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(Calanoida, Cyclopoida and Harpacticoida)
from the Chihuahuan Desert

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— Martha A. Gutiérrez-Aguirre

Preface

This work presents the taxonomy, morphology and distribution of the free-living, freshwater copepods that inhabit ephemeral aquatic habitats in one binational reserve known as the Chihuahuan Desert. This desertic zone is part of the large North American biogeographic region called Altiplano Mexicano, which is shared by Mexico and the United States. A joint effort was made to synthesize findings about the diversity of the copepods that inhabit this peculiar geographic area (in North America), where aquatic systems are scarce and ephemeral; this group of microcrustaceans has received little attention in these extreme aquatic habitats. This work represents the largest effort to study this group in desert-related aquatic habitats to date.

This document is the result of collaborative work among colleagues from different institutions in Mexico (Universidad de Quintana Roo, Cozumel and El Colegio de la Frontera Sur, Chetumal) and the United States (University of Texas, El Paso). It includes a taxonomic and morphological assessment of 33 species, three of which were unknown to science prior to the completion of the work.

The copepod fauna of freshwater systems in the Chihuahuan Desert presented in this book was surveyed with samples collected between 2003 and 2007 (Table I). Approximately one hundred biological samples were examined. The samples were obtained from habitats including natural lakes, ephemeral waters, springs, and reservoirs in the 3 eco-regions of this desert: this area is considered to be of high priority among hydrological basins of northern Mexico and southwestern Texas; thus, some of the areas considered here are protected to varying degrees. Finally, due to the geographic location of the Chihuahuan Desert and the sampling effort, a latitudinal fringe that represents the transition between Nearctic and Neotropical regions of approximately 340,000 km^2 was covered. This area is equivalent to 60% of the Iberian Peninsula surface.

In this book, we present updated information about the most abundant and diverse group of crustaceans on the planet. The analysis presented in this book was performed by authors who have worked in a biogeographical area that has remained virtually unexplored but at the same time is considered megadiverse. This book profusely describes and illustrates this biodiversity, focusing on freshwater copepods.

In the first chapter, information about the genera of freshwater copepods living in Mexico is synthesized: the manuscripts, authors and species richness described and inventoried throughout the country are summarized analytically. The basic anatomy useful for the classification of free-living copepods is described and profusely illustrated with scanning electron microscopy (SEM).

A taxonomic analysis of several species of freshwater copepods inhabiting the Chihuahuan Desert is carried out in the second chapter. The analysis of each species considers detailed morphological descriptions, illustrations of these features with SEM or line drawings, a list of verified records and literature, and a distribution summary.

The third chapter presents a biogeographical analysis of the species described and inventoried in the Chihuahuan Desert, considering both bibliographical and basic research.

Table I. Localities and selected habitat features of copepod species found in the Chihuahuan Desert. nd = no data available.

Site	Species	Collection Date	Latitude	Longitude	Temperature (°C)	pH	Conductivity (μmScm^{-1})
Presa Chihuahua, Chihuahua, México	*Leptodiaptomus novamexicanus* (Herrick, 1895)	16. IV.2006	28.5762166	-106.1711833	18.7	8.37	366
		06.I.2006			10.3	8.08	352
	Eucyclops chihuahuensis Suárez-Morales and Walsh, 2009	16.IV.2006			18.7	8.37	366
Presa La Boquilla, Chihuahua, México	*Leptodiaptomus siciloides* (Lilljeborg, 1889)	16.IV.2006	27.5361333	-105.4011333	23.0	8.64	286
	Leptodiaptomus novamexicanus (Herrick, 1895)	16.IV.2006					
Lago Colina, Chihuahua, México	*Leptodiaptomus novamexicanus* (Herrick, 1895)	16.IV.2006	27.5724000	-105.4004666	20.2	8.29	296
	Aglaodiaptomus clavipes (Schacht, 1897)	06.I.2006			15.4	7.78	516
	Eucyclops conrowae Reid, 1992	06.I.2006					
Presa Francisco I. Madero, Chihuahua, México	*Leptodiaptomus siciloides* (Lilljeborg, 1889)	06.I.2006	28.1626166	-105.6321833	13.9	7.90	281
Los Hundidos, Coahuila, México	*Leptodiaptomus connexus* (Light, 1938)	09.I.2006	26.8711666	-102.0204166	13.5	8.05	735
	Macrocyclops albidus albidus (Jurine, 1820)	09.I.2006					
Poza Tortugas, Coahuila, México	*Eucyclops cuatrocienegas Suárez*-Morales and Walsh, 2009	07.VII.2006	26.9314500	-102.1247000	27.7	7.82	1600
El Refugio bridge, Cerro Torreón, Coahuila, México	*Metacyclops deserticus* Mercado-Salas and Suárez-Morales, 2013	10.X.1981	25.583785	-102.750573	nd	nd	nd
Balmorhea Lake, Reeves Co, Texas, USA	*Eurytemora affinis* (Poppe, 1880)	31.III.2006	30.9663333	-103.7134000	16.9	8.16	3503
	Macrocyclops albidus albidus (Jurine, 1820)	24.II.2007			11.7	8.42	3297
	Acanthocyclops americanus (Marsh, 1893)	31.III.2006			16.9	8.16	3503
	Mesocyclops edax (Forbes, 1891)	31.III.2006					
	Paracyclops poppei (Rehberg, 1880)	31.III.2006					

Site	Species	Collection Date	Latitude	Longitude	Temperature (°C)	pH	Conductivity (μmScm^{-1})
Roadside sample Rio Bravo floodplain, Hudspeth Co., Texas, USA	*Acanthocyclops americanus* (Marsh, 1893)	19.X.2005	30.8551333	-105.3608833	nd	nd	nd
Indian Hotsprings, Soda Spring, Hudspeth Co., Texas, USA	*Microcyclops dubitabilis* Kiefer, 1934	19.X.2005	30.8276388	-105.3173055	21.8	7.54	5174
Diamond Y Spring, Pecos Co., Texas, USA	*Eucyclops festivus* Lindberg, 1955 *Paracyclops poppei* (Rehberg, 1880)	31.III.2006 31.III.2006	31.0010666	-102.9242833	20.2	6.87	7271
Diamond Y Roadside Seep, Pecos Co., Texas, USA	*Cletocamptus sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004 *Nitokra* cf. *lacustris* (Schmankewitsch, 1875)	31.III.2006 31.III.2006	31.0088000	-102.9225333	21.8	7.90	12780
East Sandia Spring, Reeves Co., TX, USA	*Leptocaris stromatolicolus* Zamudio-Valdéz and Reid, 1990	31.III.2006	30.9909666	-103.7288666	20.1	7.08	5206
LK Holloman, Otero Co., New Mexico, USA	*Apocyclops dimorphus* (Kiefer, 1934)	17.XI.2006	32.8074500	-106.1227833	9.6	8.95	24550
Ernst Canyon tinaja # 7, Big Bend National Park, Brewster Co., Texas, USA	*Tropocyclops prasinus* s. str. (Fischer, 1860)	08.X.2003	29.2559944	-103.0119500	29.6	9.34	172
Cattail Falls, Big Bend National Park, Brewster Co., Texas, USA	*Tropocyclops prasinus* s. str. (Fischer, 1860)	18.V.2006	29.2731805	-103.3355138	21.4	7.68	548
Paint Gap Tank, Big Bend National Park, Brewster Co., Texas, USA	*Thermocyclops tenuis* (Marsh, 1910)	14.V.2006	29.3878555	-103.3026750	34.3	9.35	209

Site	Species	Collection Date	Latitude	Longitude	Temperature (°C)	pH	Conductivity (μmScm^{-1})
Glenn Spring, Big Bend National Park, Brewster Co., Texas, USA	*Microcyclops dubitabilis* Kiefer, 1934	17.V.2006	29.1744166	-103.1575000	30.1	8.19	720
Tuft Canyon pool, Big Bend National Park, Brewster Co., Texas, USA	*Microcyclops dubitabilis* Kiefer, 1934	07.I.2003	29.1511500	-103.4855000	11.4	7.29	915
Mescalero Canyon Pond, HTSHS, El Paso Co., Texas, USA	*Mastigodiaptomus albuquerquensis* (Herrick, 1895)	06.X.2006	31.9188166	-106.0403666	23.8	8.87	219
Dripping Springs, Big Bend National Park, Brewster Co., Texas, USA	*Paracyclops chiltoni* (Thomson, 1882)	16.V.2006	29.4049666	-103.3078583	23.3	7.67	702

Chapter 1
Introduction and anatomical terminology in copepoda

The freshwater zooplankton is represented mainly by heterotrophic metazoans that have biologica and anatomic adaptations to dwell in the water column. Members of this community exhibit a wide array of feeding habits, including strictly herbivorous, omnivorous, predatory, detritivorous, and even cannibalistic. Zooplankton is ecologically important in any aquatic system because they are a key link to transfer the energy generated by the primary producers onto the secondary consumers. Because of their diversity and abundance, rotifers, cladocerans, and copepods are the most relevant groups of the freshwater zooplankton communities. Freshwater copepods represent a lineage that has successfully invaded the continental waters. They are typically small crustaceans that can be found in virtually all aquatic habitats from hot springs to glacial meltwater pools, and from deep ocean trenches to high altitude lakes (Boxshall and Halsey, 2004). In continental or inland waters, copepods are predominantly represented by three orders: Calanoida, Cyclopoida, and Harpacticoida (Dole-Olivier *et al.*, 2000). Members of the Calanoida are represented in freshwater by the family Diaptomidae and a few species of the Centropagidae and Temoridae, which are predominantly marine families. Diaptomids tend to be planktonic, limnetic forms whereas the Cyclopoida are represented by planktonic as well as littoral forms. Harpacticoids are essentially benthic and interstitial and can be captured by vegetation washings and near-shore plankton trawls.

Mexico represents an interesting area in terms of biogeography because it is a transitional fringe between the two largest American biogeographic regions, the Nearctic and the Neotropical. Thus, it is important to generate reliable inventories of these crustaceans in Mexico based on constant and formal taxonomic studies. There are several publications related to the knowledge of the species richness and distribution of freshwater copepods in the country, but there are vast areas of Mexico where a few or none records of copepods exists, like the Northwest and Southern regions. States into these regions are Baja California Sur, Sonora, West of Chihuahua, Nayarit, Colima, Guerrero and Oaxaca (Suárez-Morales and Reid, 1998; Suárez-Morales *et al.*, 2010).

Basic taxonomic studies of freshwater copepods in Mexico are still limited because of factors like: a) relatively little sampling efforts and weak interest in the basic analysis of zooplankton (Suárez-Morales and Reid, 1998) and b) the inconstant development of the taxonomic research of these groups in Mexico and Latin America. Fortunately, since 1990 efforts have increased to conduct research initiatives considering high quality standards and expanded geographic reaches for complete taxonomic descriptions and distributional analysis of Copepoda in Mexico (Elías-Gutiérrez *et al.*, 2001; Suárez-Morales and Elías-Gutiérrez, 2003).

In Mexico around 110 species of freshwater, free-living Calanoida, Cyclopoida and Harpacticoida copepods, have been recorded. An account of the copepod genera recorded in Mexico is presented in Table I.

The taxonomy of freshwater copepods is highly dynamic; several genera and species were assumed to be cosmopolitan and American records of these species have to be revised (Mercado-Salas *et al.*, 2015; Gutiérrez-Aguirre and Cervantes-Martínez, 2016). Hence, the morphology of the species recorded has to be carefully examined in establishing records because the description and interpretation of biogeographic patterns depend on the accuracy of the taxonomical evaluation. This work is focused on presenting a detailed account of the morphology of the free-living Copepoda inhabiting freshwater systems like lakes, ponds, temporary pools, springs and lagoons from different areas of the Chihuahuan Desert binational region, including the Mexican states of Chihuahua and Coahuila and Texas, United States.

Previously, up to 38 species of copepods were recorded in the area (Suárez-Morales *et al.*, 2010). In this work the morphological analysis of most of the 20 species was performed with both Scanning Electron Microscopy (SEM) and light microscopy emphasizing the characters deemed as taxonomically informative in each of the three main orders represented in the area: Calanoida, Cyclopoida, and Harpacticoida. This study complements previous taxonomical studies from different regions of Mexico, most of them involving the description of new species or local species lists (see Suárez-Morales *et al.*, 2008; Mercado-Salas, 2009; Suárez-Morales and Walsh, 2009; Mercado-Salas *et al.*, 2013; Gutiérrez-Aguirre *et al.*, 2014). This is the first detailed taxonomic and morphologic account of the copepod fauna from this arid binational area.

Table I. Number of species in genera of freshwater Copepods recorded in Mexico according with Dussart and Defaye (1995), Suárez-Morales et al. (1996), Suárez-Morales and Reid (1998), Suárez-Morales and Elías-Gutiérrez (2003), Suárez-Morales and Reid (2003), Suárez-Morales (2004), Suárez-Morales and Iliffe (2005), Elías-Gutiérrez et al. (2008), Mercado-Salas (2009), Mercado-Salas and Suárez-Morales (2009), Mercado-Salas et al. (2009), Suárez-Morales and Walsh (2009), Suárez-Morales et al. (2010a, 2010b), Mercado-Salas and Suárez-Morales (2011), Gutiérrez-Aguirre and Cervantes-Martínez (2013), Gutiérrez-Aguirre et al. (2013), Mercado-Salas and Álvarez-Silva (2013), Mercado-Salas et al. (2013), Mercado-Salas and Suárez-Morales (2014), Gutiérrez-Aguirre et al. (2014), Mercado-Salas et al. (2015), Gutiérrez-Aguirre and Cervantes-Martínez (2016a; 2016b) and Mercado-Salas et al. (2018).

Genera recorded in México	Number of species
Subclass: Copepoda Infraclass: Neocopepoda Superorder: Gymnoplea Order: Calanoida Family: Centropagidae Giesbrecht, 1892	
Osphranticum Forbes, 1882	1
Family: Temoridae G. O. Sars, 1903	
*Eurytemora** Giesbrecht, 1881	1
Family: Diaptomidae G. O. Sars, 1903 Subfamily: Microdiaptominae Elías-Gutiérrez and Suárez-Morales, 1998	
Microdiaptomus Tafall, 1942	1
Subfamily: Diaptominae Kiefer, 1932	
Aglaodiaptomus Light, 1938	1
Arctodiaptomus Kiefer, 1932	1
Leptodiaptomus Light, 1938	6
Mastigodiaptomus Light, 1939	10
Prionodiaptomus Light, 1939	1

Hesperodiaptomus Light, 1938	1
Skistodiaptomus Light, 1939	1
Family: Pseudodiaptomidae G. O. Sars, 1903	
Pseudodiaptomus Sars, 1902	1
Superorder: Podoplea	
Order: Cyclopoida	
Family: Cyclopidae G. O. Sars, 1913	
Subfamily: Eucyclopinae Kiefer, 1927	
Halicyclops Norman, 1903	2
Ectocyclops Brady, 1904	2
Eucyclops Claus, 1893	17
Paracyclops Claus, 1893	4
Homocyclops (Herrick, 1882)	1
Tropocyclops Kiefer, 1927	2
Macrocyclops Claus, 1893	2
Subfamily: Cyclopinae Kiefer, 1927	
Orthocyclops Forbes, 1897	1
Apocyclops Kiefer, 1932	2
Thermocyclops Kiefer, 1937	3
Mesocyclops G. O. Sars, 1914	12
Megacyclops Kiefer, 1927	1
Acanthocyclops Kiefer, 1927	9
Diacyclops Kiefer, 1927	5
Metacyclops Kiefer, 1927	2
Microcyclops Claus, 1893	7
Neutrocyclops Kiefer, 1936	1
Order: Harpacticoida Family: Ameiridae Monard, 1927	
Nitokra Boeck, 1864	5
Nitocrella Chappuis, 1924	1
Parapseudoleptomesochra Lang, 1965	1
Stygonitocrella Petkovski, 1976	1
Family: Canthocamptidae Sars, 1906	
Attheyella (Mrazekiella) Chappuis, 1929	1
Bryocamptus (Bryocamptus) Chappuis, 1929	1
Elaphoidella Chappuis, 1928	1
Moraria T. Scott, 1893	1
Family: Darcythompsoniidae Lang, 1936	
Leptocaris T. Scott, 1899	1
Family: Diosaccidae Sars, 1906	
Schizopera G. O. Sars, 1905	1
Family: Cletodidae T. Scott, 1904	
Cletocamptus Schmankewitsch, 1875	1

Species of *Eurytemora* (*) are mainly distributed in brackish waters, but *Eurytemora affinis* has been recorded in North American freshwaters systems in the last decades (Lee and Frost, 2002).

General anatomy of the Copepoda

Free-living copepods are found in marine, freshwater and even semi-terrestrial conditions, including soil water films, mosses or bromeliads (Dole-Olivier *et al.*, 2000; Suárez-Morales *et al.*, 2010). Currently 10 orders are recognized within the Subclass Copepoda (Huys and Boxshall, 1991) and have been described about 24 000 species worldwide.

Some species of the three orders inhabit in underground environments in Mexico. The ability of copepods to occupy such different habitats is because from an overall body pattern, have developed structural, physiological and behavioral changes that allowed them to be the most diverse group of crustaceans in the planet.

The entire body is segmented, each segment is a somite: the cephalic and thoracic somites form the prosome, while the urosome is composed by the abdominal segments plus the anal somite (= telson) which carries a pair of caudal ramus, but no appendages (Figs. 1, 2) (Marcote, 1986; Huys and Boxshall, 1991; Dussart and Defaye, 1995; Suárez-Morales *et al.*, 1996).

All prosomites bear paired articulated ventral appendages: the cephalic appendages include the antennules (A1), antennae (A2), mandibles, maxillules, maxillae, and maxillipeds (Figs. 1, 2). The antennules have a sensory function, while the rest of the cephalic appendages have swimming and feeding functions. Antennules and fifth legs can be modified in males, and serve functions related to reproduction (Fig. 1). The detailed morphology in frontal and caudal views of all these appendages is useful to differentiate at species level.

Thoracic appendages are the trunk limbs or swimming legs, which are adapted for natation; the morphology of the first to fourth limbs (P1, P2, P3, and P4 in Fig. 2) is general: the coxa fixed the limb to the body through one protopodite, and on the basis are fixed the endopodal (Enp) and exopodal (Exp) ramus (Figs. 1, 2). The endopodal or exopodal ramus can be 2- o 3-segmented. The right and left limbs are connected by the intercoxal sclerite (Fig. 2).

Two caudal ramus are articulate to anal somite, each rami bears a serial of caudal setae (Fig. 2); the position and length of these caudal setae are taxonomically important, especially in Cyclopoida and Harpacticoida. The next nomenclature for each caudal setae is used for identification, directional terms ("outer", "inner") with respect to midline of the body:

- Lateral caudal seta (II)
- Outermost caudal seta (III)
- Median outer caudal seta (IV)
- Median inner caudal seta (V)
- Innermost caudal seta (VI)
- Dorsal caudal seta (VII)

Fig. 1. General anatomy of the free-living freshwater Copepoda (Calanoida: Diaptomidae). Habitus, ventral view, showing appendages (upper, left); male fifth leg, ventral showing taxonomically relevant characters (upper right), female fifth legs (bottom, left); and middle section of modified male right antennule (segments 6-15) (bottom, right)

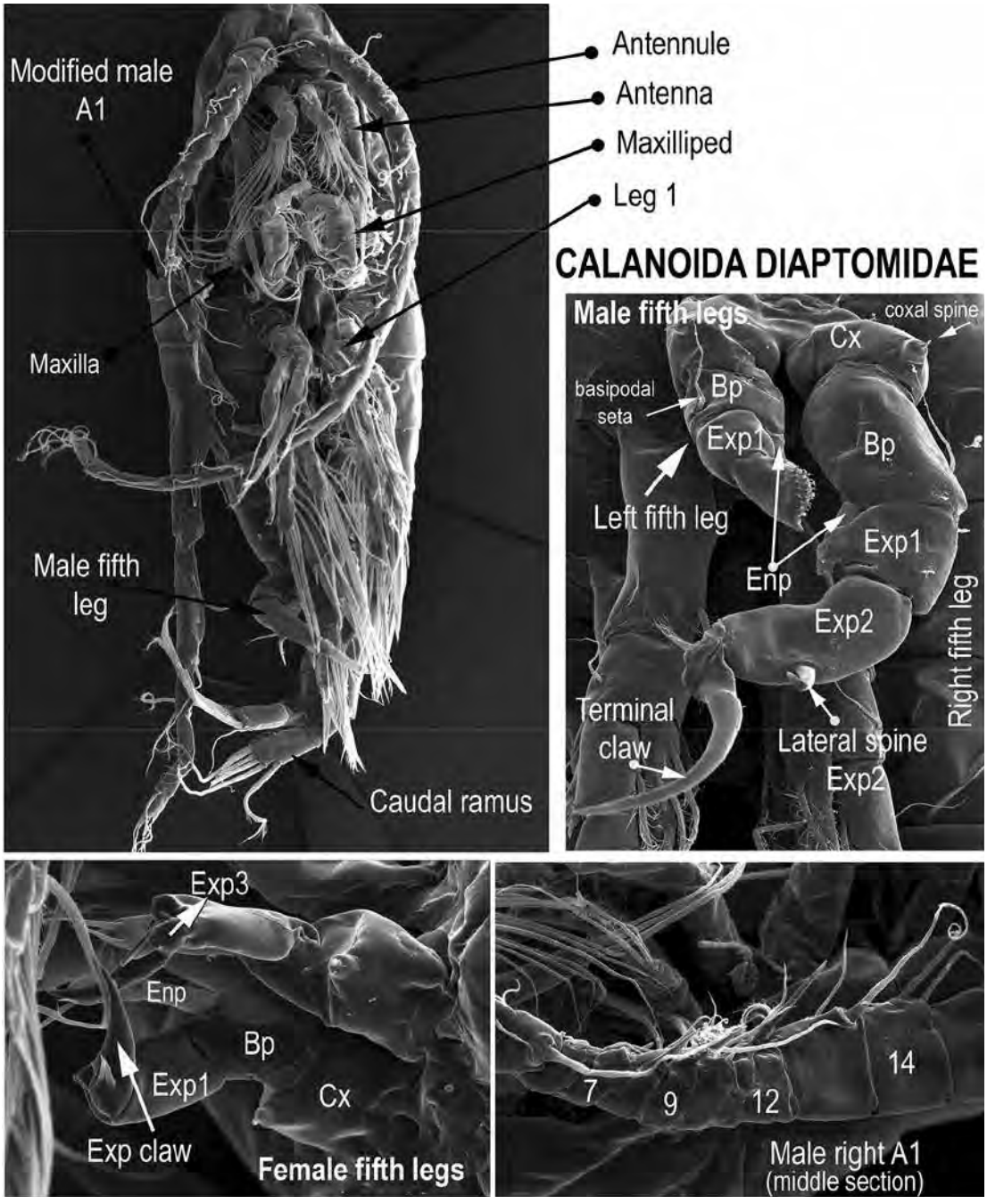
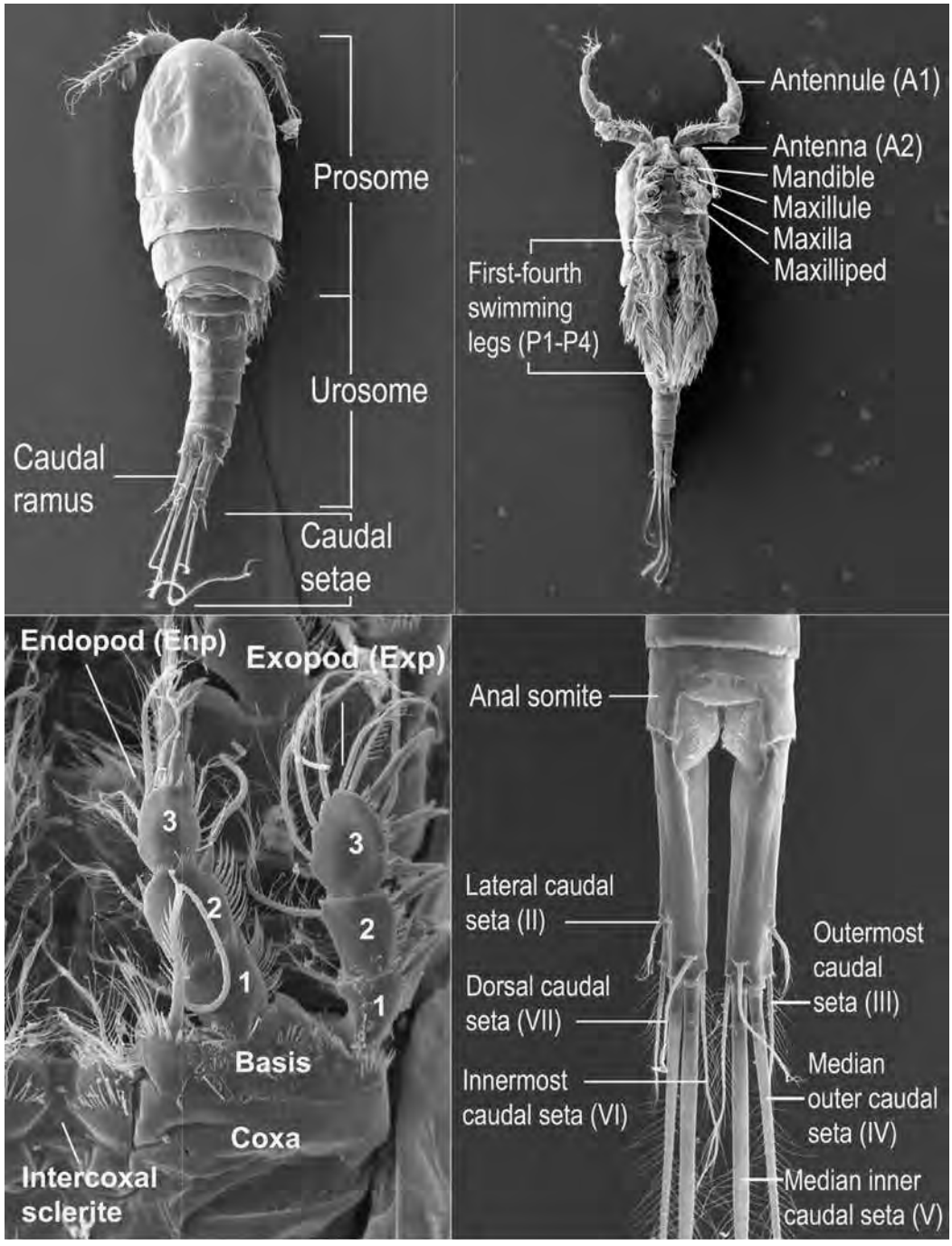


Fig. 2. General anatomy of the free-living freshwater Copepoda (Cyclopoida). Habitus, dorsal (upper, left); position and nomenclature of cephalic and thoracic appendages (upper right), general structure of bi-ramous swimming legs (bottom, left); and nomenclature of the caudal setae (bottom, right)



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Chapter 2
Species of Copepoda (Calanoida, Cyclopoida, Harpacticoida) from the Chihuahuan Desert

The organisms described in this section inhabit several freshwater ecosystems in the Chihuahuan Desert. The collection, processing, fixation and preservation of the biological material were carried out following standard methods, which have been widely described elsewhere (Serranía-Soto, 1996; Segers, 1995; Hołyńska *et al*., 2003; Suárez-Morales y Gutiérrez-Aguirre, 2001).

The species richness of the Calanoida, Cyclopoida and Harpacticoida present in diverse biological samples was determined. Later, descriptions of morphological characteristics and/or appendices considered taxonomically important for each species were made. The illustrations of the species were made with light microscopy and, above all, with Scanning Electron Microscopy (SEM).

Some specimens were deposited in the zooplankton reference collection of El Colegio de la Frontera Sur (Chetumal, Quintana Roo, Mexico). In the description of material examined in each case, the access number is provided after the acronym ECOCH-Z. Below is a description of the species examined, the taxonomic arrangement can be found in the Table I in the Chapter 1.

Leptodiaptomus connexus (Light, 1938)
Figs. 1 A-F, 2F-H

Diaptomus (Leptodiaptomus) connexus Wilson and Yeatman, 1959.
Leptodiaptomus connexus Elías-Gutiérrez *et al*., 2008: 187, Fig. 21.

Material: Two adult males ethanol-preserved from Los Hundidos, 09.I.2006, ECO-CH-Z-03660. Two adult females and two adult males from Los Hundidos, 09.I.2006 for SEM.

Female: A1 with one seta on segments 13-19. Exp3 of P5 vestigial, represented for two short spines, fused to Exp2 (Fig. 1A). Enp of P5 longer than Exp1, bearing two long apical seta (Figs. 1B, 2F). Coxa of P5 with one strong spine, and basis bearing one short seta (Fig. 1B). Short genital double-somite with length width ratio around 1.0, and with protrusions on the half length of the genital double-somite (Fig. 1C). Inner margin of caudal rami hairy.

Male: Right A1 with long spiniform process on segment 8: longer than the bearing segment, and longer than the length of segment 12 (Fig. 2G). Strong spiniform processes on segments 10, 11, and 13; antepenultimate segment with a fang-like projection, shorter than penultimate segment (Fig. 2H). Rigth Exp2 of P5 elongated, aculeus sited distally, its length is around the half width of the segment (Fig. 1E). P5 resembling *L. siciloides*, except for hyaline projection on right Exp1, on medial position and square-shaped in *L. siciloides* vs. elliptical, distally inserted process in *L. connexus* (arrowed in Fig. 1F).

Remarks: *L. connexus* and *L. siciloides* are very similar; in fact, the taxonomic relation between both species is not clear (Wilson and Yeatman, 1959). The differences among both species is the relative length of the spiniform process on segment 8 (of the right A1 in males), and the length ratio of the genital double-somite (in females). In this study we agree with Wilson and Yeatman (1959), Zamudio-Valdés (1991), and Elías-Gutiérrez *et al*. (2008) to consider them as separate species, but further studies are necessary to explore if these forms are in fact, different.

Distribution: Nearctic. Chihuahuan desert, and Coahuila Mexico (Zamudio-Valdés, 1991), lakes and lagoons in the West of Canada and Southeast of USA (Wilson and Yeatman, 1959; Zamudio-Valdéz, 1990; Suárez-Morales *et al*., 2010).

Fig. 1. ***Leptodiaptomus connexus*** **female from Los Hundidos, Coahuila, Mexico. A, P5 detail of Enp and Exp2. B, P5 frontal. C, fifth pediger and genital double-somite, dorsal. Male from Los Hundidos D, P5 left Exp2. E, P5 right Exp2. F, P5 right Exp1 caudal, hyaline projection arrowed. Measurements in micrometers**

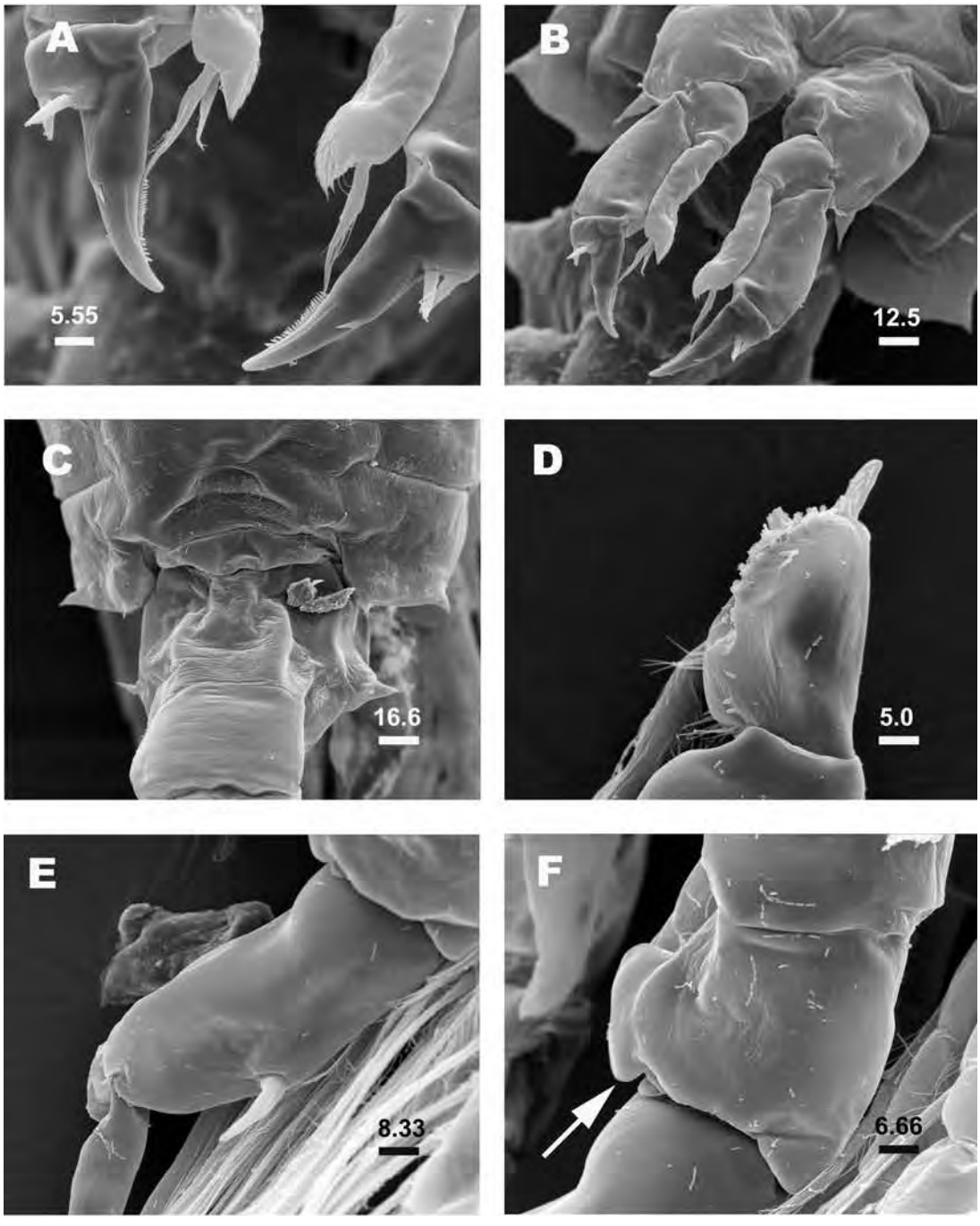
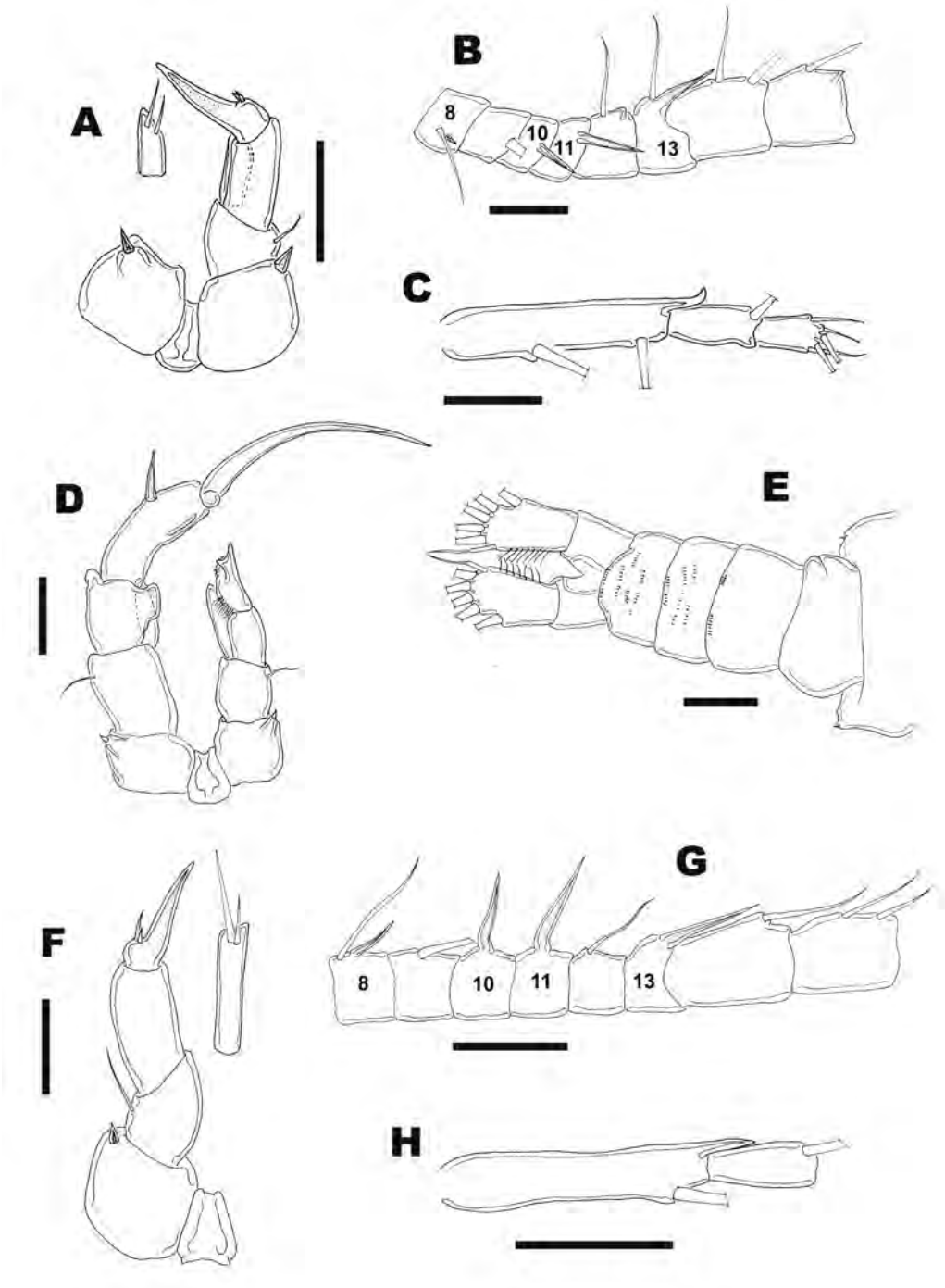


Fig. 2. ***Leptodiaptomus siciloides*** **from Presa Francisco I. Madero, Chihuahua, Mexico. Female: A, P5 Enp separated. Male: B, right A1 segments 8-15. C, right A1, antepenultimate, penultimate and ultimate segments. D, P5. E, urosomites, dorsal.** ***Leptodiaptomus connexus*** **from Los Hundidos, Coahuila. Female: F, P5 Enp separated. Male: G, right A1 segments 8-15. H, right A1, antepenultimate and penultimate segments. Scale bars = 50 µM.**



Leptodiaptomus siciloides (Lilljeborg, 1889)
Fig. 2A-E

Diaptomus (Leptodiaptomus) siciloides Wilson and Yeatman, 1959, Fig. 29
Leptodiaptomus siciloides Dussart and Defaye, 1995: 155, Figs. L52.
Leptodiaptomus siciloides Silva-Briano and Suárez-Morales, 1998: 27-33
Leptodiaptomus siciloides Suárez-Morales *et al*., 2000: 5-14, Figs: 25-30.

Material: One adult male and six females ethanol-preserved from Boquillas, 16.IV.2006, ECO-CH-Z-03659; 2 males preserved in alcohol 70% from Presa Francisco I. Madero 06.I.2006, ECO-CH-Z-03661; 3 females and 3 males preserved in alcohol 70% from Presa Francisco I. Madero, 05. I.2006, ECO-CH-Z-03663.

Female: A1 with one seta on segments 13-19. Exp3 of P5 vestigial, represented for two short spines, fused to Exp2. Enp of fifth leg as long as Exp1, bearing two apical seta (Fig. 2A). Coxa with one strong spine, and basis bearing one short seta. Inner margin of furcal rami hairy.

Male: Right A1 with short spine on segment 8: 0.3-0.4 times the length of both, the bearing segment, and the twelve segment (Fig. 2B). Strong spiniform process on segments 10, 11, and 13 (Fig. 2B); antepenultimate segment with a hook like projection shorter than penultimate segment (Fig. 2C).

Right P5 with a squarish hyaline process oriented inwards on Exp1; Exp2 bearing a thin, distal lamella; a short aculeus (0.4-0.6 times the length of the segment; and as long as the width of the segment), and a long, slender apical hook (1.6-2.1 times the length of the segment) (Fig. 2D). Right Enp cylindrical, reaching distal margin of Exp1 (Fig. 2D).

Left basipodite and Exp1 rectangular in shape; Exp2 hairy, armed with small blunt spinules, and with distal, digitiform processes. Left Enp cylindrical, long, reaching the distal half of Exp2 (Fig. 2D). Dorsal surfaces of the second, third, and fourth urosomites with tiny spines (Fig. 2E).

Distribution: Nearctic. Almost all North America, except the North and the East coasts (Wilson and Yeatman, 1959; Suárez-Morales *et al*., 2010).

Leptodiaptomus novamexicanus (Herrick, 1895)
(Figs. 3, 4)

Diaptomus (Leptodiaptomus) novamexicanus Wilson and Yeatman, 1959.
Leptodiaptomus novamexicanus Suárez-Morales *et al*., 1996: 100-102, Fig. 19.
Leptodiaptomus novamexicanus Elías-Gutiérrez *et al*., 2008: 186, Fig. 20.

Material: 3 adult males ethanol-preserved from Boquillas, 16.IV.2006, ECO-CH-Z-03620; 15 females, 12 males preserved in alcohol 70% from Boquillas, 16.IV.2006, ECO-CH-Z-03621; 13 females, 16 males ethanol-preserved from Presa Chihuahua, 16.IV.2006, ECO-CH-Z-03622; One female preserved in alcohol 70% from Presa Chihuahua, 06.I.2006, ECO-CH-Z-03623; 16 females, 6 males, preserved in alcohol 70% from Boquillas, 16.IV.2006, ECO-CH-Z-03624; 9 females, 8 males for SEM from Lago Colina, 16.IV.2006.

Female: Exp3 of P5 vestigial, represented for two short spines, fused to Exp2 (Fig. 3A). Enp of fifth leg longer than Exp1 (Fig. 3B), bearing two apical seta, and numerous apical spines (Fig. 3A). Coxa with one strong spine; basipodite bearing one short seta. Left lateral wing of last prosomite short; right lateral wing large, projected (Fig. 3C), bearing one tiny spine (Fig. 3D). Genital dou-

ble-somite with right and left lateral, rounded projections (Fig. 3E). Genital area with two lateral, rectangular cameras, flanked by two angled opercules (Fig. 3F).

Male: Urosomites with groups of spines on dorsal surface, distal spines along second and third segments are longer (Fig. 4A).

Right A1 with a hook like projection in antepenultimate segment, which begins at medial margin of the bearing segment (Fig. 4B). Strong spiniform processes on segments 10, 11, and 13 (Fig. 4C).

Right P5 with a bulbous projection on the basal area of basipodite (arrowed in Fig. 4D, E), right Exp1 shorter than right Enp, which is cylindrical (Fig. 4F). Left P5 with rectangular basipodite; left Exp1 short, with almost the half-length of left Enp, which bear numerous spines directed inward. Exp2 with two digitiform processes, hairy (Fig. 4F).

Distribution: Nearctic. In USA, lakes in Rocky Mountains at Utah, coastal region of the Pacific, California; Columbia Britanica in Canada (Wilson and Yeatman, 1959). North, central and south-eastern regions in Mexico (Elías-Gutiérrez et al., 2008; Suárez-Morales *et al*., 2010).

Fig. 3. ***Leptodiaptomus novamexicanus*** **female from Lago Colina, Chihuahua, Mexico. A, P5 detail of Enp and Exp2. B, P5 frontal. C, last prosomites and genital double-somite dorsal. D, right lateral wing of last prosomite. E, genital double-somite ventral. F, genital field. Measurements in micrometers**

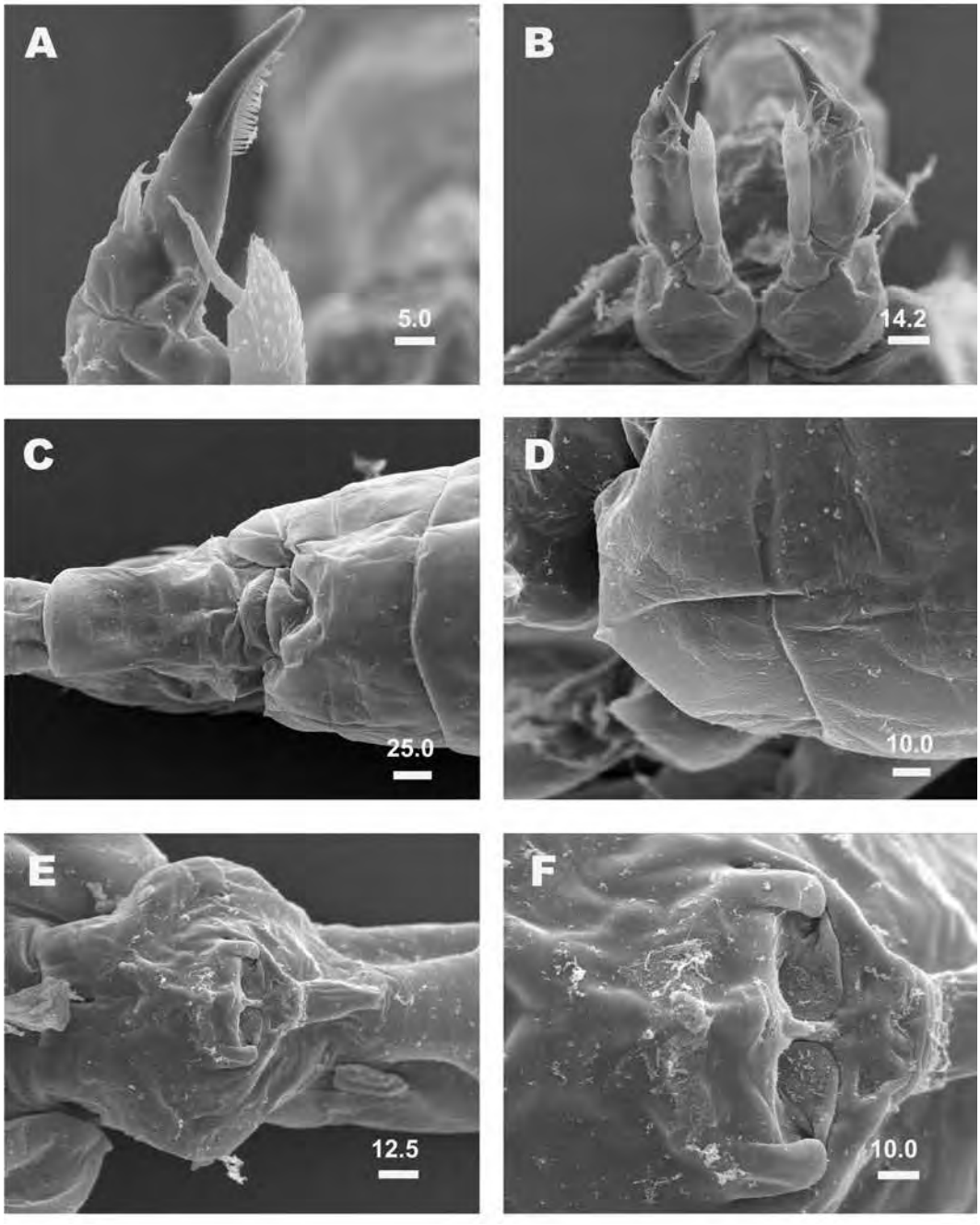
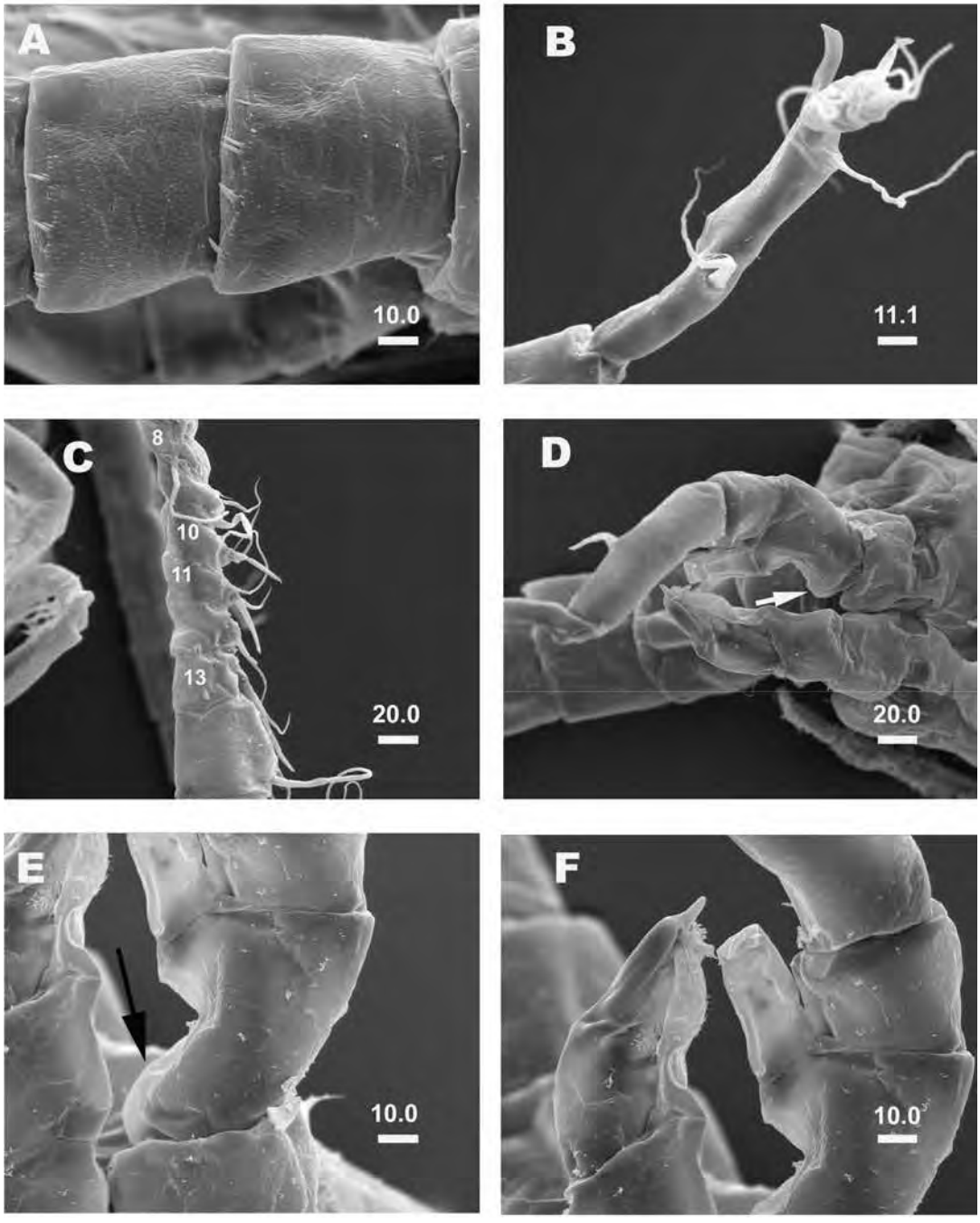


Fig. 4. ***Leptodiaptomus novamexicanus*** **male from Lago Colina. A, urosomites dorsal. B, right A1, antepenultimate segment. C, right A1 segments 8-14. D, P5 frontal, projection of basipodite arrowed. E, P5 basal projection of basipodite arrowed. F, P5 left Exp, left Enp, and right Enp. Measurements in micrometers**



Aglaodiaptomus clavipes (Schacht, 1897)
(Figs. 5, 6)

Diaptomus (Aglaodiaptomus) clavipes Wilson and Yeatman, 1959.
Diaptomus clavipes Cole, 1961: 433.

Material: One adult female, 2 adult males, from Lago Colina, 18.IV.2006, ECO-CH-Z-03616. Two adult females and two adult males for SEM.

Female: No dorsal projection on fifth pediger. Antennule with one seta strongly curved on segments 17, 19, 20 and 22; P1 with one spine on Exp1. Basis of P5 with one lateral setae. End of P5 as long as Exp1, cylindrical, apically with two large setae, plus short spines (Fig. 5A, B). Exp3 of P5 fused to Exp2, bearing three strong spines (Fig. 5B).

Male: Exopodites of P5 bi-segmented (Fig. 5C), left Exp1 quadrangular, distally hairy. Left Exp2 cylindrical, hairy, with one distal, strong seta frontally (arrowed in Fig. 5D); and one finger-like seta caudally (arrowed in Fig. 5E). Left Enp long, reaching the half-length of left Exp2, with short spines on inner margin, and strong spines distally (Fig. 5F).

Basipodite of right leg with a long, strongly curved process on caudal view, one basal triangled projection, and one short, bulbose projection on medial surface (Fig. 5E). Right Enp short, unisegmented, distally spiny (Fig. 5D).

Right antennules with spiniform process on segments 10, 11, and 13 (Fig. 6A); segment 21 with lateral, narrow, hyaline membrane (Fig, 6B).

Distribution: Nearctic. Lakes and ponds of East Canada, Southeast and Southwest USA (Wilson and Yeatman, 1959), the arid and semiarid regions of Sonora (Cole, 1961), and Chihuahua desert (Suárez-Morales *et al*., 2010) and lakes above 1500 m.a.s.l. in Chiapas, Mexico (Gutiérrez-Aguirre and Cervantes-Martínez, 2013).

Fig. 5. ***Aglaodiaptomus clavipes*****, female from Lago Colina. A, P5 frontal. B, P5, detail of distal regions of endopodite and exopodite. C,** ***Aglaodiaptomus clavipes*****, male from Lago Colina, P5, frontal. D, P5, detail of endopodal and exopodal segments, frontal. E, P5, detail of right basis, and apical region of left exopodite, caudal. F, P5 detail of left endopodal segment, caudal**

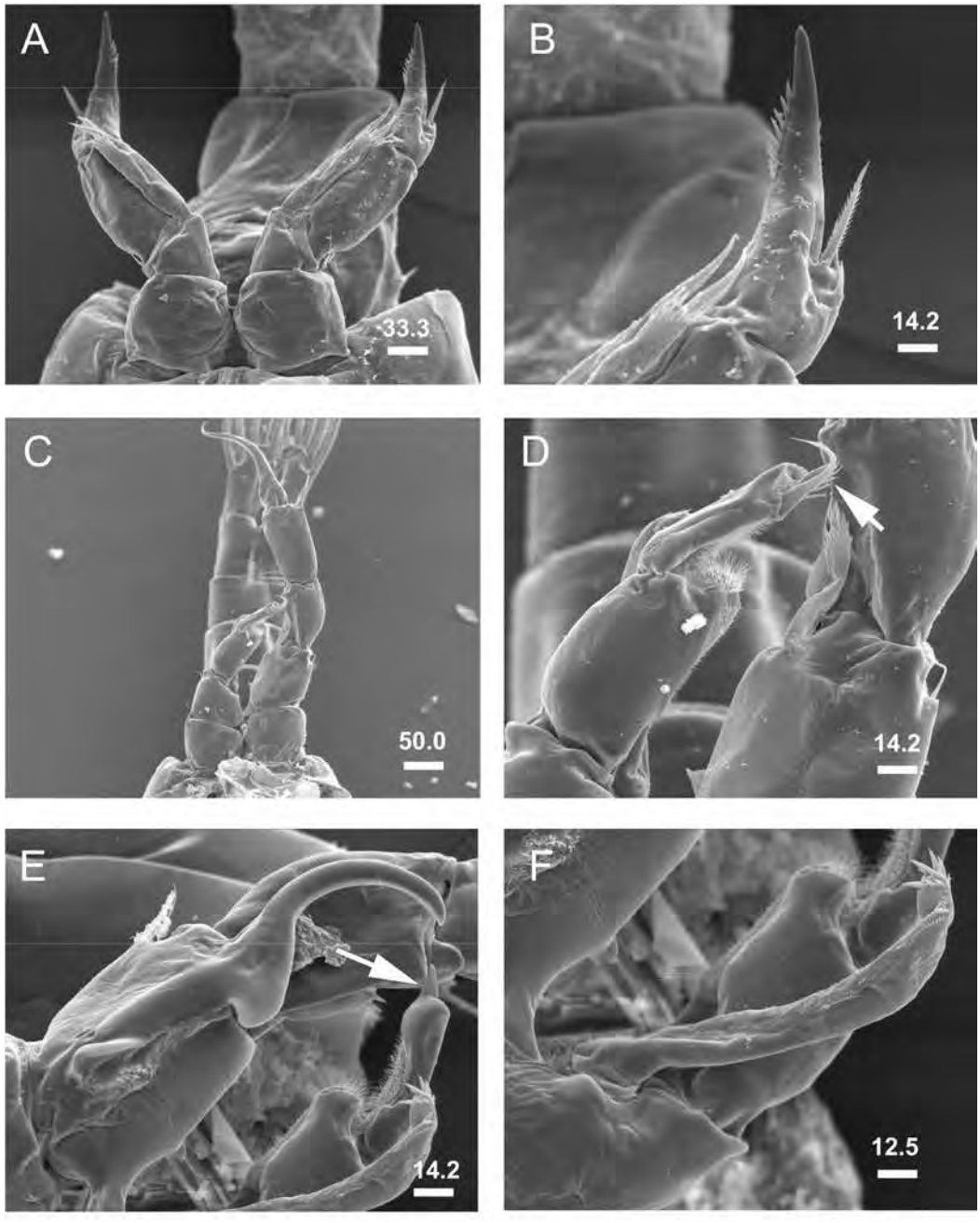
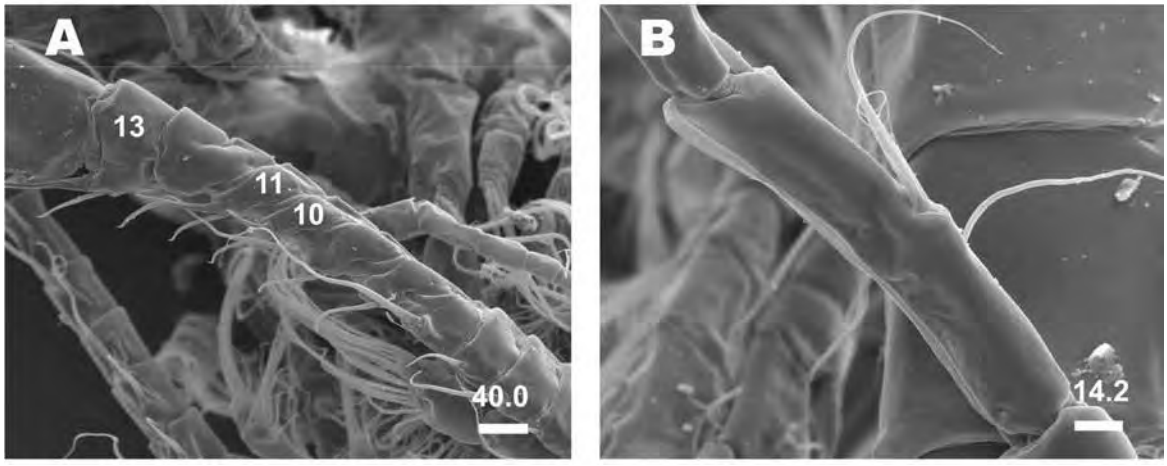


Fig. 6. *Aglaodiaptomus clavipes*, male from Lago Colina, A, right antennule, segments 5-13. B, right antennule, segment 21



Mastigodiaptomus albuquerquensis (Herrick, 1895)
(see figures in Gutiérrez-Aguirre *et al*., 2014)

Diaptomus albuquerquensis (Herrick, 1895): 40-47.
Diaptomus (Mastigodiaptomus) albuquerquensis Wilson and Yeatman (1959).
Mastigodiaptomus albuquerquensis Bowman 1986: 239, 242; Figs. 3D, I, J, M, N; 4B, C, H, M, N, O.
Mastigodiaptomus albuquerquensis Dussart and Defaye, 1995: 162, Fig. 58.
Mastigodiaptomus albuquerquensis s. str. Gutiérrez-Aguirre *et al*., 2014: 6-7, Figs. 5-6.

Material: Three adult females and five adult males from Hueco Tanks State Park and Historic Site, Texas 06.1.2006.

Female: 1.47 to 1.87 mm of body length including caudal ramus. Rostrum with spines 1.5-3.6 times longer than wide. Dorsal process of last prosomite variable from high frontally concave, to low frontally convex. Lateral-ventral region of prosomites with tiny spines.

First leg (P1), with 3-segmented Exp and 2-segmented Enp. The rest of the trunk limbs (P2-P4) with 3-segmented Exps and Enps. Exp1 to Exp3 of P1-P4 with one lateral spine.

Fifth leg with 2-segmented Enp, which bears 2 apical, long setae and short setules diagonally arranged. In average, the Exp1P5 is 2.3 times longer than EnpP5.

Genital double-somite slightly longer than wide, bulbous, asymmetrical: right spine more proximal and larger than the left spine. Egg-sac carrying until 20-40 eggs. Hair-like setae along lateral and medial margins of caudal ramus.

Male: 1.37 to 1.82 mm of body length including caudal ramus. Rostrum with spines 2.6 times longer than wide. Cuticular surface of prosomites smooth. Antennule 22-segmented, with spines on segments 10, 11, and 13 to16. The tip of spine on segment 10, does not reach the distal margin of the bearing segment. Antepenultimate antennular segment with a hook-like projection. Left wing of last prosomite with one large spine ventrally, and one seta dorsally. Caudal ramus pilose medially.

Coxal segments of male P5 with one long spine each. Right basipodite proximally bulbose, one rounded membrane medially, and one sclerotization distally which is angled, butterfly-like. Right Enp and right Exp1 similar in length. Right Exp2 with one curved, medial hyaline membrane; in

the distal half of this segment is inserted one long (longer than the length of right Exp2), almost straight aculeus.

Distribution: Neotropical. States of Rocky Mountains and South of Utah (Wilson and Yeatman, 1959; Bowman, 1986), Texas, Arizona (USA), Chihuahuan Desert (Suárez-Morales *et al*., 2010), northern and central Mexico including Zacatecas, Chihuahua, Durango, and some localities in the Transmexican Volcanic Belt (Gutiérrez-Aguirre *et al*., 2014).

Eurytemora affinis (Poppe, 1880)
(Figs. 7-9)

Eurytemora affinis Wilson and Yeatman, 1959.
Eurytemora affinis Suárez-Morales *et al*., 2008: 679-694, Figs. 2-5.

Material: Six adult males and one adult female from Balmorhea Lake, 31.III.2006 for SEM. For additional material, see Suárez-Morales *et al*. (2008).

Female: total body length 1.44-1.51 mm, excluding furcal setae, antennules reaching fifth prosomite (Fig. 8A), A1 with two elements on segments 13-18 (Fig.7A), P5 with quadrangular basipodite; Exp two-segmented, Exp1 with two lateral spine-like setae which are subequal in length and one medial pointed, nude process. Exp2 with two terminal spine-like seta, lateralmost shorter (Figs. 7B, 8D).

Lateral wings of fifth prosomite strongly projected, triangular (Fig. 7C). Rostral points bulbose proximally, and then enlarged (Fig. 8B), P3-P4 with 2-segmented Enps (Fig. 8C), EnpP1 1-segmented. Genital double-somite laterally produced into large triangular processes, which bear spines on the apex, triangular genital operculum (Fig. 7D). Caudal rami long, more than three times longer than width, with spines on entire dorsal surface (Figs. 7E, 8E). Anal operculum almost straight, anal somite with spines dorsally (Fig. 7F).

Male: 0.98 to1.38 mm of total body length, lateral wings of fifth prosomite rounded, urosoma slender (Fig. 9A); right antennules without spiniform processes on segments 15 and 16 (Fig. 9B); segments 18 and 19 with structures combed-like on inner margin (Fig. 9C).

Fifth leg without Enps (Fig. 9D). Right leg with basipodite medially protuberant, right Exp two-segmented, Exp1 cylindrical, large; Exp2 distally slender (Fig. 9D).

Left Exp two-segmented, Exp1 cylindrical, Exp2 with two large, digitiform, distal processes (Fig. 9E). Anal somite and caudal rami nude, or with some distal spines on anal somite, and some hair-like setae along medial and lateral margins of caudal rami (Fig. 9F).

Distribution: Assumedly cosmopolitan, probably a species complex (Lee and Frost, 2002). In coastal-estuarine systems: lakes and coastal lakes in the Atlantic, Pacific and Gulf of Mexico (Wilson and Yeatman, 1959), Balmorhea lake and Lago Colina in the Chihuahuan desert and Tamaulipas (Suárez-Morales *et al*., 2008, 2010).

Fig. 7. ***Eurytemora affinis*** **female from Balmorhea Lake, Reeves Co., Texas, USA. A, A1 segments 13-18. B, fifth leg. C, wings of fifth prosomite, lateral. D, genital double-somite, ventral. E, anal somite and caudal rami dorsal. F, anal somite, lateral. Measurements in micrometers**

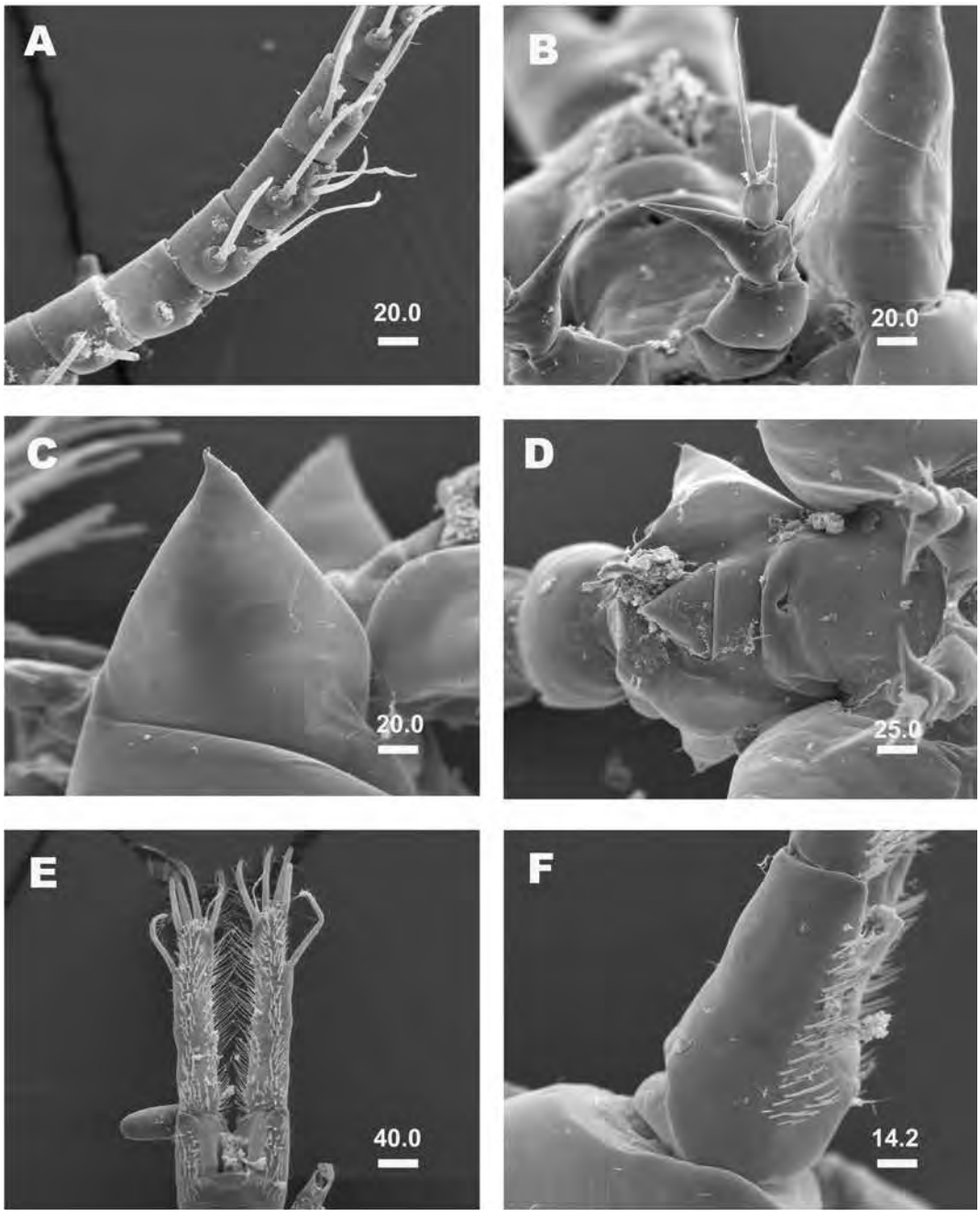


Fig. 8. ***Eurytemora affinis*** **female from Balmorhea Lake. A, habitus, ventral view. B, rostral area, ventral view. C, third legs, anterior view. D, left fifth leg, lateral view. E, caudal rami, dorsal view. Measurements in micrometers**

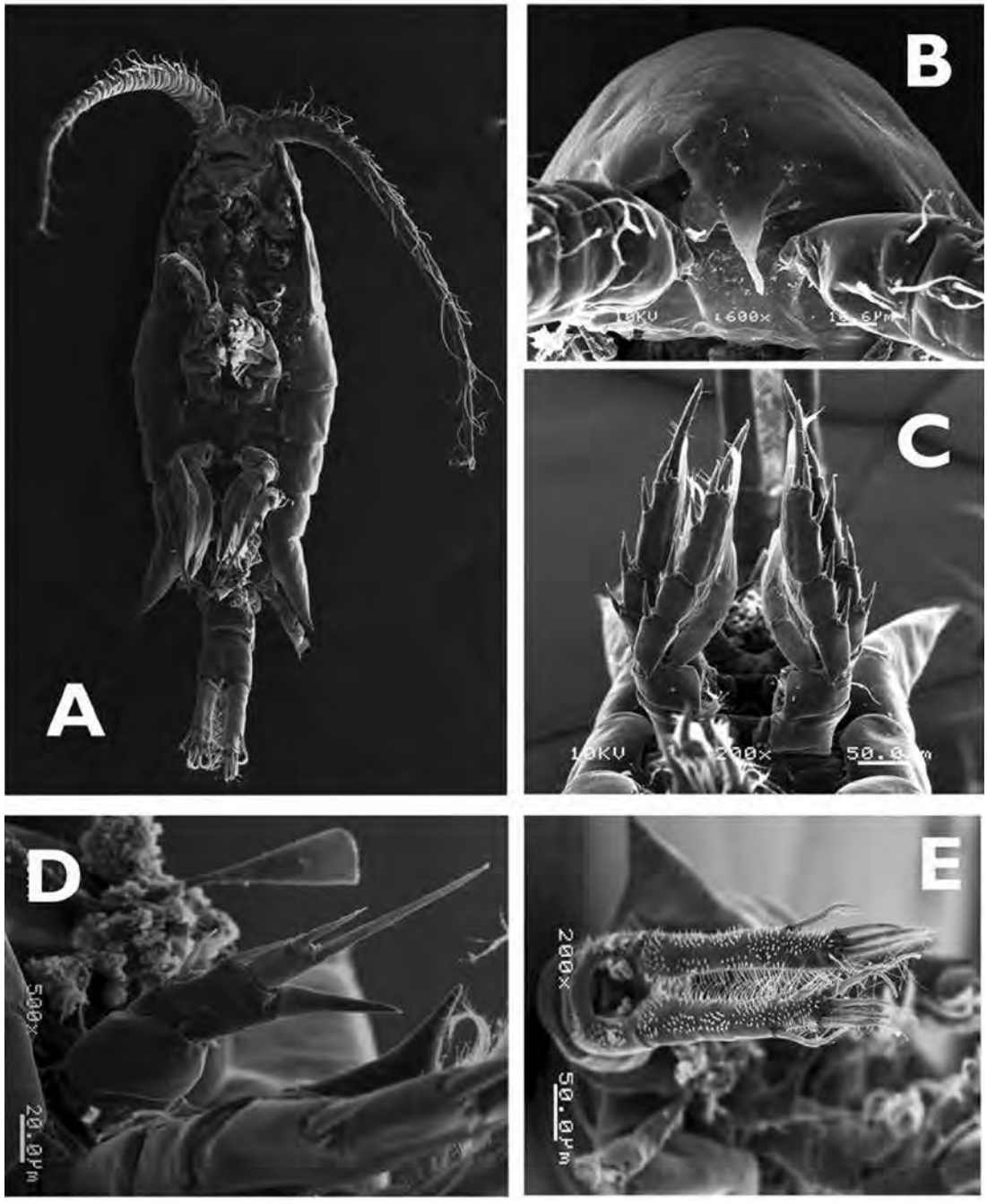
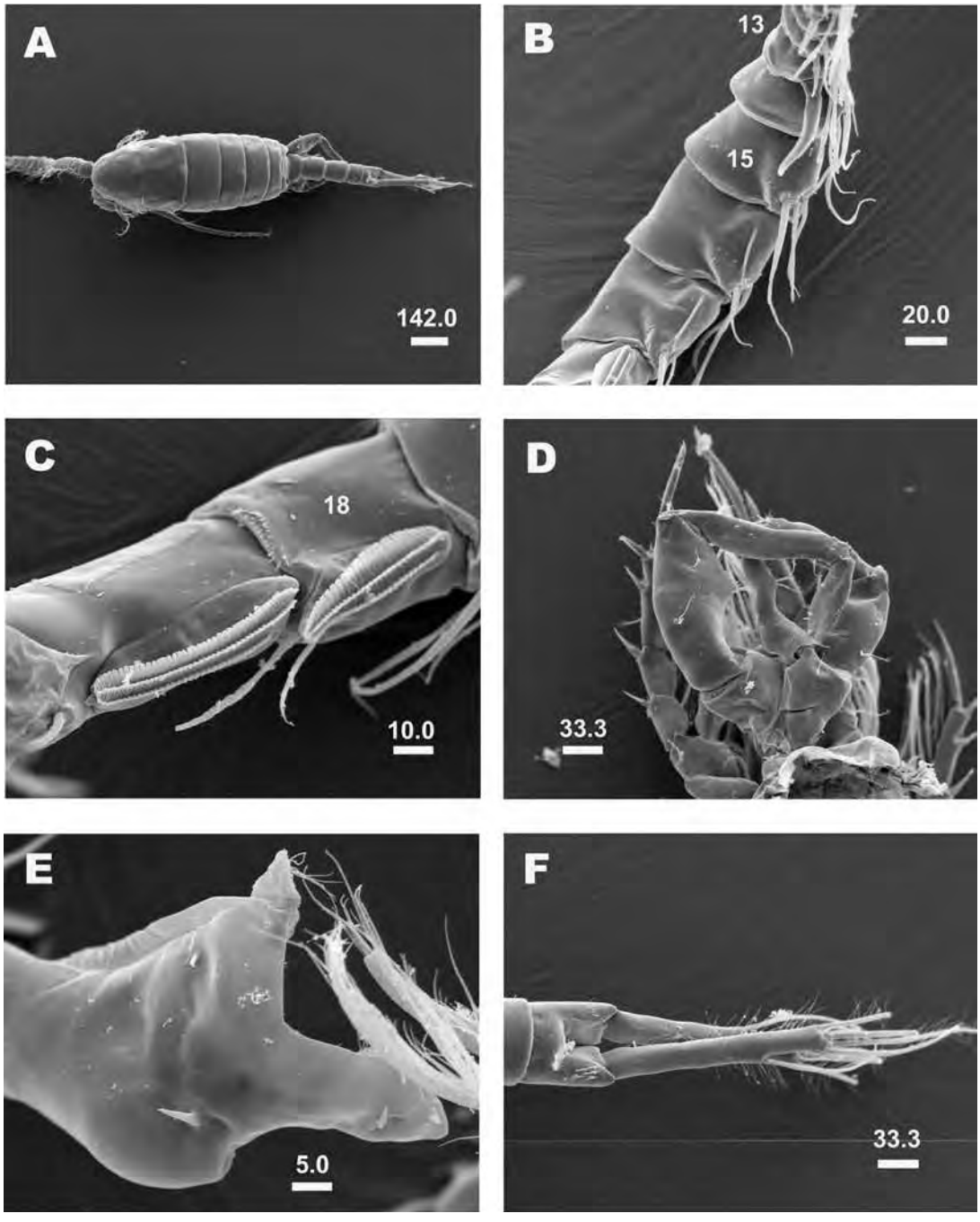


Fig. 9. *Eurytemora affinis* male from Balmorhea Lake. A, habitus. B, A1 segments 13-17. C, A1 segments 18-19. D, P5, caudal. E, P5 left Exp2. F, anal somite and caudal rami, dorsal. Measurements in micrometers



Eucyclops conrowae Reid, 1992
(Figs. 10, 11)

Eucyclops conrowae Reid, 1992: 229-237, Figs. 2-4.
Eucyclops conrowae Suárez-Morales *et al*., 1996: 173-175, Figs. 54, 56, 90a, b.
Eucyclops conrowae Suárez-Morales, 2004: 15
Eucyclops conrowae Mercado-Salas and Suárez-Morales, 2014: 14-18, Figs. 6-7.

Material: two adult females, from Lago Colina, 6.1.2006 for SEM.

Female: Surface of prosomal and urosomal somites pitted (Fig. 10A), antennules 12-segmented, short, not reaching posterior margin of the first prosomal somite; segments 10-12 with narrow hyaline lamella finely serrated (Fig. 10B), interrupted only in segment 11 (Fig. 10C). These antennular segments short: length ratio of segments 12/10 = 2.4; and length ratio of segments 12/11 = 1.58 (1.44, and 1.23 in Reid, 1992). Three-segmented Enps and Exps of P1 - P4 (Fig. 10D), spine formula 3,4,4,3. Enp2 of all four trunk limbs with two inner setae (Fig. 10D).

Intercoxal sclerite of first trunk limb with fine hair-like setules in frontal surface (Fig. 10E). Exp3P4 with 3 setae flanges-like, finely crenulated along lateral margins with few setae (Fig. 10F). Enp3P4 2 times longer than wide; medial spine subequal in length than lateral spine; inner distal seta flatted, as well as lateral seta, which bear few setules (Fig. 10F).

P5 1-segmented, with one inner, strong spine (at least 3.5 times broader than medial and outer setae); medial seta 2.1-2.4 times longer than inner spine, and 1.3 times longer than outer seta. Outer seta 1.7 times longer, than inner spine of P5 (Fig. 11A). Caudal ramus 3.8-4.2 times longer than broad (Fig. 11B). Anal somite short, 0.35-0.42 times the length of caudal ramus.

Distribution: Nearctic and Neotropical. This species was previously recorded from Florida (Reid, 1992), Mexico (Yucatan Peninsula, Coahuila, Aguascalientes) and Nicaragua (Reid, 1992; Suárez-Morales *et al*., 1996; Suárez-Morales and Reid, 1998; Mercado-Salas and Suárez-Morales, 2014).

Fig. 10. ***Eucyclops conrowae*** **female from Lago Colina, Chihuahua, Mexico. A, Detail of first prosomite. B, antennule segments 10-12. C, antennule, detail of hyaline fringe, segment 11. D, P1 and P2, frontal. E, intercoxal sclerite P1. F, Enp3P4 and tip of Exp3P4, frontal. Measurements in micrometers**

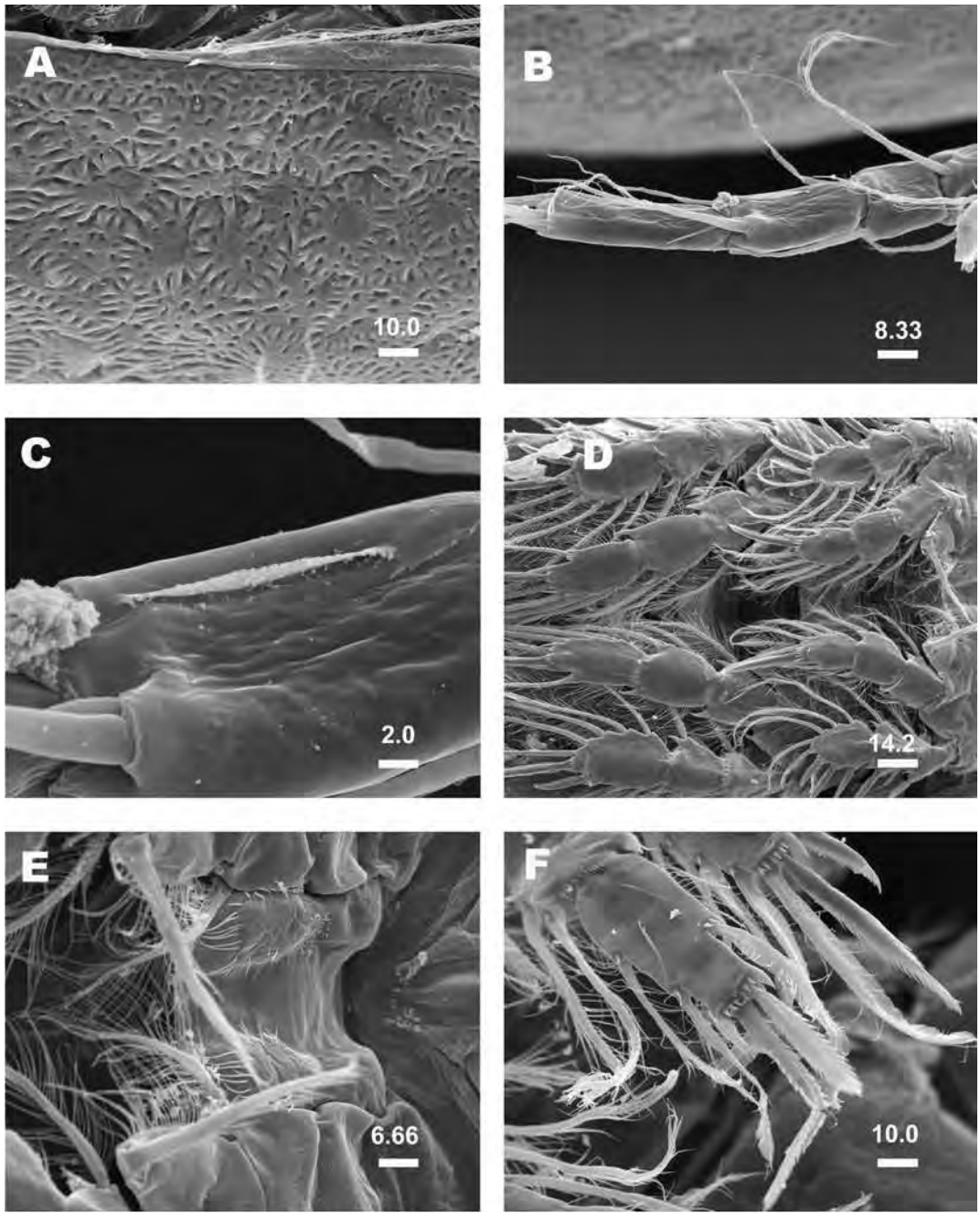
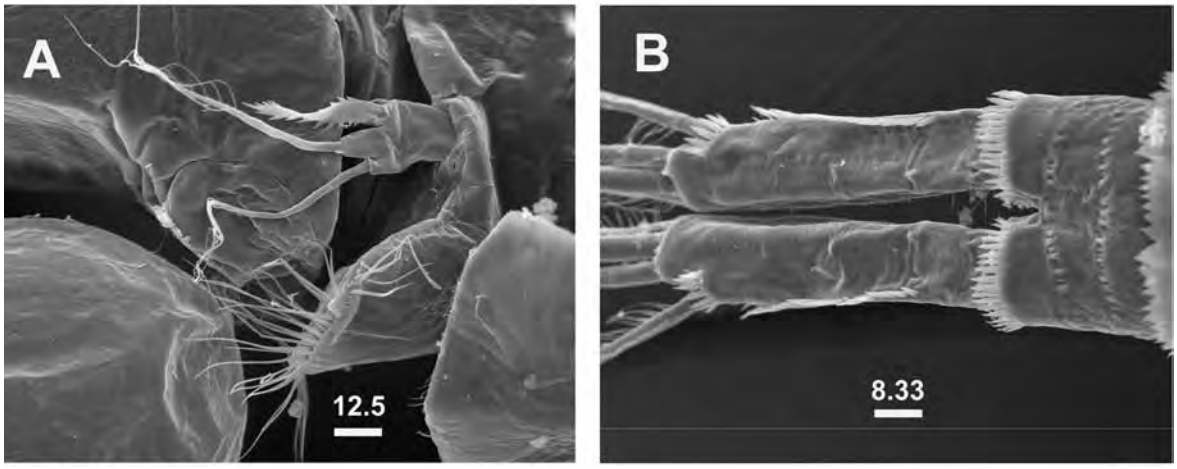


Fig. 11. ***Eucyclops conrowae*** **female from Lago Colina. A, P5. B, caudal rami ventral. Measurements in micrometers**



Eucyclops festivus Lindberg, 1955
(Fig. 12)

Eucyclops festivus Lindberg, 1955, Fig. 2a-d
Eucyclops festivus Grimaldo-Ortega *et al*., 1998: 383.
Eucyclops festivus Suárez-Morales, 2004: 617.
Eucyclops festivus Mercado-Salas, 2009, Figs. 138-139
Eucyclops festivus Gutiérrez-Aguirre *et al*., 2013: 20-23, Figs. 10, 11

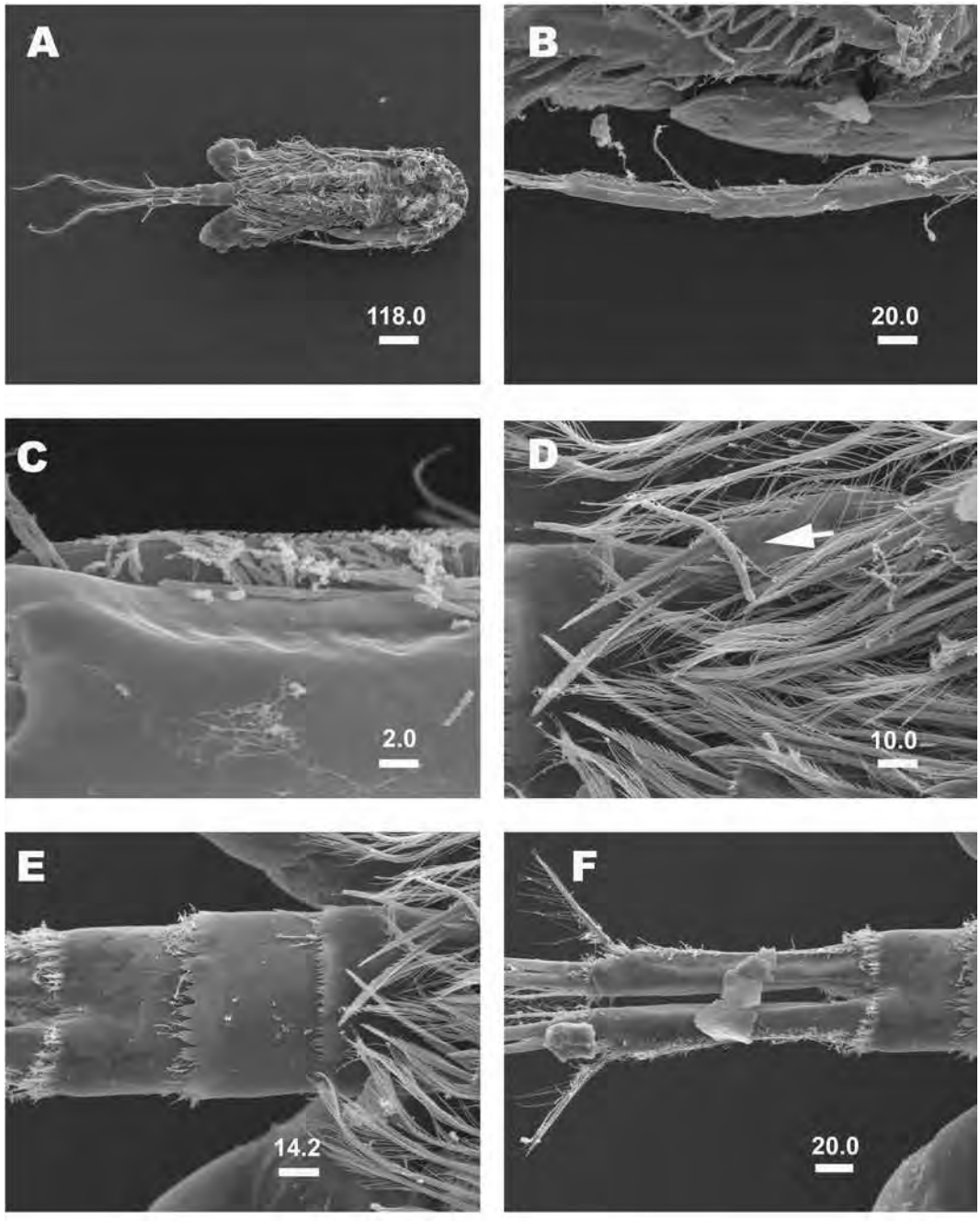
Material: one adult female from Diamond Y Spring, Pecos Co., Texas, USA. 31.III.2006 for SEM.

Female: 1.0 to 1.1 mm of total body length (Fig. 12A). Antennule reaching second prosomite (Fig. 12B); hyaline membrane on last antennular segments (10-12) finely serrated (Fig. 12B, C). Length ratio of medial/lateral spines of Enp3P4 = 1.3-1.4, frontal surface of Enp3P4 with one porous (arrow in Fig. 12D). Length/width ratio of Enp3P4 is 2.7-2.8. Fifth leg 1-segmented, with the medial seta 1.3-1.5 times longer than inner spine, and this inner spine is 1.7 times longer than outermost seta.

Ventral surface of urosomal somites smooth, with hyaline fringe strongly serrated (Fig. 12E). Caudal ramus 6.0-6.2 times longer than wide with spines along the entire outer margin (Fig. 12F).

Distribution: Nearctic. North, Central and South of Mexico. Previously *Eucyclops festivus* was recorded in systems of the Mexican states of Hidalgo, Mexico, Aguascalientes, and Chiapas, Mexico (Lindberg, 1955; Suárez-Morales and Reid, 1998; Suárez-Morales and Elías-Gutiérrez, 2003; Mercado-Salas, 2009; Gutiérrez-Aguirre *et al*., 2013).

Fig. 12. ***Eucyclops festivus*** **female from Diamond Y Spring. A, habitus. B, antennule segments 10-12. C, antennule, detail of hyaline fringe segment 11. D, Enp3P4 frontal, pore arrowed. E, urosomal somites ventral. F, anal somite and caudal rami ventral. Measurements in micrometers**



Eucyclops cuatrocienegas Suárez-Morales and Walsh, 2009
(see figures in Suárez-Morales and Walsh, 2009)

Eucyclops cuatrocienegas Suárez-Morales and Walsh, 2009: 2-10, Figs. 1-4
Eucyclops cuatrocienegas Mercado-Salas *et al*., 2015: 49-52, Figs. 29-30

Material: One dissected adult female, deposited in the zooplankton collection of ECOSUR (hollotype: ECO-CHZ- 3586) from Poza Tortugas, Coahuila, Mexico (26˚55.887 N; 102˚07.482 W), 07.VII.2006; one dissected adult male (allotype: ECO-CHZ-3588), same date, and site. Five undissected adult females, ethanol-preserved (paratypes: ECO-CHZ-3587), same locality and date.

Female: total body length 0.77-0.84 mm, excluding furcal setae, antennules 12-segmented, reaching posterior margin of the first prosomal somite. Hyaline, smooth, slender membrane on antennular segments 10-12. Dorsal surface of prosomal and urosomal somites smooth. Intercoxal sclerite of first leg completely naked caudally. Intercoxal sclerite of third leg with a row of small but strong spinules along distal margin, on caudal surface (on row I according with Mercado-Salas *et al*., 2015).

Caudal surface of fourth intercoxal sclerite ornamented: rows of tiny spinules on distal and medial positions (rows I, and II respectively), basal position (row III) with longer spines. Length ratio of medial/lateral spines of Enp3P4 = 1.4-1.5. Length/width ratio of Enp3P4 is 2.5-3.1; length ratio of medial spine of Enp3P4/segment length = 1.3.

Fifth leg with a short inner spine 1.3 times as long as the free segment, plus one medial and one lateral setae which are equal in length and more than 2.2 times longer than the inner spine.

Caudal ramus 3.1-3.7 times longer than wide with spines along the 65% of the lateral margin, inner margin smooth. Dorsal caudal seta (VII) 0.4 times the length of caudal ramus, and 1.1 times the length of outermost caudal seta (III). Innermost caudal seta (VI)/outermost caudal seta (III) = 1.3.

Male: Dorsal surface of prosomal and urosomal somites smooth, total body length excluding furcal setae 0.68 mm. 14-segmented, geniculated antennule. Caudal ramus around 2.8 times longer than wide, lateral and medial margins smooth. Fifth leg with one remarkably short inner spine, as in females.

Sixth leg with short lateral and medial setae, which are sub equal in length and 2 times shorter than the inner spine. The stout inner spine of sixth leg reaching the proximal third of succeeding urosomite.

Distribution: Possibly endemic to a few localities in the Mexican state of Coahuila, in the Chihuahuan Desert region (Suárez-Morales and Walsh, 2009; Suárez-Morales *et al*., 2010).

Eucyclops chihuahuensis Suárez-Morales and Walsh, 2009
(see figures in Suárez-Morales and Walsh, 2009).

Eucyclops chihuahuensis Suárez-Morales and Walsh, 2009: 15-19, Figs. 9-10
Eucyclops pseudoensifer Suárez-Morales *et al*., 2010: 526
Eucyclops chihuahuensis Mercado-Salas *et al*., 2015: 45-49, Fig. 28

Material: One adult female, deposited in the zooplankton collection of ECOSUR (hollotype: ECO-CHZ- 3589) from Presa Chihuahua, a reservoir near the city of Chihuahua, northern Mexico (28˚34.540 N; 106˚0 9. 932 W), 16.IV.2006; one undissected adult female (paratype: ECO-CHZ-3590), same date, site, and collector. Four undissected adult females, ethanol-preserved (paratypes: ECO-CHZ-3590), same locality and date.

Female: total body length excluding caudal setae 0.6-0.7 mm, antennule 12-segmented, hyaline

membrane, finely serrated on segments 10-12. Caudal surface of intercoxal sclerite of P1with long hair-like spinules, only on row II. BspP1with long, pinnate medial spine reaching distal margin of Enp2P1.

Intercoxal sclerite of P3 with long hair-like spinules on rows I, II, and III (caudally). Caudal surface of intercoxal sclerite of P4 with long hair-like setules on row I, and long spinules separated by a wide gap on rows II, and III. Fourth leg with long coxal spine, reaching well beyond distal margin of Bsp. Coxal spine of P4 with heteronomous ornamentation. Length/width ratio of Enp3P4 is 2.2-2.5; length ratio of medial spine of Enp3P4/segment length = 1.1. Length ratio of medial/lateral spines of Enp3P4 = 1.1-1.3.

P5 is a free segment bearing 3 elements: lateral seta as long as, or slightly shorter than inner spine. Medial seta of P5 2.8 times longer than lateral seta, and 1.7-2 times the length of inner spine.

Length/width ratio of caudal ramus = 4.3–4.5: lateral margin armed with row of slender spinules increasing in size distally. Dorsal caudal seta (VII) 0.43–0.45 times as long as caudal ramus. Innermost terminal seta 0.85 times as long as ramus, and 0.8 times as long as outermost caudal seta (III). Innermost caudal seta (VI)/outermost caudal seta (III) = 1.3.

Distribution: Possibly endemic to a few localities in the Mexican state of Coahuila, in the Chihuahuan Desert region (Suárez-Morales and Walsh, 2009; Suárez-Morales *et al.*, 2010).

Macrocyclops albidus albidus (Jurine, 1820)
(Figs. 13, 14)

Macrocyclops albidus albidus Reid, 1985: 98-99, Figs. 66-69.
Macrocyclops albidus Reid, 1992: 239-241, Fig. 5.
Macrocyclops albidus Suárez-Morales *et al.*, 1996: 176-178, Figs. 59-60.

Material: three adult females and one adult male preserved in alcohol 70% from Balmorhea Lake, 24. II. 2007, ECO-CH-Z-04093. Four adult female from Los Hundidos, 9.I.2006 for SEM.

Female: Oval prosome; slender urosome; total body length excluding caudal setae = 0.83-1.0 mm. Antennules reaching last segment of prosome, 17-segmented (Fig. 13A). Segments 15-17 of A1 with serrated, hyaline membrane (Fig. 13B, C). Maxilliped with syncoxa bearing three setae, surface nude caudally; basis with two long armed setae, plus one row of spines caudally (arrowed in Fig. 13D), and long acute setae frontally; Enp two-segmented, first segment with one long, armed seta; Enp2 bearing three setae. Intercoxal sclerites of P1 and P2 with one line of tiny spines caudally (Fig. 13E, F). Intercoxal sclerite of P1 with two marginal, rounded projections bearing spinules (Fig. 13E).

Intercoxal sclerite of P3 with two low, rounded projections bearing tiny spinules (Fig. 14A). Basipodite of P4 with nude inner margin, intercoxal sclerite armed on caudal surface: one row of tiny spines proximally, one row of acute spines medially, and one row of acute spines on distal margin (Fig. 14B).

P5 two-segmented (Fig. 14C), proximal segment armed with spines and one long seta; distal segment bearing three long setae (Fig. 14D).

Crenulated hyaline fringe along distal margin of each urosomites (Fig. 14E), anal somite slightly shorter than caudal rami, with a continuous row of spinules along its distal margin. Anal opercule straight, nude anus (Fig. ¬14F). Caudal ramus 2.03-2.06 times longer than width; length ratio of dorsal caudal seta (VII)/caudal rami = 1.74-1.83.

Distribution: Cosmopolitan (Reid, 1985), the specimens surveyed here has the short furcal rami (about two times longer than width), common in tropical forms from southern Brazil, Brazilian Amazon, Venezuela and widespread in the USA; and the presence of setae instead than spine on distal segment of P5 is a general feature of North American populations of *M. albidus* (Reid, 1992). North, central and southeastern regions in Mexico (Elías-Gutiérrez *et al*., 2008; Suárez-Morales *et al*., 2010).

Fig. 13. ***Macrocyclops albidus albidus*** **female from Los Hundidos, Coahuila. A, habitus. B, A1, segments 16-17. C, A1, detail of segment 17. D, Maxilliped, spines on basis arrowed, caudal. E, P1 intercoxal sclerite. F, P2 intercoxal sclerite. Measurements in micrometers**

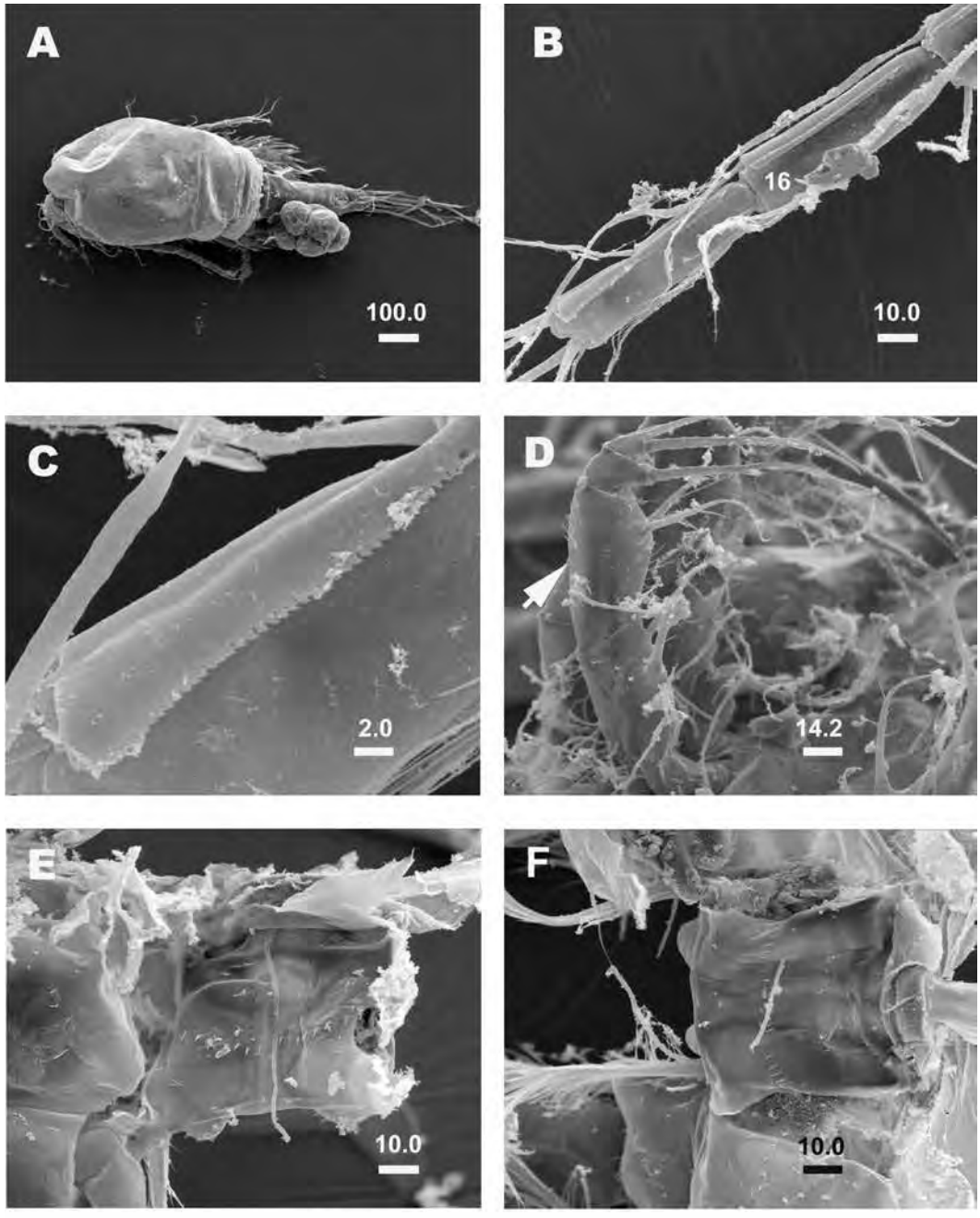
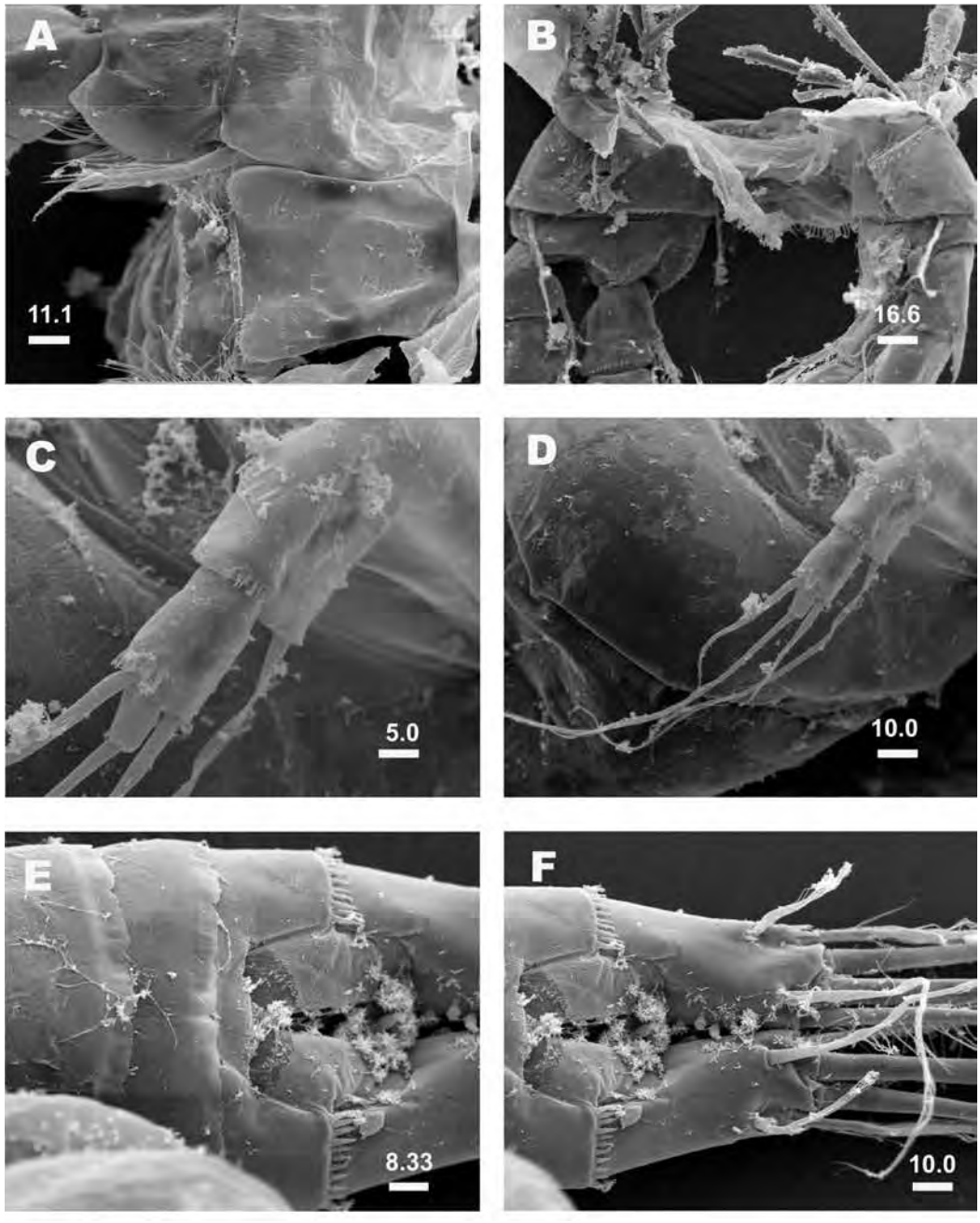


Fig. 14. ***Macrocyclops albidus albidus*** **female from Los Hundidos, Coahuila. A, P3 intercoxal sclerite. B, P4 coxa, basis and intercoxal sclerite. C, free segments of P5. D, P5. E, urosomal and anal somites dorsal. F, anal somite and caudal rami dorsal. Measurements in micrometers**



Paracyclops chiltoni (Thomson, 1882)
(Figs. 15, 16)

Paracyclops fimbriatus chiltoni Reid, 1985: 33, Fig. 75.
Paracyclops chiltoni Karaytug and Boxshall, 1999: 371-379, Figs. 1-2.
Paracyclops chiltoni Mercado-Salas and Suárez-Morales, 2009: 2801-2804. Figs. 6-7.

Material: four adult females, and three adult males from Dripping Springs, Big Bend National Park, Brewster Co., Texas, USA, 16.V.2006 for SEM.

Female: Body dorso-ventrally flattened, prosome anteriorly wider, urosome narrowed (Fig. 15A); 8-segmented antennules, reaching third region of first prosomite (Fig. 15A, B), ornamentation of each antennular segment as follows (s= seta; ae= aesthetasc): 8s, 7s + ae, 4s, 4s, 2s, + ae, 2s, 2s, + ae, 6s + ae (Fig. 15B). A continuous row of strong spines along both, dorsal and ventral distal margins of anal somite (arrowed, Fig. 15C); distance among caudal ramus shorter than the width of each ramus (Fig. 15C). Anal opercule convex; single row of spines along both lateral margins of anal aperture, and parallel rows of tiny spinules along the medial axes of anal aperture (Fig. 15D). Caudal ramus 4.1-4.3 times as long as wide, with spines on the insertion of both outermost caudal seta (III), and lateral caudal setae (II) (Fig. 15C, E); transversal row of spines at the base of lateral caudal seta on dorsal surface (Fig. 15E). Hyaline fringe of urosomites serrated distally, surface of urosomites pitted (Fig15F).

Male: body shape as described for females (Fig. 16A), antennules 15-segmented, arrange of setae and aesthetasc as follows: 8s + ae, 4s, 2s + 2s + ae, 2s, 2s, 2s, 2s, 2s + ae, 2s, 2s, 2s, 6s, 3s, + ae, 11s + ae (Fig. 16B). Presence of one setae (called the element A) large, wide, and glandular in the first antennular segment, as mentioned by Karaytug and Boxshall (1999) (arrowed Fig. 16B).

Distribution: Cosmopolitan. North and South America (Reid, 1985; Karaytug and Boxshall, 1999; Mercado-Salas and Suárez-Morales, 2009; Suárez-Morales *et al*., 2010).

Fig. 15. ***Paracyclops chiltoni*** **female from Dripping Springs. A, habitus. B, antennules. C, anal somite, and caudal ramus ventral. D, anal somite dorsal. E, caudal ramus dorsal. F, genital somite dorsal. Measurements in micrometers**

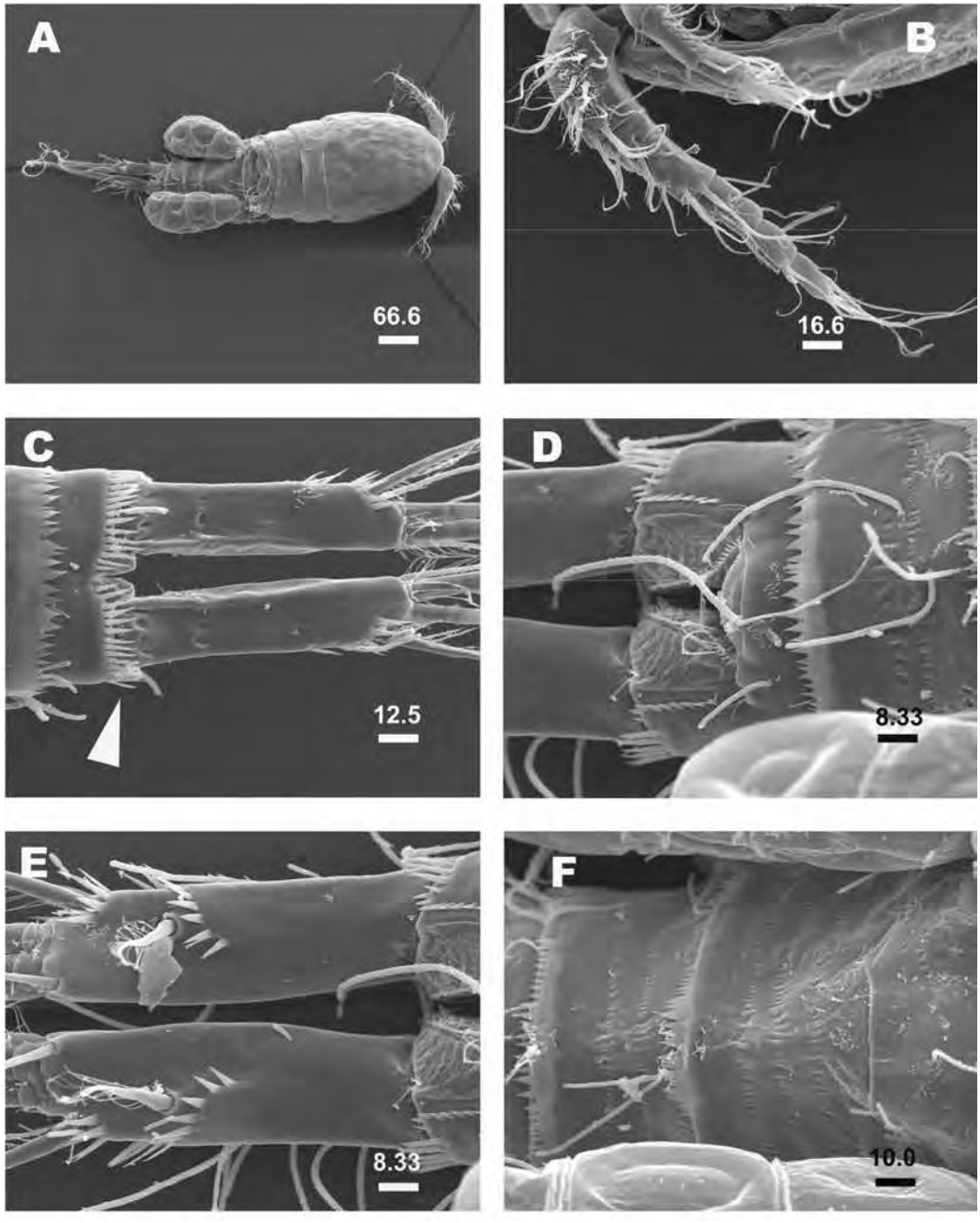
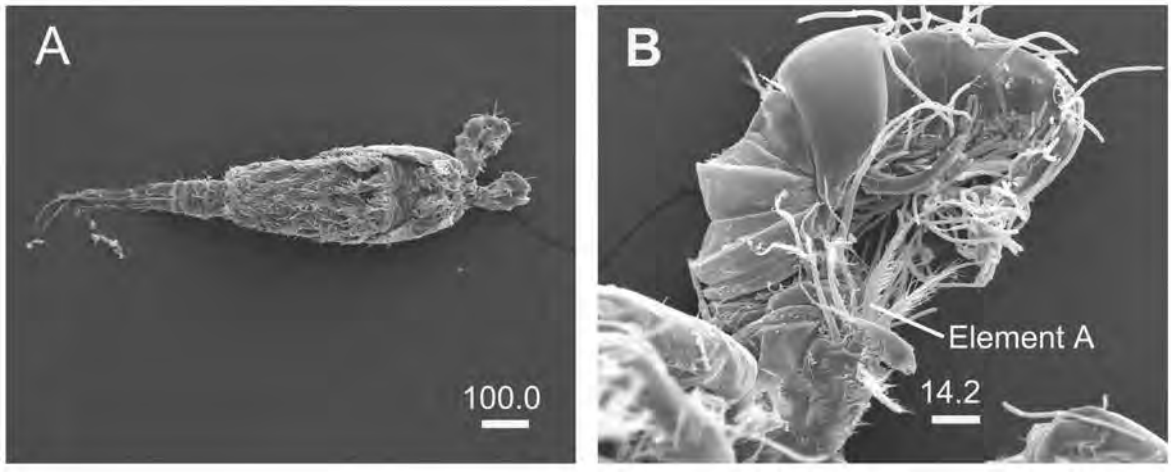


Fig. 16. *Paracyclops chiltoni* male from Dripping Springs. A, habitus. B, antennules (element A, arrowed). Measurements in micrometers



Paracyclops poppei (Rehberg, 1880)
(Figs. 17, 18)

Paracyclops fimbriatus poppei Reid, 1985: 33, Fig. 71.
Paracyclops poppei Karaytug and Boxshall, 1999: 371-379, Fig. 4.

Material: Two adult females, four adult males, from Diamond Y Spring, Pecos Co., Texas, USA. 31.III.2006, ECO-CH-Z-03619. Seven females and four adult males for SEM, same locality.

Female: P5 one-segmented with two apical long setae, and one apical shorter spine. Body dorso-ventrally flattened, prosome wider anteriorly, urosome narrowed (Fig. 17A); antennules 8-segmented, reaching the half-length of first prosomite (Fig. 17B), one row of long spines on first antennular segment; ornamentation of each antennular segment as follows (s= seta; ae= aesthetasc): 8s, 7s + ae, 4s, 4s, 2s, + ae, 2s, 2s, + ae, 6s + ae (Fig. 17B). Urosomites pitted, distal hyaline fringe serrated (Fig. 17C). Anal opercule straight (Fig. 17D); anal somite ornamented dorsally: parallel rows of spinules along lateral, anal aperture, plus a row of strong spines on dorsal and ventral distal margin of anal somite (Fig. 17D). Caudal ramus 2.7-3-0 times as long as wide, with spines on the insertion of outermost caudal seta (III), and lateral caudal setae (II); a continuous row of spines from the base of the lateral caudal seta to dorsal surface, following the longitudinal axes of caudal ramus (Fig. 17D).

Male: body shape as described for female (Fig. 17E), antennules 15-segments, arrange of setae and aesthetasc as follows: 8s + ae, 4s, 2s + 2s + ae, 2s, 2s, 2s, 2s, 2s + ae, 2s, 2s, 2s, 6s, 3s, + ae, 11s + ae (Fig. 17F).

Two setae (called the elements A, and C) in the first antennular segment as mentioned by Karaytug and Boxshall (1999) (arrowed in Fig. 18A). Enps and Exps of thoracic legs 3-segmented (Fig. 18B). Sixth leg with two thin setae, and one lateral spine (Fig. 18C). Spines on anal somite as described for females, except that in the males, the spines on anal aperture are thinner and longer than in females (Fig. 18D). Caudal ramus 3.2-3.4 timer longer than wide, ornamented as in the females (Fig. 18D).

Distribution: Cosmopolitan. North and South America (Reid, 1985; Karaytug and Boxshall, 1999; Suárez-Morales *et al.*, 2010).

Fig. 17. ***Paracyclops poppei*** **female from Diamond Y Spring, Pecos Co., Texas, USA. A, habitus. B, antennules. C, urosomites dorsal. D, anal somite and caudal ramus dorsal. Male from Diamond Y Spring. E, habitus, F, antennule. Measurements in micrometers**

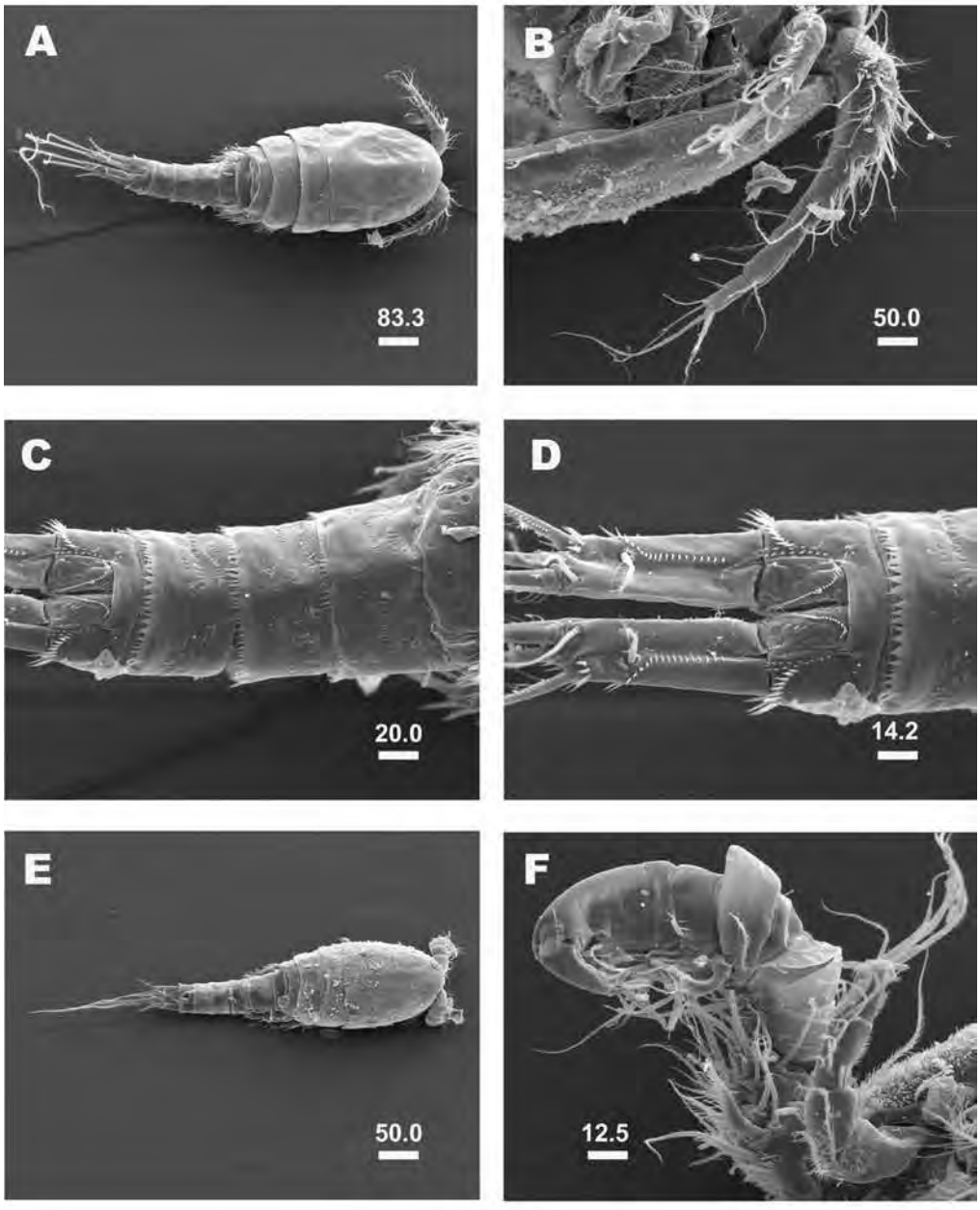
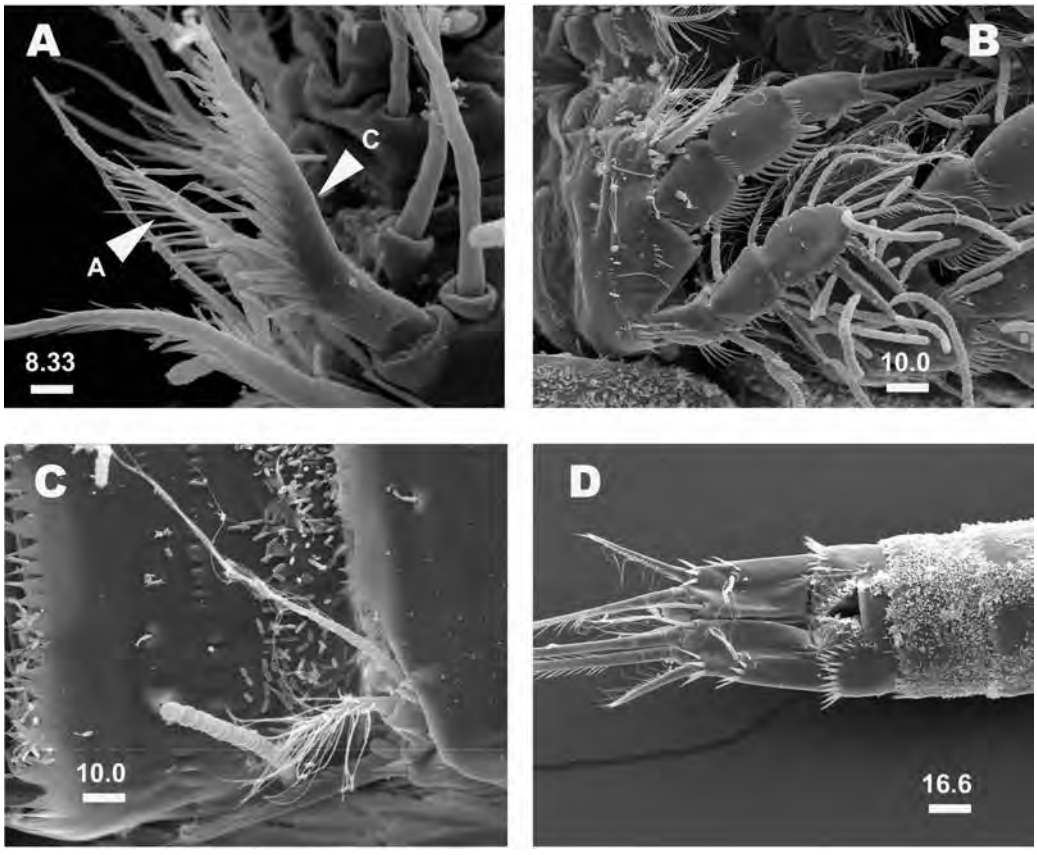


Fig. 18. ***Paracyclops poppei*** **male from Diamond Y Spring. A, detail of elements A, and C of the first antennular segment (arrowed). B, P1. C, sixth leg. D, anal somite and caudal ramus dorsal. Measurements in micrometers**



Tropocyclops prasinus s. str. (Fischer, 1860)
(Fig. 19)

Topocyclops prasinus s. str. Reid, 1991: 14-15.
Topocyclops prasinus s. str. Suárez-Morales *et al.*, 1996: 182

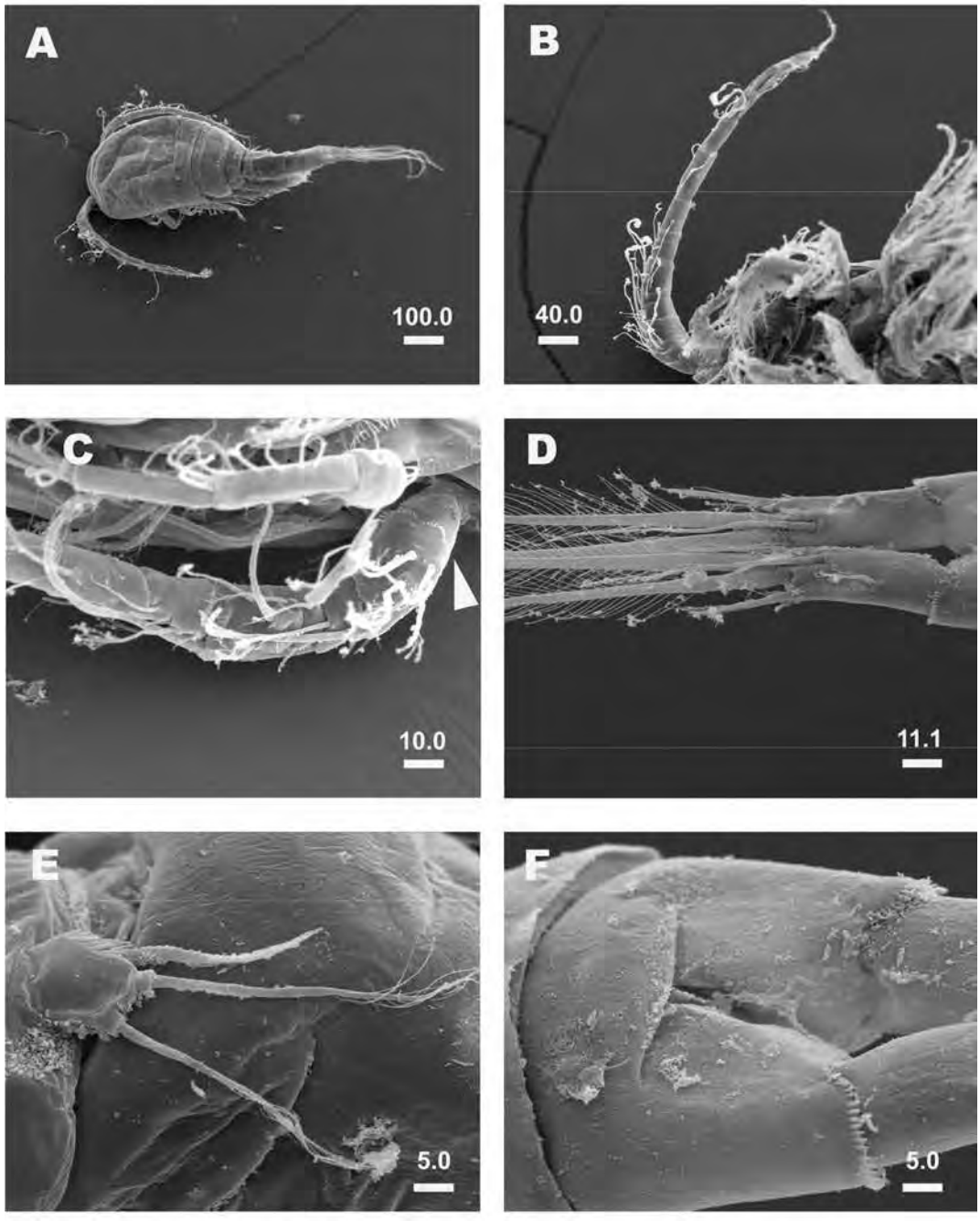
Material: One adult female from Ernst canyon tinaja # 7, Big Bend National Park, Brewster Co., Texas, USA. 8.X.2003, and one adult female from pool at the base of Cattail Falls, Big Bend National Park, Brewster Co., Texas, USA. 18.V. 2006 for SEM.

Female: Total body length 0.7 mm. Antennules reaching distal margin of last prosomite. Urosome slender, shorter than prosome (Fig. 19A). Antennules 12-segmented; first antennular segment with two rows of spinules on inner surface (Fig. 19B, C). Caudal ramus 2.3-2.6 times longer than wide; dorsal caudal seta 1.4-1.6 times longer than caudal rami (Fig. 19D).

Enp3P4 2.3-2.6 times longer than width; medial spine of Enp3P4 is 2.2-2.4 times longer than lateral spine. Spine formula of thoracic legs 3, 4, 4, 3. Fifth leg reduced to one segment bearing one inner spine and two setae. Several tiny spines at base of inner spine of fifth leg (Fig. 19E). Surface of anal somite smooth in dorsal view, with tiny spinules along entire ventral and dorsal margins, and convex anal opercule (Fig. 19F).

Distribution: Cosmopolitan (Reid, 1991; Suárez-Morales *et al.*, 2010).

Fig. 19. ***Tropocyclops prasinus*** **s. str., female from pool at the base of Cattail Falls, Big Bend National Park, Brewster Co., Texas, USA. A, habitus. B, antennules. C, detail of spines on first antennular segments (arrowed). D, caudal ramus and caudal setae dorsal. E, P5. F, anal somite dorsal. Measurements in micrometers**



Acanthocyclops americanus (Marsh, 1893)
(Figs. 20, 21)

Acanthocyclops americanus s. str. Miracle *et al*., 2013: 870-878, Figs. 3-6.
Acanthocyclops robustus Einsle, 1996: 73, Fig. 53.
Acanthocyclops robustus Suárez-Morales *et al*., 2010: 526.
Diacyclops A Suárez-Morales *et al*., 2010: 526.
Syn: *Acanthocyclps trajani* Mirabdullayev and Defaye, 2002: 14-18, Figs. 24-27.

Material: 3 adult males preserved in alcohol 70% from Lago Colina, 6.I.2006, ECO-CH-Z-04091; One adult female preserved in alcohol 70% from Roadside sample Rio Bravo 19.X.2005, ECO-CH-Z-04090; five adult females and three copepodids preserved in alcohol 70% from Lago Colina, 18. IV. 2006, ECO-CH-Z-04089; One dissected male on semipermanent slide from Balmorhea Lake, Texas USA 31.III.2006, ECO-CH-Z-04088; one adult female on two semipermanent slides from Balmorhea Lake, Texas USA 31.III.2006 (ECO-CH-Z-04086: antennule, antenna, mandible, maxillule, maxille, and maxillied; and on ECO-C-Z-04087: P1-P4 and urosome).

Female: 1250 -1300 μm of total body length; smooth dorsal and ventral surfaces of prosomal and urosomal somites (Fig. 20A, B). Antennule 17-segmented, short, ending at distal margin of first prosomite (Fig. 20A), armed as follows (s= seta; sp= spine, ae= aesthetasc): 8s, 4s, 2s, 6s, 3s+1sp, 1s+1s, 2s, 1s, 1s, 0, 1s, 1s+1ae, 0, 1s, 2s, 2s+1ae, 7s+1ae (Fig. 20C). Antennal endopodite 3-segmented; Enp2 bearing 9 setae (Fig. 20D). No spines next to antennal exopod; antennal Bsp with three rows of spines caudally (Fig. 20E).

Maxillar basipodite (Fig. 20F) with one claw-like projection armed with fine spinules on the concave margin. Distal coxal maxillar endite with two setae, proximal seta with tiny spines at its base, bifurcated; distal seta smooth. Maxilliped with rows of strong spines on basis and Enp 1 (Fig. 20G).

Spinal formula of P1-P4 exopodites is 3 4, 4, 4. Intercoxal sclerite of P1 with long setae on distal margin. Basipodite of P1 with inner spine, which reaches third Enp (Fig. 20H). P4 (Fig. 20I) with spines on intercoxal sclerite: one row caudally, and one frontally. Coxal plate with four groups of strong spines. Inner basis of P4 with setules. Enp3P4 2.65-3.08 times as long as wide; medial apical spine is 1.1-1.2 times longer than lateral spine; with either medial-distal and lateral setae situated at same level (0.59-0.66 times the segment length) (Fig. 20J). Fifth leg 2-segmented: basal segment with long seta, distal segment bearing a short subapical spine and a long apical seta (Fig. 20B, K).

All urosomites with serrated hyaline membrane. Anal aperture with a row of long spines. Caudal rami 3.8-5.2 times as long as wide, with tiny spines on dorsal and ventral surfaces (Fig. 21A); implantation of outermost caudal seta (III) provided with spinules (Fig. 21A). innermost caudal seta (VI) 0.95-1.11 times as long as caudal ramus; innermost caudal seta (VI)/median inner caudal seta (V) = 0.23-0.32; innermost caudal seta (VI)/median outer caudal seta (IV) = 0.33-0.4; innermost caudal seta (VI)/outermost caudal seta (III) = 1.59-1.7; innermost caudal seta (VI)/dorsal caudal seta (VII) = 1.3-1.8.

Male (Fig. 21B-I): Armature of P1-P5 similar with those of females. No spines next to Exp of antennal basis, Exp2 of A2 with eight setae. Enp3P4 with a lateral, fine seta; this segment is 2.5-2.8 times as long as wide; medial spine 1.1-1.2 longer than lateral spine. P6 with one long seta (twice the length of inner spine and medial seta). Caudal ramus 3.6-4.1 times as long as wide. Implantation of lateral (II) and median outer caudal setae (IV) with spinules. VI/caudal ramus length = 0.9-1.1; VI/V = 0.19-0.23; VI/IV = 0.3-0.36; VI/III = 1.6-1.84; VI/VII = 1.04-1.4. Anal somite as described in females.

Distribution: Cosmopolitan. Europe, West Asia, North, Central and South America (Miracle *et al*., 2013).

Fig. 20. ***Acanthocyclops americanus*** **female from Balmorhea Lake. A, habitus. B, genital double somite. C, antennule. D, antennae frontal. E, antennal basis caudal. F, Maxilla. G, Maxilliped, syncoxa separated and roted. H, P1, Enp and one plumose seta separated. I, P4 coxa, basis, and intercoxal sclerite. J, Enp3P4. K, P5. Photos with measurements in micrometers; scale bars in drawings = 50 μM**

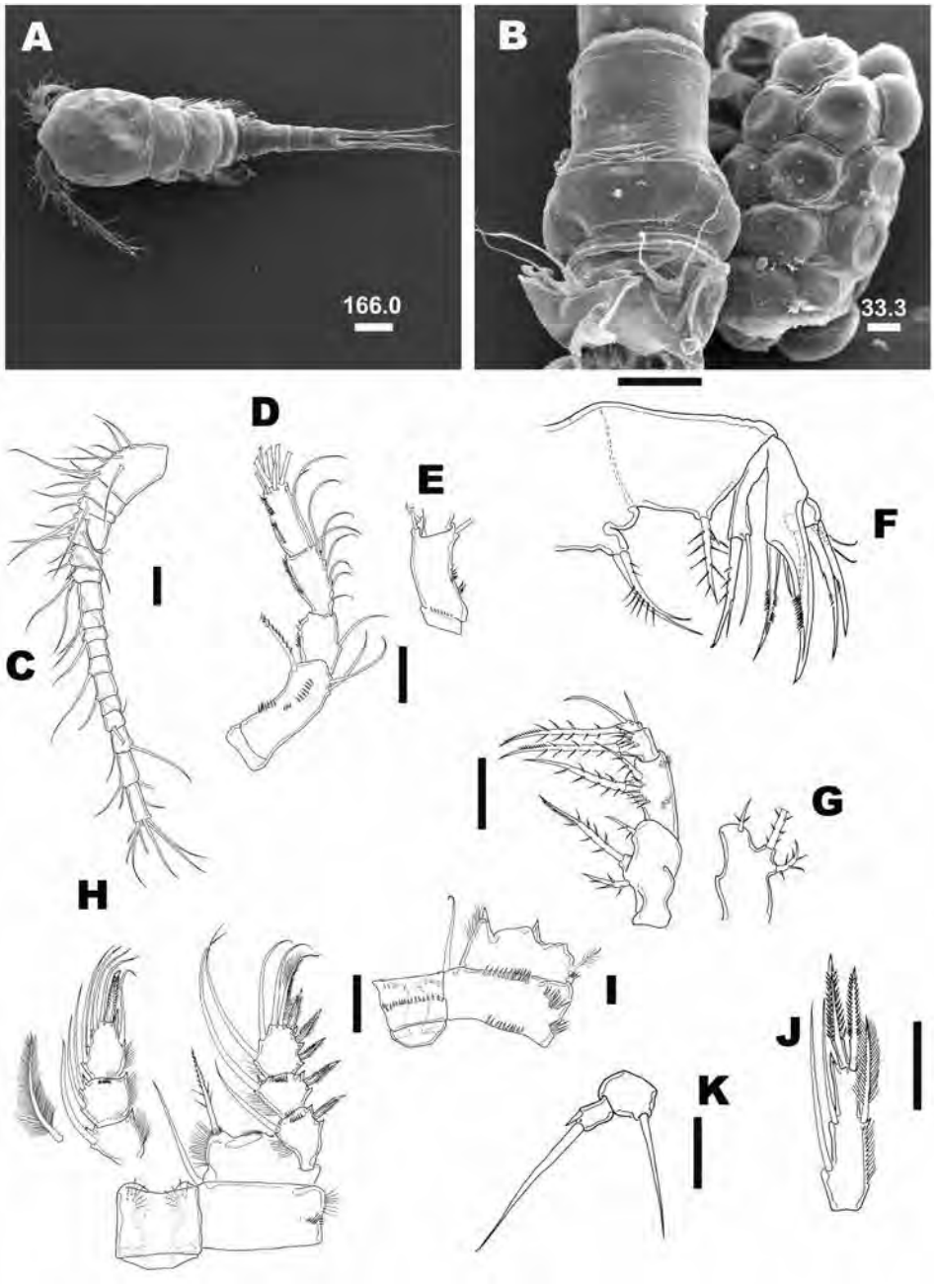
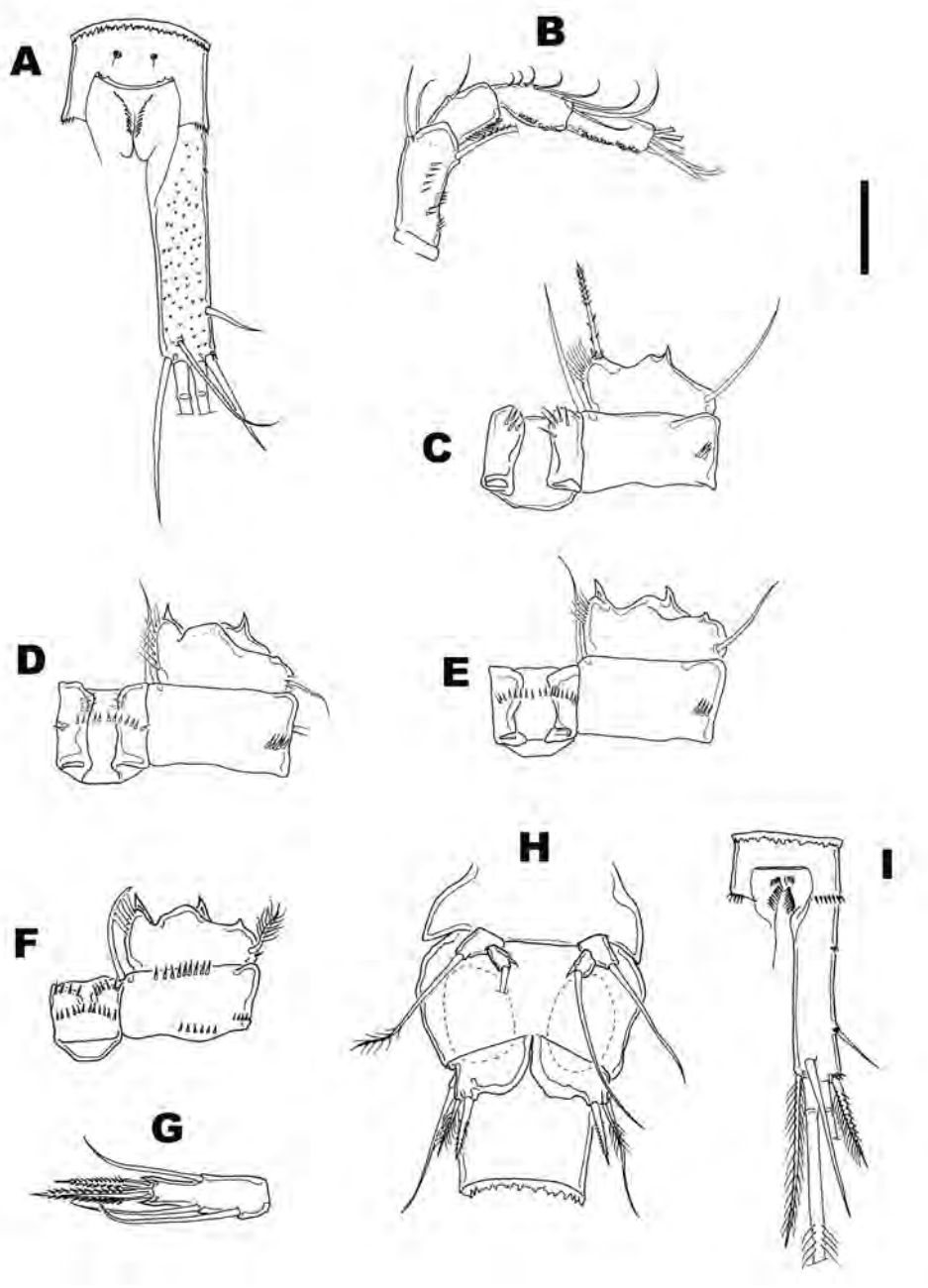


Fig. 21. ***Acanthocyclops americanus*** **female from Lago Colina. A, anal somite and caudal rami dorsal. Male from Balmorhea Lake. B, antennae frontal. C, P1 coxa, basis, and intercoxal sclerite. D, P2 coxa, basis, and intercoxal sclerite. E, P3 coxa, basis, and intercoxal sclerite. F, P4 coxa, basis, and intercoxal sclerite. G, Enp3P4. H, fifth pediger and two urosomites, ventral. I, anal somite and caudal rami, dorsal. Scale bars = 50 μM**



Metacyclops deserticus Mercado-Salas and Suárez-Morales, 2013
(see figures in Mercado-Salas *et al.*, 2013)

Metacyclops deserticus Mercado-Salas *et al.*, 2013: 4-14, Figs. 1-5

Material: One adult female dissected (paratype: ECO-CH-Z-08585), one adult male (allotype: ECO-CH-Z-08586). Fifteen adult un-dissected females, ethanol-preserved (paratypes: ECO-CH-Z-08587). All collected in pond at El Refugio bridge, Cerro Bola, Km 70, east of Torreón city, federal highway 40, Coahuila (25°35'02"N, 102°45'02"W), 10.X.1981.

Female: total body length is 0.72-0.87 mm excluding caudal setae. Antennule short, not reaching distal margin of first pediger, 11-segmented. Anal somite with tiny spines on distal margin, dorsal and ventrally.

Caudal ramus is 3.5-3.8 times longer than wide, with lateral and medial margins naked. Dorsal caudal seta (VII) is 0.4-0.5 times the length of caudal ramus; outermost caudal seta (III) 0.6–0.7 times as long as caudal ramus. Innermost caudal seta (VI) about 0.5 times as long as caudal ramus. Length ratio of innermost caudal seta (VI)/ outermost caudal seta (III) = 0.8–0.84.

Intercoxal sclerites of P1-P4 naked, distal margins with rounded projections. All Enps and Exps of P1-P4 two-segmented. Spinal formula 3433.

Medial margin of Basis of P1 with row of hair-like setae and long slender spine, reaching middle margin of Enp2P1, row of hair-like setules along. Lateral spine Enp2P1 strong, slightly longer than segment.

Enp2P4 about two times longer than wide (1.9), apical spine of Enp2P4, 0.8 times as long as the segment. Basal segment of P5 fused to somite, subrectangular, 1.2 times longer than wide, bearing one inner spine slightly shorter than the segment and one apical seta about 4 times longer than inner spine. Additionally, one dorsal, plumose seta on lateral margin of fifth pediger.

Sixth leg armed with relatively long plumose seta, and with 2 short, subequal smooth spines.

Distribution: Possibly endemic to a restricted area near the type locality of the Mexican state of Coahuila, in the Chihuahuan Desert region (Mercado-Salas *et al.*, 2013).

Apocyclops dimorphus (Kiefer, 1934)
(Fig. 22)

Apocyclops dimorphus Coelho Botelho, 1999; Figs. 28-41.
Apocyclops dimorphus Reid and Hribar, 2006

Material: 5 adult females, 3 adult males, 28 copepodites alcohol preserved; from Lake Holloman, Otero Co., New Mexico. 17.XI.2006 (ECOCHZ-3617). One dissected adult female preserved on glycerine (from the same locality) in three semi-permanent slides: A1, and A2 appendages (ECOCHZ-4081); Mandible Maxillule, Maxile, Mxp, and Abd (ECOCHZ-4082); P1-P4 (ECOCHZ-4083).

Female: Body length 1.2-1.3 mm. Body slender distally, prosome slightly longer than urosome (Fig. 22A). Antennules 11-segmented (Fig. 22B), reaching distal third of first prosomal segment (Figs. 22A). Length/width ratio of genital double somite: 1.0-1.1 (Fig. 22A, I). Bi-segmented exopodites and endopodites on P1-P4, spinal formule is 4-4-4-3 (Fig. 22C-F). Coxal and basis surfaces of P1 smooth, with one spine, almost as long as Enp on inner basis margin (Fig. 22C). Intercoxal sclerites of P1 to P4 with rounded outgrowths, inner margin basis of P2 to P4, distally acute. P4 without ornaments on coxal and basis surfaces; one medial, short seta on coxa; and one lateral, long seta

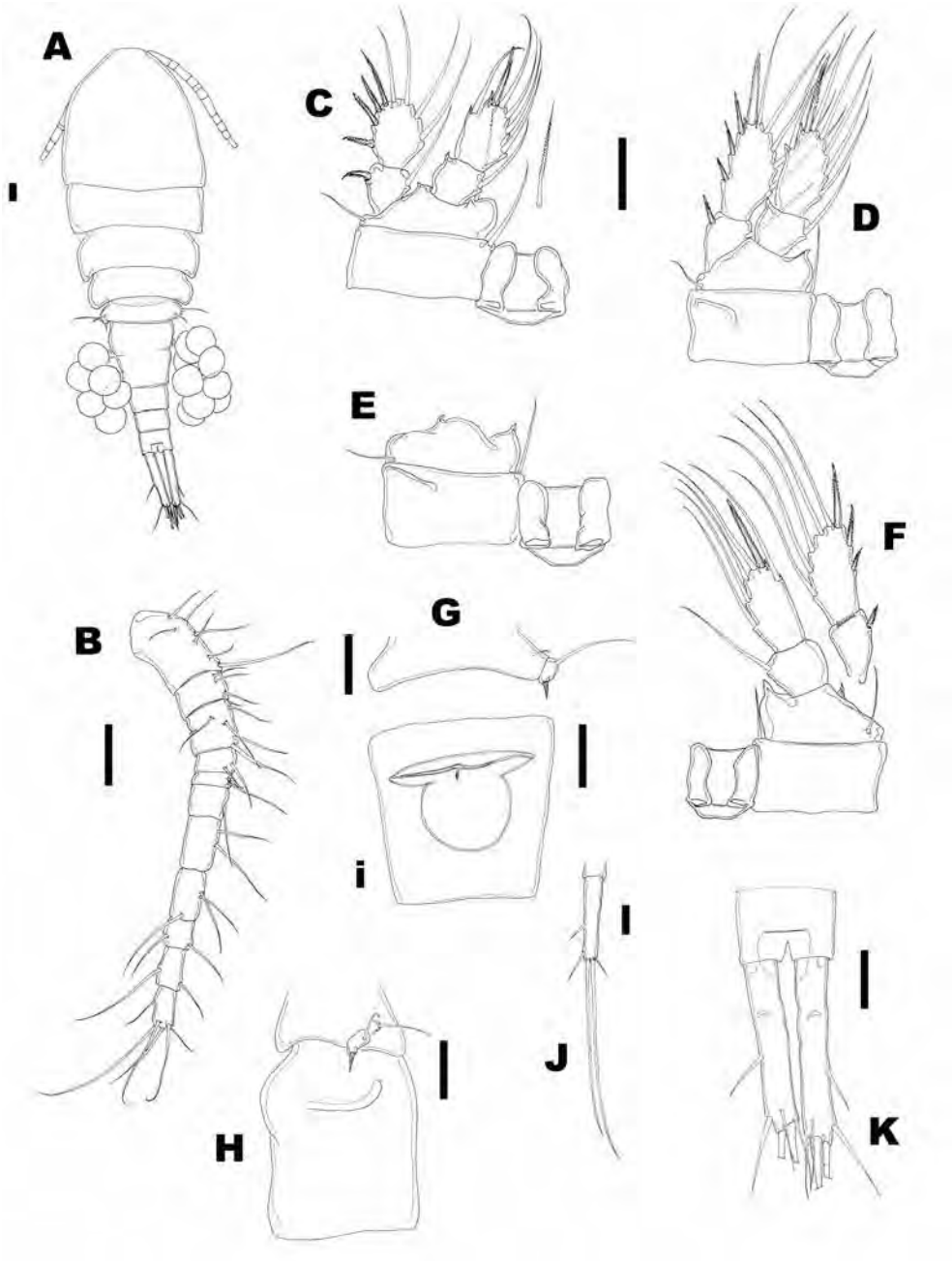
on basis. Enp2P4 1.9-2.0 times as long as wide; medial spine 0.88-0.9 times as long as the segment (Fig. 22F). Basal segment of P5 plate-like, around 0.5 times as long as wide; fused to lateral margin of the nude fifth pediger; bearing a long, lateral seta 4.3 times longer than inner spine (Fig. 22G); one small setae directed dorsally (Fig. 22H).

Genital double somite not strongly wide proximally, almost square like; copulatory burse sac-like, with wide lateral arms, and a very thin, inner channel (Fig. 22I).

Length to width ratio of caudal ramus 5.5-5.8 (Fig. 22J, K), anal somite bare, anal margin straight, smooth. Medial inner caudal seta (V) 1.2-1.2 times longer than median outer caudal seta (IV) (Fig. 21J). Dorsal caudal seta (VII) short: 1.2-1.25 times longer than lateral caudal seta (II); 0.8-0.85 times the length of the outermost caudal seta (III); and with the same length of the innermost caudal seta (VI) (Fig. 22K).

Distribution: Nearctic. The species has been recording in Florida (Reid and Hribar, 2006), the North Atlantic region (Ferrari and Ivanenko, 2001), and the arid and semi-arid regions of Chihuahua, Mexico (Suárez-Morales *et al*., 2010).

Fig. 22. ***Apocyclops dimorphus*** **female from Lake Holloman, Otero Co., New Mexico. A, habitus dorsal. B, antennules. C, P1. D, P2. E, coxa, basis, and intercoxal sclerite P3. F, P4. G, fifth pediger ventral. H, fifth pediger, and genital double somite, lateral. I, genital double somite, ventral. J, caudal rami with setae ventral. K, anal somite and caudal rami dorsal. Scale bars = 50 µM**



Microcyclops dubitabilis Kiefer, 1934
(Figs. 23-26)

Microcyclops rubellus Reid, 1990: 181
Microcyclops rubellus Reid, 1992: 245-249, Fig. 8
Microcyclops rubellus Suárez-Morales *et al*., 1996: 136-138, Fig: 45-46
Microcyclops dubitabilis Fiers *et al*., 2000: 246-247, Figs. 28-29
Microcyclops rubellus Suárez-Morales *et al*., 2010: 526
Microcyclops dubitabilis Gutiérrez-Aguirre and Cervantes-Martínez, 2016: 43-47, Figs. 6-8

Material: Two adult females for SEM, from Soda pond located at Indian Hotsprings, Hudspeth Co., Texas, USA. 19.X.2005. One adult female and one adult male for SEM, from Glenn Spring located in Big Bend National Park, Brewster Co., Texas, USA; and one adult female for SEM, from Tuft BBNP, 07.I.2003.

Female: Body length 0.6-0.7 mm. Body slender distally, prosome slightly longer than urosome (Fig. 23A). Antennules 11 or 12-segmented, reaching distal third of first thoracic segment (Fig. 23A, C). Fifth pediger nude (Fig. 23A, B). Antennal basis with three rows of delicate spinules caudally: one along the main axis and two basal, transversal (arrowed in Fig. 23D). Maxilliped with three setae on syncoxa, the lateralmost, nude. Basis with two long setae plus a group of tiny spinules, frontally; Enp 2-segmented with 1 and 3 setae respectively (Fig. 23E).

Thoracic limbs bi-segmented, spinal formulae: 3, 4, 4, 3. Coxal and basis surfaces of P1 smooth; inner basis of P1 with one short spine slightly longer than Enp1P1 (Fig. 24A). Inner margin of basipodite of P1 pilose, and spine on inner basis armed with tiny spinule-like setules in homonomous ornamentation (Fig. 24B).

P5 reduced to one bared, cylindrical segment that bears one long seta distally (Figs. 23B, 24C). Genital double somite 1.25-1.30 times longer than wide; irregular distal hyaline fringe on abdominal segments (Fig. 24D).

Length to width ratio of caudal ramus 2.5-2.7, inner margin naked (Figs. 24E, 23A); with or without tiny spines on the base of lateral caudal seta (II in Fig. 25A), and strong spines on the base of outermost caudal seta (III in Fig. 25A). Dorsal caudal seta (VII in Fig. 25A) 1.1-1.3 as long as caudal ramus.

Anal somite with spines along entire dorsal and ventral margins (arrowed in Fig. 24E). Both median caudal setae (IV, and V in Fig. 24F) with heteronomous ornamentation: proximal setules are wider than distal setules.

Distal margin of prosomal somites smooth (Fig. 25B), inner margin of basis of P4 with short hairs (arrowed, Fig. 25C). Sixth leg with two short spines and one long seta (Fig. 25D).

Male: Body length 0.49-0.5 mm excluding caudal setae. Prosome represents 55.6% of total body length. Long aesthetascs on first to fourth antennal segments (Fig. 26A, B). Rostrum pointed, Enp2 of antenna bearing 9 setae (Fig. 26B). First leg (Fig. 26D) and free segment of P5 as described for female (Fig. 26 C, E). Sixth leg reduced to one inner spine, one medial setae, and one lateral seta that reaches the distal third of second urosomal somite (Fig. 26C).

Distribution: Neotropical. Haiti, Guadeloupe Islands, Venezuela, Mexico, and Florida; probably some records of *M. rubellus* in America could be *M. dubitabilis* (see Gutiérrez-Aguirre and Cervantes-Martínez, 2016). In Mexico, records of *M. dubitabilis* have been confirmed in Chiapas, Yucatan Peninsula, Tabasco (Fiers *et al*., 2000; Gutiérrez-Aguirre and Cervantes-Martínez, 2016) central and northern regions.

Fig. 23. ***Microcyclops dubitabilis*** **female from Glenn Spring located in Big Bend National Park, Brewster Co., Texas, USA. A, habitus. Female from Tuft BBNP. B, fifth pediger and P5, ventral. Female from Soda pond located at Indian Hotsprings, Hudspeth Co., Texas, USA. C, antennules. D, antennal basipodite, caudal. E, Maxilliped, frontal. Measurements in micrometers.**

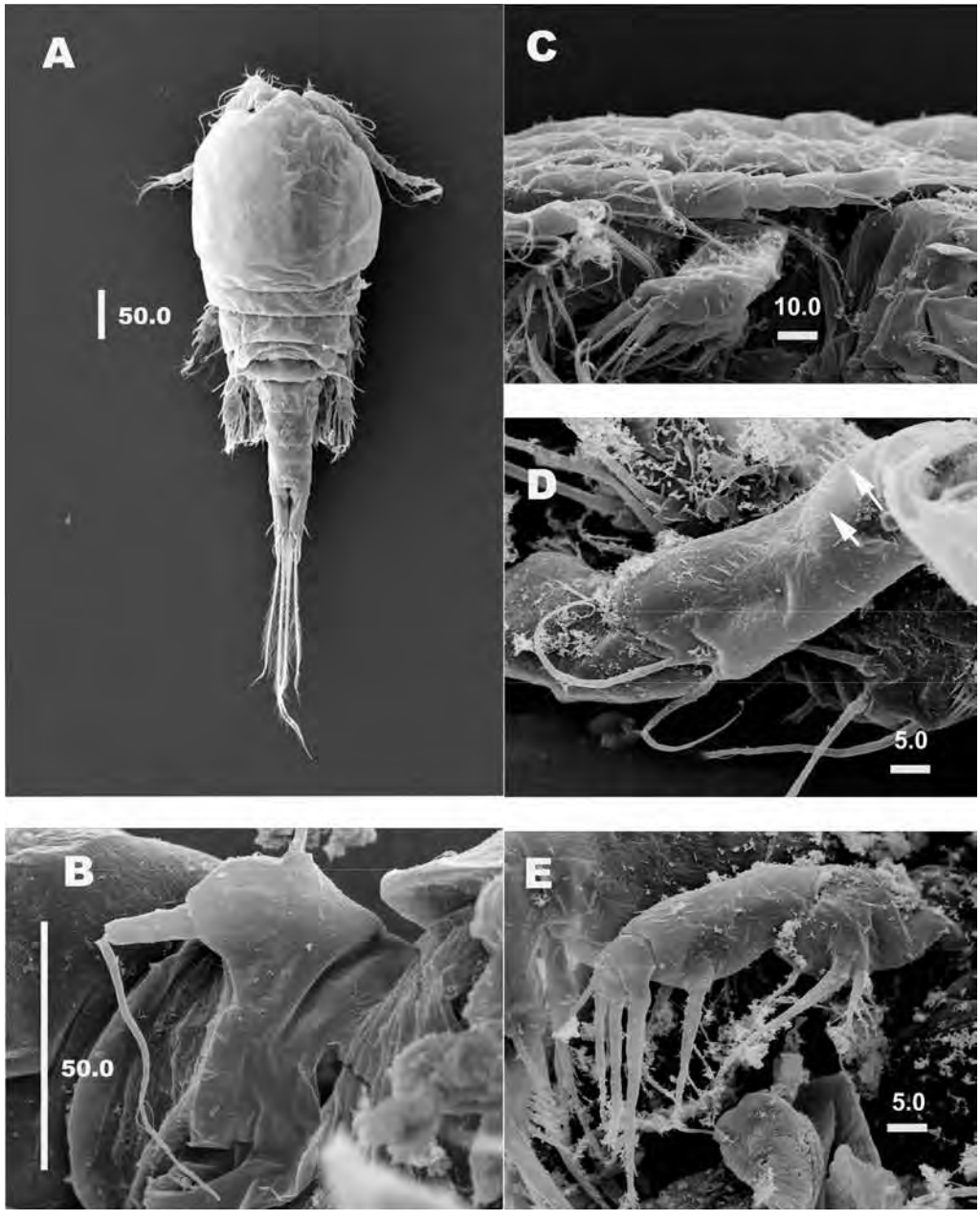


Fig. 24. ***Microcyclops dubitabilis*** **female from Soda pond located at Indian Hotsprings, Hudspeth Co., Texas, USA. A, P1, frontal. B, P1 detail of basipodite and Enp1. C, P5. D, genital double somite ventral. E, anal somite and caudal ramus ventral. F, detail of caudal medial setae. Measurements in micrometers**

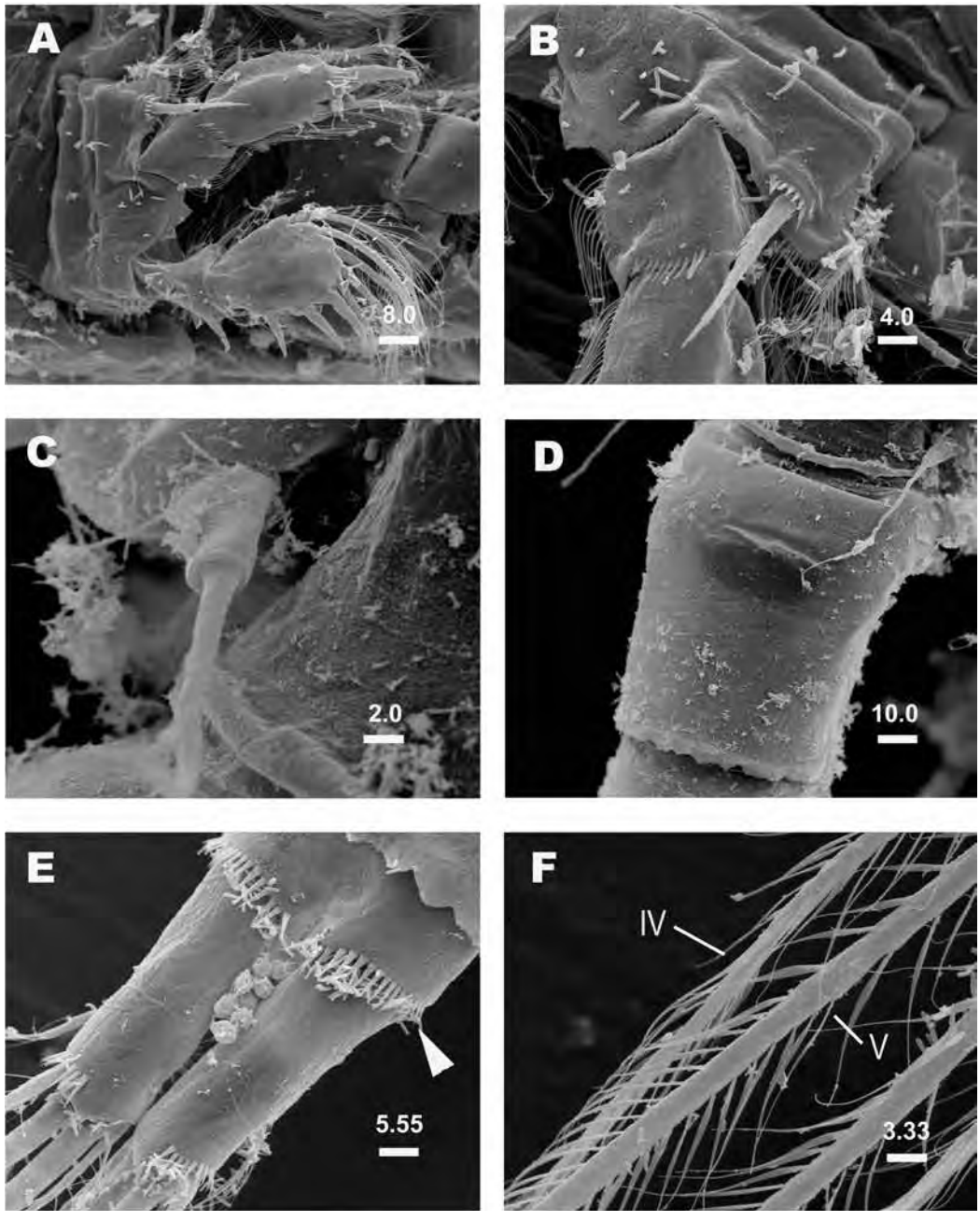


Fig. 25. ***Microcyclops dubitabilis*** **female from Glenn Spring located in Big Bend National Park, Brewster Co., Texas, USA. A, caudal setae dorsal. B, prosomites and urosomites dorsal. C, medial basis of P4. D, sixth leg. Measurements in micrometers**

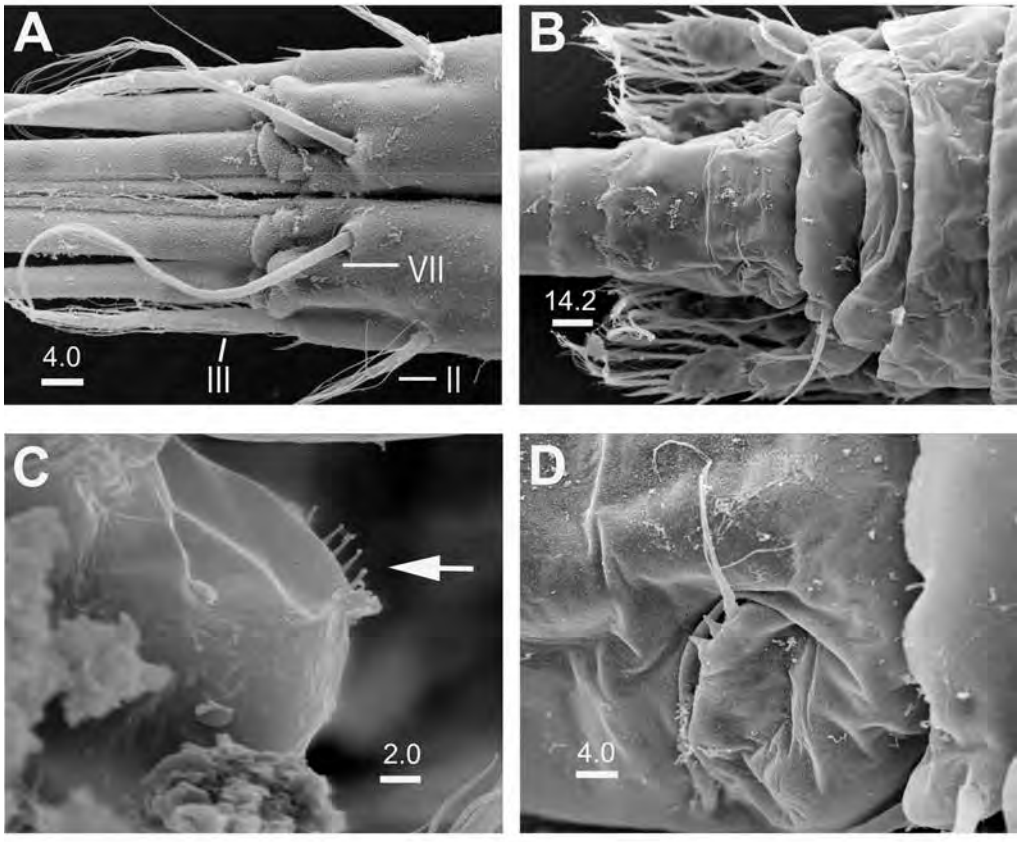
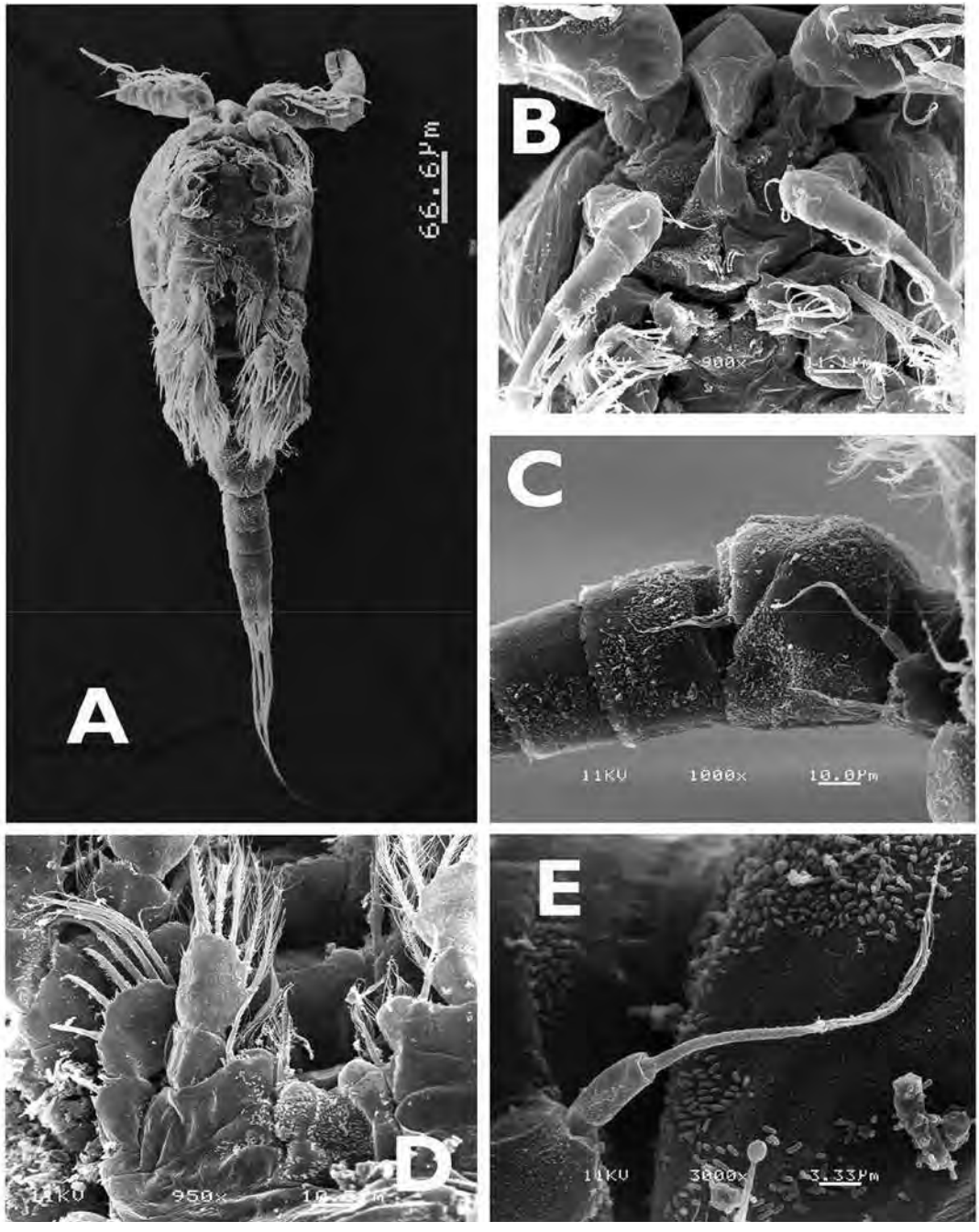


Fig. 26. ***Microcyclops dubitabilis*** **male from Glenn Spring located in Big Bend National Park, Brewster Co., Texas, USA. A, habitus, ventral view. B, cephalic region, ventral view. C, urosome, fifth and sixth legs, lateral view, D, first leg, E, fifth leg. Measurements in micrometers**



Mesocyclops edax (Forbes, 1891)
(Fig. 27)

Mesocyclops edax (S. A. Forbes) G. O. Sars, 1914: 58
Mesocyclops edax Smith and Fernando, 1980: 11, Figs 9E-I
Mesocyclops edax Reid, 1990: 180
Mesocyclops edax Reid and Moreno, 1999: 581-583, Figs. 1-3
Mesocyclops edax Dodson and Silva-Briano, 1996: 168
Mesocyclops edax Suárez-Morales *et al*., 1996: 126-128
Mesocyclops edax Hołyńska *et al*., 2003: 37-41, Figs. 9-10

Material examined. One adult female, alcohol preserved from Balmorhea Lake, collected 31.III.2006.

Female= 1.25 ±0.20 mm of boby length excluding caudal setae. Prosomite attenuated, length = 0.72 mm; A1 reaching second prosomite. Length of the elongated urosomite = 0.56 mm (Fig. 27A). Antennule 17 –segmented; armament per segment as follows (s: seta, ae: aesthetasc, sp: spine): 8s, 4s, 2s, 5s, 4s, 2s+ae, 2s, 1s, 1s, 0, 1s, 1s+ae, 0, 1s, 2s, 2s+ae, 7s+ae. Inner surface of first antennular segment with one row of short spines, length ratio of two distalmost antennular segments 16/17= 0.9; hyaline membrane on lasts antennular segments smooth (Fig. 27B).

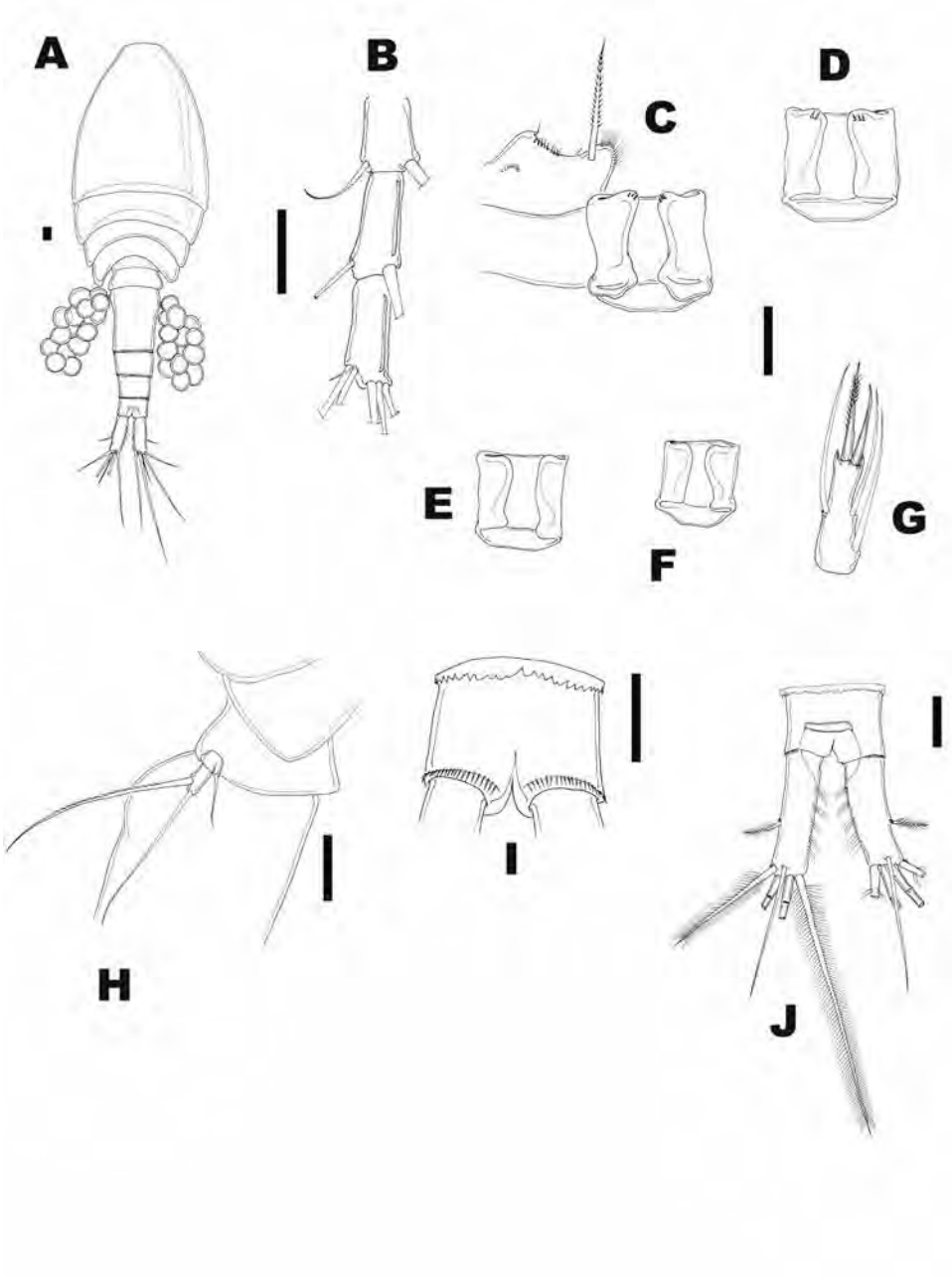
Intercoxal sclerite of P1 with tiny spinules on frontal surface of outgrowths. Basipodite of P1 with inner margin pilose, plus one long, armed spine; and one row of acute spines on medial surface (Fig. 27C).

Distal margin of intercoxal sclerite of P2 with low rounded projections, bearing 2-3 short spinules frontally (Fig. 27D). Intercoxal sclerites of P3 and P4 nude, without projections (Fig. 27E, F). Length ratio of medial/lateral spines of Enp3P4, 0.8. Length/width ratio of Enp3P4 = 2.4 (Fig. 27G). First urosomite nude; proximal segment of P5 bearing a short seta. Subdistal spine on terminal segment of P5 armed with tiny spinules, is 1.18 times as long as distal seta (Fig. 27H).

Hyaline fringe irregular in all urosomites (Fig. 27A, I). Genital double-somite relatively large, representing 35% of urosome length. Length/width ratio of genital double somite = 1.36. Length/width ratio of caudal rami 3.67; inner margin with 4-5 transversal rows of hair-like setae (Fig. 27J). Lateral seta of caudal rami slightly distal (inserted at 57% the length of outer margin). Strong spines at insertion of both lateral and outermost caudal setae (Fig. 27J). Length ratio of the caudal setae: innermost caudal seta (VI)/outermost caudal seta (III) = 2.05; VI/dorsal caudal seta (VII) = 2.0 (Fig. 27J).

Distribution: Widely distributed in Nearctic region, with valid records in Antilles (Cuba), Mexico and Central America (Reid and Moreno, 1999; Suárez-Morales *et al*., 2010; Hołyńska *et al*., 2003).

Fig. 27. ***Mesocyclops edax*** **female from Balmorhea Lake. A, habitus dorsal. B, A1 segments 15-17. C, P1 detail of coxa, inner basis, and intercoxal sclerite. D, P2 intercoxal sclerite. E P3, intercoxal sclerite. F, P4, intercoxal sclerite. G, Enp3P4. H, first urosomite, and genital double-somite lateral. I, anal somite ventral. J, anal somite and caudal rami dorsal. Scale bars = 50 µM**



Thermocyclops tenuis (Marsh, 1910)
(Figs. 28, 29)

Thermocyclops tenuis Reid, 1985: 48, Figs. 207-209
Thermocyclops tenuis Reid, 1990: 182
Thermocyclops tenuis Suárez-Morales *et al.*, 1996: 140-141, Fig. 50
Thermocyclops tenuis Elías-Gutiérrez *et al.*, 2008: 226, Fig. 61

Material: One female and one male for SEM from Paint Gap Tank located in Big Bend National Park, Brewster Co., Texas, USA, 14. V. 2006.

Female: Total body length 0.95 mm (Fig. 28A), antennules 17-segmented; ultimate and penultimate antennular segments with serrated hyaline fringe (Fig. 28B, C). Enp and Exp of all thoracic limbs 3-segmented (Fig. 28D); medial margin of basipodite of P1 hairy, bearing long spine-like seta, P1 with smooth intercoxal sclerite (Fig. 28D, E). Intercoxal sclerite of P4 without ornamentation, with low projections. Medial spine of Enp3P4 more than 1.8 times longer than lateral spine. P5 two-segmented: proximal segment with one setae, terminal segment bearing one long spine, and one apical seta, both subequal in length (Fig. 28F).

Anal somite with one row of tiny spines along distal, ventral margin (Fig. 29A), caudal ramus 3.5-4.5 times longer than wide without hair-like setae on medial margin, implantation of lateral caudal, and outermost caudal setae without spinules (Fig. 29A). Length ratio of innemost caudal seta (VI)/ outermost caudal seta (III) = 3.8; VI/dorsal caudal seta (VII) = 1.4 (Fig. 29B).

Male: 0.75 mm of total body length (Fig. 29C). Antennules 17-segmented, ultimate and antepenultimate segments with smooth surfaces (Fig. 29D). Sixth leg is a plate that bears 3 elements: one long outermost seta which is 1.7 times longer than the innermost spine, and 3 times longer than the medial spine; innermost spine of sixth leg is 1.8 times longer than the medial spine (Fig. 29E). Caudal ramus nude on medial margins, 3 times longer than wide and tiny spinules at insertions of lateral caudal and outermost caudal setae (Fig. 29F).

Distribution: Neotropical. Southern U. S. A., North, Central, and Yucatan Peninsula of Mexico (Wilson, 1936; Reid, 1990; Suárez-Morales *et al.*, 1996; Suárez-Morales *et al.*, 2010), Cuba (Smith and Fernando, 1980) Central America, Lesser Antilles, Paraguay, Uruguay (Mirabdullayev *et al.*, 2003) and Brazil (Kiefer, 1936).

Fig. 28. ***Thermocyclops tenuis*** **female from Paint Gap Tank located in Big Bend National Park, Brewster Co., Texas, USA. A, habitus. B, antennule, segments 15-17. C, antennule, detail segment 16. D, P1. E, P1, detail of coxa, basis and intercoxal sclerite. F, fifth leg. Measurements in micrometers**

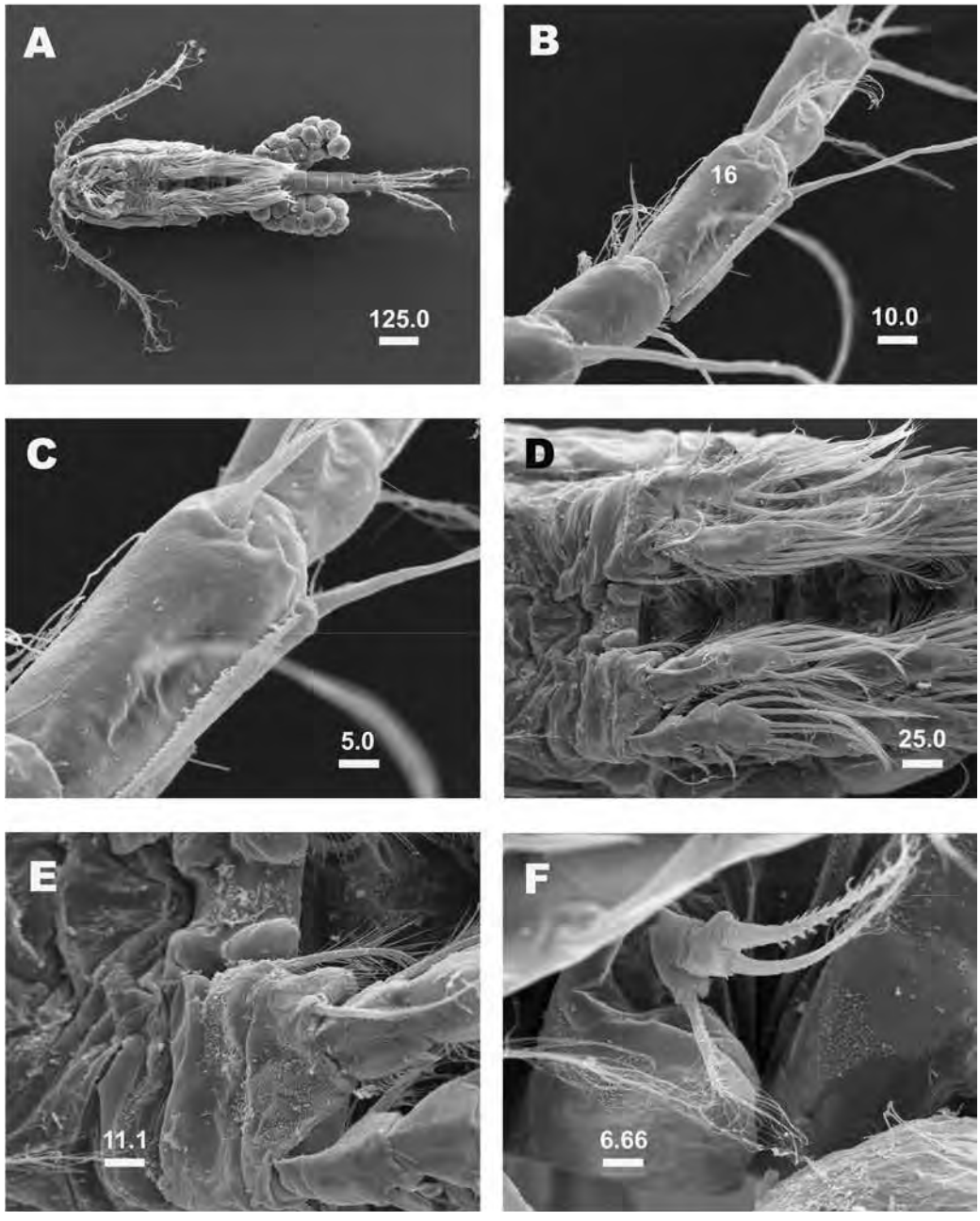
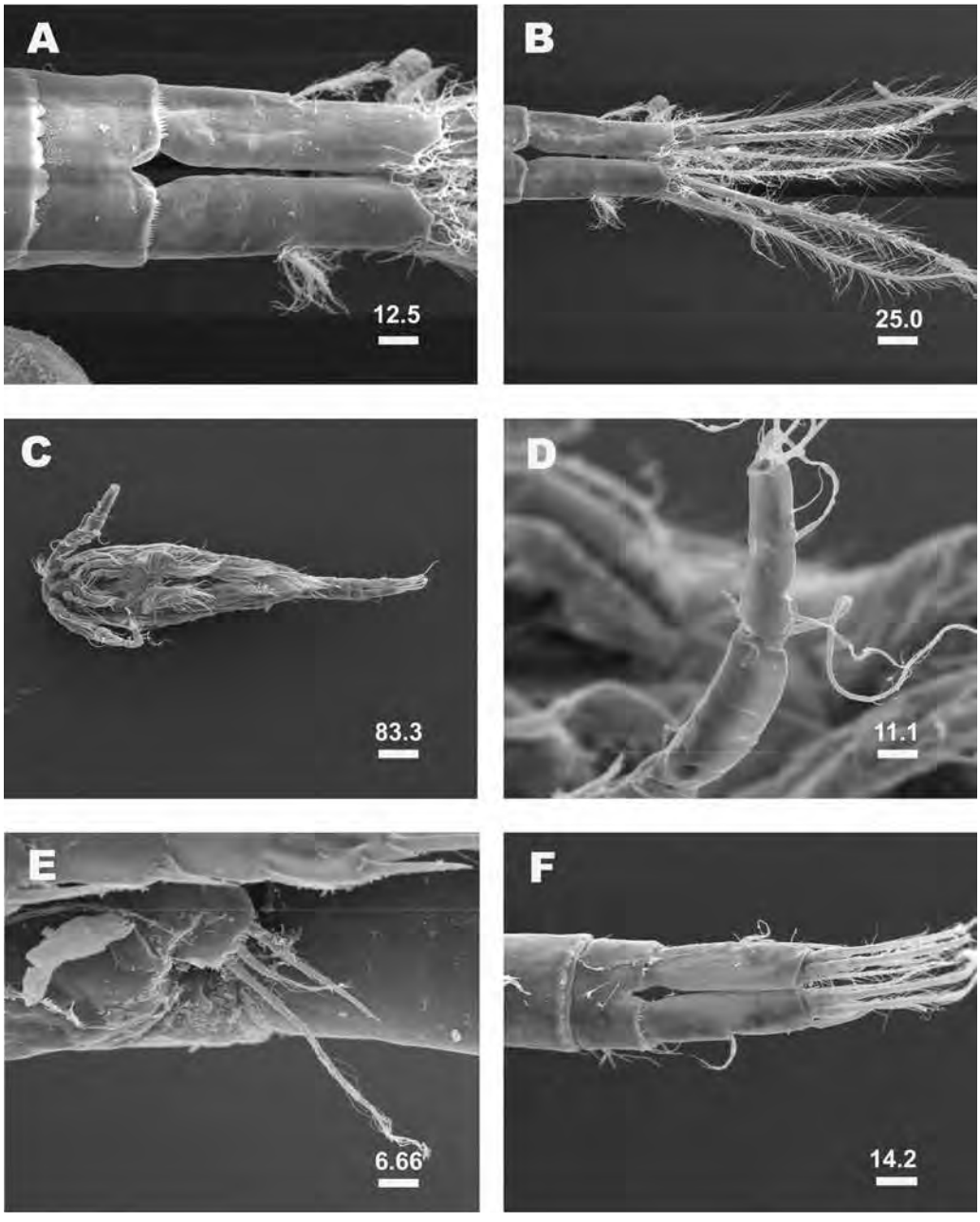


Fig. 29. ***Thermocyclops tenuis*** **female from Paint Gap Tank located in Big Bend National Park, Brewster Co., Texas, USA. A, anal somite and caudal ramus ventral. B, caudal ramus with setae. Male from Paint Gap Tank. C, habitus. D, antennule, ultimate and penultimate segments. E, sixth leg. F, anal somite and caudal ramus ventral. Measurements in micrometers**



Nitokra cf. *lacustris* (Schmankewitsch, 1875)
(Figs. 30, 31)

Nitokra cf. *lacustris* Suárez-Morales *et al*., 1996: 211-212

Material: Two adult females and one adult male from Diamond Y Roadside Seep, Pecos Co., Texas, USA. 31.III.2006 for SEM.

Female: Cylindrical body (Fig. 30A). Endopodal and exopodal ramus of P1 with similar length (Fig. 30B), Exp3P1 (arrowed in Fig. 30B) with 2 lateral spines plus 3 apical setae (5 elements), Enp3P1 with 3 elements. One medial setae in Enp1, and Enp2 of P1. Exp3P2, and Exp3P3 with 3 lateral spines (7 elements in Fig. 30C). Endopodal and exopodal ramus of P1-P4 3-segmented.

Antennule short, 8-segmented, fourth segment with one long aesthetasc, its length is beyond the antennular tip (Fig. 30D). Setal armament per segment as follows: 1s, 9s, 8s, 4s + 1ae, 2s, 3s, 3s, 8s.

Urosomites with a ring of strong spines along distal margins (arrowed in Fig. 30E), caudal rami and anal somite similar in length, distal spines of anal somite reaching the proximal third of caudal ramus (Fig. 30F).

Basal segment of P5 with 5 apical setae and lateral spines; distal segment elliptical 6-setulated, the lateral seta is shorter than the apical setae (Fig. 31A).

Genital field with one central rounded plate, flanked by two laterally enlarged arms (Fig. 31B).

Male: Cylindrical body, ventral plate of first prosomite directed inwards (Fig. 31C), P1 as described for female. Ramus of P1-P4, 3-segmented. Antennule geniculated, densely setulated (Fig. 31D).

Distribution: Previously recorded in Chetumal and Celestún, in the Yucatán Peninsula (Suárez-Morales *et al*., 1996), and in the arid and semi-arid regions of Chihuahua, Mexico (Suárez-Morales *et al*., 2010).

Fig. 30. ***Nitokra*** **cf.** ***lacustris*** **female from Diamond Y Roadside Seep, Pecos Co., Texas, USA. A, habitus. B, P1. C, P2 and P3. D, antennule. E, urosome. F, anal somite and caudal ramus, ventral. Measurements in micrometers**

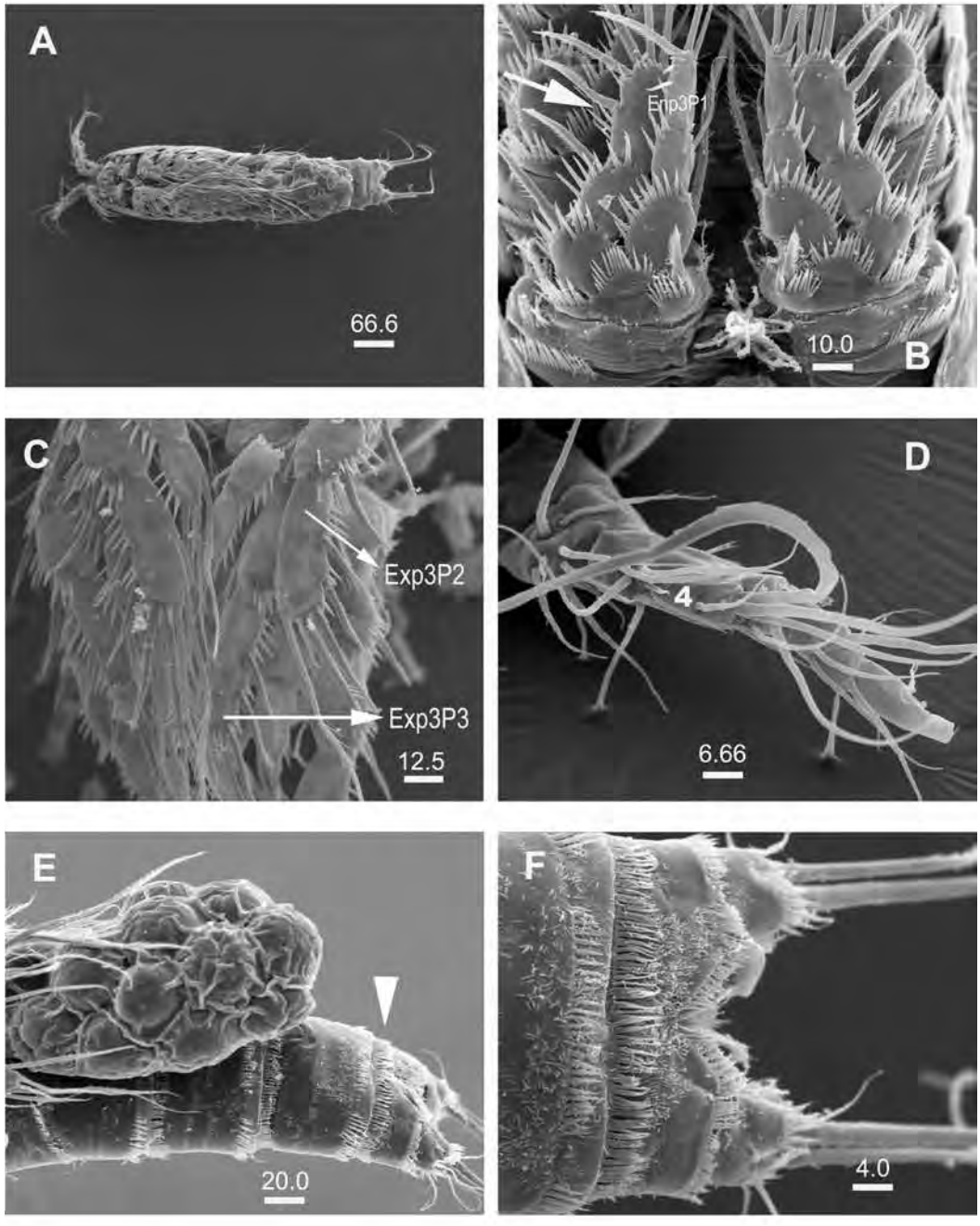
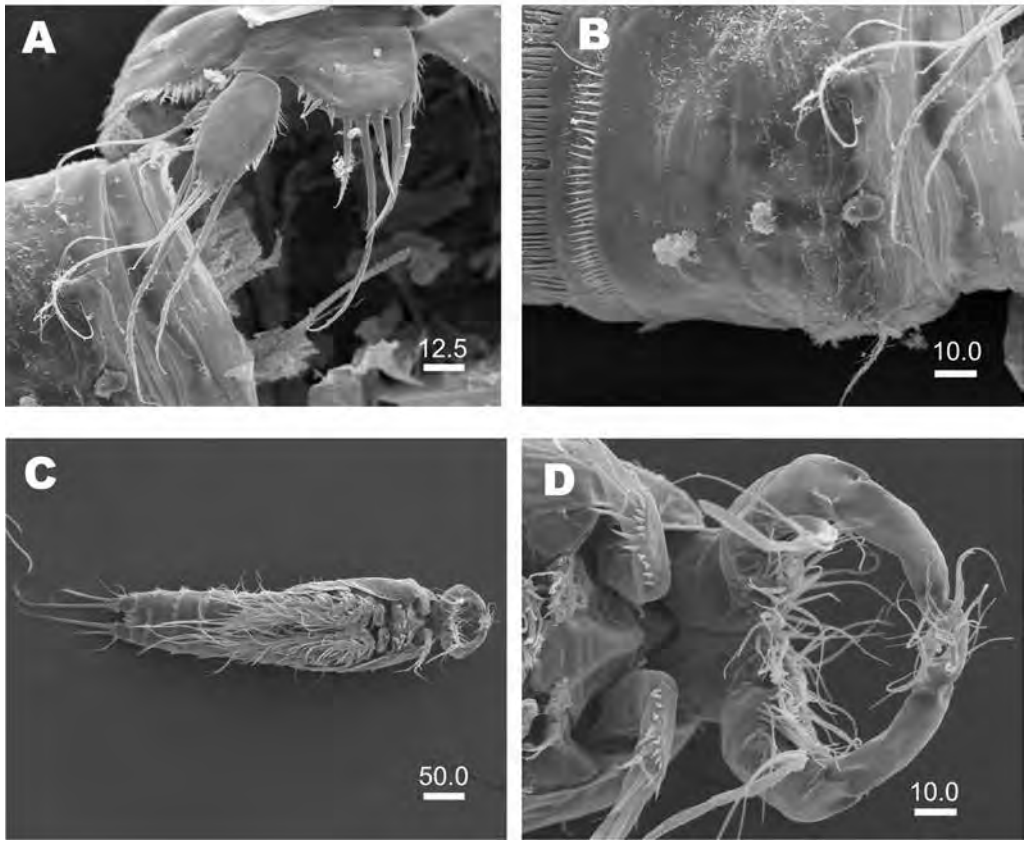


Fig. 31. *Nitokra* cf. *lacustris* female from Diamond Y Roadside Seep, Pecos Co., Texas, USA. A, fifth leg. B. Genital field ventral. Male from Diamond Y Roadside. C, habitus. D, antennules, ventral. Measurements in micrometers



Leptocaris stromatolicolus Zamudio-Valdéz and Reid, 1990
(Figs. 32, 33)

L. stromatolicolus Zamudio-Valdéz and Reid, 1990: 47-54, Figs. 1-21

Material: Nine adult females preserved in alcohol 70% (in two bottles), from East Sandia spring, Reeves Co., Texas, USA. 31.III.2006. ECO-CH-Z-003625, and ECO-CH-Z- 003626.

Female: Body cylindrical, total body length 370-380 μm, smooth prosomites and urosomites (Fig. 32A-B), anal somite twice the length of the urosomal somites (Fig. 32B). Antennules 5-segmented; second, third and fifth antennular segments with setae. Fourth antennular segment with a strong spinform process (Fig. 32C). Antenna with a cylindric allobasis, Enp bearing strong, plenty spines (Fig. 32D). Maxillule with strong, bifid spines on arthrite (Fig. 32E).

Maxilliped with nude syncoxa, plus two distal setulated segments (Fig. 32F). P1 with 3-segmented Exp; Exp1 and Exp2 with one lateral spine; Exp3 with one lateral spine plus three apical setae

(Fig. 33A); P1 with 1-segmented Enp bearing one distal spine and one medial, pectinated seta (Fig. 33B). P2 with 2-segmented Enp (Fig. 33A). Genital, and anal somites with tegument smooth, caudal rami twice longer than broad (Figs. 33C, D).

Distribution: Most species of *Leptocaris* genus inhabit in brackish waters, *L. stromatolicolus* however, is considered as a continental species, potentially endemic; was described with specimens from Cuatro Ciénegas system, in the Chihuahuan desert of Mexico (see Zamudio-Valdéz and Reid, 1990; Zamudio-Valdéz 1991).

Fig. 32. ***Leptocaris stromatolicolus*** **female from East Sandia spring, Reeves Co., Texas, USA. A, prosomites, lateral. B, urosomites, lateral. C, A1. D, antenna. E, maxilla. F, maxilliped. Measurements in micrometers**

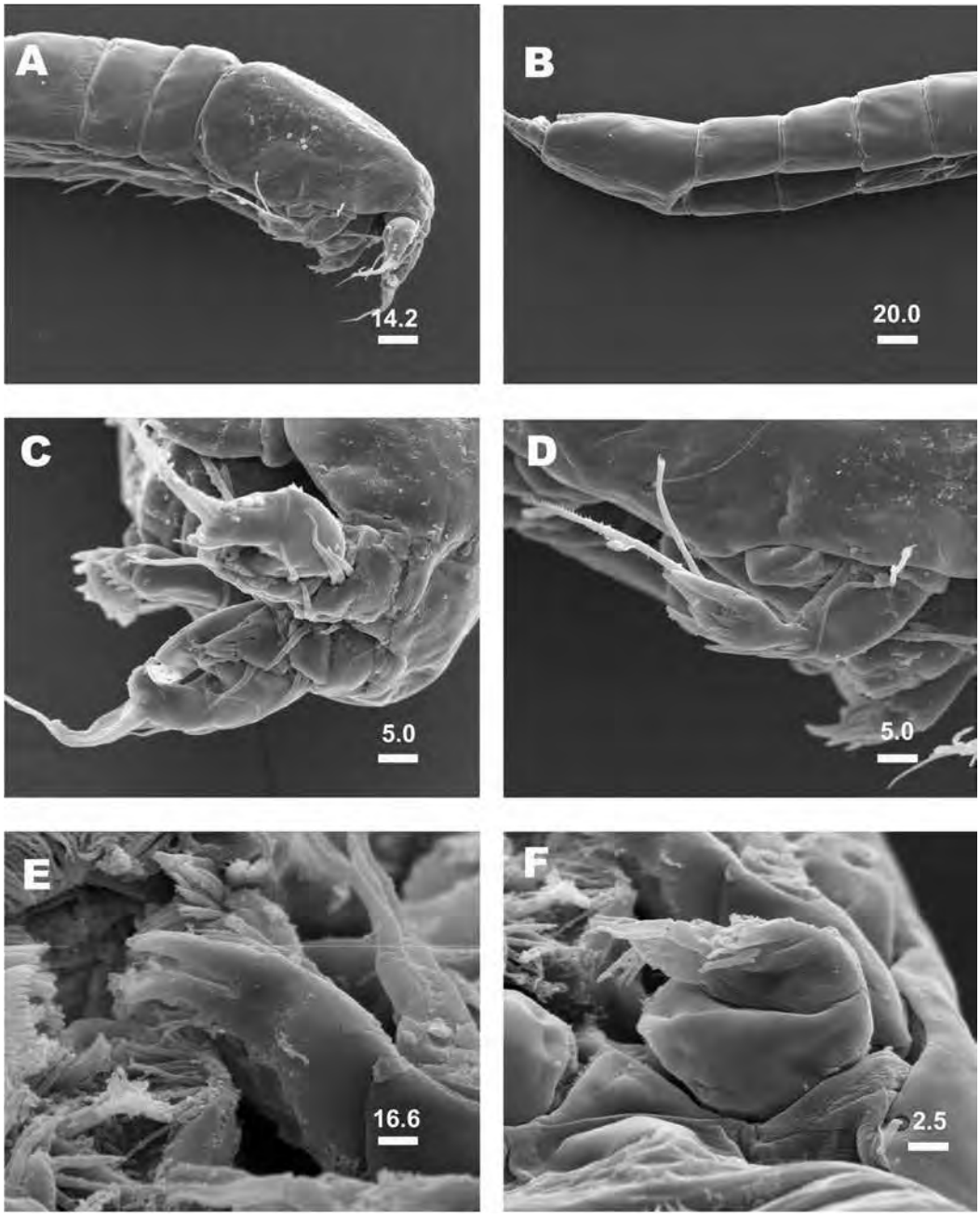
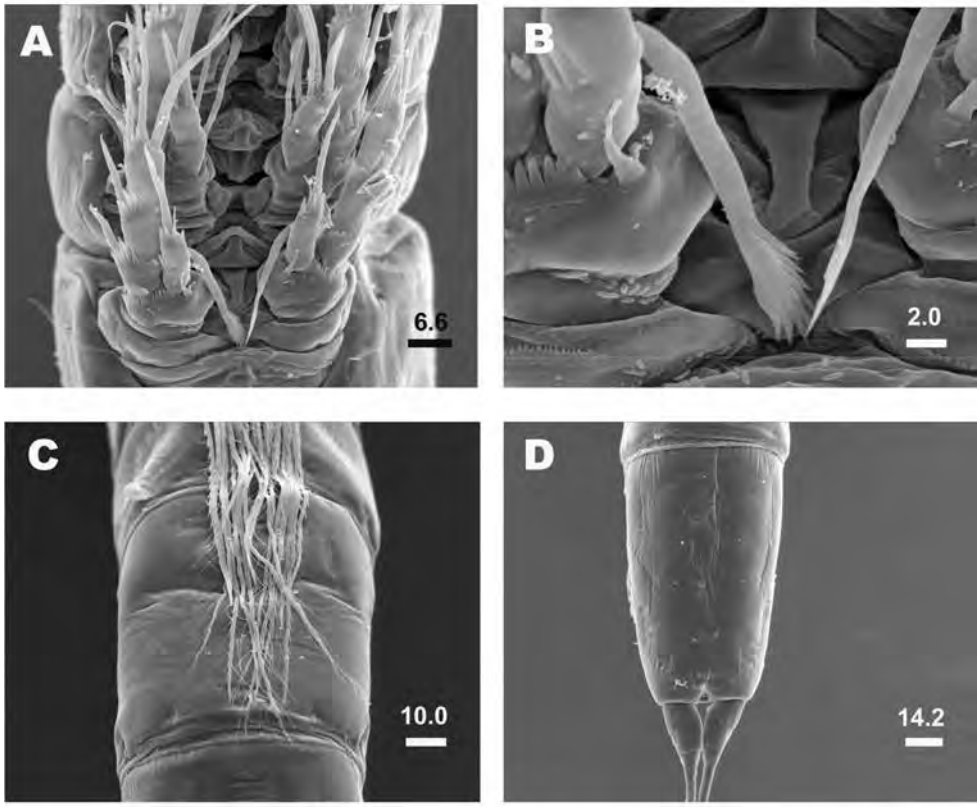


Fig. 33. ***Leptocaris stromatolicolus*** **female from East Sandia spring, Reeves Co., Texas, USA. A, thoracic limbs. B, P1, detail of basipodite, and Enp1. C, genital double-somite, ventral. D, anal somite, and caudal rami, ventral. Measurements in micrometers**



Cletocamptus sinaloensis Gómez, Fleeger, Rocha-Olivares and Foltz, 2004
(Figs. 34, 35)

Cletocamptus sinaloensis Gómez et al., 2004: 2698-2710, Figs. 24-33
Cletocamptus sinaloensis Gómez, 2005: 3109-3115, Figs. 6-13
Cletocamptus deitersi Suárez-Morales *et al*., 2010: 527

Material: Five adult females from Diamond Y Roadside Seep, Pecos Co., Texas, USA. 31.III.2006 for SEM.

Female: Cylindrical body (Fig. 34A). Entire distal margin of all prosomites and urosomites covered with strong spines (Fig. 34B). Antennule short, 6-segmented, first segment with 2 rows of strong spines, fourth segment with one long aesthetasc, its length is beyond the antennular tip (Fig. 34C). Setal armament per segment as follows: 0, 9s, 5s, 4s + 1ae, 0, 8s + 1 ae.

Dorsal and ventral surfaces of prosomites and urosomites with parallel rows of short spines (Fig. 34B, D). Anal somite and caudal ramus with similar length (Fig. 34D), surface of caudal rami smooth (Fig. 34D, E), two lateral setae without spines on their bases on caudal rami (Fig. 34E). Antenna 2-segmented, spiny basal and distal antennal segments (Fig. 34F).

Maxilliped segments armed with abundant, strong spines (Fig. 35A).

Exopodal ramus of P1-P4 3-segmented, and longer than the 2-segmented endopodal ramus of all trunk limbs (Fig. 35B, C). Exp3P1 with 1 lateral spine plus 3 apical, and 1 medial setae (5 elements). One medial setae on Exp2 of all limbs (Fig. 35B, C). Exp3P2, and Exp3P3 with 1 lateral spine (5 elements in Fig. 35C).

Basal segment of P5 with 6 setae, the lateral-most seta is on lateral bulbous (Fig. 35E); distal segment of P5 6-setulated (Fig. 35D).

Distribution: Nearctic and Neotropical. Several localities of Sinaloa, Northwestern Mexico (Gómez *et al*., 2004), the arid and semi-arid regions of Chihuahua, Mexico (recorded as *C. deitersi* in Suárez-Morales *et al*., 2010), and Brazil (Gómez 2005).

Fig. 34. ***Cletocamptus sinaloensis*** **female from Diamond Y Roadside Seep, Pecos Co., Texas, USA. A, habitus dorsal. B, urosomite dorsal. C, Antennule. D, Anal somite and caudal rami ventral. E, Caudal ramus lateral. F, Antenna. Measurements in micrometers**

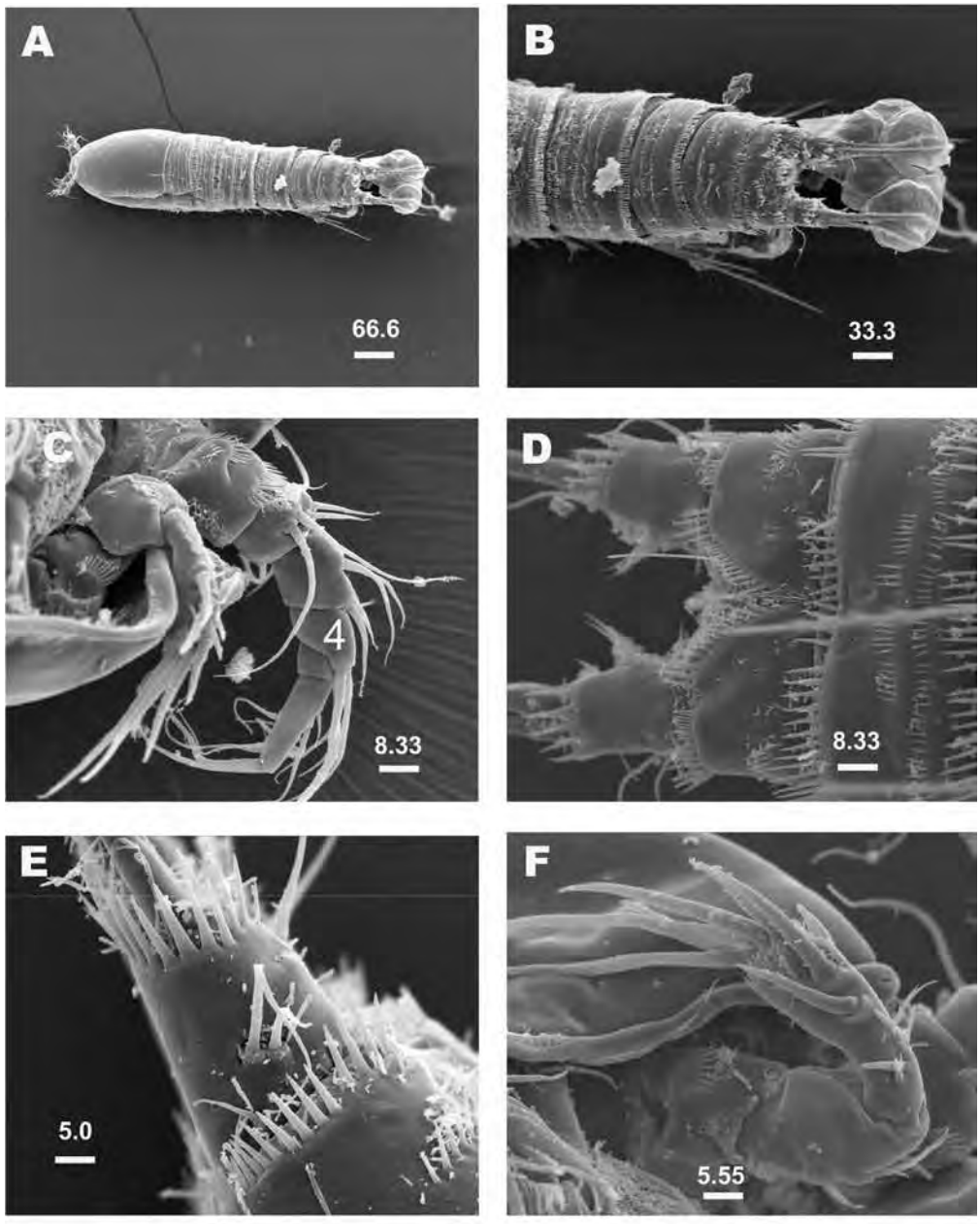
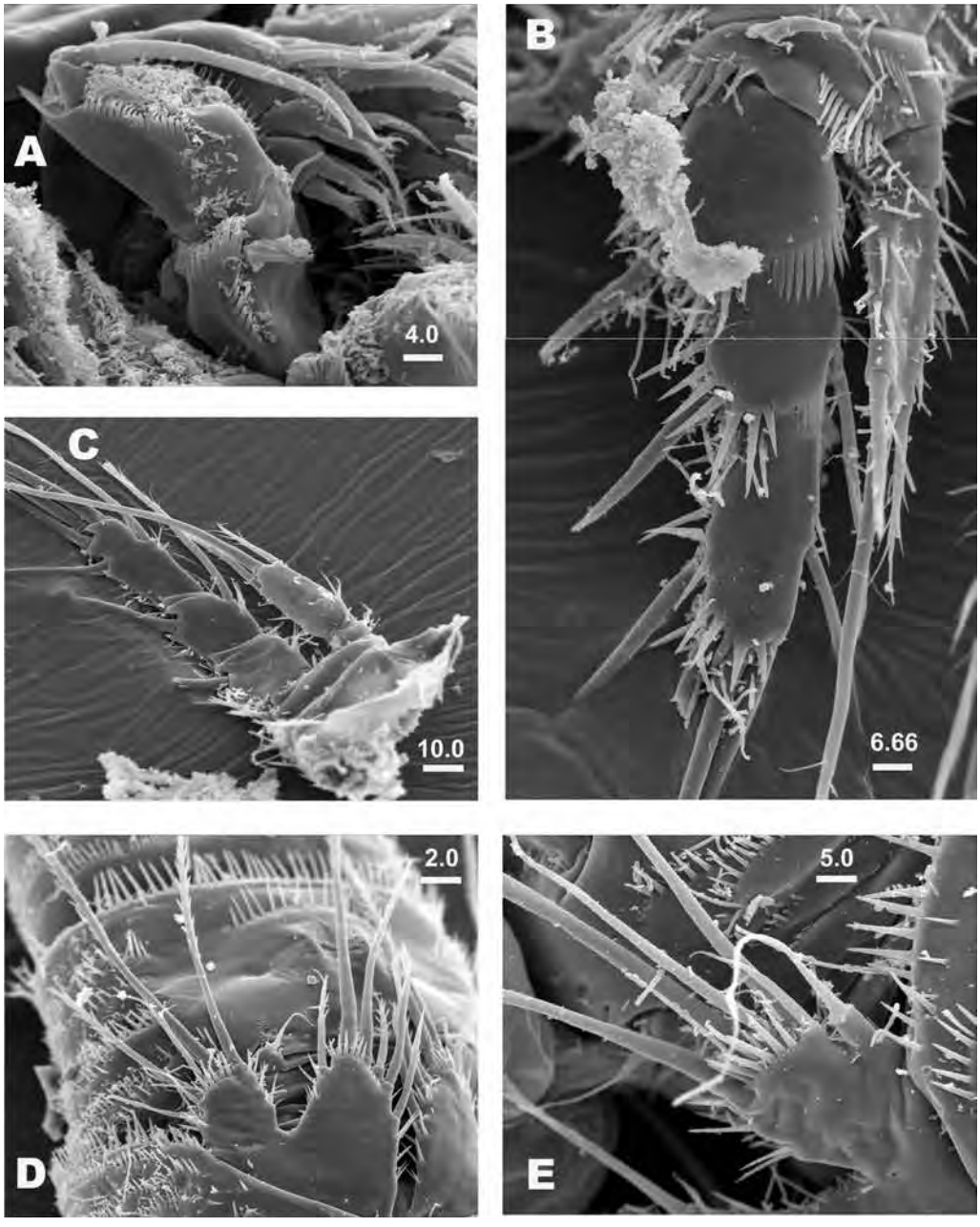


Fig. 35. ***Cletocamptus sinaloensis*** **female from Diamond Y Roadside Seep, Pecos Co., Texas, USA. A, Maxilliped. B, P1. C, P3. D, P5 and genital double-somite ventral. E, Detail of lateral lobe of P5. Measurements in micrometers**



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Chapter 3
Geographic distribution of the freshwater copepods from the Chihuahuan Desert

One recent taxonomical analysis (Mercado-Salas et al., 2015) confirmed the presence of *Eucyclops pectinifer* (Crangin, 1883) and *E. prionophorus* Kiefer, 1931 in the Chihuahuan Desert region in addition to the four species of the genus analysed here. In the same region the presence of *Ectocyclops rubescens* Brady, 1904; *Tropocyclops extensus* Kiefer, 1931; *Mesocyclops longisetus longisetus* (Thiébaud, 1912); *M. reidae* Petkovski, 1986; *Acanthocyclops vernalis* (Fischer, 1853), *Microcyclops ceibaensis* (Marsh, 1919); *Nitokra* cf. *spinipes* Boeck, 1865; and *Onycocamptus mohammed* (Blanch and Rich, 1897) was confirmed in studies by Suárez-Morales *et al*. (2010) and Mercado-Salas and Suárez-Morales (2011, 2012).

The records of *Eucyclops bondi* Kiefer, 1934; *E. pseudoensifer* Dussart, 1984; and *Microcyclops varicans* (G. O. Sars, 1863) from the Chihuahuan Desert region are doubtful (see these records in Suárez-Morales *et al*., 2010). Recently, Mercado Salas and Suárez-Morales (2014) and Gutiérrez-Aguirre and Cervantes-Martínez (2016) speculated that these species are strictly Caribbean, South American, and Palearctic, respectively.

Similar efforts have been made to study the richness of freshwater, free-living copepods in other regions in Mexico, resulting in inventories of 22 species in Tabasco (Gutiérrez-Aguirre and Suárez-Morales, 2001), 35 in the Transmexican Volcanic Belt (Suárez-Morales and Reid, 1998), 59 in the Yucatan Peninsula (Suárez-Morales and Reid, 2003) and 33 in this survey (see also Mercado-Salas and Suárez-Morales, 2011, 2012). These inventories include species of Calanoida, Cyclopoida and Harpacticoida.

As in other Mexican continental areas such as Central Mexico, southeastern Mexico and the Yucatan Peninsula, the composition of the species recorded in the Chihuahuan Desert shows a mixture of Nearctic, Neotropical, Caribbean, endemic and cosmopolitan affinities.

The copepod species recorded here have a more extensive distribution, including in different biogeographic provinces, which have been described by Morrone (2001) or Lévêque *et al*. (2008) based on the congruent distributions of diverse organisms.

Except for *Mastigodiaptomus albuquerquensis*, a Neotropical species, and *Eurytemora affinis*, which is considered cosmopolitan, all the Calanoida species recorded in the Chihuahuan Desert have Nearctic affinities. Diaptomidae is the dominant family in the freshwater systems of the world, and in this study, the presence of three species of the Diaptomidae genus *Leptodiaptomus* is notable because this genus is considered endemic to the Nearctic region (Boxshall and Defaye, 2008).

Nearctic species. *Leptodiaptomus connexus*, *E. pectinifer*, *A. dimorphus* and *M. edax* are the most widely distributed species in the Nearctic region and are also present in the Mexican Plateau, Great Lakes, Hudson Bay, Mississippi, and Atlantic Coastal provinces.

Some Nearctic species have been recorded in one or two provinces considered Neotropical. For instance, *Leptodiaptomus novamexicanus* has one record in the Yucatan Peninsula [recorded by Wilson (1936) see Suárez-Morales *et al*., (1996)]. Brandorff (2012) recorded *L. siciloides* in Hispaniola Province; *A. clavipes* and *E. festivus* were recorded in Chiapas Province (Gutiérrez-Aguirre and Cervantes-Martínez, 2013); *C. sinaloensis* was described with specimens from the Mexican Plateau province but recently was recorded in Brazil (Gómez, 2005); and *M. edax* is widely distributed in the Yucatan Peninsula, Chiapas, and Cuban provinces.

Neotropical species. Most of the species analysed here are considered Neotropical and belong to the subfamily Cyclopinae, followed by Eucylopinae. In addition to these records from the Mexican Plateau province, species such as *M. longisetus longisetus* and *M. reidae* were previously recorded in Mississippi Province, Central America, the Antilles, Colombia, San Andrés, Argentina and Chilean provinces.

Another Neotropical species with one northern record is *E. conrowae*, which is present in the Atlantic Coastal province and common in the Yucatan Peninsula and Central America. Within the Diaptomidae *Mastigodiaptomus albuquerquensis* is considered Neotropical, but recently, only the records from the Mexican Plateau and Transmexican Volcanic Belt provinces were confirmed (Gutiérrez-Aguirre *et al*., 2014).

Species with more records from the Mexican Plateau, Transmexican Volcanic Belt, Caribbean and Central American provinces include *E. rubescens*, *E. prionophorus*, and *M. ceibaensis*.

Finally, species with a distribution extending to South America include *M. dubitabilis* and *T. tenuis*, which have been recorded in the Mexican Plateau, the Transmexican Volcanic Belt, Chiapas, the Gulf of Mexico, the Yucatan Peninsula, Central America, the Lesser Antilles, Pampa, and Venezuelan Provinces.

The level of endemism is remarkable in the surveyed region; the seven species with this status are *E. cuatrocienegas*, *E. chihuahuensis*, *T.* cf. *extensus*, *M. deserticus*, *N.* cf. *lacustris*, *N.* cf. *spinipes*, and *L. stromatolicolus*. Therefore, the ratio of the number of endemic species to the total number of records of freshwater, free-living copepods in the Chihuahuan Desert is 0.21. This number is very similar to that recorded in the Yucatan Peninsula (0.20), which is considered to be a more deeply studied region in Mexico (Suárez-Morales and Reid, 2003).

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Freshwater copepods
(Calanoida, Cyclopoida and Harpacticoida)
from the Chihuahuan Desert

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Tiraje: 500 ejemplares

This document is the result of collaborative work among colleagues from different institutions in Mexico (Universidad de Quintana Roo, Cozumel and El Colegio de la Frontera Sur, Chetumal) and the United States (University of Texas, El Paso). This work presents the taxonomy, morphology and distribution of the free-living, freshwater copepods that inhabit ephemeral aquatic habitats in one binational reserve known as the Chihuahuan Desert. This desertic zone is part of the large North American biogeographic region called Altiplano Mexicano, which is shared by Mexico and the United States. A joint effort was made to synthesize findings about the diversity of the copepods that inhabit this peculiar geographic area, where aquatic systems are scarce and ephemeral. It includes a taxonomic and morphological assessment of 33 copepod species and contains over forty individual drawings, and 37 plates of photographs of Scanning Electron Microscopy (SEM).

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