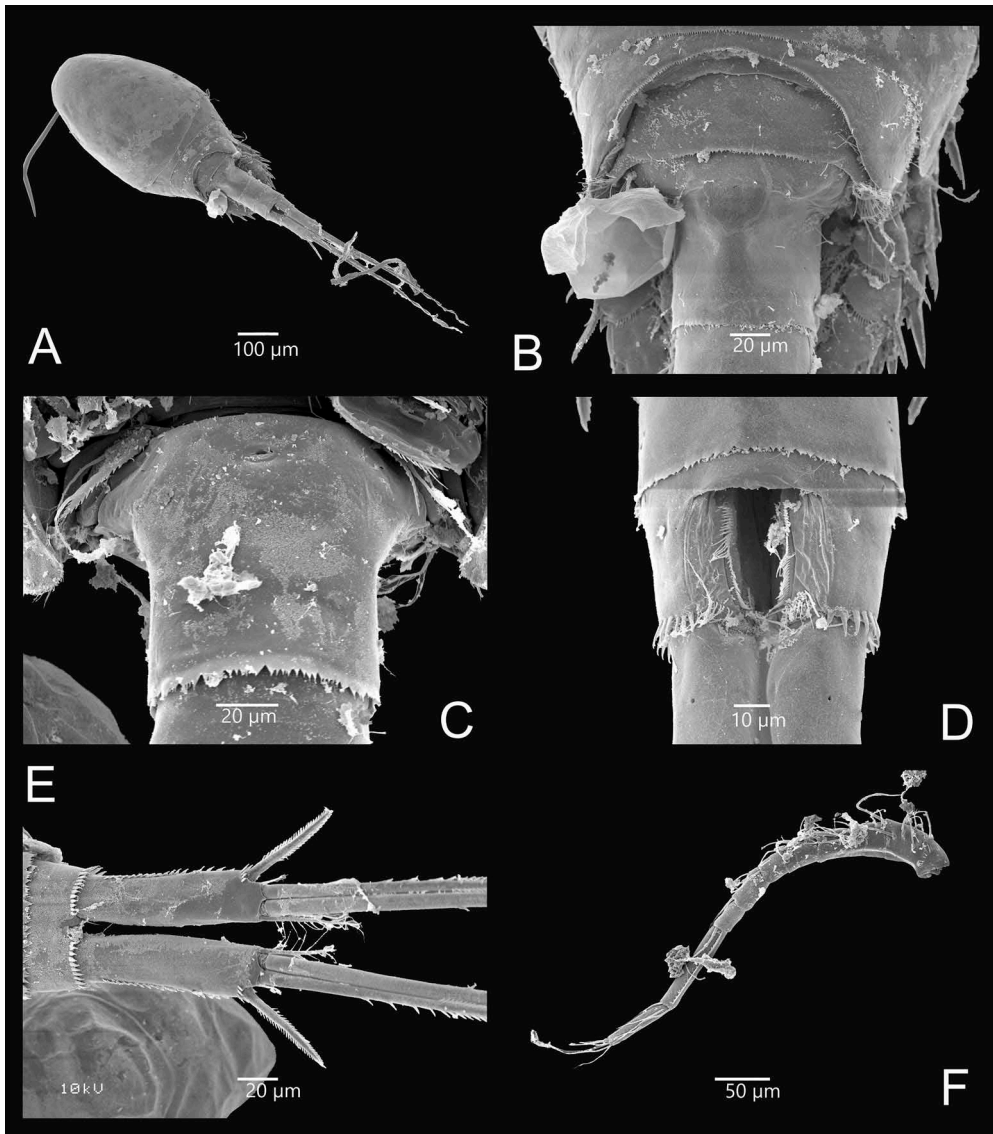


Figure 50. *Eucyclops defaye* sp. nov. Adult female. (A) Habitus, dorsal; (B) genital somite, dorsal; (C) genital somite, ventral; (D) anal operculum, dorsal; (E) caudal rami, ventral; (F) antennule.

somite symmetrical (Figure 50C), representing 12.5% of total body length; anterior third of genital double somite expanded laterally. Seminal receptacle with rounded lateral arms on posterior margin, typical of the *serrulatus*-complex. Anal operculum slightly rounded and serrate (Figure 50D). Length/width of caudal rami = 4.6; inner margin of caudal ramus naked; strong spinules covering 53% with respect to the total length of ramus. Dorsal seta (VII) 0.5 times as long as caudal ramus and 0.9 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.2. Lateral caudal seta (II) inserted at 76% of caudal ramus.

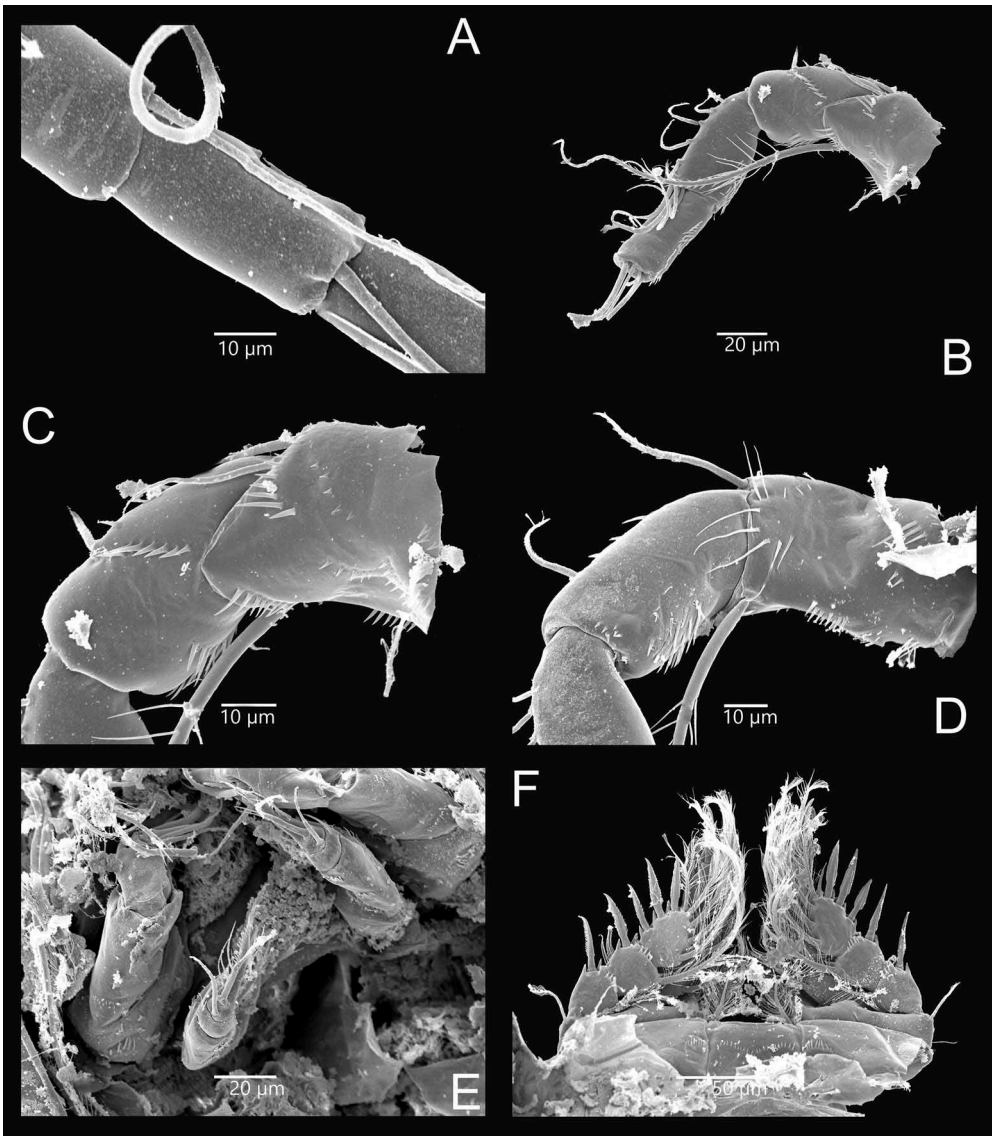


Figure 51. *Eucyclops defaye* sp. nov. Adult female. (A) Antennule segment 9; (B) antenna, caudal; (C) antennal basis, caudal; (D) antennal basis and Enp1, frontal; (E) maxilla and maxilliped; (F) P1, caudal.

Antennule (Figures 48C–D, 50F, 51A). Tip reaching posterior margin of second pediger. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(8s). One transverse row of spinules on first segment. Spine on sixth segment reaching midlength of seventh antennular segment.

Antenna (Figures 48E–F, 51B–D). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with rows of spinules on frontal surface: N1(V), N2(VI), N3(7), N4(7), N5(6), N6(7), N15(5), N17(8), N18(3); on caudal surface: N7(5), N8(6),

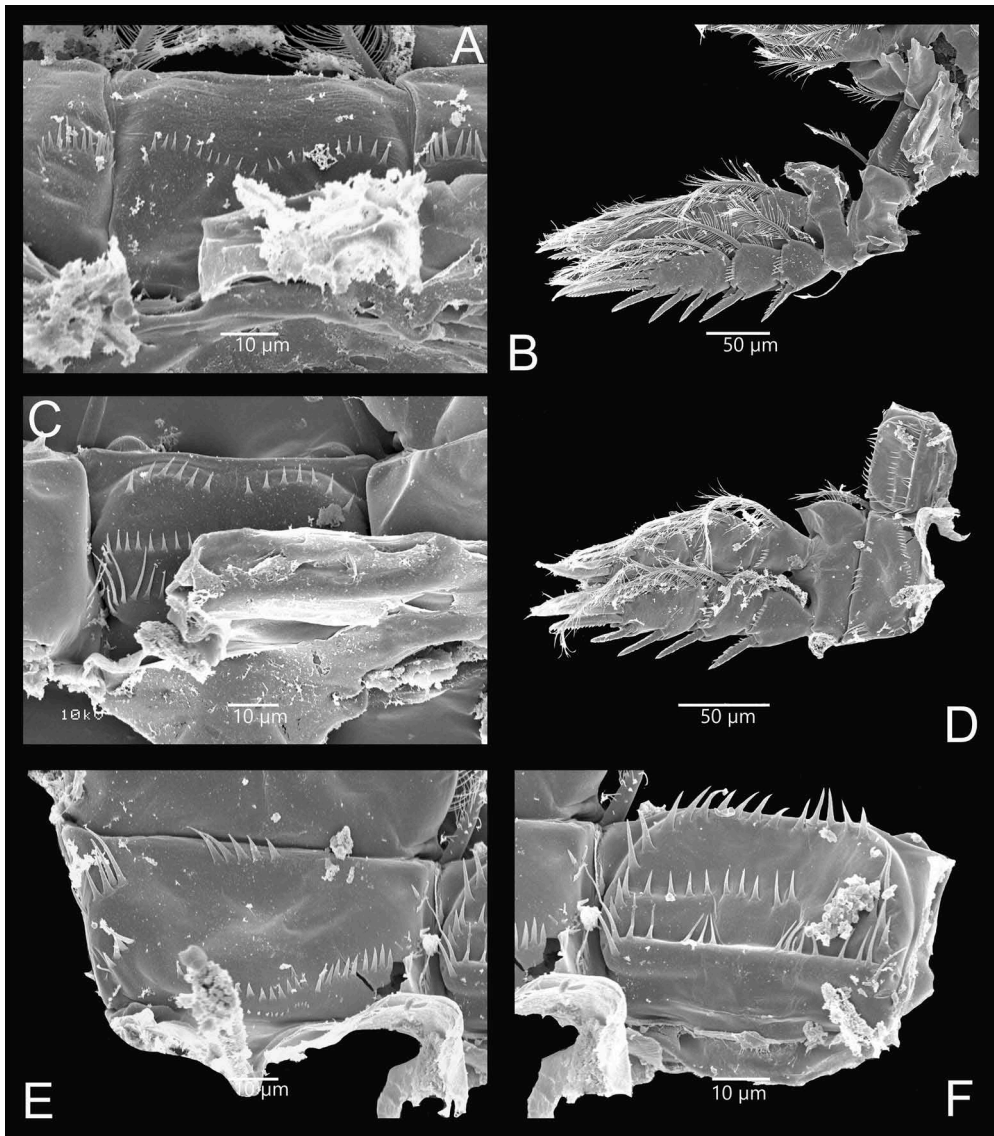


Figure 52. *Eucyclops defaye* sp. nov. Adult female. (A) Intercoxal sclerite P1, caudal; (B) P3, caudal; (C) intercoxal sclerite P3, caudal; (D) P4, caudal; (E) coxa P4, caudal; (F) intercoxal sclerite P4, caudal.

N9+10(7), N11(7), N12(7), N14(4), N16(14). Caudal surface of Enp1 with B1(5), B2(7) and B3(3).

Leg 1 (Figures 49A–C, 51F, 52A). Frontal surface of intercoxal sclerite smooth (rows not observed), caudal surface with row II continuous, bearing 21 strong but small spinules, row I absent. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal spine) long exceeding apical margin of Enp3, 1.1 times as long as Enp. Length/width ratio Enp3 = 1.2, apical spine of Enp3 being 1.1 times as long as Enp3.

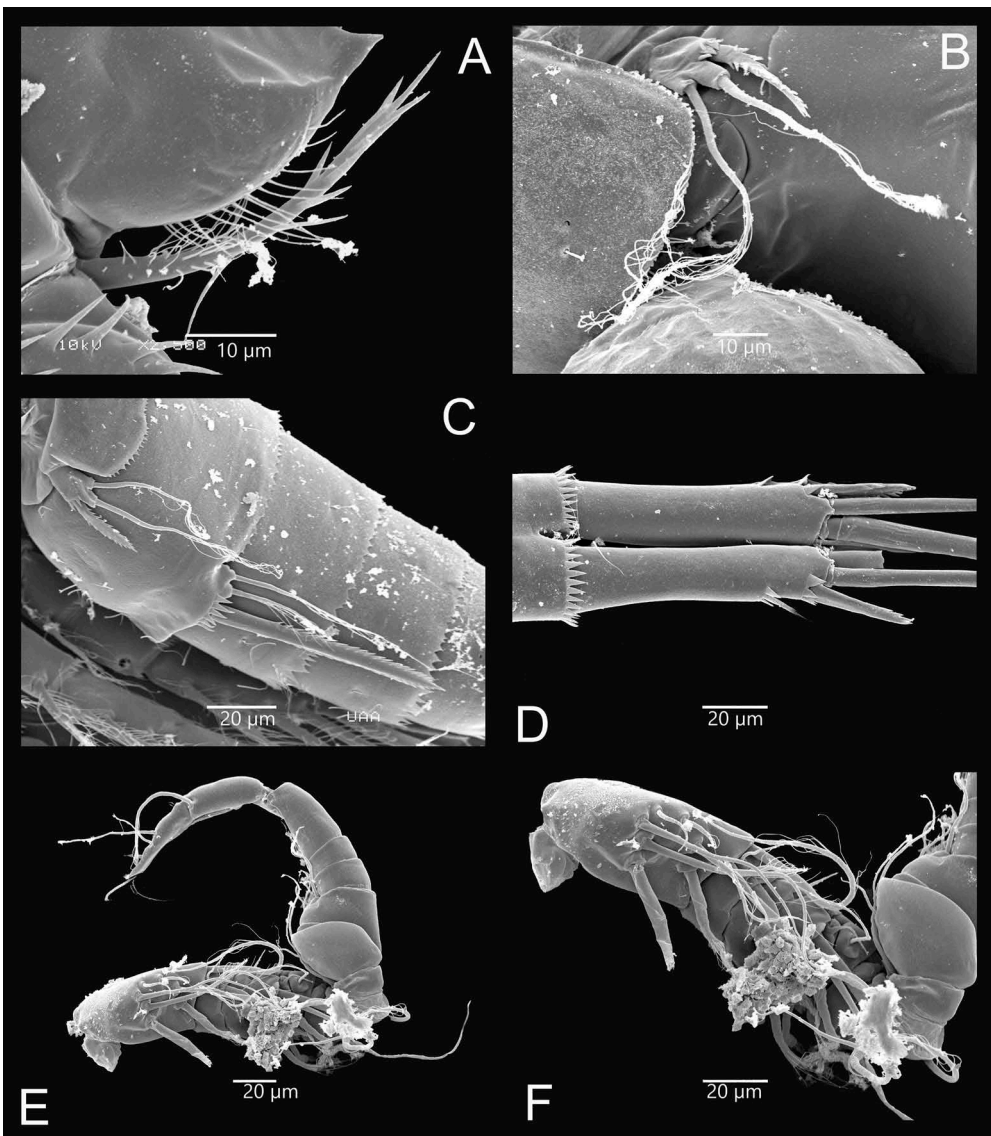


Figure 53. *Eucyclops defaye* sp. nov. Adult female, A–B; adult male, C–F. (A) Coxal spine P4; (B) P5; (C) P5 and P6; (D) caudal rami, ventral; (E) antennule; (F) antennule.

Leg 2 (Figure 49D–G). Frontal surface of intercoxal sclerite with row I bearing strong spinules arranged in a semicircular pattern; caudal surface with rows I and II continuous, row I with 14 minute spinules and row II with 23. Distal margin of intercoxal sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C-D. Length/width ratio of Enp3 = 1.7, apical spine of Enp3 being 1.1 times as long as Enp3. No modified setae present.

Leg 3 (Figures 49H, 52B–C). Frontal surface of intercoxal sclerite with minute spinules arranged in a semicircular pattern on each side; caudal surface with row I bearing small,

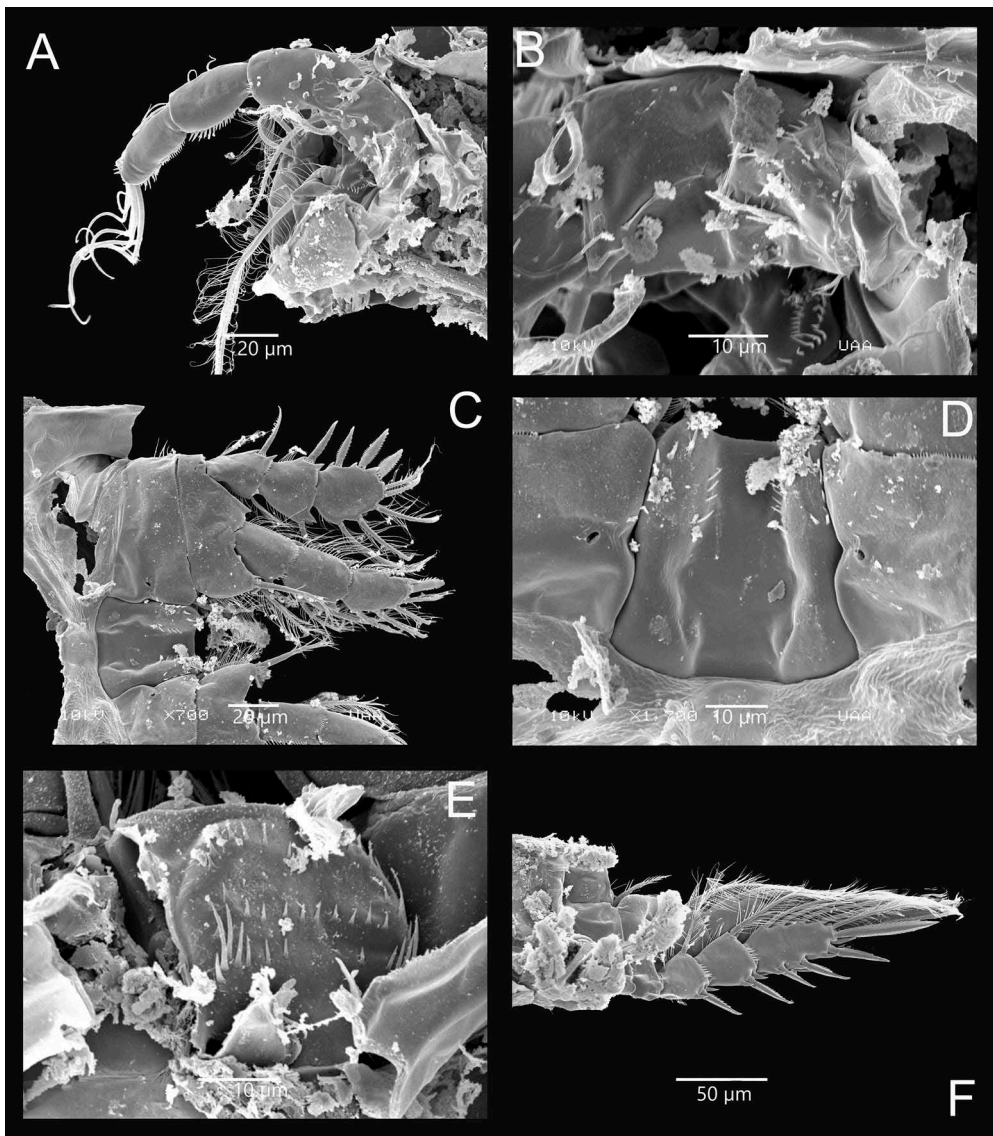


Figure 54. *Eucyclops defaye* sp. nov. Adult male. (A) Antenna, frontal; (B) antennal basis, frontal; (C) P1, frontal; (D) intercoxal sclerite P1, frontal; (E) intercoxal sclerite P3, caudal; (F) P4, frontal.

strong spinules (gap in middle section), row II continuous, bearing small, slender spinules; row III continuous, with strong, long spinules (spinules adjacent to outer margins longer than those in middle section). Distal margin with two rounded, chitinised projections. Coxa with strong, biserially setulated inner coxal seta, basally with long hairs and distally with strong spinules along both margins. Caudal coxal surface with spinule formula = A. Length/width ratio of Enp = 2.0, apical spine of Enp3 being 1.1 times as long as Enp3. Modified setae present in Exp and Enp.

Leg 4 (Figures 49I–J, 52D–F, 53A). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface of sclerite with row I bearing minute spinules arranged in a semicircular pattern, caudal surface of sclerite with row I bearing long, strong spinules, row II continuous, with small spinules; row III with strong, slightly longer spinules, small gap in middle section. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; proximal inner margin with long hairs, distal margin with strong spinules, outer margin with two distal spinules, proximally setulated, gap in middle margin. Spinule formula on caudal surface = A-B-C + D-E-F-H-J. Length/width ratio Enp3 = 2.4, length ratio inner spine of Enp3/length Enp3 = 1.2; length ratio outer spine of Enp3/length Enp3 = 0.7; length ratio inner/outer spines Enp3 = 1.8. Lateral seta of Enp3 inserted at 64% of segment. Modified setae in Enp and Exp.

Leg 5 (Figures 48B, 53B). Free segment subrectangular, 1.8 times longer than wide, bearing one strong inner spine and two setae; medial seta 1.8 times longer than outer seta and 2.3 times longer than inner spine. Inner spine 1.4 times longer than segment.

Remarks. As mentioned in the remarks section of other species, *E. defayeeae* sp. nov. shares with *E. elegans* and *E. tziscao* some characters like the rounded, serrate anal operculum, but differs from *E. elegans* in the body length and the length/width ratio of the caudal ramus; in this new species the ramus is 4.6 times longer than wide, vs a ratio of over 6.0 found in *E. elegans*. This new species can be easily distinguished from *E. tziscao* by the ornamentation of the frontal surface of the antennal basis: row II bears long hairs in *E. defayeeae* sp. nov., but in *E. tziscao* it has small, strong spinules.

Mexican records of *E. bondi* are now assignable to either *E. tziscao* or *E. defayeeae* sp. nov. These three species share general morphometric values and the same armature of the caudal surface of the intercoxal sclerite of P4. Both Mexican species can be easily distinguished from *E. bondi* if males are available. The sixth leg in *E. bondi* differs from that of *E. tziscao* and *E. defayeeae* sp. nov. in having a remarkably short inner spine and a medial seta as long as or slightly longer than the spine, and an outer seta longer than the inner spine. In both *E. tziscao* and *E. defayeeae* sp. nov., the inner spine is always much longer than both the medial and the outer setae. *Eucyclops tziscao* and *E. defayeeae* sp. nov. can be distinguished because in the former species the frontal surface of the antennal basis row N2 bears short spinules vs long hairs in *E. defayeeae* sp. nov. Rows N6, N7, N14, N16 and N18 are present in *E. defayeeae* sp. nov. but they are absent in *E. tziscao* (Gutiérrez-Aguirre et al. 2013). The ornamentation on the caudal surface of P1 and P2 intercoxal sclerites differs between these species: in *E. defayeeae* sp. nov. row I of P1 is absent but it is present in *E. tziscao*, and row I of P2 is present in *E. defayeeae* sp. nov. but it is absent in *E. tziscao*. The presence of caudal spinules on P3 row I is another distinctive character in *E. defayeeae* sp. nov. Among the species distributed in Mexico, this character is shared with *E. cuatrocieneas* and *E. mittmanni* sp. nov.

The only other known congener sharing the presence of long hairs in row N2 with *E. defayeeae* sp. nov. is *E. wixarica*, but N6 is absent in *E. wixarica* sp. nov.; in addition, rows N9 and N10 are separated in *E. wixarica* sp. nov. but fused in *E. defayeeae* sp. nov. Additional differences between these two species include the ornamentation of the caudal surface of the P1 intercoxal sclerite: row I is present and bears minute spinules in

E. wixarica but it is absent in *E. defayeeae* sp. nov. The ratio of basipodal spine/length of Enp of P1 is 0.6 in *E. wixarica*, while in *E. defayeeae* sp. nov. the spine is remarkably long (about 1.1). Also, modified setae were observed in P3 and P4 of *E. defayeeae* sp. nov., while in *E. wixarica* all swimming setae are normal.

***Eucyclops mittmanni* sp. nov.** Mercado-Salas and Suárez-Morales
(Figures 55–60)

Material examined

Holotype. Adult ♀ specimen dissected, mounted in glycerin sealed with Entellan (ECO-CH-Z-04948).

Paratypes. Seven adult ♀♀ undissected ethanol-preserved (90%) (ECO-CH-Z-04949). Samples from type locality collected 18 February 1989 by Marcelo Silva-Briano.

Type locality

Creek at Sierra Fria 21 km north of Village La Labor, Calvillo, Aguascalientes, Mexico.

Etymology

This species is warmly dedicated to Dr. Hans-Walter Mittmann (Staatliches Museum für Naturkunde Karlsruhe, Germany) who is in charge of the Kiefer Collection.

Distribution

Aguascalientes.

Description

Female. Habitus as in Figure 57A. Average length excluding caudal setae = 1216 µm. Whole body (caudal ramus included) ornamented with small cuticular pits. Prosome representing 58% of total body length, symmetrical in dorsal view. Prosomal fringes finely serrate dorsally. Urosomal fringes strongly serrate. Genital double somite symmetrical (Figure 57B), representing 10% of total body length; proximal third of genital double somite slightly expanded laterally. Seminal receptacle with rounded lateral arms on posterior margin, typical of the *serrulatus*-complex. Length/ratio of caudal ramus = 7.5; inner margin of caudal ramus naked; strong spines covering 69% with respect to the total length of ramus. Dorsal seta (VII) 0.5 times as long as caudal ramus and 0.8 times as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 0.8. Lateral caudal seta (II) inserted at 78% of caudal ramus.

Antennule (Figures 55B, 57F, 58A-B). Tip reaching posterior margin of fourth pediger. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(8s). One transverse row of spinules on first segment. Spine on sixth segment not reaching medial margin of seventh segment.

Antenna (Figures 55C–E, 58C–E). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp(1s, 9s, 7s, respectively). Basis with row of spinules on frontal surface: N1(VI),

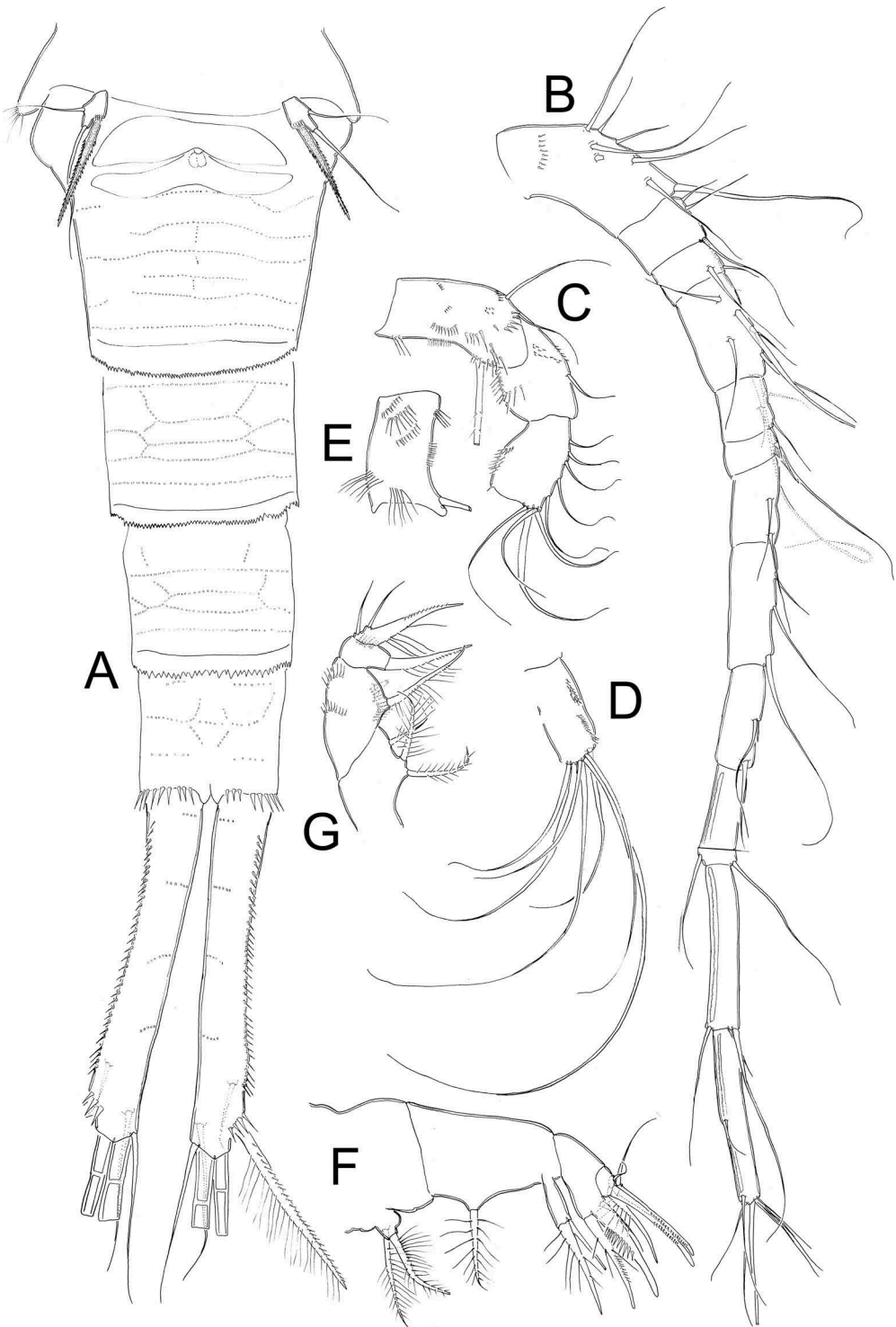


Figure 55. *Eucyclops mittmanni* sp. nov. Adult female. (A) Urosome, ventral; (B) antennule; (C) antenna, caudal; (D) Enp3 antenna; (E) antennal basis, frontal; (F) maxilla; (G) maxilliped.

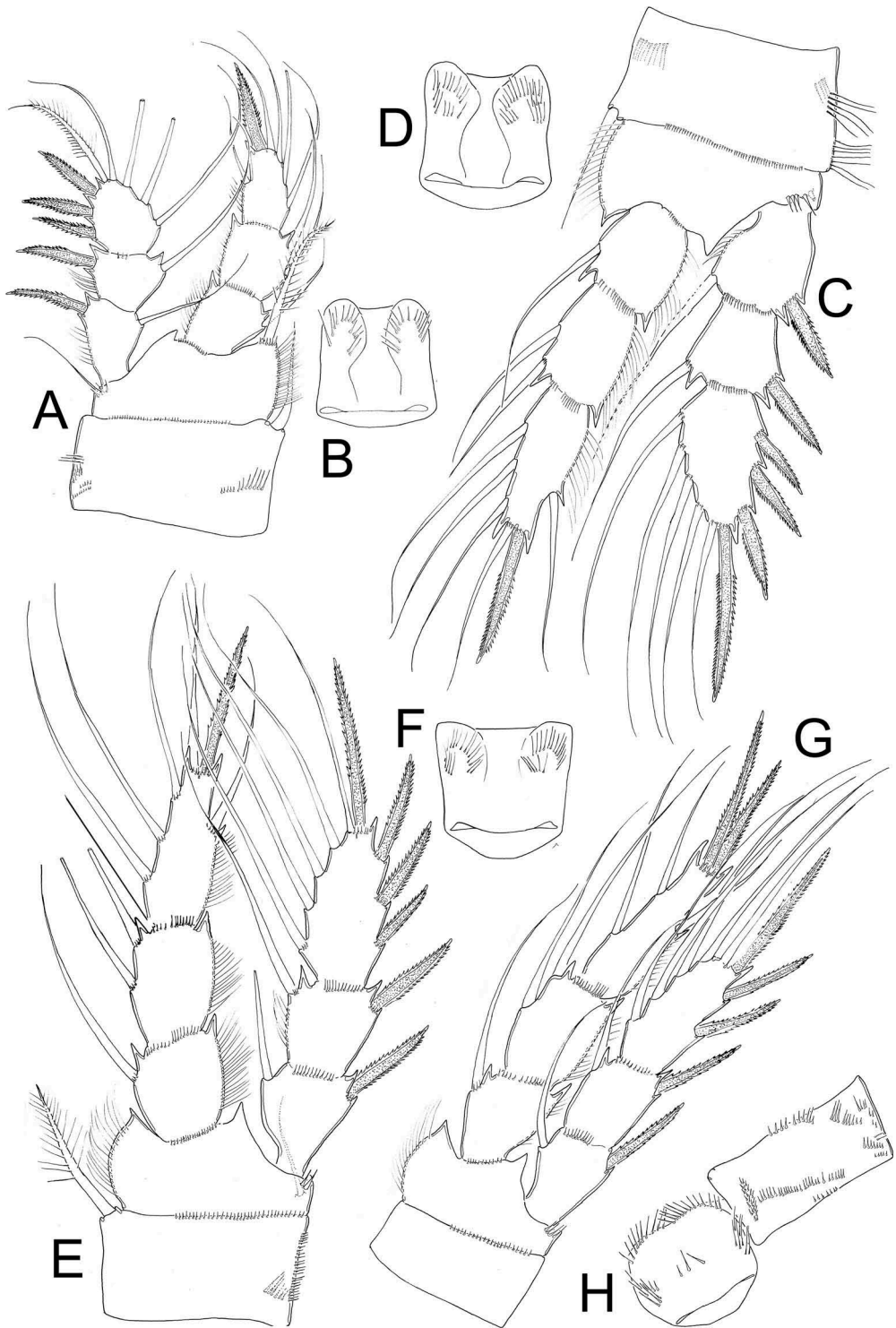


Figure 56. *Eucyclops mittmanni* sp. nov. Adult female. (A) P1, frontal; (B) intercoxal sclerite P1, frontal; (C) P2, frontal; (D) intercoxal sclerite P2, frontal; (E) P3, frontal; (F) intercoxal sclerite P3, frontal; (G) P4, frontal; (H) coxa and intercoxal sclerite P4, caudal.

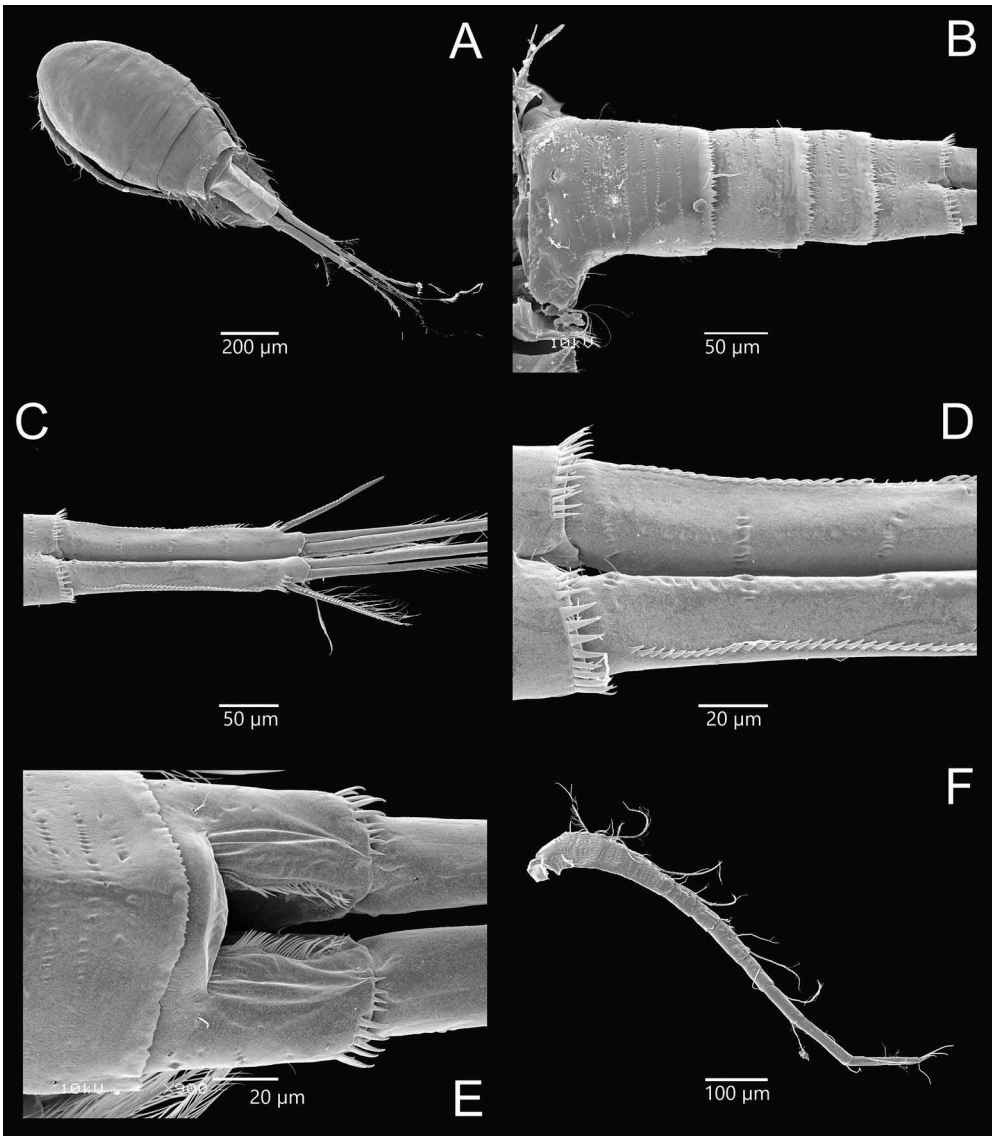


Figure 57. *Eucyclops mittmanni* sp. nov. Adult female. (A) Habitus, dorsal; (B) urosome, ventral; (C) caudal rami, ventral; (D) ornamentation details, caudal rami; (E) anal operculum, dorsal; (F) antennule.

N2(VI), N3(9), N4(8), N5(9), N15(9), N17(15); on frontal surface: N7(5), N8(5) N9+N10(5), N11(7), N12(10), N13(6), N14(7), N16(5), N19(5), N20(8), N21(5). Caudal surface of first Enp with B2(13) and B3(5).

Leg 1 (Figures 56A–B, 59A–B). Frontal surface of intercoxal sclerite with row I bearing long spinules on each side; caudal surface with row I continuous, bearing 15 minute spinules, row II continuous, with 20 minute spinules, distal margin with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with

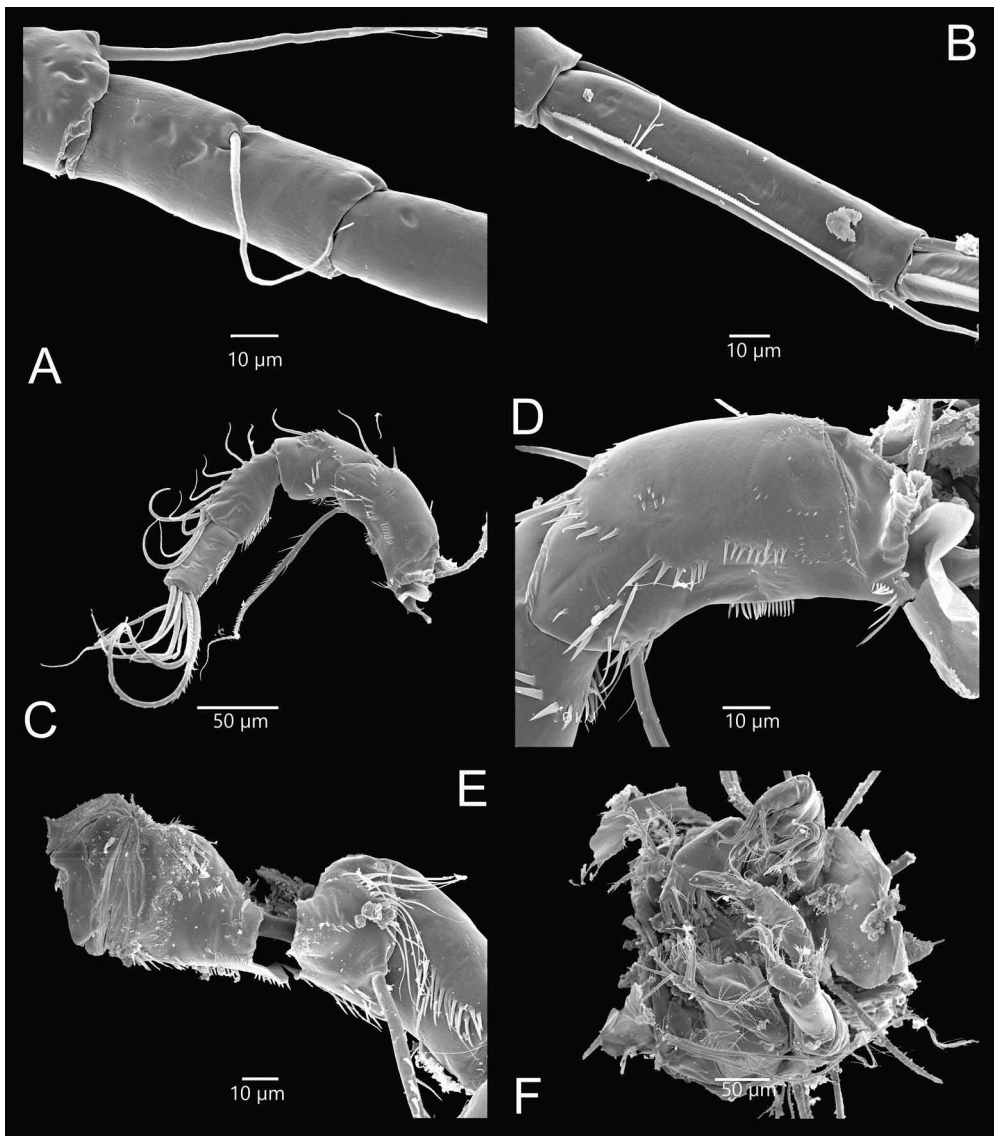


Figure 58. *Eucyclops mittmanni* sp. nov. Adult female. (A) Antennule, segment 9; (B) antennule, segment 11; (C) antenna, caudal; (D) antennal basis, caudal; (E) antennal basis, frontal; (F) mouthparts.

spinule formula = A-B-C. Inner basal seta (basipodal spine) not reaching middle margin of Enp3, 0.7 times as long as Enp. Length/width ratio Enp3 = 1.8, apical spine of Enp3 being 1.2 times as long as Enp3.

Leg 2 (Figures 56C–D, 59C). Frontal surface of intercoxal sclerite with row I bearing spinules arranged in circular pattern on each side; caudal surface with row II continuous, with 20 minute spinules, row I absent, distal margin with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule

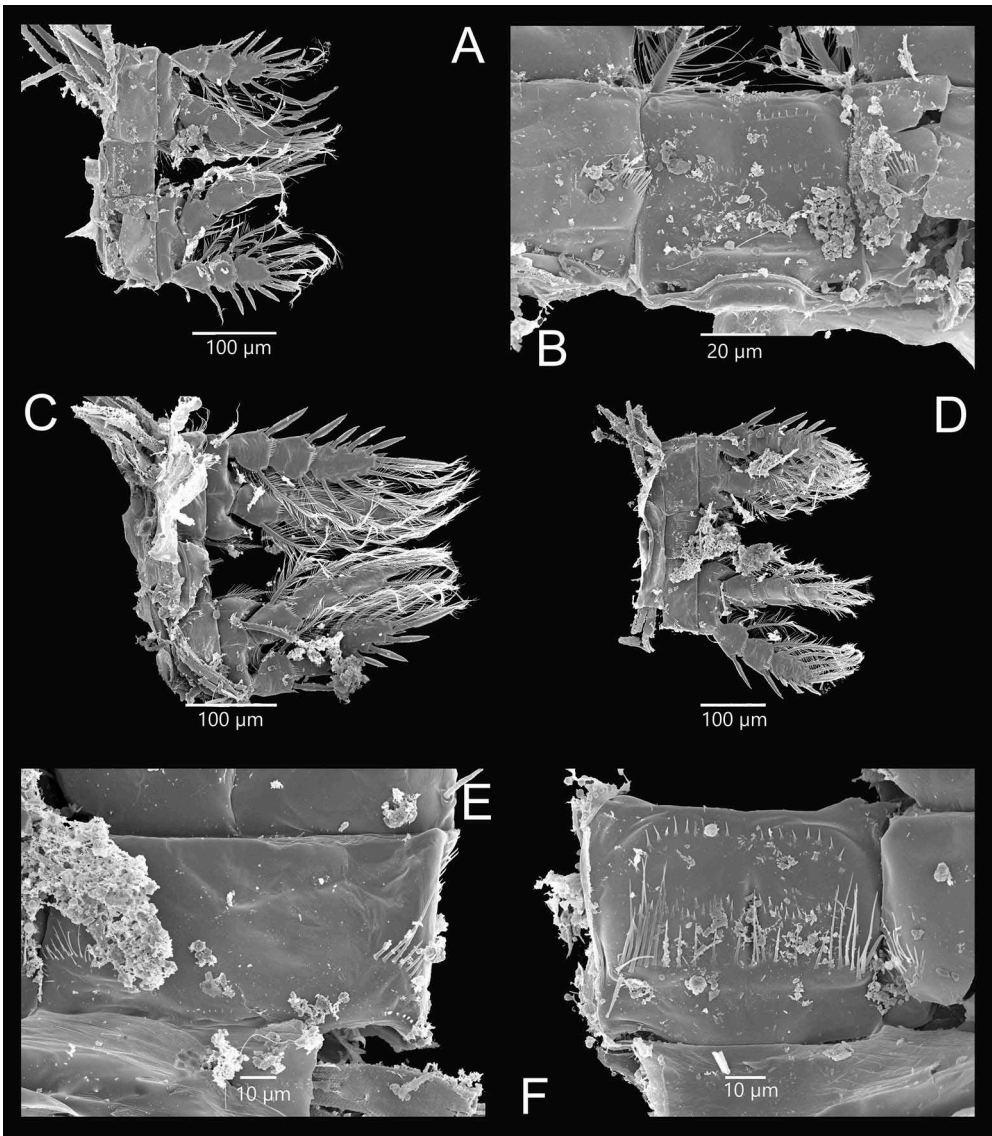


Figure 59. *Eucyclops mittmanni* sp. nov. Adult female. (A) P1, caudal; (B) intercoxal sclerite P1, caudal; (C) P2, frontal; (D) P3, caudal; (E) coxa P3, caudal; (F) intercoxal sclerite P3, caudal.

formula = A-B-C-D. Small spinules along insertion of basipodite (frontal surface). Length/width ratio of Enp3 = 2.7, apical spine of Enp3 as long as segment (Enp3). No modified setae present.

Leg 3 (Figure 56E–F). Frontal surface of intercoxal sclerite with row I armed with long spinules arranged in a circle on each side, all spinules about the same length; caudal surface of intercoxal sclerite with row I bearing 8–10 small spinules on each side (small gap in the middle), row II continuous, with minute spinules (27–30); row III continuous,

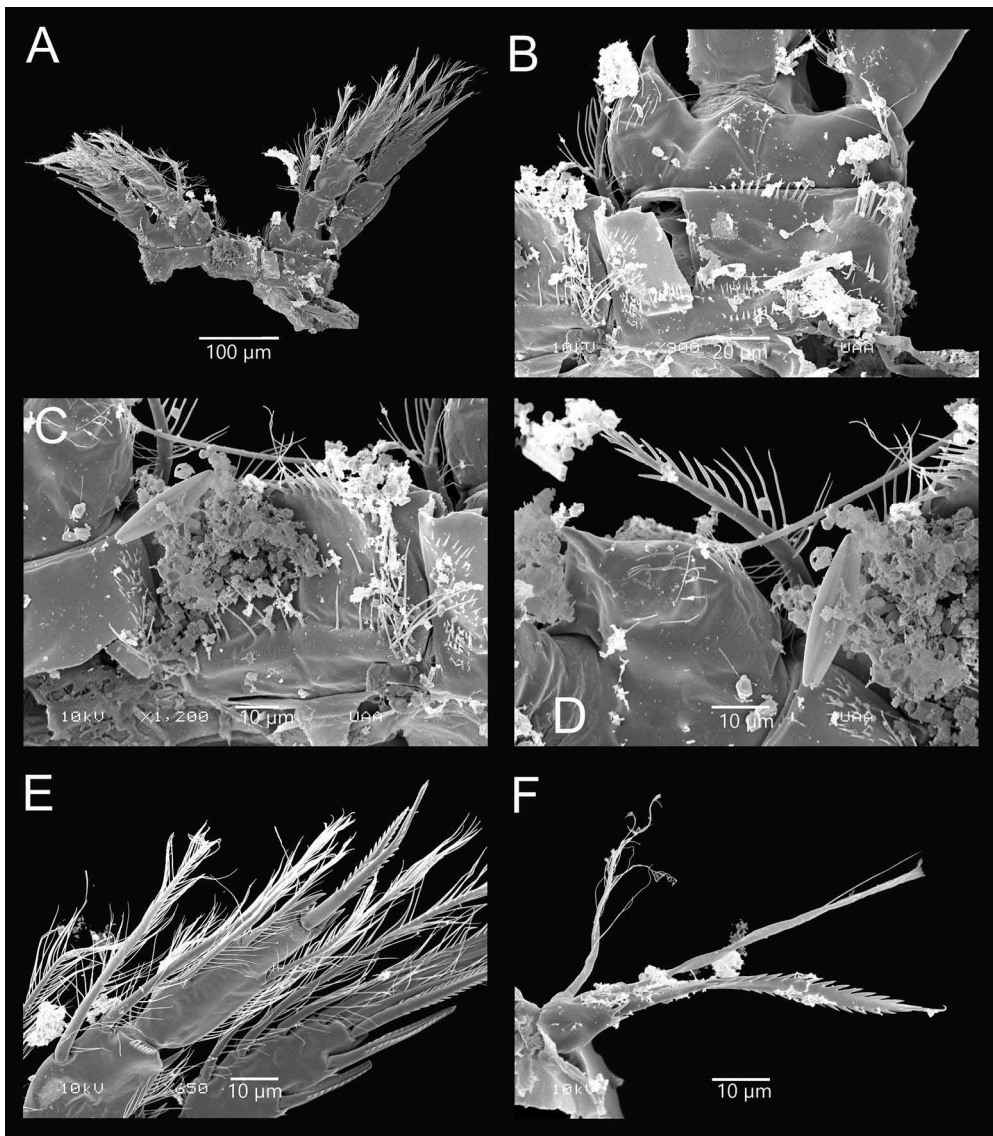


Figure 60. *Eucyclops mittmanni* sp. nov. Adult female. (A) P4, caudal; (B) coxa and basis P4, caudal; (C) intercoxal sclerite P4, caudal; (D) coxal spine P4; (E) Enp3 P4; (F) P5.

with 25–28 long spinules, spinules adjacent to outer margin longer than medial ones. Distal margin with two rounded, chitinised projections. Coxa with strong, biserially setulated coxal seta, ornamented basally with long hairs and distally with strong spinules. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp3 = 2.7, apical spine of Enp3 as long as segment (Enp3). No modified setae present.

Leg 4 (Figures 56G–H, 59C–E). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface with row I bearing long hairs arranged

in semicircular pattern; caudal surface of intercoxal sclerite with row I bearing 10–11 strong long spinules on each side with small gap between, row II discontinuous, with long hair spinules adjacent to outer margins and three strong, long spinules in middle section. Row III with long hair–spinules in outer margins. Frontal surface of coxa with spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; proximal inner margin with long hairs, distally with spinules; outer margin with three spinules on distal surface and basally with hairs, gap in middle margin. Caudal coxal surface with spinule formula = A-B-C + D-E-F-H-J. Length/width ratio Enp3 P4 = 3.7, length ratio inner spine of Enp3/length Enp3 = 1.0; length ratio outer spine of Enp3/length Enp 3 = 0.8; length ratio inner/outer spines Enp3 = 1.3. Lateral seta of Enp3 inserted at 62% of segment. No modified setae in Enp and Exp.

Leg 5 (Figures 59F, 60F). Free segment subrectangular, 1.6 times longer than wide, bearing one inner spine and two setae; medial seta 1.6 times longer than outer seta and 1.1 times longer than inner spine. Inner spine 2.7 times longer than segment.

Remarks. *Eucyclops mittmanni* sp. nov. is closely related to *E. elegans*; it is possible that some Mexican and North American records of the latter species are now assignable to *E. mittmanni* sp. nov. Most of the records of *E. elegans* (Suárez-Morales, 2004) have been based upon the length of its caudal ramus, which is remarkably longer than that of closely related species like *E. pectinifer* and *E. serrulatus*. This apparently unique character might have prevented further analysis of specimens from different geographic areas or Mexico. In the recent redescription of *E. elegans* (Mercado-Salas and Suárez-Morales, 2014b) from material deposited in different collections and including specimens from different geographic areas of the continent, differences were found between North American (NA) and South American (SA) populations of this species. It is suggested that the NA and SA specimens could represent two independent species. *Eucyclops mittmanni* sp. nov. differs from both forms of *E. elegans* by a combination of different characters, but, as expected, it appears to be more closely related to the NA form of *E. elegans*. Morphometrical values do not differ among these species, but it is important to mention that *E. elegans* NA (body length = 1061 μm) and *E. elegans* SA (1100 μm) are both slightly smaller than *E. mittmanni* sp. nov. (1216 μm). The new species shares with the SA populations a round and smooth anal operculum; the same structure is also rounded but serrate in the NA form. Some of the main differences observed between both the SA and NA forms of *E. elegans* and *E. mittmanni* sp. nov. are related to the ornamentation pattern of the antennal basis. In the three forms the frontal surface has the same pattern except for *E. elegans* NA, which shows N18, and in *E. mittmanni* sp. nov. N1 and N2 are completely separated, thus contrasting with the fused condition observed in the two forms of *E. elegans*. The ornamentation pattern on the caudal surface also differs among both forms of *E. elegans* and *E. mittmanni* sp. nov.: in *E. elegans* SA rows N7, N14, N22 are absent, while in *E. elegans* NA and *E. mittmanni* sp. nov. they are present. Like many other Mexican congeners, *E. elegans* NA bears row N18, a character that is absent in *E. mittmanni* sp. nov. The new species is the only one among the Mexican *Eucyclops* that has rows N19 and N20; it shares the presence of N20 with *E. chihuahuensis* only. The ornamentation of P1 and P2 intercoxal sclerites is similar in the three forms but some differences were observed in the P3 caudal surface. In

E. elegans NA row I bears long hair-spinules, a character shared with other Mexican species of *Eucyclops*, but divergent from both *E. mittmanni* sp. nov. and *E. elegans* SA in which row I has small strong spinules, also present in *E. defayae* sp. nov. and *E. cuatrocienegas*. In the new species, row III has remarkably long, strong spinules that are shorter in *E. elegans* NA. The ornamentation of the caudal surface of the P4 coxa and intercoxal sclerite is another useful character to separate the three forms: in *E. mittmanni* sp. nov. and *E. elegans* SA row II is divided into three sections, two close to the outer margins and one bearing long spinules in the middle section, whereas this row is continuous and bears small but strong spinules in *E. elegans* NA. The coxal surface of P4 is more ornamented in the new species than in the two forms of *E. elegans*, and rows B, C and E are present in *E. mittmanni* sp. nov. and are absent in *E. elegans*, but *E. elegans* has row G, absent in the new species.

***Eucyclops estherae* sp. nov.** Mercado-Salas and Suárez-Morales
(Figures 61–66)

Material examined

Holotype. Adult ♀ specimen dissected, mounted in glycerin, slides sealed with Entellan (ECO-CH-Z-04636).

Allotype. Adult ♂, dissected, mounted in glycerin, slides sealed with Entellan (ECO-CH-Z-04637).

Paratypes. Twelve adult ♀♀ undissected ethanol-preserved (90%) (ECO-CH-Z-04638). Samples from type locality collected 15 October 2006 by Marcelo Silva-Briano and Nancy F. Mercado-Salas.

Type locality

San Francisco Pond, San Francisco, San Luis Potosí, Mexico (22°03′13.8″ N; 99°50′50.3″ W).

Etymology

This species is warmly dedicated to the late Mrs. Esther Ruiz Jiménez, the beloved grandmother of the first author (NFM-S).

Distribution

Central and Northern Mexico (San Luis Potosí, Durango, Coahuila).

Description

Female. Habitus as Figure 63A–B. Average length excluding caudal setae = 770 µm. Prosome widest at end of cephalosome and second pediger, representing 57% of total body length, symmetrical in dorsal view (Figure 63C). Prosomal fringes slightly serrate dorsally (Figure 63C). Urosomal fringes strongly serrate. Genital double somite symmetrical (Figure 63D), representing 8% of total body length; anterior third of genital double somite expanded laterally. Seminal receptacle with rounded lateral arms, posterior margin with sinuous sac (Figure 61A). Length/ratio of caudal rami = 5.5; inner margin

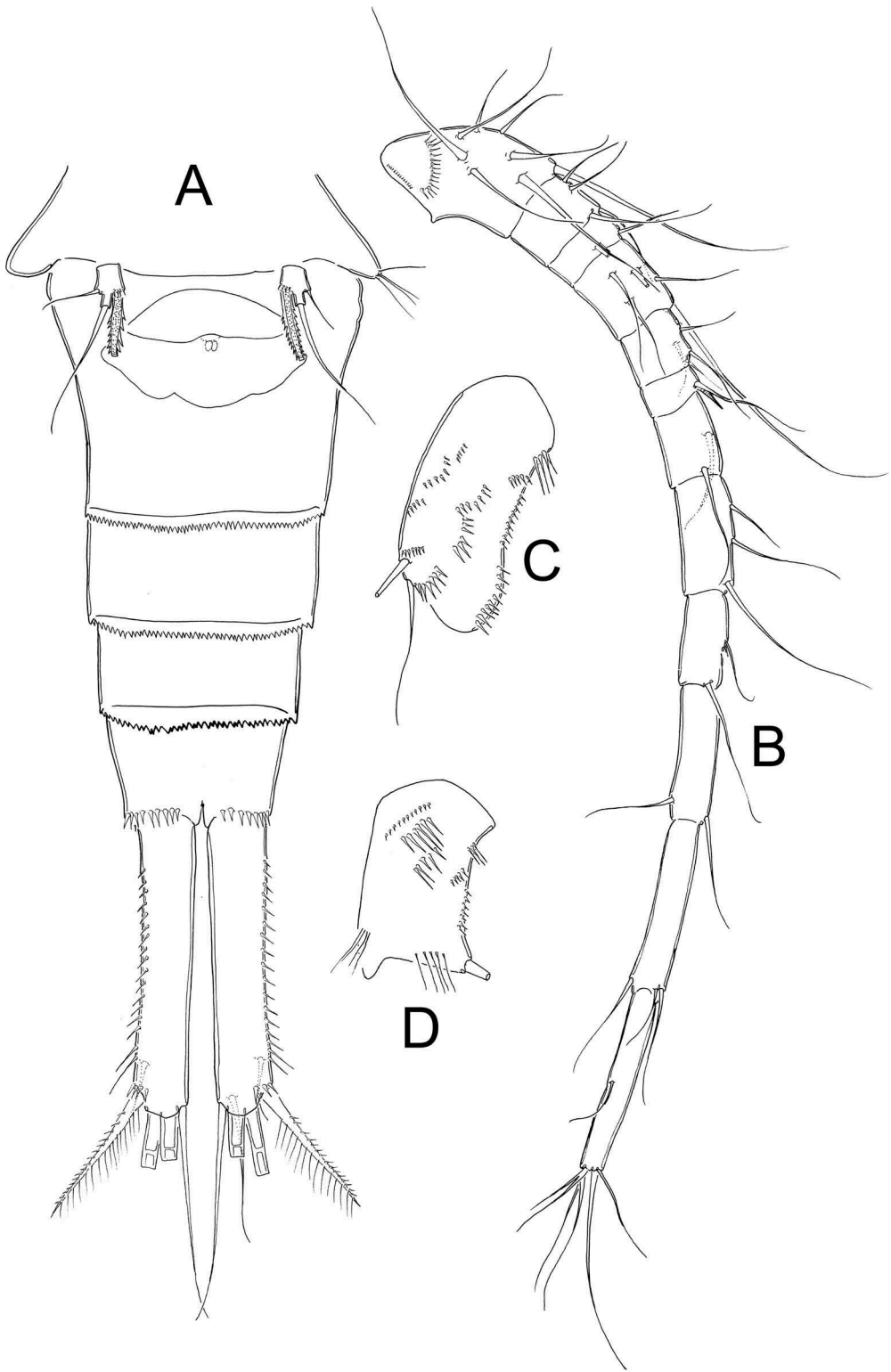


Figure 61. *Eucyclops estherae* sp. nov. Adult female. (A) Urosome, ventral; (B) antennule; (C) antennal basis, caudal; (D) antennal basis, frontal.

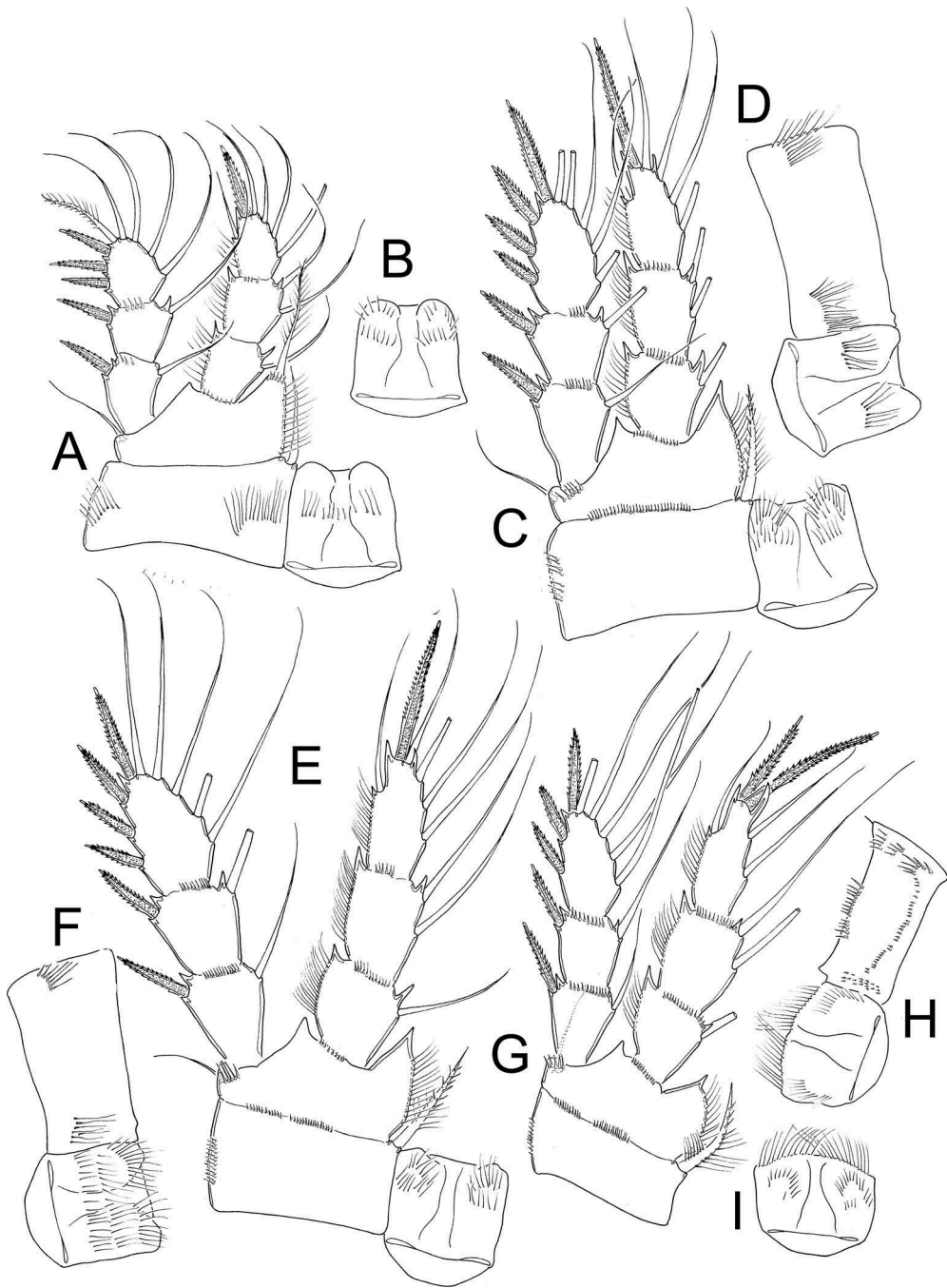


Figure 62. *Eucyclops estherae* sp. nov. Adult female. (A) P1, caudal; (B) intercoxal sclerite P1, frontal; (C) P2, frontal; (D) coxa and intercoxal sclerite P2, caudal; (E) P3, frontal; (F) coxa and intercoxal sclerite P3, caudal; (G) P4, frontal; (H) coxa and intercoxal sclerite P4, caudal; (I) intercoxal sclerite P4, frontal.

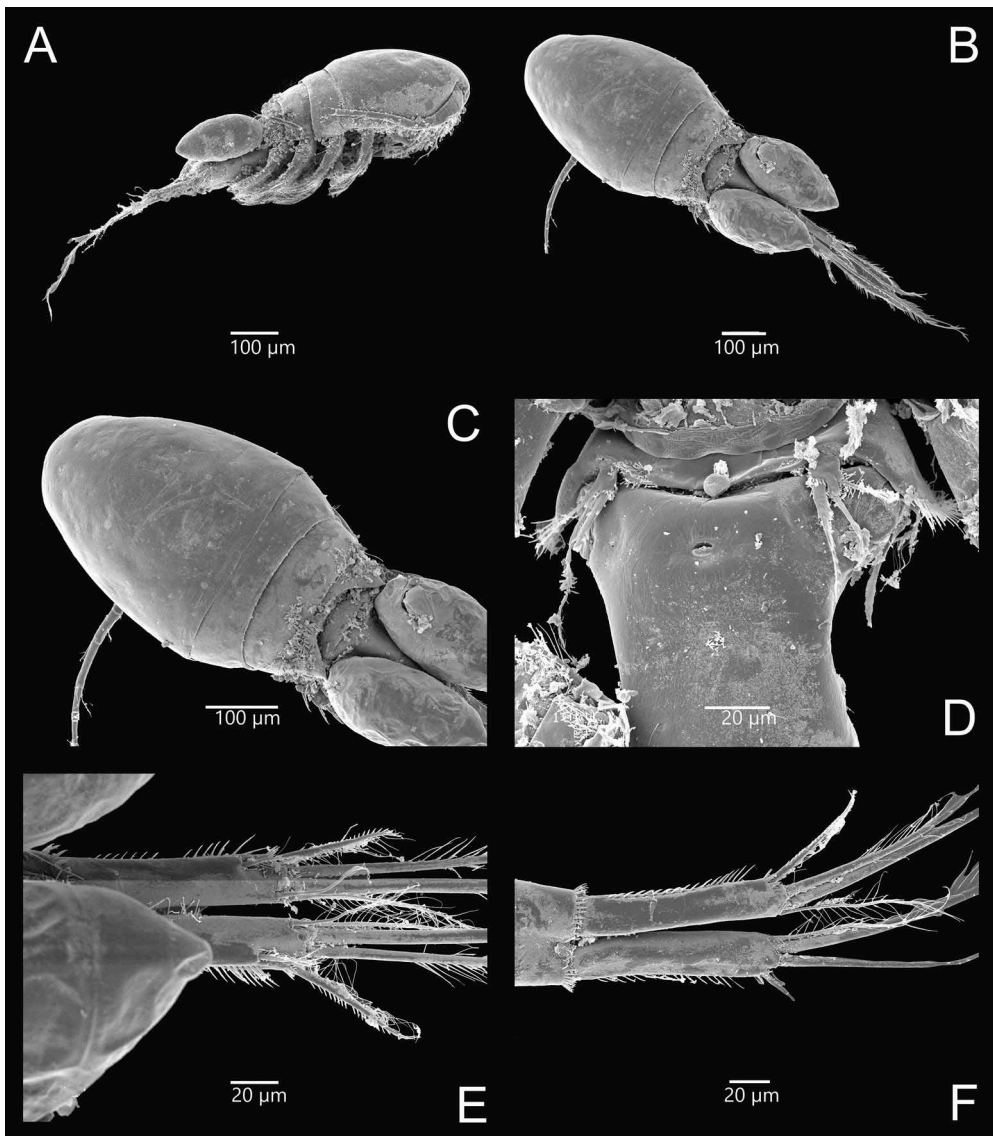


Figure 63. *Eucyclops estherae* sp. nov. Adult female. (A) Habitus, lateral; (B) habitus, dorsal; (C) prosome, dorsal, (D) genital somite, ventral; (E) caudal rami, dorsal; (F) caudal rami, ventral.

of caudal ramus naked; strong spines covering 67% with respect to the total length of ramus. Dorsal seta (VII) 0.5 times as long as caudal ramus and as long as outermost caudal seta (III). Ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.5. Lateral caudal seta (II) inserted at 80% of caudal ramus.

Antennule (Figures 61B, 64A–D). Tip reaching posterior margin of third pediger. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(4s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(7s). First segment with two rows of spinules, proximal row

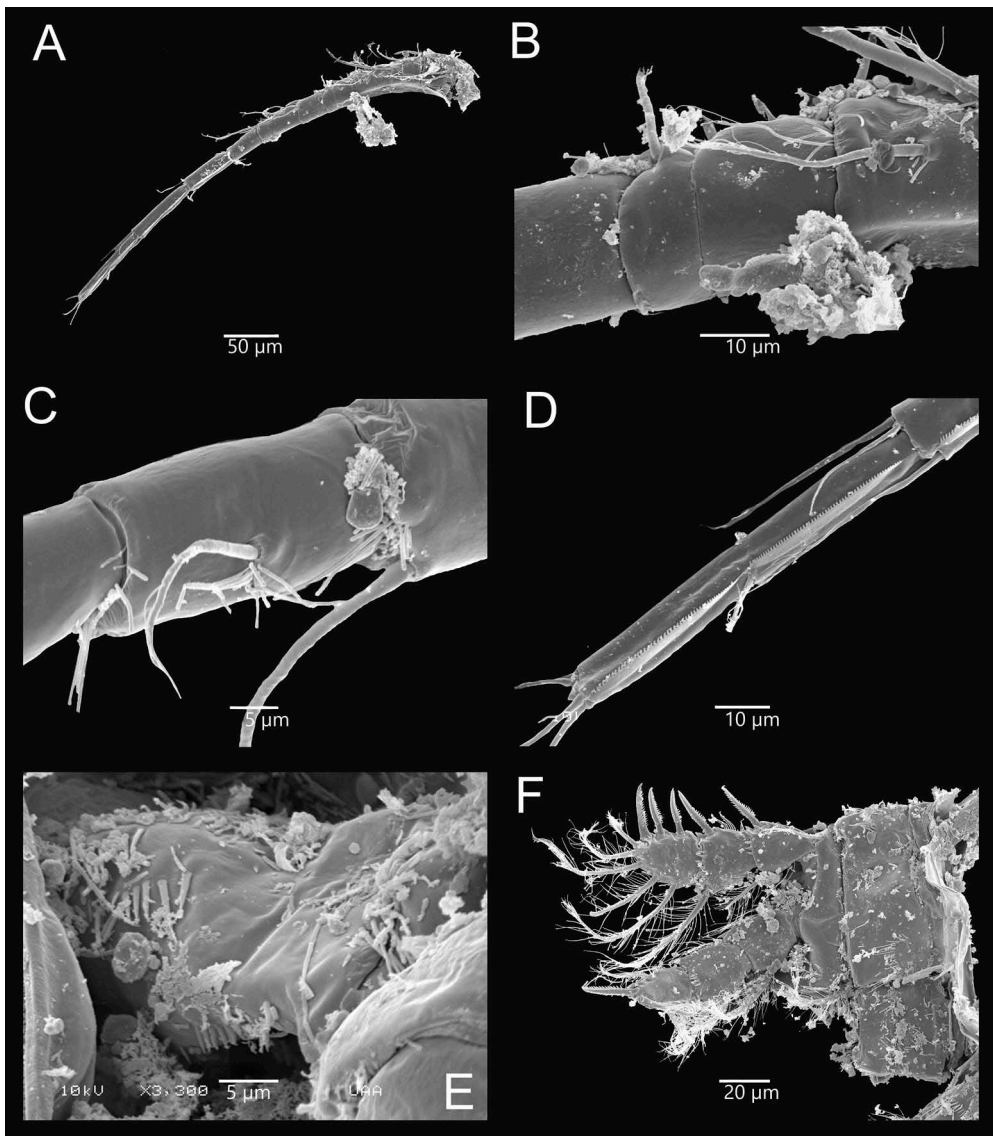


Figure 64. *Eucyclops estherae* sp. nov. Adult female. (A) Antennule; (B) antennule, segment 6; (C) antennule, segment 9; (D) antennule, segment 12; (E) antennal basis, frontal; (F) P1, caudal.

bearing minute spinules, second row with stronger, slightly longer spinules. Spine on sixth segment not reaching medial margin of seventh segment.

Antenna (Figures 61C–D, 64E). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with row of spinules on frontal surface: N1(V), N2(4), N3(4), N4(5), N5(6), N15(4), N17(11), N18(4); on frontal surface: N7(6), N8(6), N9+10(9), N11(6), N12(7), N13(5), N14(5), N22(8). Caudal surface of first Enp with B1(7) and B2(6).

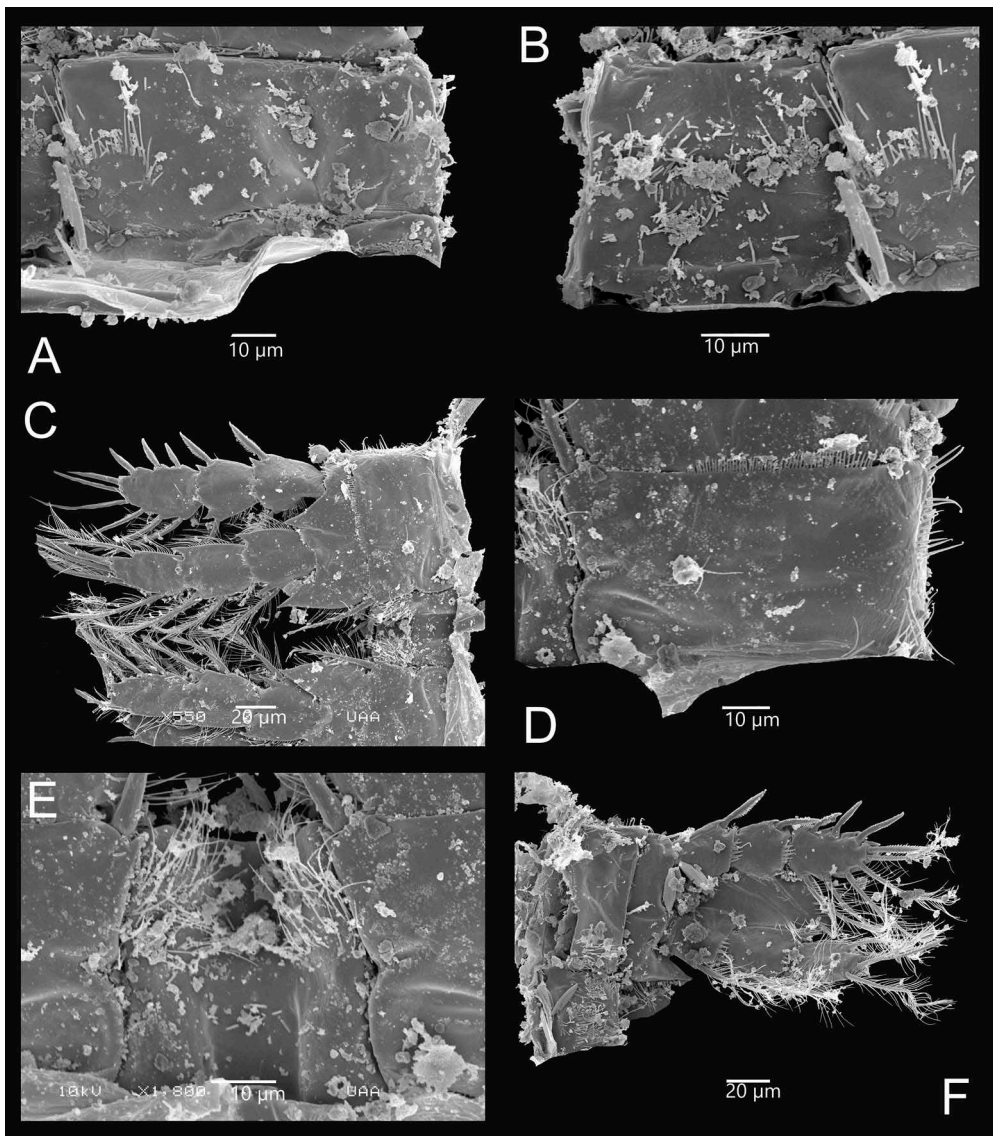


Figure 65. *Eucyclops estherae* sp. nov. Adult female. (A) Coxa P1, caudal; (B) intercoxal sclerite P1, caudal; (C) P2, frontal; (D) coxa P2, frontal; (E) intercoxal sclerite P2, frontal; (F) P3, caudal.

Leg 1 (Figures 62A–B, 64F, 65A–B). Intercoxal sclerite with row I bearing small hairs arranged in circular pattern on each side of frontal surface; caudal row II armed with long hair–setules on middle margin, medial setules slightly shorter, distal margin with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Inner basal seta (basipodal spine) not reaching middle margin of Enp3, 0.6 times as long as Enp. Length/width ratio Enp3 = 1.5, apical spine of Enp3 being 1.2 times as long as Enp3.

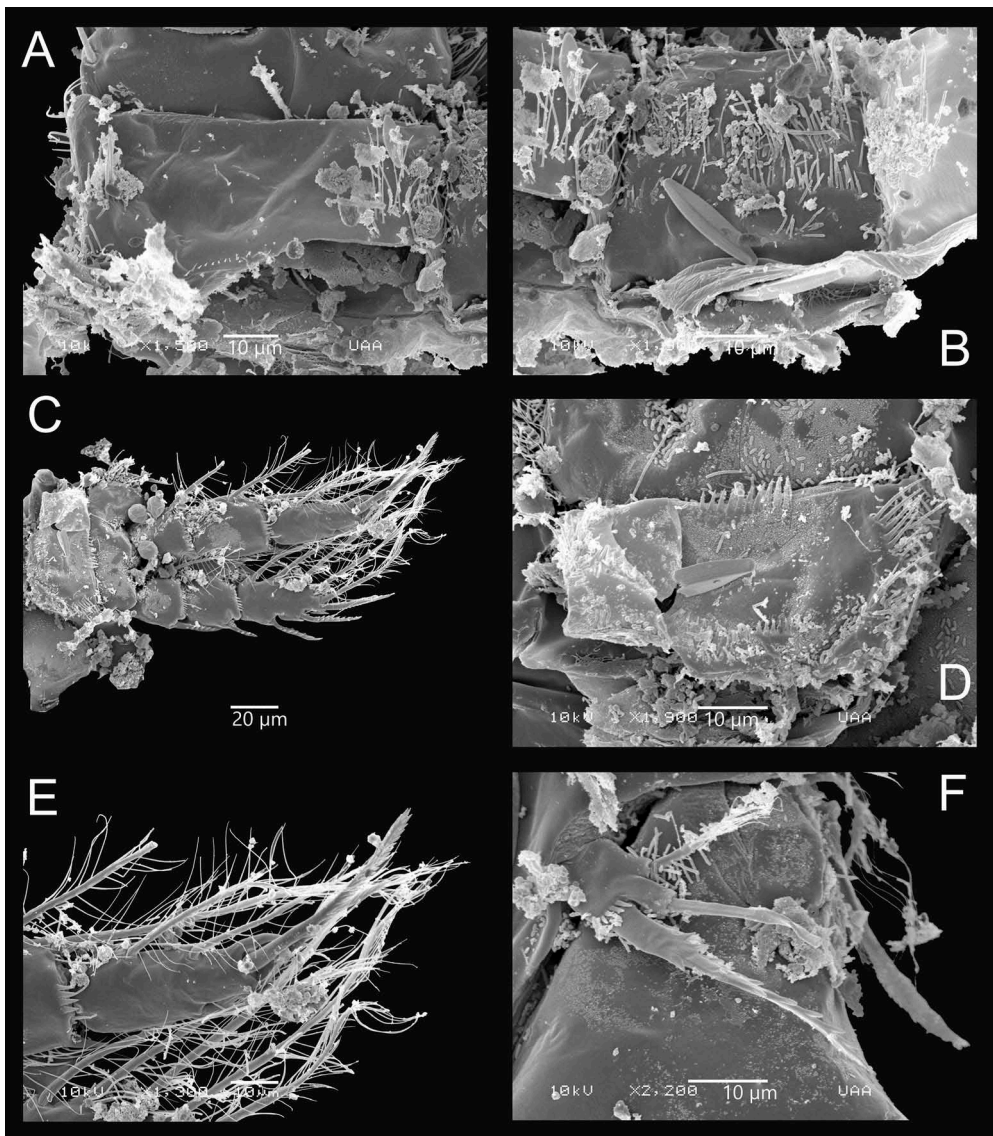


Figure 66. *Eucyclops estherae* sp. nov. Adult female. (A) Coxa P3, caudal; (B) intercoxal sclerite P3, caudal; (C) P4, caudal; (D) coxa P4, caudal; (E) Enp3 P4; (F) P5.

Leg 2 (Figures 62C–D, 65C–D). Frontal surface of intercoxal sclerite with row I bearing hairs arranged in circular pattern on each side; caudal row II bearing 7–8 long hair-spinules on each side (gap in middle margin), row I absent. Distal margin of sclerite with two rounded, chitinised projections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Small spinules along insertion of basipode (frontal surface). Length/width ratio of Enp3 = 2, apical spine of Enp3 being 1.4 times as long as segment (Enp3). No modified setae present.

Leg 3 (Figures 62E–F, 65F, 66A–B). Intercoxal sclerite with frontal row I bearing hairs arranged in a circular pattern on each side; caudal surface with row I bearing nine long hairs on each side (small gap in the middle section); row II continuous, bearing long hairs (about 16); row III continuous, bearing slightly shorter hairs setules (about 18). Distal margin with two rounded, chitinised projections. Coxa with strong, biserially setulated coxal seta. Caudal coxal surface with spinule formula = A-B-C. Length/width ratio of Enp3 = 2.1; apical spine of Enp3 being 1.2 times longer than Enp3. No modified setae present.

Leg 4 (Figures 62G–I, 66C–D). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface with row I bearing hairs arranged in a semicircular pattern on each side; caudal surface of intercoxal sclerite with row I bearing long hairs, about 13 on each side (small gap between them), row II bearing 7–9 hairs on each side (adjacent to outer margins); row III bearing 3–7 hairs on each side. Frontal surface of coxa with spinules at insertion of Bsp. Inner coxal seta with heterogeneous ornamentation; proximal inner margin with long hairs and distally with strong spinules; outer margin basally with hairs and distally naked. Caudal coxal surface with spinule formula = A-B-C + D-E-G-H-J. Length/width ratio Enp3 = 2.6, length ratio inner spine of Enp3/length Enp3 = 1.3; length ratio outer spine of Enp3/length of Enp3 = 0.9; proportion inner/outer spine Enp3 = 1.4. Lateral seta of Enp3 inserted at 65% of segment. No modified setae in Enp and Exp.

Leg 5 (Figure 66F). Free segment subrectangular, 1.5 times longer than wide, bearing one strong inner spine and two setae; medial seta 3 times longer than outer seta and 1.4 times longer than inner spine. Inner spine 2.5 times longer than segment.

Male. Prosome symmetrical in dorsal view. Urosome slightly elongated. Caudal ramus smooth along both inner and outer margins, except for strong spinules at insertion of lateral seta. Length/width ratio of caudal ramus = 4.0, dorsal seta (VII) 0.6 times as caudal ramus and 1.1 times as long as outermost caudal seta (III). Innermost caudal seta (VI)/outermost caudal seta (III) ratio = 2.0. Lateral caudal seta (II) inserted at 68% of ramus length.

Antennule. Armature as follows: 1(5s+3ms), 2(3s), 3(1s+2ms), 4(1s+1ms), 5(1s), 6(2s), 7(2s), 8(2s), 9(0), 10(2s), 11(1sp), 12(2s), 13(0), 14(0), 15(3s), 16(6s).

Antenna. Basis with spinule groups on frontal surface: N1(III), N2(3), N3(6), N4(6), N5(6), N15(4), N17(10), N18(4) and on caudal surface: N7(5), N8(5), N9+10(5), N11(5), N12(7), N13(4), N14(6).

Legs 1–4. Enp and Exp of all swimming legs three-segmented, armed as in females.

Leg 5. Free segment subrectangular, 2.1 times longer than wide, bearing one inner spine and two setae, medial seta longer than inner spine and outer seta (about 1.2 times), inner spine and outer seta equal in size.

Leg 6. Represented by a small, low plate adjacent to lateral margin of genital somite, armed with one strong spine and two unequal setae. Inner spine reaching posterior margin of fourth urosomite, inner spine 1.8 times longer than medial seta and 2.2 times as long as outer seta. Small and strong spinules presents at insertion of inner spine.

Remarks. *Eucyclops estherae* sp. nov. is closely related to both *E. festivus* and *E. wixarica* sp. nov. because they have similar morphometrical characters. The new species can be distinguished by a unique combination of characters. It differs from these two species by the presence of a sinuous lobe on posterior margin of seminal receptacle, which is present also in *E. alekseevi* sp. nov., *E. angeli* and *E. prionophorus*. The new species differs from *E. festivus* in details of the antennal basis ornamentation; in *E. estherae* sp. nov. rows N6 and N16 are absent while both rows are present in *E. festivus*. In *E. estherae* sp. nov. caudal row I of P1 intercoxal sclerite is absent, while this row is present in *E. festivus*; also, row II bears long hairs in the new species and in *E. festivus* it is formed by minute spinules. The P2 sclerite differs between these two species: in the caudal surface of *E. estherae* sp. nov. row I is absent and it is present in *E. festivus*; row II bears long hairs in the new species vs minute spinules in *E. festivus*. All caudal rows of the intercoxal sclerite of P3 differ between these species. In *E. estherae* sp. nov. all rows have long hairs whereas a different pattern is present in *E. festivus*; it has hairs only in row I and rows II and III bear strong spinules. The intercoxal sclerite of P4 shows differences in both surfaces; in the frontal surface *E. estherae* sp. nov. bears hairs arranged in a semicircle while in *E. festivus* this row is straight, armed with minute spinules. On the caudal surface all rows in *E. estherae* are armed with long hairs, thus diverging from *E. festivus*, in which these rows bear spinules. The medial seta of P5 is remarkably long in the new species when compared with the outer seta (3.0); other species with long medial setae are *E. chihuahuis* (2.8) and *E. wixarica* sp. nov. (2.4); the rest of the Mexican species show values ranging between 1.0 and 2.0.

***Eucyclops ishidai* sp. nov.** Mercado-Salas and Suárez-Morales
(Figures 67–72)

Material examined

Holotype. Adult ♀ specimen dissected, mounted in glycerin sealed with Entellan (ECO-CH-Z-05049).

Allotype. Adult ♂, dissected, mounted in glycerin sealed with Entellan (ECO-CH-Z-05050).

Paratypes. Seven adult ♀♀ undissected, ethanol-preserved (ECO-CH-Z-05051). Samples from type locality collected 19 February 1989 by Marcelo Silva-Briano.

Type locality

Creek at Sierra Fria, 21 km from La Labor, Calvillo, Aguascalientes, Mexico.

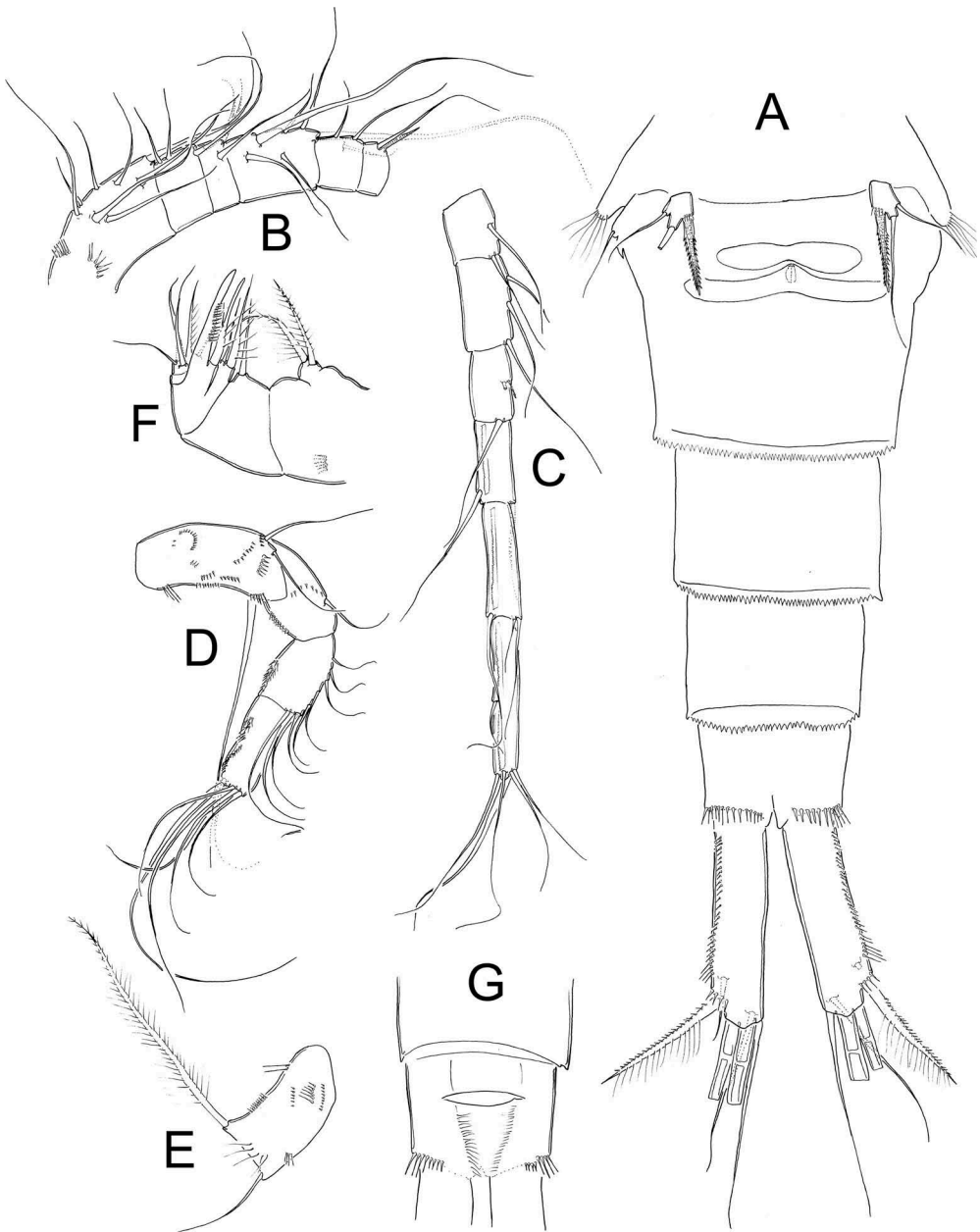


Figure 67. *Eucyclops ishidai* sp. nov. Adult female. (A) Urosome, ventral; (B) antennule, segments 1–6; (C) antennule, segments 7–12; (D) antenna, caudal; (E) antennal basis, frontal; (F) maxilla; (G) anal operculum, dorsal.

Etymology

This species is dedicated to Dr. Teruo Ishida, who pioneered the exploration of new morphological characters to distinguish closely related species of *Eucyclops*.

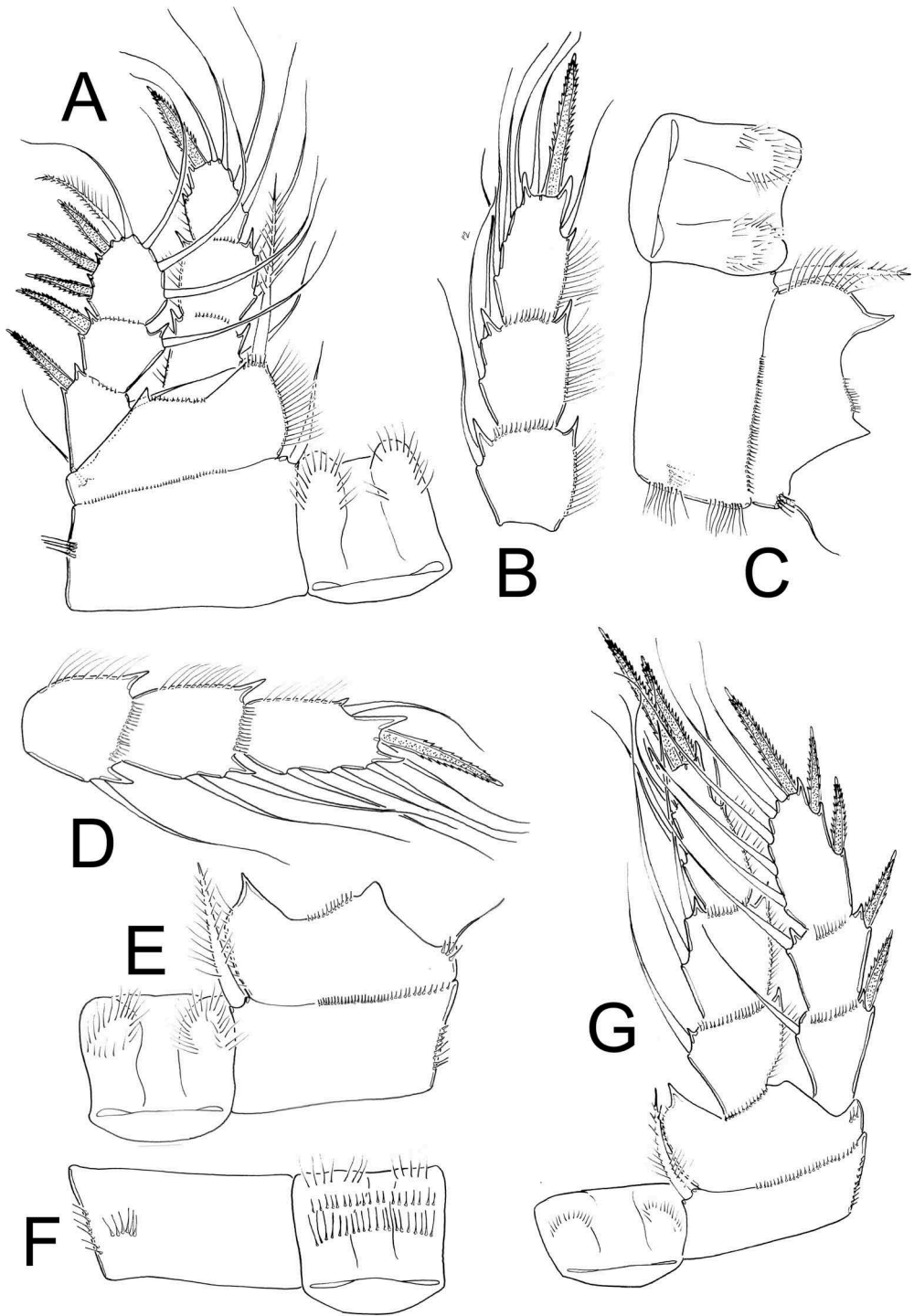


Figure 68. *Eucyclops ishidai* sp. nov. Adult female. (A) P1, frontal; (B) endopod P2; (C) coxa and intercoxal sclerite P2, frontal; (D) endopod P3; (E) coxa, basis and intercoxal sclerite P3, frontal; (F) coxa, basis and intercoxal sclerite P3, caudal; (G) P4, frontal.

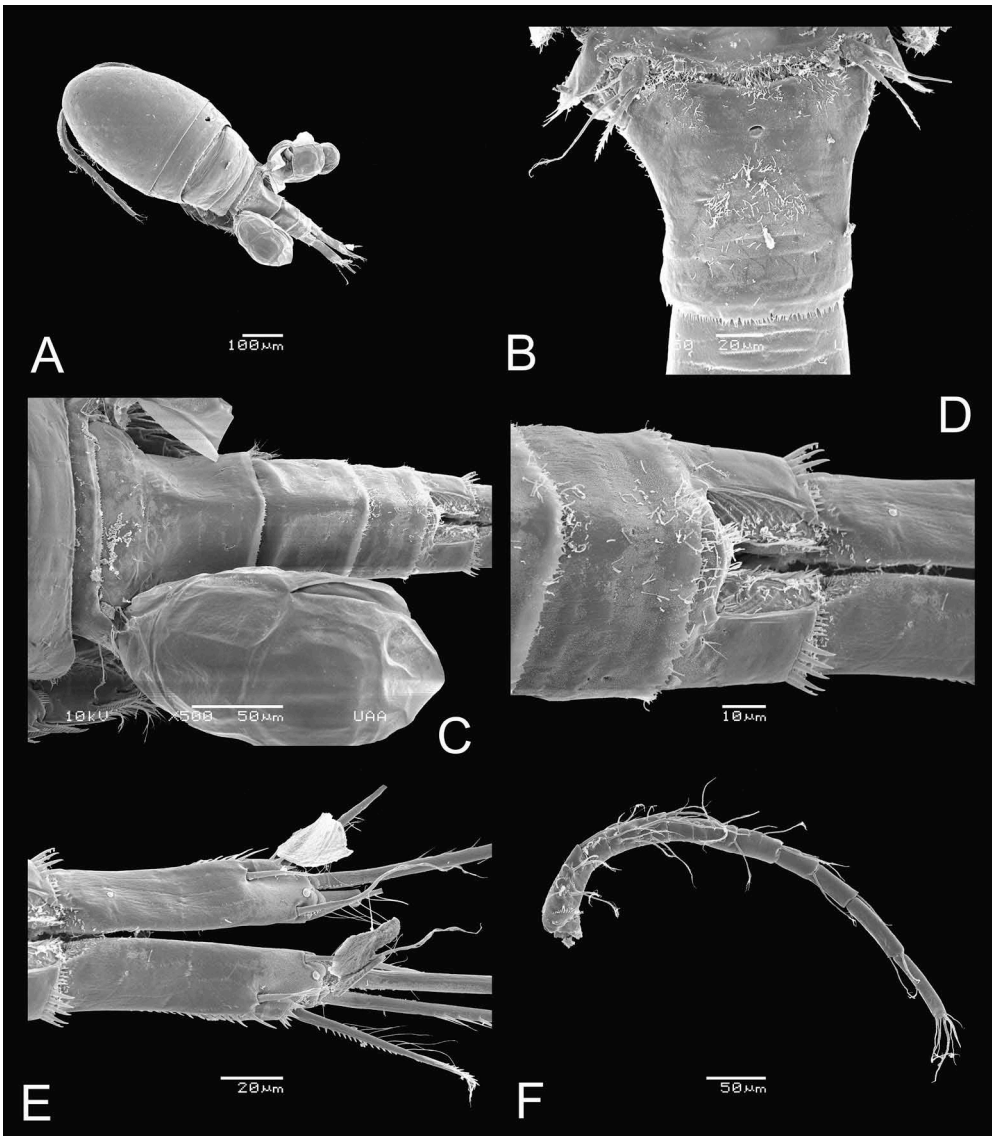


Figure 69. *Eucyclops ishidai* sp. nov. Adult female. (A) Habitus, dorsal; (B) genital somite, ventral; (C) urosome, dorsal; (D) anal operculum, dorsal; (E) caudal rami, dorsal; (F) antennule.

Distribution

Central and Northern Mexico (Aguascalientes, Zacatecas, Chihuahua).

Description

Female. Habitus as in [Figure 69A](#). Average length excluding caudal setae = 788 µm. Body surface (including caudal rami) ornamented with small pits. Prosome widest at end of cephalosome and second pediger, representing 62% of total body length, symmetrical in dorsal view. Prosomal fringes finely serrate in dorsal surface. Five-segmented

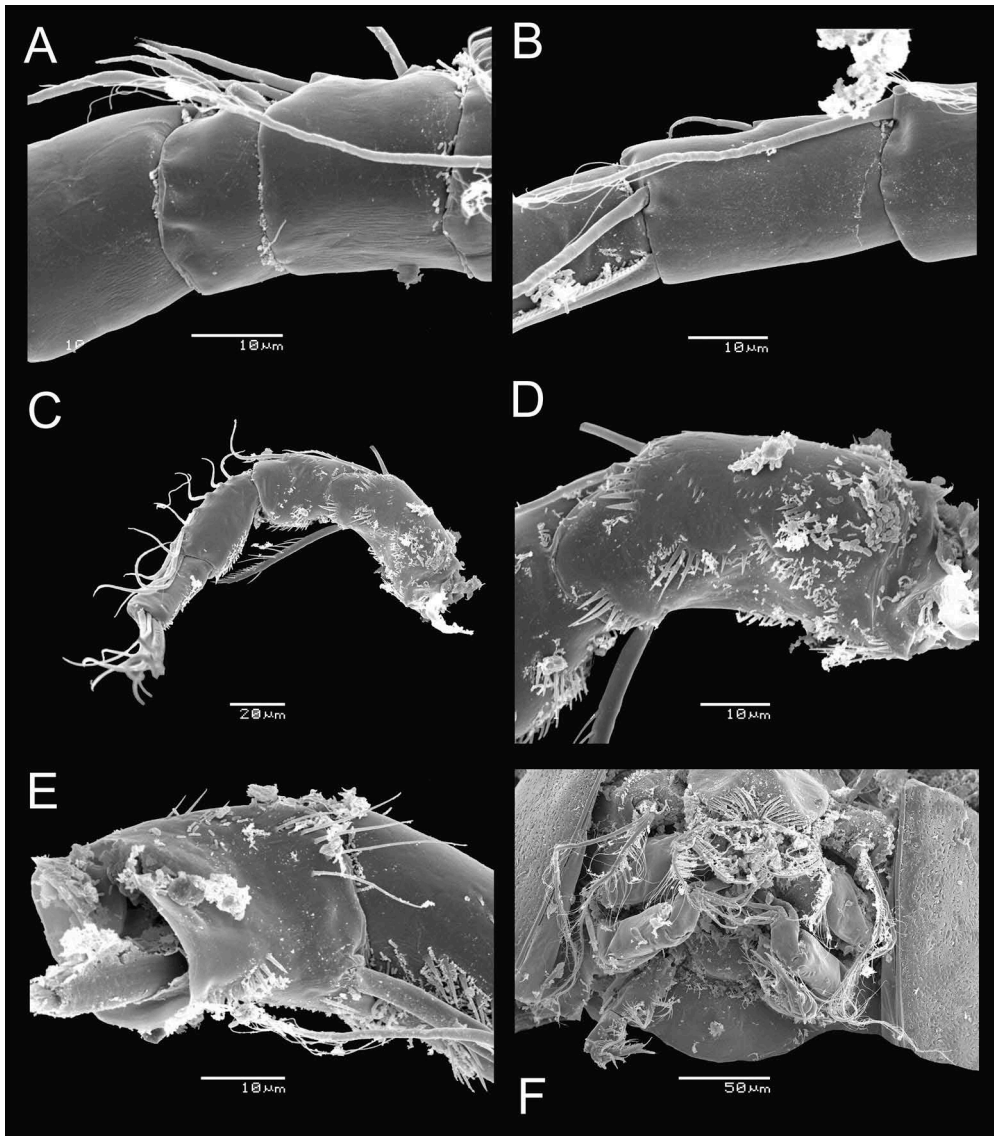


Figure 70. *Eucyclops ishidai* sp. nov. Adult female. (A) Antennule, segment 6; (B) antennule, segment 9; (C) antenna, caudal; (D) antennal basis, caudal; (E) antennal basis, frontal; (F) mouthparts.

urosome, slightly elongated; first urosomite with long setules on lateral margin; urosomal fringes serrate dorsally and ventrally; posterior margin of anal somite with row of strong spinules. Genital double somite symmetrical (Figure 69B), representing 13.4% of total body length; anterior half of genital somite slightly expanded. Seminal receptacle with rounded, slender lateral arms on posterior margin, typical of the *serrulatus*-complex. Anal somite subequal in length to preanal somite, anal operculum rounded (Figures 67G, 69D). Length/width of caudal ramus = 4.1; inner margin of caudal rami naked; strong spinules covering 64% of total length of ramus. Dorsal seta (VII) 0.8 times as long

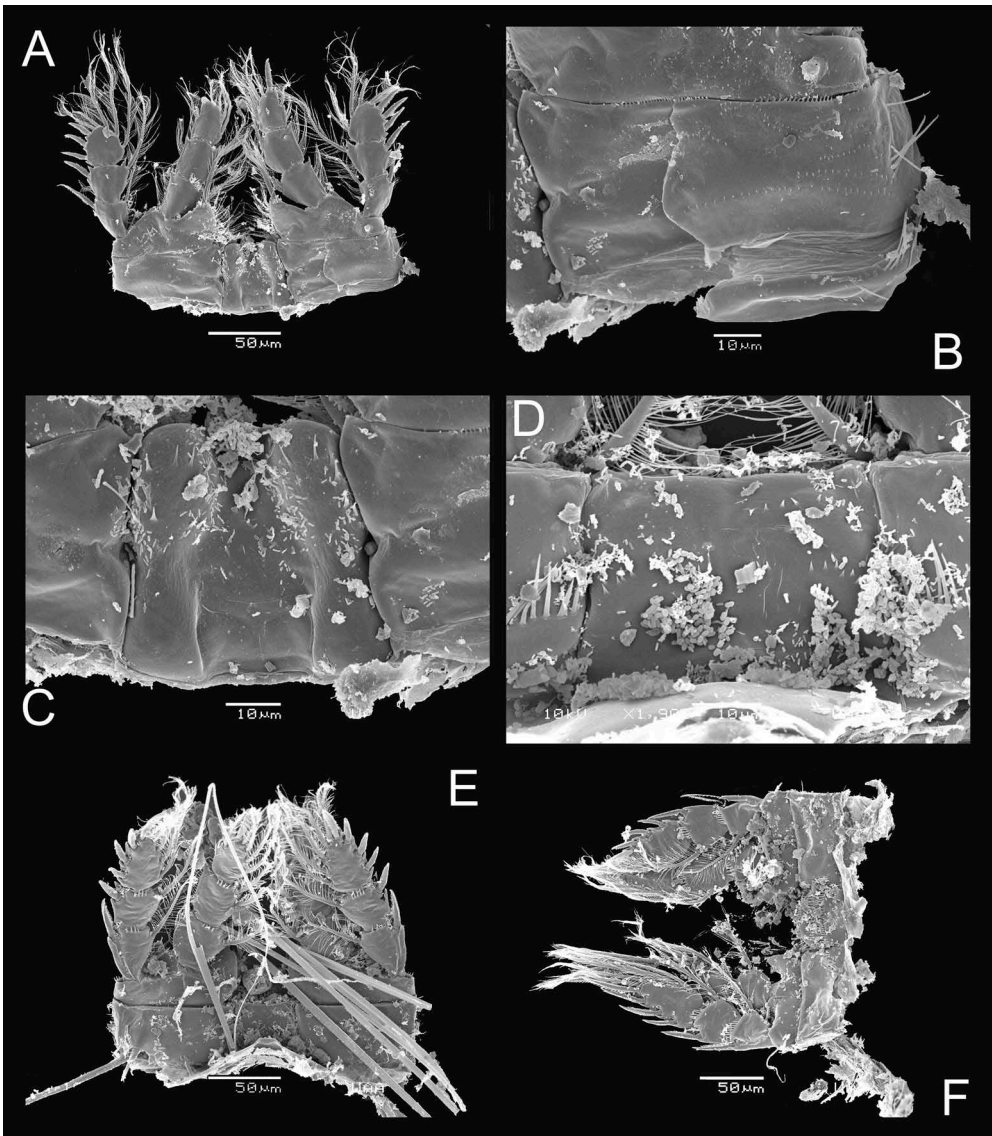


Figure 71. *Eucyclops ishidai* sp. nov. Adult female. (A) P1; (B) basis P1, frontal; (C) intercoxal sclerite P1, frontal; (D) intercoxal sclerite P1, caudal; (E) P2, frontal; (F) P3, caudal.

as caudal ramus and 1.2 times as long as outermost caudal seta (III). Length ratio of innermost caudal seta (VI)/outermost caudal seta (III) = 1.5. Lateral caudal seta (II) inserted at 76% of caudal ramus. All terminal setae plumose.

Antennule (Figures 67B–C, 69F, 70A–B). Twelve-segmented, tip barely reaching beyond posterior margin of cephalosome; smooth, slender hyaline membrane on segments 10–12, antennules ornamented with small pits. Armature per segment as follows: 1(8s), 2(4s), 3(2s), 4(6s), 5(3s), 6(1s+1sp), 7(2s), 8(3s), 9(2s+1ae), 10(2s), 11(3s), 12(7s),

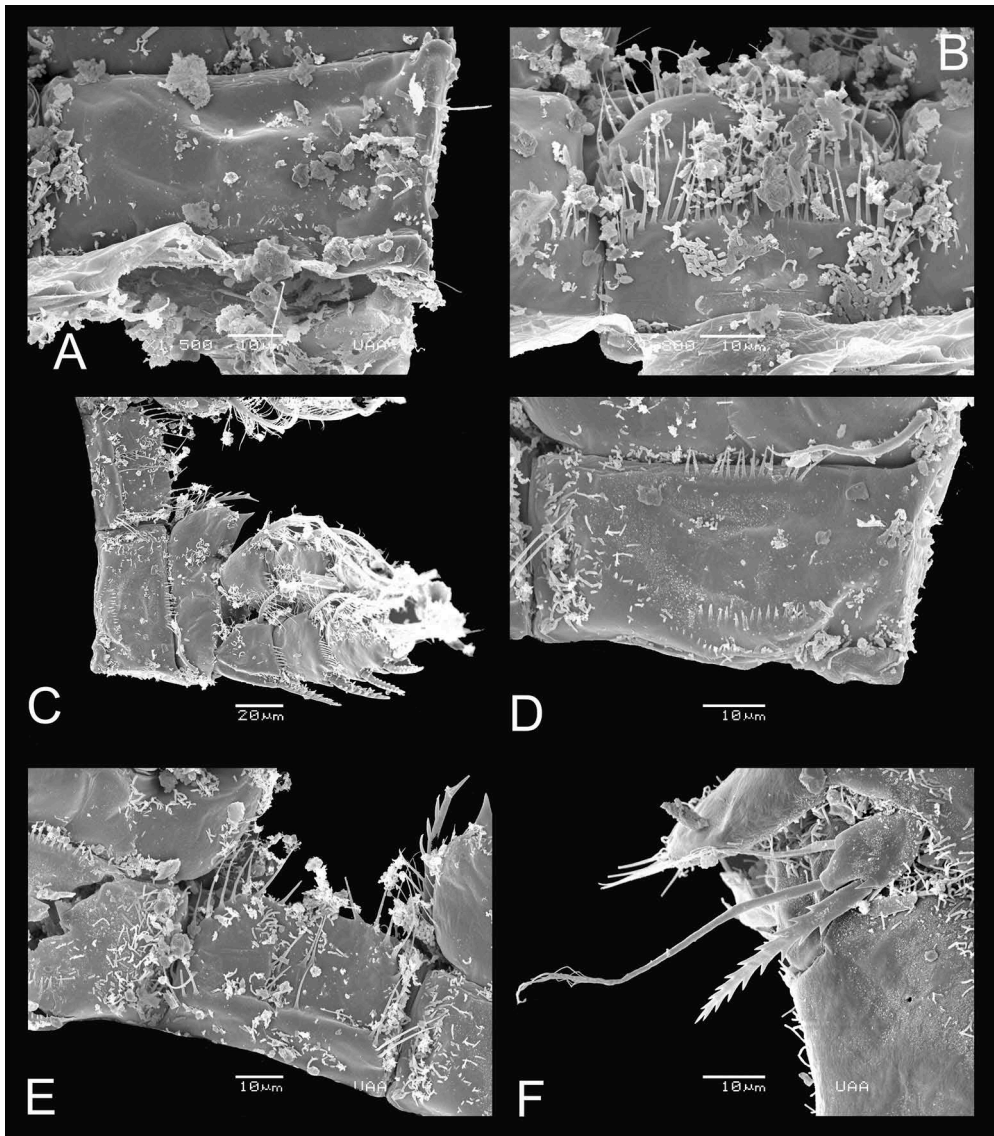


Figure 72. *Eucyclops ishidai* sp. nov. Adult female. (A) Coxa P3, caudal; (B) intercoxal sclerite P3, caudal; (C) P4, caudal; (D) coxa P4, caudal; (E) intercoxal sclerite P4, caudal; (F) P5.

Transverse row of strong spinules on first segment. Spine on sixth segment reaching medial margin of seventh segment.

Antenna (Figures 67D–E, 70C–E). Coxa (unarmed), basis (2s+Exp), plus three-segmented Enp (1s, 9s, 7s, respectively). Basis with row of spinules on frontal surface: N1(V), N2(4), N3(6), N4(6), N5(9), N15 (4), N17(10); on caudal surface: N7(5), N8(6), N9+10(8), N11(8), N12(8), N13(4), N14(7), N16(6), N22(8). Caudal surface of first Enp with B2(7). Mouthparts as in [Figure 70F](#).

Leg 1 (Figures 68A, 70A–D). Frontal surface of intercoxal sclerite with row I bearing small spinules arranged in a semicircular pattern, caudal surface with rows I and II bearing minute spinules, row I continuous, row III divided in three sections. Inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C. Row of minute spinules along insertion of basipodite. Inner basal seta (basipodal spine) reaching middle margin of Enp3, 0.7 times as long as Enp. Length/width ratio of Enp3 = 1.6, apical spine of Enp3 being 0.7 times as long as Enp.

Leg 2 (Figures 68B–C, 71E). Frontal surface of intercoxal sclerite with row I bearing hairs arranged in circular pattern; caudal row II continuous, bearing spinules. Distal margin of intercoxal sclerite with two rounded, chitinised projections, inner coxal seta biserially setulated, caudal coxal surface with spinule formula = A-B-C-D. Length/width ratio of Enp3 = 1.8, apical spine of Enp3 1.2 times as long as Enp3. No modified setae observed.

Leg 3 (Figures 68D–F, 71F, 72A–B). Frontal surface of intercoxal sclerite with row I armed with hairs arranged in a circle on each side; caudal surface with row I bearing 10–12 long and very slender spinules on each side, small gap between it (row not continuous), row II continuous with strong short spinules (17–19) and; row III continuous bearing 20–26 long but strong spinules. Distal margin of sclerite with two rounded chitinised projections. Coxa with strong biserially setulated inner coxal seta, basally with long hairs and distally with strong spinules at both edges. Caudal coxal surface with spinule formula A-B-C. Small spinules along insertion of basipodite (frontal surface). Length/width ratio of Enp 3 = 2.1, apical spine slightly shorter than Enp3 (about 0.9 times). No modified setae observed.

Leg 4 (Figures 68G, 72C–E). Distal margin of intercoxal sclerite with two low, rounded, chitinised projections. Frontal surface of sclerite with row I bearing hairs arranged in semicircular pattern in both sides of surface. Caudal row I with seven long and slender spinules on each side and a small gap in the middle, row II bearing very long spinules, divided into three sections: two on outer margins and one medial; row III bearing long, slender spinules, also divided into three sections, two on outer margins and one in medial margin. Frontal surface of coxa with row of small spinules at insertion of Bsp. Inner coxal spine with heterogeneous ornamentation; proximal inner margin with long hairs and with strong spinules distally, outer margin with one distal spinule basally setulated, gap in middle margin. Caudal coxal surface with spinule formula = A-C + D-E-F-H-J. Length/width ratio of Enp3 = 3.1, inner spine of Enp3 as long as Enp3 (1.0), length ratio of outer spine of Enp3/length Enp3 = 0.7; length ratio inner/outer spines of Enp3 = 1.4. Lateral seta of Enp3 inserted at 67% of segment. No modified setae observed.

Leg 5 (Figure 72F). Free segment subrectangular, 1.1 times as long as wide, bearing one strong inner spine and two setae, medial seta 1.7 times longer than outer seta and 1.6 times longer than inner spine. Inner spine 2.3 times longer than segment.

Male. Unknown.

Remarks. Records of *E. ishidai* sp. nov. were previously assigned to *E. pectinifer* (Mercado-Salas and Suárez-Morales, 2012); however, significant differences were found among these closely related species. The two species share the presence of N1 bearing long hairs on the frontal surface of antennal Bsp and the presence of spinules on N2 and the absence of N6, while they differ because of the presence of N22 in *E. ishidai* sp. nov. while it is absent in *E. pectinifer*. Both species share as well a typical seminal receptacle of the *serrulatus*-complex and a rounded and smooth anal operculum. Main differences can be found in the ornamentation of the intercoxal sclerites of the swimming legs. *Eucyclops ishidai* sp. nov. presents an intercoxal sclerite of P1 with rows I and II present and bearing minute spinules, while in *E. pectinifer* row I is absent and row II bears long spinules. The intercoxal sclerite of P2 is similar in both species, row I being absent and row II present; in *E. ishidai* sp. nov. it is represented by small spinules while in *E. pectinifer* it bears long hairs. Another species that seems to be closely related to *E. ishidai* sp. nov. is *E. tziscaao*. In the former species the anal operculum is rounded and smooth, while in *E. tziscaao* it is serrated. Ornamentation of the frontal surface of the antennal basis of *E. ishidai* sp. nov. is more complex than it is in *E. tziscaao*. In *E. ishidai* sp. nov. rows N7, N13, N14, N16, N18 and N22 are present, while in *E. tziscaao* they are absent. Ornamentation of the intercoxal sclerites is similar in both species.

Morphometrics and binary characters

In order to test the taxonomic value of the morphometric variables traditionally used in the separation of the species (Lindberg 1955; Reid 1985; Suárez-Morales 2004; Alekseev and Defaye 2011) we performed a statistical analysis using boxplots with the aid of the statistical program R 3.0.2. (R Development Core Team 2008). We included 22 morphometrical characters measured in the 17 species included herein. We observed (Figure 73) a lack of significant variation and a remarkable overlap of data in the morphometric characters used in the separation of species of the genus. The only characters that appear to have a consistent variation among species and that could be deemed useful in the separation of species are the length/width ratio of the caudal ramus (2), the length/width ratio of P4 Enp3 (14) and the spine and setae proportions of the fifth leg armature (19–22), but even in these characters, variation is relatively weak, so they should not be used as defining characters.

The cluster analysis was performed using Euclidean distance in order to classify and verify dissimilarities among species in relation to the shared characters (Figure 73). It included all characters (morphometric and binary) examined. The cluster in Figure 73B shows the results obtained using morphometrical data only.

Discussion

After performing this upgraded taxonomic analysis of the Mexican fauna of *Eucyclops*, we have evidence to state that all the species known to be distributed in Mexico belong to the *serrulatus*-group, based on the diagnostic characters established by Alekseev and Defaye (2011). Additional to these basic characters, we found well-conserved patterns in the ornamentation of the swimming legs that could be a reliable tool to distinguish even closely related species. In one of the few studies that explore

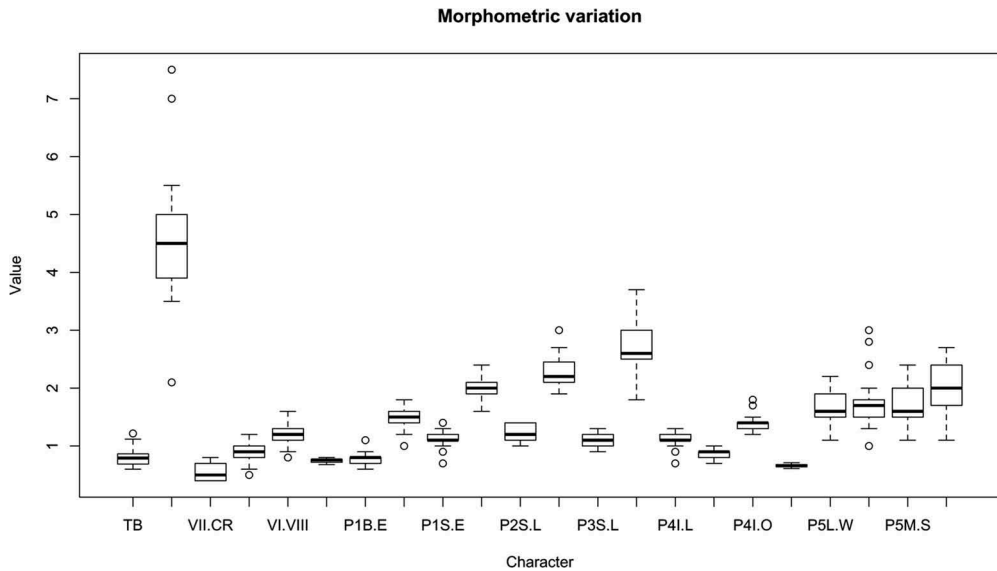


Figure 73. Boxplot of morphometric variation of Mexican species of *Eucyclops*. Abbreviations on the x-axis indicate the character used: TB, total body size; VII/CR, proportion seta VII/length caudal rami; VI/III, proportion seta VI/seta III; P1B.E, basipodal spine/Enp P1; P1S.E, spine/W Enp3 P1; P2S.L, spine/Enp P2; P3S.L, spine/Enp3 P3; P4I.L, inner spine/L Enp3 P4; P4I.O, inner spine/outer Enp3 P4; P5L.W, proportion length/width; P5M.S, proportion medial seta/inner spine.

the taxonomic value of the ornamentation patterns of all the swimming legs, Einsle (1985) emphasised the uniformity of such patterns within species and outlined their remarkable interspecific variations. Furthermore, Einsle (1985) stressed the taxonomic importance of the presence of rows rather than the number of elements in each row, which often varies among individuals. Our observations support these statements; in addition, the type of elements in each row is constant within species and varies among species. We consider the type of elements the presence of hairs, hair-spinules and spinules. Based on our analysis, we can advance the following micro-characters as the most stable and reliable in *Eucyclops*: (1) coxal formula A-B-C on the caudal surface of P1; (2) frontal row I of the P1 intercoxal sclerite; (3) caudal row II of intercoxal sclerite (P1), its position always at the same level of row C of coxa, and the presence or absence of row I; (4) coxal formula A-B-C-D on the caudal surface of P2; (5) row I of the frontal surface of P2 always close to round, chitinised projections; (6) caudal row II always present at the same level as row D of the coxal surface and, in some species, an additional row I above row II; (7) coxal formula A-B-C on the caudal surface of P3, (8) row I of the frontal surface of the intercoxal sclerite of P3 close to round, chitinised projections; (9) caudal surface of the intercoxal sclerite of P3 with three rows, the first (row I) close to the proximal margin, the second (row II) below the first and the third at the same level as row C of the coxal surface; (10) caudal surface of the coxa in P4 as described by Alekseev and Defaye (2011); (11) row I of the frontal surface of the intercoxal sclerite P4; (12) caudal surface with pattern as described by Alekseev and Defaye (2011) with rows I, II and III.

With the exception of caudal row I of the intercoxal sclerite of P1 and P2, these characters are always present in *Eucyclops* but the type of ornamentation elements varies among species. Previous surveys on the ornamentation patterns of coxae and intercoxal sclerites have been performed analysing the fourth leg and the P1 of some genera (Karaytug 1999). This is the first time that ornamentation patterns of all swimming legs (P1–P4) are analysed and compared. Based on the ornamentation of P4, Hołyńska (2000) recognised different lineages in *Mesocyclops* that were geographically consistent; she also outlined the relevance of these patterns as signals of evolution in copepods. According to Huys and Boxshall (1991), Karaytug and Boxshall (1999) and Hołyńska (2000), the ornamental patterns in the coxal plate of the fourth swimming leg could represent a key character in the recognition between males and females of the same species, because the male antennules and the female coxae are in contact during mating. This might be true in *Eucyclops*; this ornamentation pattern could be a key factor in intraspecific sexual recognition. Additional observations of the Mexican material revealed that when caudal row III of the P4 intercoxal sclerite is armed with hairs (always long), the three caudal rows of P3 will have hairs too; also, when caudal row I of P4 bears spinules (small or long), at least two of the three rows present at the caudal surface of the intercoxal sclerite of P3 will bear spinules as well. The only species with long hairs in caudal row I of P4 are *E. wixarica*, *E. defayeeae* and *E. chihuahuensis*. In the taxonomic literature on American species of *Eucyclops*, the ornamentation elements of several species have been described as bearing long hair–spinules on this row, but we consider that some of them refer to long spinules and that should be analysed in order to determine if this pattern is constant among species.

Most of the species distributed in Mexico – with the exception of *E. mittmanni* and *E. tziscao* – have row N18 on the frontal surface of the antennal basis. This structure should be reviewed in the rest of the American *Eucyclops* because it could represent a character with the potential to separate Nearctic/Neotropical species from those of Palearctic origin (in *E. serrulatus* this row is absent, as it is in many European, African and Asian species; Ishida 1997, 2001, 2002, 2003; Alekseev et al. 2006; Alekseev 2008, 2010; Alekseev and Defaye 2011). Our analysis of the ornamentation patterns of the antennal basis allowed us to add rows of spinules to the pattern proposed by Alekseev et al. (2006) and Alekseev and Defaye (2011). Some of the Mexican specimens examined have additional rows that do not fit in the previously described patterns and, thus, were important to identify groups of species.

The use of morphometric characters in the delimitation of species of *Eucyclops* has been proven to have a limited taxonomic value, and has led to underestimation of the biodiversity of the genus not only in Mexico but on the entire continent. Many species have been recorded under names of presumed 'cosmopolitan' species such as *E. elegans*, *E. pectinifer*, *E. bondi* and *E. pseudoensifer*. The examination of the ornamental patterns present in the four swimming legs and the antennal basis is here advanced as a more reliable set of data to achieve more accurate species delimitation on the continent. In addition, frequently ignored male-related characters such as (1) the presence of modified setae on the antennule and (2) the shape of the sixth leg are deemed useful when differences in females are subtle. An example of this situation is represented by records of *E. bondi*; since its description (Kiefer 1934) it has been recorded in Central America, the Antilles and Mexico by several authors (Collado et al.

1984; Reid 1992; Suárez-Morales et al. 1996, 2010; Grimaldo-Ortega et al. 1998; Suárez-Morales and Reid 1998; Bruno et al. 2005; Dussart and Defaye 2006; Gaviña and Aranguren 2007; Elías-Gutiérrez et al. 2008; Mercado-Salas 2009; Suárez-Morales and Walsh 2009; Mercado-Salas et al. 2012; Mercado-Salas and Suárez-Morales 2012). However, based on an analysis of the type material and an examination of the ornamentation patterns of the antennal basis and swimming legs, we concluded that *E. bondi* is not distributed in Mexico and records of this species could be assigned to *E. tziscao*, *E. defayae* or *E. cuatrociénegas*. Records from southern Mexico appear to be assignable to *E. tziscao*, those from Central Mexico could correspond to *E. defayae* and the northern records could represent *E. cuatrociénegas*. The types of environments where these species were recorded differ and could represent an ecological niche separation among these species: *E. tziscao* is found in permanent water bodies surrounded by oak–pine forest, *E. defayae* dwells in ephemeral ponds in semi-arid environments and *E. cuatrociénegas* is distributed in arid environments in the Chihuahuan Desert.

According to Alekseev (pers. comm. NFM-S), *Eucyclops serrulatus* s. str. is present in Mexico as a result of recent introductions by human activities; however, we did not find the strict form but two new, closely related species instead. Previous Mexican records published under the name of *E. serrulatus* are now correctly re-assigned. *Eucyclops wixarica* sp. nov. and *E. alekseevi* sp. nov. are two of the species previously recorded as *E. serrulatus*, mainly because of the possession of row N2 armed with long hairs. The other two species bearing long hairs in the frontal row N2 are *E. elegans* and *E. mittmanni* sp. nov., but these were not assignable to *E. serrulatus* s. str. because of their remarkably long caudal rami and differences in the P6 of males. Both species are distributed in the central–northern region of Mexico. *Eucyclops solitarius* was described by Herbst (1962) from a water body in Brazil and then synonymised with *E. elegans* (Dussart and Defaye 2006), but in the light of the new, upgraded taxonomic standards set in the genus, specimens from the type locality of *E. solitarius* should be revised to reveal whether the south American form of *E. elegans* is assignable to *E. solitarius*.

Historical records of *E. pectinifer* in Mexico were reassigned to six closely related species that are distinguishable from each other: *E. pectinifer*, *E. cuatrociénegas*, *E. alekseevi* sp. nov., *E. defayae* sp. nov., *E. ishidae* sp. nov. and *E. prionophorus*. We did not find a consistent distributional pattern among these species, but the southernmost record of this group in central Mexico suggests that these species have Nearctic affinities. Records of *E. pseudoensifer* in Mexican territory seem to be associated with *E. chihuahuensis*, *E. wixarica* and *E. estherae*, all with northern distributions and thus having Nearctic affinities. Geographic disjunction between populations of *E. pseudoensifer* and *E. chihuahuensis*, *E. wixarica* sp. nov. and *E. estherae* sp. nov. confirms different origins of these species, the first with Neotropical affinities (distributed in Central and South America) and the latter species with Nearctic affinities (central–north of Mexico). The species with Southern distributions were *E. torresphilipi* and *E. angeli*, both deemed endemic to their type localities; *E. torresphilipi* was recently recorded from lakes in the state of Puebla (pers. comm. Barrera-Moreno 2012), but this record should be checked. If this record is confirmed, the distribution of this species will be expanded to central Mexico. It is noteworthy to mention that species of *Eucyclops* were absent from samples obtained in northwest Mexico, including the Baja California Peninsula and the states of

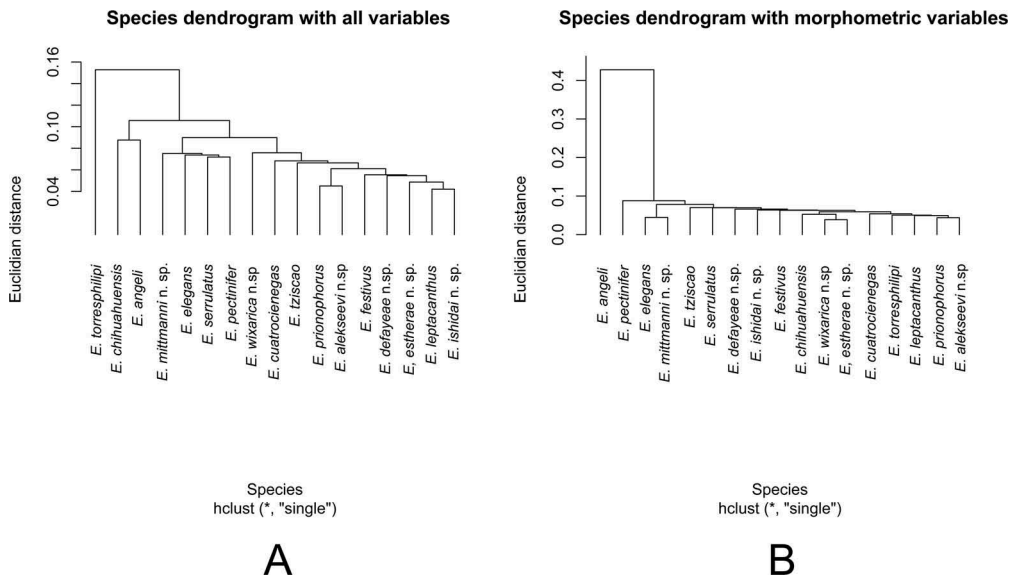


Figure 74. Cluster analysis of Mexican species of *Eucyclops*. (A) Dendrogram obtained using all variables; (B) dendrogram obtained using morphometric values.

Sinaloa and Sonora. Thus, it is probable that the Sierra Madre Occidental mountain belt and the Gulf of California represent a geographic barrier limiting the distribution of *Eucyclops* in Mexico; it is necessary to obtain more samples from this area in the country to confirm this assumption.

We performed an analysis of variables using boxplots in order to graphically analyse the variability of the characters examined. We emphasised the evaluation of morphometrical characters traditionally used in the separation of species of *Eucyclops*. Most of the characters have weak variations and thus are not informative in species delimitation; extreme values (Figure 74) were obtained in some morphometric characters, like the total length of the caudal ramus. The species that represent these extreme values were *E. mittmanni* sp. nov., *E. elegans* and *E. angeli*, the first two species with remarkably long caudal rami and the third with very short caudal rami. Differences between the cluster obtained using morphometric characters and that incorporating both binary and morphometric characters are important to highlight, but the groups obtained are not geographically consistent. One of the explanations for this is the lack of material from larger geographical areas in Mexico which may contain forms that could be used in searching biotic components. It is also important to mention that all species (in both clusters) appear as independent entities, suggesting that the new species described herein are well supported and that it is possible to separate them from their congeners. The cluster with all characters (morphometric and binary) provided a clearer separation among species, thus supporting the idea that the use of ornamental patterns is an important tool to species delimitation in the genus.

It is also clear that the diversity of the genus in Mexico was underestimated; prior to this survey, the number of species of *Eucyclops* in Mexico was 16 (including *E. agilis*, *E. serrulatus* and *E. speratus*); however, records of *E. breviramatus*, *E. bondi*, *E. conrowae*,

E. delachauxi, *E. speratus* and *E. pseudoensifer* were determined incorrectly, and thus these species are not distributed in the country. The addition of eight new species and the confirmation of nine species previously recorded in Mexico resulted in an updated figure of 17 species dwelling in the country. Future taxonomic works in areas of Mexico that are currently unknown or subsampled are expected to reveal more undescribed species.

KEY TO SPECIES OF *EUCYLOPS* DISTRIBUTED IN MEXICO

1. Frontal surface of antennal basis with rows N1 and N2 both bearing hair-like elements..... 2
 - Frontal surface of antennal basis with row N1 bearing hairs/spinules and N2 with spinules..... 6
2. Frontal surface of antennal basis with N1 and N2 fused (see [Figures 2E, 6F](#))..... *E. elegans*
 - Frontal surface of antennal basis with N1 and N2 clearly separated (see [Figure 55E](#)) 3
3. Caudal surface of intercoxal sclerite of P4 with row I bearing hairs; rows I, II and III of caudal surface of intercoxal sclerite of P3 with hairs..... 4
 - Caudal surface of intercoxal sclerite of P4 with row I bearing spinules; rows I, II and III of caudal surface of intercoxal sclerite of P3 with spinules..... 5
4. Caudal surface of intercoxal sclerite of P1 and P2 with rows I and II present and represented by short hairs. Proportion of innermost caudal seta VI/outermost caudal seta III less than 1.0 times and propoportion of medial seta/outer seta of P5 always less than 1.5 times..... *E. wixarica* sp. nov.
 - Caudal surface of intercoxal sclerites of P1 and P2 only with row II present (row I absent) with long hairs. Proportion of innermost caudal seta VI/outermost caudal seta III more than 1.5 times and propoportion of medial seta/outer seta of P5 always more than 3.0 times..... *E. estherae* sp. nov.
5. Caudal surface of intercoxal sclerite of P1 with rows I and II present and bearing small spinules. Caudal surface of intercoxal sclerite of P2 bearing small spinules, row I absent. Caudal surface of antennal basis with N19 present. Body length < 1200 μm , caudal rami elongated, over 6.0 times longer than wide..... *E. mittmanni* sp. nov.
 - Caudal surface of intercoxal sclerite of P1 with one row (II) only, row I absent. Caudal surface of intercoxal sclerite of P2 with rows I and II present, bearing small spinules. Caudal surface of antennal basis with N19 absent. Body length $\approx 800 \mu\text{m}$, caudal rami under 5.0 times longer than wide, not elongated..... *E. defayae* sp. nov.
6. Caudal surface of intercoxal sclerite of P4 with row I with hairs; rows I, II and III of caudal surface of intercoxal sclerites of P3 with hairs in all cases; frontal surface of antennal basis with N1 bearing long and strong spinules..... *E. chihuahuensis*
 - Caudal surface of intercoxal sclerite of P4 with row I with spinules; rows I, II and III of caudal surface of intercoxal sclerite of P3 bearing spinules or a combination of some

- rows with hairs; frontal surface of antennal basis with N1 bearing long hairs or spinules 7
7. Caudal surface of intercoxal sclerite of P1 with rows I and II present, both rows bearing small or minute spinules 8
- Caudal surface of intercoxal sclerite of P1 naked or only with row II present, with small spinules..... 11
8. Caudal surface of intercoxal sclerite of P2 with rows I and II present, both rows bearing small or minute spinules 9
- Caudal surface of intercoxal sclerite of P2 with only one row (II) present, with small spinules..... 10
9. Seminal receptacle with the typical shape of the *serrulatus*-complex (Figure 2A); antennal basis with rows N6 and N13 present. Body length more than 800 μm , proportion of dorsal seta VII/outermost caudal seta III less than 0.6 times, free element of P5 elongated about 2.1 times longer than wide *E. festivus*
- Seminal receptacle with posterior margin with a sinuous sac (Figure 9A), antennal basis with N6 and N13 absent. Body length not more than 700 μm , proportion of dorsal seta VII/outermost caudal seta III almost 1.0 times, free element of P5 not elongated about 1.5 times longer than wide..... *E. prionophorus*
10. Seminal receptacle with the typical shape of the *serrulatus*-complex (Figure 2A); anal operculum serrated; caudal surface of antennal basis with row N7 present, but rows N13, N14, N16 and N22 absent. Body length not more than 650 μm ; apical spine of Enp3 P1 elongated 2.1 times longer than Enp3 P1; free segment of P5 slightly elongated 2.1 times longer than wide..... *E. tziscao*
- Seminal receptacle normal with the typical shape of the *serrulatus*-complex; anal operculum smooth; antennal basis with row N17 absent but rows N13, N14, N16 and N22 present. Body length more than 750 μm ; apical spine of Enp3 P1 small, about 0.7 times longer than total length of Enp3 P1; free segment of P5 bot elongated 1.1 times longer than wide..... *E. ishidai* sp. nov.
11. Caudal surface of intercoxal sclerite of P2 with rows I and II present; caudal rami remarkably short (2.1 times longer than wide)..... *E. angeli*
- Caudal surface of intercoxal sclerite of P2 with only one row (II) present; caudal rami more than 3.5 times longer than wide 12
12. Frontal surface of antennal basis with N1 bearing spinules, anal operculum serrated, slightly rounded..... *E. leptacanthus*
- Frontal surface of antennal basis with N1 bearing long hairs, anal operculum smooth and rounded, with or without gap at middle section..... 13
13. Caudal surface of intercoxal sclerite of P3 with row I bearing long hairs. Coxa of P4 with row J divided into three sections with small spinules (Figure 27J); anal operculum smooth and rounded but with small gap at middle section (Figure 27A)..... *E. torresphilipi*

- Caudal surface of intercoxal sclerite of P3 with row I bearing spinules. Coxa of P4 with row J normal (one group only; [Figure 10H](#)); anal operculum smooth and rounded but without gap at middle section..... 14
- 14. Seminal receptacle normal with the typical shape of the *serrulatus*-complex ([Figure 2A](#)); antennal basis with rows N6, N13 and N14 present, row N22 absent. Body length more than 800 μm ; free segment of P5 elongated, about 2.2 times longer than wide; medial and outer setae of P5 about the same length; inner spine of P5 particularly short, about the length of or slightly longer than the segment (1.0–1.3 times)..... *E. cuatrocienegas*
- Seminal receptacle with posterior margin with a sinuous sac ([Figure 9A](#)); antennal basis with N22 present but N6, N13, N14 absent. Body length not more than 750 μm ; free segment of P5 subrectangular, about 1.5 times longer than wide; P5 with medial seta clearly longer than outer seta (about 1.5 times). Inner spine of P5 about 2.0 times longer than free segment..... *E. alekseevi* sp. nov.

Acknowledgements

This work is part of the first author's (NFM-S) doctoral thesis, developed at El Colegio de la Frontera Sur (ECOSUR). This contribution was supported by CONACyT project 133404-Investigación Científica Básica 2009. The support and comments of members of the thesis committee, Drs. Martha A. Gutiérrez-Aguirre, and David González-Solís are deeply appreciated by the authors of this work. We gratefully acknowledge the support of Araceli Adabache, Laboratorio de Ecología, Universidad de Aguascalientes, for help and advice in the SEM processing and examination of the specimens. Also, we thank MSc Laura Fernández-Pérez for her kind help in the statistical analysis of the numerical data presented. Cuahutemoc Ruíz Pineda helped in polishing the final edition of the SEM photographs. We gratefully acknowledge the key support of Dr. Hans-Walter Mittmann (Staatliches Museum für Naturkunde, Karlsruhe), Dr. Danielle Defaye (Muséum National d'Histoire Naturelle, Paris), Drs Frank D. Ferrari and Chad Walter (National Museum of Natural History Smithsonian Institution, Washington, DC), Victor Alekseev (Russian Academy of Sciences) and Rosa María Hernández (El Colegio de la Frontera Sur, Chetumal) for loaning the material examined in this work. We also acknowledge the help, time and patience of Jörg Pertzelt and Gerald Islebe in translating the original descriptions of species from German to English.

Disclosure statement

No potential conflict of interest was reported by the authors.

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