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Two New Species of *Acanthocyclops* Kiefer, 1927 (Copepoda: Cyclopoida: Cyclopinae) with Pilose Caudal Rami from Semiarid Areas of Mexico

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Nancy F. Mercado-Salas, Eduardo Suárez-Morales, and Marcelo Silva-Briano (2009) Two new species of *Acanthocyclops* Kiefer, 1927 (Copepoda: Cyclopoida: Cyclopinae) with pilose caudal rami from semiarid areas of Mexico. *Zoological Studies* **48**(3): 380-393. Two new species of the freshwater cyclopoid copepod genus *Acanthocyclops* Kiefer, 1927 are described from ponds in the state of Aguascalientes, Central Mexico. The first species, *A. caesariatus* sp. nov. differs from its congeners by a unique combination of characters including 17 segmented antennules, the inner margin and dorsal and ventral surfaces of the caudal rami being strongly hairy, the coxal plate of leg 1 with rows of long spines, the caudal ramus 3.8 times as long as wide, and the dorsal seta about 1.5 times as long as caudal rami. The second species, *A. marceloi* sp. nov., has a relatively weak pilose pattern on the inner margin of the caudal rami, but these are covered with spinules arranged in symmetrical patches ventrally and irregularly on the dorsal surface; the length/width ratio of the caudal rami is 3.3. As in the other new species, the coupler of leg 1 is armed with spinules, but with a different pattern. Both new species resemble other forms with 17 segmented antennules and hairy caudal rami such as the North American *A. carolinianus* Yeatman and the European *A. gordani* Petkovski. The discovery of these new species in Central Mexico, which are both related to Nearctic forms, seems to be a result of radiation of these northern forms into Neotropical areas; the diversity of this genus in Middle America is underestimated and deserves further study. http://zoolstud.sinica.edu.tw/Journals/48.3/380.pdf

Key words: Limnology, Cyclopidae, Diversity, Crustacean zooplankton.

The genus *Acanthocyclops* Kiefer, 1927 contains more than 70 nominal species and subspecies (Boxshall and Halsey 2004, Dussart and Defaye 2006). Knowledge of this genus in the Americas is still limited and asymmetrical. Currently, the genus includes 12 species in North America (Yeatman 1959, Reid 1990a, 1998, Williamson and Reid 2001), and it appears to be quite less diverse in South America, where only 4 species have been recorded (Reid 1985, Rocha and Botelho 1998). In Mexico, Central America, and the insular Caribbean, *Acanthocyclops* robustus (Sars, 1863) and *A. vernalis* (Fischer, 1853), 2 presumably cosmopolitan species, have long been the only species recorded in the area (Reid 1990a, Suárez-Morales and Reid 1998). More recently, 3 new species were described from different regions of Mexico (Reid and Suárez-Morales 1999, Fiers et al. 2000, Mercado-Salas 2006), suggesting that the diversity of the genus in Middle America deserves further taxonomic research in order to discover cryptic or endemic species with restricted distributional ranges, as indicated by Dodson et al. (2003).

In Mexico, most of the few records of *Acanthocyclops* from the northern and central

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regions of the country, that comprise semi-arid environments, have been assigned to either *A. vernalis* or *A. robustus*; both are representative of the Nearctic copepod fauna (Reid and Suárez-Morales 1999). From a recent survey of the cyclopoid copepods of the state of Aguascalientes, North-Central Mexico, a new species of this genus was described (Mercado-Salas et al. 2006); it has important morphologic affinities with Nearctic forms. Several specimens obtained from the same survey were tentatively identified as *Acanthocyclops* cf. *carolinianus* Yeatman, 1944 and *A.* cf. *rebecae* Fiers, 2000 (Mercado-Salas 2007); these specimens were taxonomically reexamined and recognized as belonging to undescribed taxa. In this contribution, 2 new species of *Acanthocyclops* are described based on female specimens collected from ponds in Aguascalientes, Mexico. The significance of these findings is discussed in terms of the currently known diversity and distributional patterns of the genus in the interface between the Nearctic and Neotropical Regions.

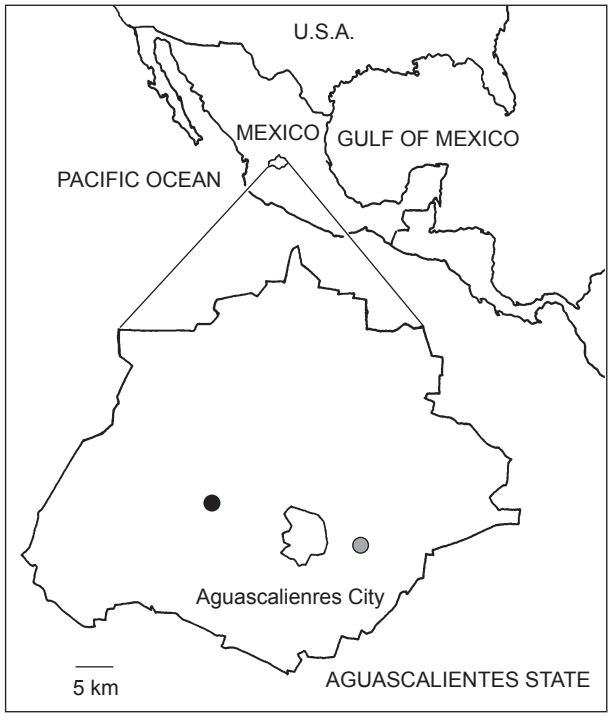

Fig. 1. Map of the state of Aguascalientes, central Mexico. The sampled sites where the species of *Acanthocyclops* were collected are indicated with a solid circle (El Colorín) and a light-gray circle (El Sotoyal).

MATERIALS AND METHODS

Zooplankton samples were collected between 1989 and 2003 in more than 500 water bodies from the Mexican state of Aguascalientes (see Dodson and Silva-Briano 1996, Mercado-Salas 2007). Samples were collected using standard plankton nets or a hand net hauled near the shoreline of the ponds. The biological material was then fixed and preserved in 4% formalin. Copepods were sorted out from the entire original samples and maintained in 70% ethanol with glycerin. Several female specimens of *Acanthocyclops* with pilose caudal rami were collected from 2 different ponds during this survey. A close examination of these specimens was performed in the laboratory, and differences were found with respect to previously known species of the genus, thus prompting a deeper analysis. Specimens were dissected and examined following the techniques described by Williamson and Reid (2001) and Reid (2003). Dissected specimens were mounted on semipermanent slides with glycerin sealed with Entellan®, a commercial, fast-drying mounting medium and sealant. Scaled drawings were prepared at 100x magnification with a camera lucida mounted on a standard Olympus CX31 compound microscope. These hitherto unknown species were described and illustrated following current standards for the taxonomic study of the genus (Einsle 1996, Fiers et al. 2000). Emphasis was given to describing the ornamentation of the coxal plates and the armature of the swimming legs and caudal rami, including the length and proportions of the caudal setae and the structure of the 5th legs. Specimens of the new species were deposited in the collection of zooplankton held at El Colegio de la Frontera Sur (ECO-CH-Z), Chetumal, Mexico. Original samples were placed in the Laboratory of Ecology, Univ. of Aguascalientes, Aguascalientes, Mexico.

RESULTS

SYSTEMATIC ACCOUNT

Order Cyclopoida G.O. Sars, 1886

Family Cyclopidae Burmeister, 1834

Subfamily Cyclopinae Burmeister, 1834

Genus *Acanthocyclops* Kiefer, 1927

Acanthocyclops caesariatus Mercado-Salas and Suárez-Morales sp. nov.

(Figs. 2-4)

Material examined: *Holotype*: Adult ♀, dissected, mounted in glycerin sealed with Entellan (ECO-CHZ-03612), El Sotoyal Pond, Aguascalientes, Central Mexico (21°54'N, 102° 10'W; UTM: 2424266.36 Y, 792789.71 X), coll. 28 Sept. 1991 by Marcelo Silva-Briano. Paratype. Adult ♀, undissected, same locality and date; ethanol-preserved (ECO-CHZ-03613).

Type locality: El Sotoyal Pond (21°54'N, 102° 10'W; UTM: 2424266.36 Y, 792789.71 X), State of Aguascalientes, Central Mexico (Fig. 1); a small, ephemeral water body with some human influence.

Description: Female (Fig. 2A). Total body length of holotype 0.924 mm from anterior end of cephalothorax to posterior margin of caudal rami. Body robust, cephalothorax relatively long, slightly expanded laterally at midlength of cephalosome in dorsal view; lateral margins of pedigers 3 and 4 straight, produced posteriorly. Cephalothorax 0.615 mm long, representing 67% of total body length. Dorsal surface smooth, antennules reaching end of 1st pediger. Urosome relatively slender, formed by 5 somites: 5th pediger plus 4 succeeding somites. Genital double-somite moderately expanded at proximal 1/2. Anal and preanal somites equally sized.

Antennule (Fig. 2C): 17 segmented in all specimens; armature of each segment as follows (s, seta; ae, aesthetasc; sp, spine): 1(8s), 2(2s), 3(2s), 4(6s), 5(3s), 6(1s + sp), 7(2s), 8(2s), 9(2s), 10(0s), 11(1s); 12(1s + ae), 13 (0s), 14(1s), 15(2s), 16(3s),17(7s). Antennule reaching middle of 2nd thoracic somite. Dorsal surface of 1st segment with row of spinules.

Table 1. Armature of swimming legs 1-4 (spines in Roman numerals, setae in Arabic numerals) of *Acanthocyclops caesariatus* sp. nov. and *A. marceloi* sp. nov. The sequence is from external to internal positions

	Coxa	Basis	Endopodite	Exopodite
Leg 1	0-1	1-I	0- ; 0-0; 0-2	I-0; I-0; 0,3
Leg 2	0-1	1-0	1-0; 2-0; 3,1,I,1	I-1; I-1; IV,1,4
Leg 3	0-1	1-0	1-0; 2-0; 3,1,I,1	I-1; I-1; IV,1,4
Leg 4	0-1	1-0	1-0; 2-0; 2,II,1	I-1; I-1; III,1,4

Antenna (Fig. 2D): 4 segmented, basis with 4 groups of unsocketed spines on caudal surface. Largest spines arranged longitudinally on medial position, additional group adjacent to 1st one, with a few spines of same size. Basis with long exopodal seta biserially pinnate plus 2 basipodal setae of equal size. First segment of endopodite with a single outer seta and inner row of spinules. Second segment of endopod with 4 lateral and 4 terminal outer setae; inner margin with a row of short hair-like setules. Third endopodal segment with 7 terminal setae, inner margin with a row of hair-like setules and spines.

Mandible (Fig. 3A): Gnathobase with 7 strongly chitinized teeth and long dorsal seta armed with inner row of spinules. Mandibular palp with usual set of 2 long and 1 short setae.

Maxillule (Fig. 3B): Precoxal arthrite with 3 heavily chitinized distal claws and 2 spiniform setae on frontal side. Endopod subquadrate, with 3 unequally long apical setae.

Maxilla (Fig. 3C): Precoxa and coxa not fused; precoxal endite armed with 2 strong biserially setulated setae. Coxa with single long seta on distal inner margin; coxal caudal surface naked. Proximal basipodal endite well developed, with 2 apical setae, 1 furnished with spinules and noticeably thicker than the other. Claw-like basal endite relatively short, endite with 2 setae, both inserted near base of claw. Endopod with 1 segment, with 2 strong, long spiniform setae plus 2 short, slender setae.

Maxilliped (Fig. 3D): 4 segmented. Syncoxa with 3 spiniform setae along inner margin with distal row of spinules. Basis with 2 setulated setae and 3 transverse rows of spines. Endopod 2 segmented, 1st segment with wide-based, stout basal spine sparsely spinulated. Second endopod armed with 3 elements: 1 proximal strong, spiniform sparsely spinulated seta plus 2 shorter unarmed setae.

Leg 1 (Figs. 3E, F): Intercoxal sclerite with row of 4 long spinules on each side of anterior surface, distal margin with 2 rounded chitinized projections. Coxa with strong, biserially setulated inner coxal seta; row of spinules and distal tuft of hair-like elements near outer margin of segment. Basis with basipodal seta on outer margin, inner margin moderately expanded, with strong, spiniform basipodal seta reaching midlength of 2nd endopodal segment; small spines along insertion of endopod. Endopod and exopod 3-segmented. Armature as in table 1.

Leg 2 (Fig. 4A): Intercoxal sclerite naked, with 2 rounded chitinized projections. Coxal surface with proximal row of small spines near outer margin and distal row of spinules along insertion of basis. Coxal spiniform seta biserially setulated. Basis with slender basipodal seta on outer margin; inner corner and middle distal margin of basis forming spiniform expansions. Endopod and exopod 3-segmented, segments 1 and 2 with distal rows of spinules and short setules. Armature as in table 1.

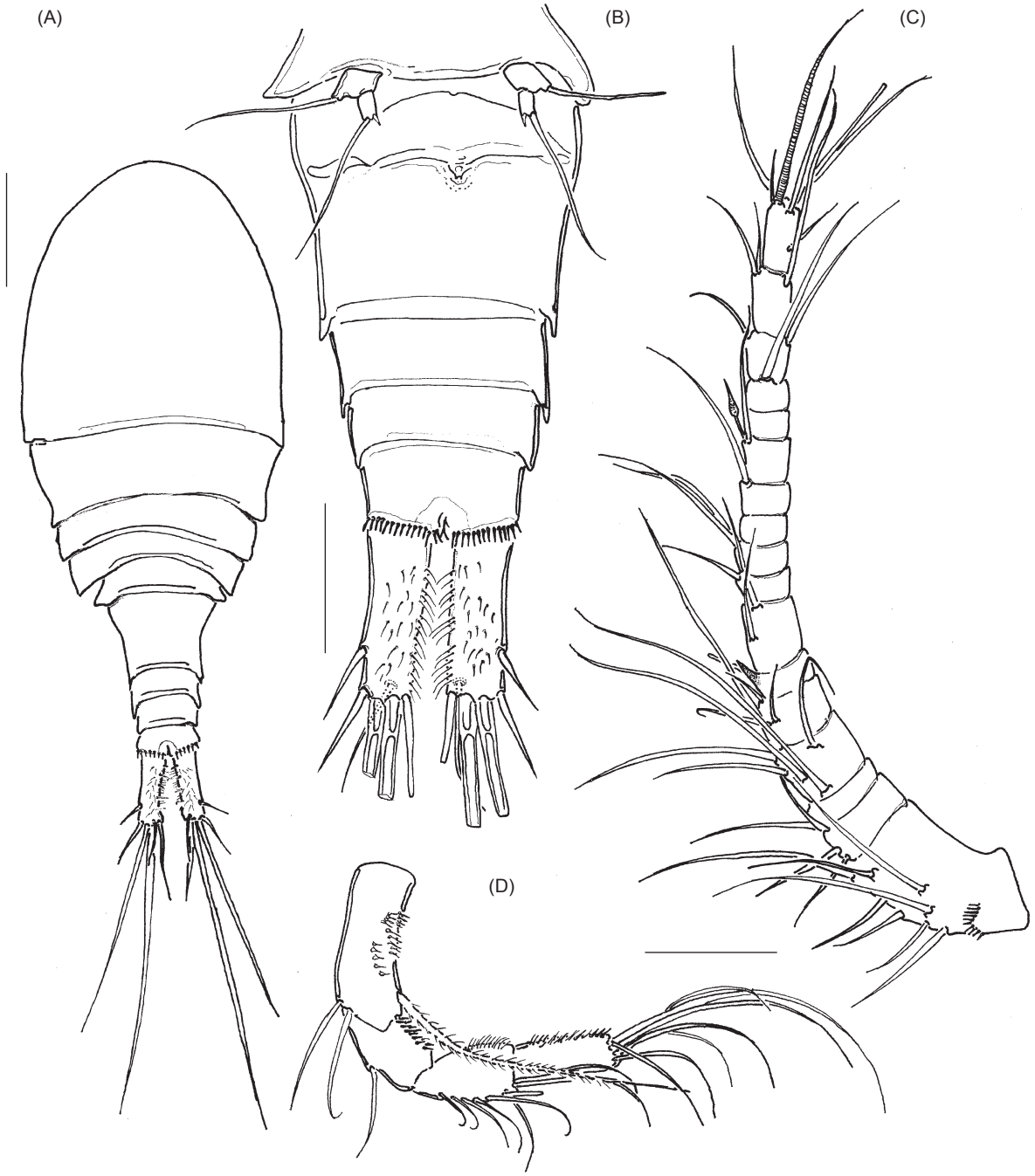

Fig. 2. *Acanthocyclops caesariatus* sp. nov. from Aguascalientes, Mexico, holotype adult female. (A) Habitus, dorsal view; (B) urosome with 5th pedigerous and genital somites, ventral view; (C) antennule; (D) antenna. Scale bars: A = 200 μm; B-D = 100 μm.

Leg 3 (Fig. 4B): Intercoxal sclerite naked, with rounded chitinized projections. Coxa with inner coxal seta and row of setules along outer margin. Basis with slender basipodal seta on outer margin, with spinules on insertion of seta; inner corner and middle distal margin of basis forming spiniform

Fig. 3. *Acanthocyclops caesariatus* sp. nov. from Aguascalientes, Mexico, holotype adult female. (A) Mandible blade; (B) maxillule; (C) maxilla; (D) maxilliped; (E) leg 1 with exopod and coxal plate; (F) leg 1 endopod. Scale bars: A, B, D = 100 μm; C = 50 μm; E, F = 50 μm.

expansions. Endopod and exopod 3-segmented, segments 1 and 2 with distal rows of spinules and short setules. Spinules along insertion of endopod. Endopod as long as exopod. Armature as in table 1.

Leg 4 (Fig. 4D): Intercoxal sclerite with single row of 10-15 spinules on anterior surface; distal margin smooth, not expanded. Coxal surface naked; inner coxal seta biserially setulated,

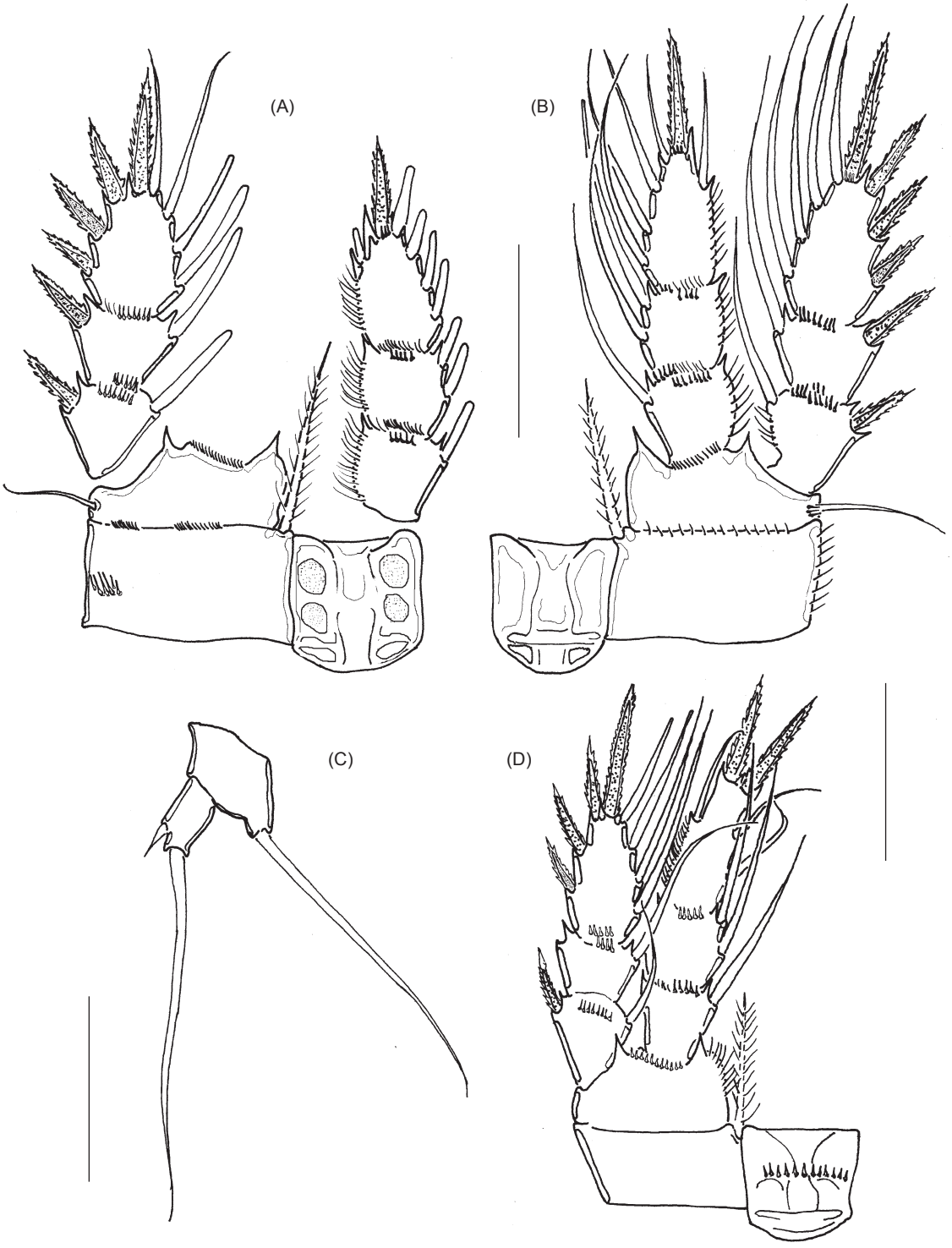

Fig. 4. *Acanthocyclops caesariatus* sp. nov. from Aguascalientes, Mexico, holotype adult female. (A) Second leg with coxal plate; (B) leg 3 with coxal plate; (C) leg 5; (D) leg 4 with coxal plate. Scale bars: A-D = 50 μm.

reaching distal margin of 1st endopodal segment. Basis without seta on outer margin, with row of spinules at insertion of endopod. Endopod and exopod 3-segmented, segments 1 and 2 with distal rows of spinules and short setules. Endopod longer than exopod. Outer and inner terminal endopodal spines serrate along most margins. Inner and outer spines subequal in length and width; length ratio of outer and inner terminal spines of 3rd endopodal segment (Enp 3) 0.83-0.95. Enp 3 length/width ratio 2.52. Insertion point of seta on outer margin of Enp 3 at 0.67 of length of segment. Length ratio of inner endopodal spine/Enp 3 of 0.82. Armature as in table 1.

Leg 5 (Fig. 4C): Leg consisting of 2 free segments, 1st (proximal) subrectangular, with moderate lateral expansion bearing long regular seta; 2nd (distal) segment about 1.5 times longer than broad, bearing long seta inserted distally. Short spiniform element inserted subdistally; spiniform element barely reaching distal margin of segment.

Urosome (Fig. 2B): Posterior margins of genital double somite, urosomites, and anal somites smooth both dorsally and ventrally; relative ratio of each urosomite 47.5: 15: 17.5: 20 (= 100). Genital double-somite representing 17% of body length (excluding caudal rami). Genital double-somite smooth on ventral and dorsal surfaces. Anterior half of genital double-somite expanded laterally. Ventral surface of anal somite smooth; distal ventral and dorsal margins with rows of 18-20 stout spines along insertion of caudal rami.

Caudal rami (Fig. 2B) representing 11.5% of total body length; ramus 0.47 times as long as urosome. Length/width ratio 3.79. Inner margin hairy, outer margin smooth; dorsal and ventral surfaces of rami pilose. Lateral terminal spiniform seta short, 0.26 times as long as caudal ramus, inserted at about 3/4 of outer margin of ramus. Dorsal seta 0.75 times as long as caudal ramus. Innermost terminal seta 0.9 times as long as caudal ramus, longer than dorsal seta. Inner median terminal seta longest, about 1.8 times longer than outer median terminal seta.

Etymology: The species is named using the Latin adjective *caesariatus*, meaning “with an elegant array of hairs”, in reference to the hairy condition of the caudal rami, and the coxa and coxal plate of the 1st swimming leg, which are among the main distinguishing characters of the species.

Remarks: Other species of *Acanthocyclops* with pilose rami but with 11- or 12 segmented antennules are *A. venustus* (Norman and Scott 1906), *A. venustoides* Coker, 1934, *A. pilosus* Kiefer, 1934 (Einsle 1996), and *A. skottsbergi* Lindberg, 1949, the latter with an uncertain status as it has been reallocated to *Diacyclops* (Morton 1985) and synonymized to *D. michaelseni* (Mrázek 1901) (Menu-Marque 1991, Dussart and Defaye 2006). The new species seems to be related to other forms with 17 antennular segments and pilose caudal rami: the Nearctic *A. carolinianus* Yeatman, 1944, and the European *A. gordani* Petkovski, 1971, which according to Einsle (1996) could be a species of *Megacyclops*. A useful character to separate *A. caesariatus* sp. nov. from these other 2 species is the length/width ratio of the caudal rami; in the new species rami are relatively shorter (ratio 3.8) than in *A. carolinianus* (5.0) and slightly longer than in *A. gordani* (3.5) (see Reid 1985, Einsle 1996). An additional difference in the new species is the presence of pilosity on the dorsal and ventral surfaces in addition to the inner margins of the caudal rami; this ornamentation pattern differs from those of the other species, in which the ventral and dorsal surfaces are naked. In both *A. carolinianus* and *A. gordani*, the inner margin is weakly hairy and covers only about 1/2 its length (Yeatman 1944, Einsle 1996); in the new species, the pilosity along the inner margin covers more than 1/2 the length of the ramus.

The spine formula of swimming legs 1-4 is another distinguishing character of the new species; it has a 3-4-4-4 formula, whereas *A. gordani* has a 2-3-3-3 pattern and in *A. carolinianus* both known patterns (2-3-3-3 or 3-4-4-4) can occur. In both *A. caesariatus* sp. nov. and *A. carolinianus*, the inner terminal caudal seta is as long as the caudal ramus, but in *A. gordani*, the seta is almost twice as long as the ramus. Also, the length ratio of the lateralmost caudal seta/medial terminal seta (0.55) differs among these species: 0.55 in *A. caesariatus* sp. nov., 0.53 in *A. carolinianus*, and 0.36 in *A. gordani*. The length ratio of the dorsal caudal seta/lateralmost terminal seta provides additional differences: in the new species the ratio is 1.18, vs. 0.87 in *A. carolinianus* and 2.3 in *A. gordani*.

Another important distinguishing character of *A. caesariatus* sp. nov. is the unique ornamentation on the coupler of the 1st leg; it has 2 rows of 3 or 4 long, slender spines (Fig. 3E), a pattern that has not been hitherto reported in any of its congeners with pilose caudal rami (Reid 1985, Einsle 1996). Furthermore, in the new species, the coxa of the 1st leg has a cluster of hair-like elements

on the outer margin close to the insertion of the basipodite and a row of spinules on the proximal ventral surface; the ornamentation differs from that of *A. carolinianus* and *A. gordani* (Einsle 1996).

The ornamentation of the 4th leg has additional characters to compare among these species. *Acanthocyclops caesariatus* sp. nov. shares a transverse row of spinules on the anterior surface of the coupler with both *A. carolinianus* and *A. gordani*. In the new species, the coxal and basipodal surface is naked except for a row of spinules on the basipod near the insertion of the endopod; in both *A. carolinianus* and *A. gordani*, these 2 segments are furnished with basal and proximal rows of spinules and lateral clusters of setules. In the new species, the ratio of the length of the outer seta/inner seta of the 3rd endopodal segment of the 4th leg (Enp 3) ranges 0.84-0.95 vs. 0.80 in *A. carolinianus* and 0.66 in *A. gordani*. The length/width ratio of this segment differs among these species; it is 2.52 in the new species, 2.1 in *A. carolinianus*, and 1.7 in *A. gordani*. In the new species, the insertion of the outer seta of Enp 3 is 0.67, resembling *A. carolinianus* (0.66) but differing from *A. gordani* (0.75). Also, the proportion of the length of the inner endopodal spine/Enp 3 is 0.82 in the new species, 0.88 in *A. carolinianus*, and 0.66 in *A. gordani*. *Acanthocyclops caesariatus* sp. nov. lacks the indentation of the 1st endopodal segment of the leg 4 present in *A. carolinianus*.

Acanthocyclops marceloi Mercado-Salas and Suárez-Morales sp. nov.

(Figs. 5-7)

Material examined: *Holotype*: Adult ♀, dissected, mounted in glycerin sealed with Entellan (ECO-CHZ-03614), creek on road from "El Colorín" to Gracias a Dios, Aguascalientes, Central Mexico (21°58'N, 102°29'W; (UTM) Y 2431080.55, X 759933.56). Coll. 10 June 1989 by Marcelo Silva-Briano. Paratypes. Two adult ♀♀, undissected, same locality, collector, and date; ethanol-preserved, vial (ECO-CH-Z-03615). Original samples with juvenile specimens in collection of M. Silva-Briano at Univ. of Aguascalientes.

Type locality: Creek on road from "El Colorín" to Gracias a Dios, Aguascalientes, Mexico. (21°58'N, 102°29'W; UTM: Y 2431080.55, X 759933.56) (Fig. 1); a small, shallow ephemeral water body with some human influence.

Description: ♀ (Fig. 5A): Total body length of holotype 1.23 mm from anterior end of cephalothorax to posterior margin of caudal rami. Body robust, cephalothorax relatively long, slightly expanded laterally at midlength of cephalosome in dorsal view; lateral margins of pedigers 3 and 4 straight, produced posteriorly. Cephalothorax length 750 mm, representing 61% of total body length. Dorsal surface smooth, antennules reaching end of 1st pediger. Urosome relatively slender, formed by 5 somites: 5th pediger plus 4 succeeding somites. Genital double-somite moderately expanded at proximal 1/2. Anal and preanal somites equally sized.

Antennule (Fig. 7B): 17 segmented in all specimens; armature per segment as follows (s, seta; ae, aesthetasc; sp, spine): 1(8s), 2(2s), 3(2s), 4(6s), 5(3s), 6(1s + sp), 7(2s), 8(2s), 9(2s), 10(0s), 11(1s); 12(1s + ae), 13 (0s), 14(1s), 15(2s), 16(3s),17(7s). Antennule reaching middle of 2nd thoracic somite. Dorsal surface of 1st segment with row of spinules.

Antenna (Fig. 5C): As in *A. caesariatus* sp. nov., except for weaker ornamentation on basis, 2nd segment of endopod with 4 lateral and 3 terminal outer setae; 3rd endopodal segment with 6 terminal setae.

Mandible (Fig. 5D): As in *A. caesariatus* sp. nov., except for gnathobase with 7 strongly chitinized teeth and short dorsal seta armed with a row of spinules.

Maxillule (Fig. 5E): Precoxal arthrite with naked surface, with 3 strong chitinized distal claws and 2 spiniform setae on frontal side. Endopod with 3 subequal apical setae.

Maxilla (Fig. 5F): As in *A. caesariatus* sp. nov.

Maxilliped (Fig. 5G): As in *A. caesariatus* sp. nov, except for smooth distal margin of syncoxa, stronger spinules on basis, and cluster of spines on 1st endopodal segment.

Leg 1 (Figs. 6A, B): As in *A. caesariatus* sp. nov., except for intercoxal sclerite with cluster of 8-10 long spinules on each side of anterior surface, and basis with small spines at insertion of inner basipodal seta. Armature as in table 1.

Leg 2 (Fig. 6C): As in *A. caesariatus* sp. nov., except for outer margin of coxa with a row of long hair-like elements and coxal spiniform seta reaching about midlength of 1st endopodal segment. Armature as in table 1.

Leg 3 (Fig. 6D): As in *A. caesariatus* sp. nov., except for naked distal margin of coxa. Armature as in table 1.

Leg 4 (Fig. 6E): As in *A. caesariatus* sp. nov., except for coxal surface with proximal (4

or 5 elements) and distal (8 or 9 elements) rows of spines and cluster of hair-like elements near outer margin, basipodal seta on outer margin, and inner and outer spines of 3rd endopodal segment subequal in length; length ratio of outer and inner terminal spines of Enp 3 of 1.0-0.95. Length/width

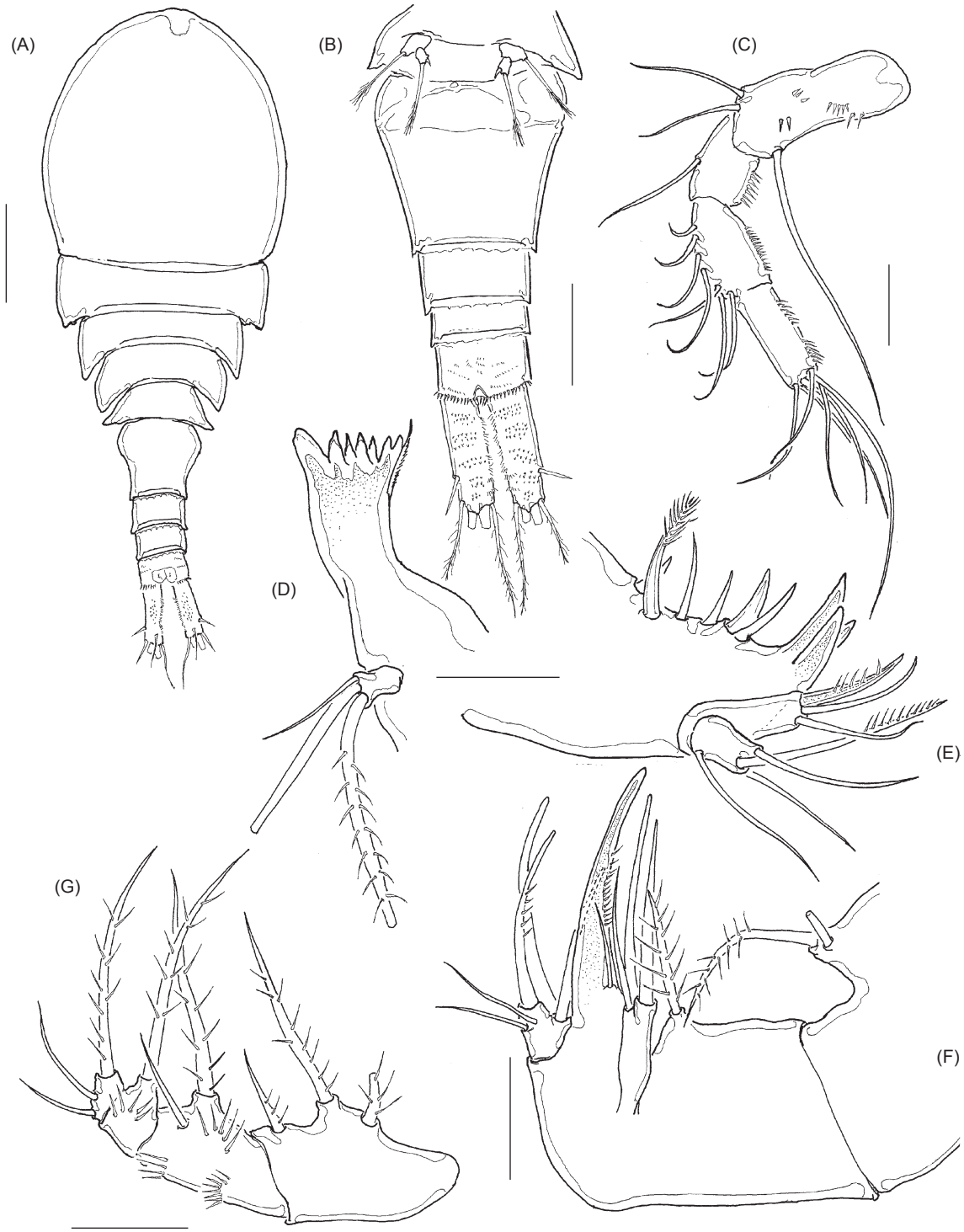

Fig. 5. *Acanthocyclops marceloi* sp. nov. from Aguascalientes, Mexico, holotype adult female. (A) Habitus, dorsal view; (B) urosome with 5th pedigerous and genital somites, ventral view; (C) antenna; (D) mandible with palp; (E) maxillule; (F) maxilla; (G) maxilliped. Scale bars: A, B = 100 μm; C-G = 50 μm.

ratio of Enp 3 of 2.2. Insertion point of seta on outer margin of Enp 3 at 0.61 of length of segment. Length ratio of inner endopodal spine/Enp 3 of 0.88. Armature as in table 1.

Leg 5 (Figs. 5B, 7D): As in *A. caesariatus* sp. nov., except for relatively shorter setae, not

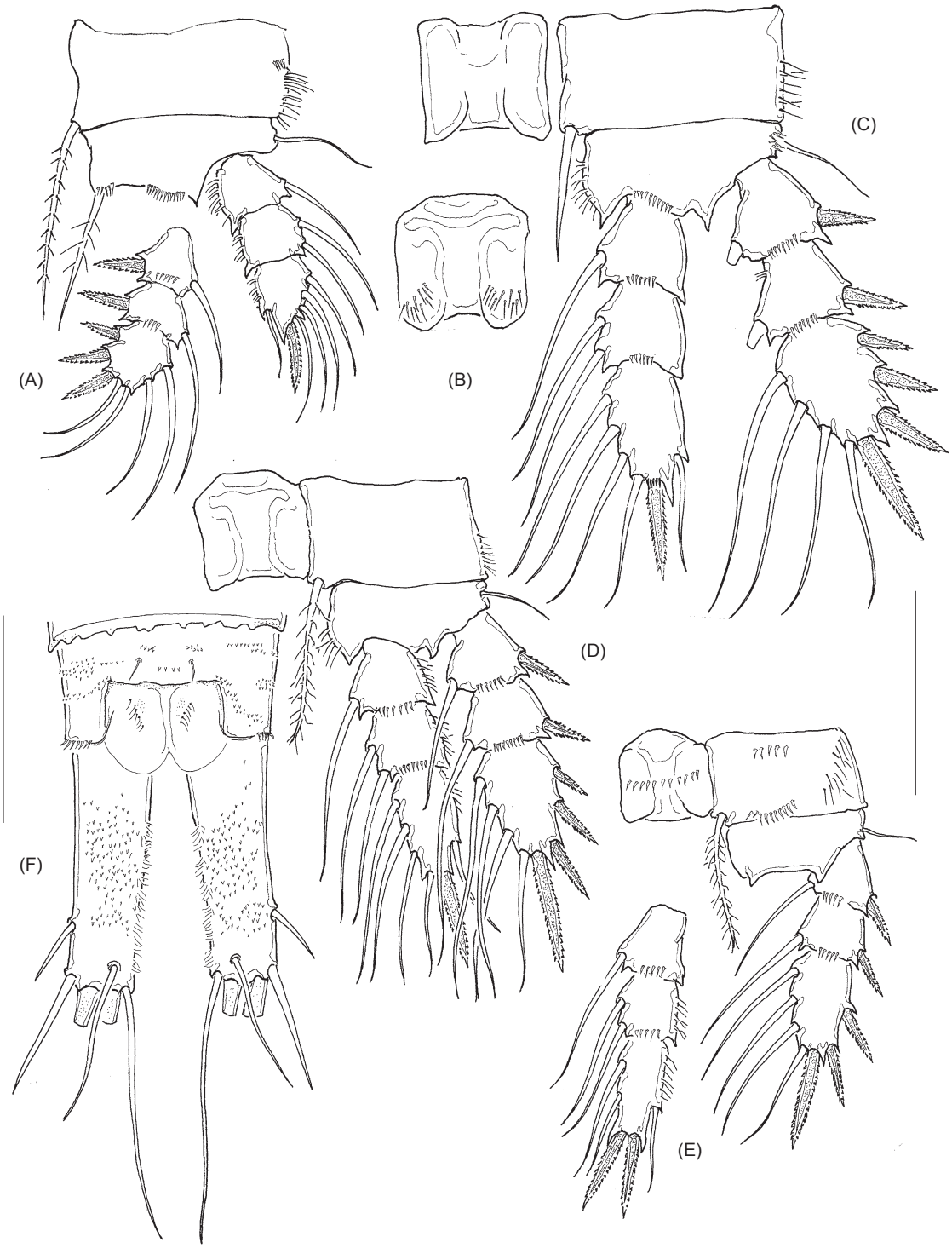

Fig. 6. *Acanthocyclops marceloi* sp. nov. from Aguascalientes, Mexico, holotype adult female. (A) Leg 1, endopod separate; (B) Leg 1 coxal plate; (C) Leg 2 with coxal plate (separate); (D) Leg 3; (E) Leg 4, endopod separate; (F) caudal rami, dorsal view. Scale bars: A-F = 50 μm.

reaching midlength of genital somite.

Urosome (Figs. 5B, 7C): Posterior margins of genital double somite, urosomites, and anal somites crenulate both dorsally and ventrally. Genital double-somite representing 13.5% of body length (excluding caudal rami). Anterior half of genital double-somite expanded laterally. Ventral surface of anal somite with rows of spinules; distal

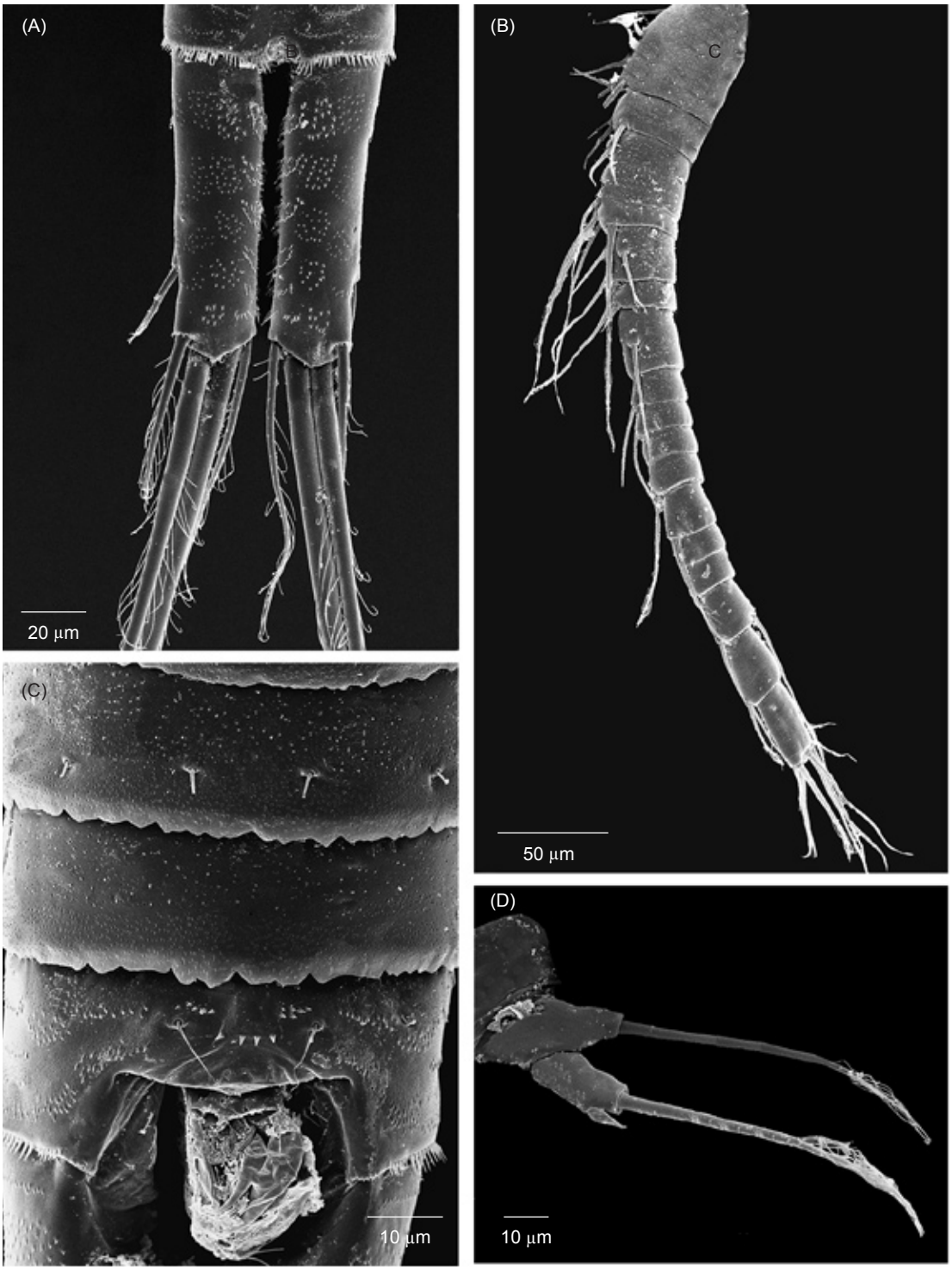

Fig. 7. *Acanthocyclops marceloi* sp. nov. from Aguascalientes, Mexico. SEM figures of female specimen. (A) Caudal rami, ventral view; (B) antennule; (C) detail of ornamentation on urosomites, ventral view; (D) 5th leg.

ventral and dorsal margins with stout spines along insertion of caudal rami.

Caudal rami (Figs. 5B, 6F, 7A): Representing 8.9% of total body length; ramus 0.32 times as long as urosome. Length/width ratio 2.8. Inner margin with short hair-like elements arranged in patches; outer margin smooth. Dorsal surface of rami largely covered with spinules in irregular pattern; ventral surface with transverse rows of spinules arranged in 4 symmetrical patches. Lateral terminal spiniform seta short, 0.29 times as long as caudal ramus, inserted at about 3/4 of outer margin of ramus. Dorsal seta 0.63 times as long as caudal ramus. Innermost terminal seta 1.15 times as long as caudal ramus, almost twice as long as dorsal seta.

Etymology: The species is named after a coauthor of this work, Marcelo Silva-Briano, Univ. de Aguascalientes, Mexico, for his many contributions to the knowledge of the freshwater zooplankton of Central Mexico and for collecting this species.

Remarks: With 17 antenular segments and pilose caudal rami, *A. marceloi* sp. nov. resembles *A. carolinianus*, *A. gordani*, and *A. caesariatus* sp. nov. A useful character to separate *A. marceloi* sp. nov. from these other congeners is the length/width ratio of the caudal ramus; in this new species, the ratio is 2.8 vs. 5.0 in *A. carolinianus*, 3.5 in *A. gordani*, 3.8 in *A. caesariatus* sp. nov., and 2.5 in *A. skottsbergi* (Reid 1985; Einsle 1996). Also, the caudal rami have a unique ornamentation pattern on the ventral and dorsal surfaces; ventrally, it has a well-defined array of spinules arranged in 4 symmetrical groups with transverse rows (Figs. 5B, 7A), and the spinulation pattern of the dorsal surface is irregular (Fig. 6F). Further, this species has tight patches of short hair-like elements along the inner margin reaching nearly to the insertion of the innermost terminal caudal seta, instead of a relatively reduced coverage found in the other species. This pattern is not present in any other known species with pilose caudal rami. In the new species, the spine formula of legs 1-4 is 3-4-4-4 as in *A. carolinianus* (also with a 2-3-3-3 pattern), *A. gordani*, and *A. caesariatus* sp. nov.

In *A. marceloi* sp. nov., the innermost terminal caudal seta is as long as the caudal ramus; *A. carolinianus* and *A. caesariatus* sp. nov. share this character, but it differs from *A. gordani* and *A. skottsbergi*, in which this setal element is longer than the caudal ramus (see Reid 1985, Einsle 1996). The ratio of the lateralmost/medialmost terminal caudal setae in *A. marceloi* sp. nov. (0.58) differs from that found in its congeners: *A. carolinianus* (0.53) and *A. gordani* (0.36). Another distinguishing character among these species is the length ratio of the dorsal seta/lateralmost terminal seta; in both *A. marceloi* sp. nov. (0.86) and *A. carolinianus* (0.87), the figure is similar, but differs from that in *A. gordani* (2.3).

Another important character separating *A. marceloi* sp. nov. from its congeners is the ornamentation of the 1st leg coupler; in the new species, it has 2 groups of spines, 8-10 on each side of the coupler. The ornamentation found in *A. caesariatus* sp. nov., with only 1 row of spines (4 on each side), is weaker than that in *A. marceloi* sp. nov. In the other species, the coupler is naked. The ornamentation on the outer margin of the 1st leg coxa also differs among these species; in *A. marceloi* sp. nov., it is represented by a row of stiff hairs and a transverse row of small spines, vs. a smooth margin in *A. carolinianus*, a single row of hairs in *A. gordani*, and a transverse row of hair-like elements in *A. caesariatus* sp. nov. The ornamentation of the 4th leg of the new species is most similar to that in *A. carolinianus*, with a transverse row of spines on the coupler, and 2 transverse rows of spines on the coxa, 1 proximal and 1 at a distal position. The proximal row of *A. carolinianus* is longer, with 11 or 12 spines, whereas only 5 or 6 are present in *A. marceloi* sp. nov. Another important character shared by both that *A. marceloi* sp. nov. and *A. carolinianus* is the indentation of the first article of the 4th leg endopod, thus differing from *A. gordani*.

Additional distinguishing characters include (1) the proportion of the length of the outer seta/inner seta of Enp 3 of the 4th leg; in both *A. marceloi* sp. nov. and *A. caesariatus* sp. nov., it is close to 1.0, but in *A. carolinianus*, the ratio is 0.80, and in *A. gordani* it is 0.66 (2). The length/width ratio of this segment is about 2.2 in *A. marceloi* sp. nov., very similar to that of *A. carolinianus* (2.1), but differs from that of *A. gordani* (1.7), and (3) the insertion point of seta on outer margin of Enp 3; in the new species the insertion is at 0.61 of the segment length, vs. 0.66 in *A. carolinianus* and 0.75 in *A. gordani*.

DISCUSSION

The morphological definition of the genus *Acanthocyclops* overlaps in many instances with that of *Diacyclops*; for decades, this has been a point of discussion among copepodologists (Stoch

2001, Karanovic 2005). The characters which allowed us to include these specimens in the genus *Acanthocyclops* are: 1) the general body shape with the 5th somite broader than the genital somite and lateral margins triangular; 2) the 5th leg represented by 2 segments, the distal one armed with a small subapical spine reaching the distal end of the basal segment; 3) antennule with 17 segments; and 4) endopodal and exopodal rami of legs 1-4 all with 3 segments (Reid 1985, Einsle 1996, Dussart and Defaye 2001).

Most of the known species of *Acanthocyclops* occur mainly in temperate and subarctic latitudes in Eurasia and North and South America; hitherto, the only true Neotropical species of *Acanthocyclops* currently known were *A. smithae* from the Yucatan Peninsula, Central America, and possibly also distributed in Cuba, *A. rebecae* from the Yucatan Peninsula, and recently, and *A. dodsoni* from Central Mexico (Mercado-Salas et al. 2006). The former 2 species appear to have affinities with the *robustus-vernalis* group (Reid and Suárez-Morales 1999, Fiers et al. 2000). Considering the number of antennular segments, the length of the basipodal spine, the spine formula, the length of the inner caudal seta, and its habitat and geographical distribution (see Reid et al. 1991, Einsle 1996, Reid and Suárez-Morales 1999, Iepure and Defaye 2008), both new species described herein are also assignable to the *robustus-vernalis* species group. These are probably remnants of an extensive radiation of Nearctic forms related to this widespread clade that speciated in an area with a high diversity of habitats (Fiers et al. 1996, Suárez-Morales et al. 2004). The close morphological resemblance of both new species with the Nearctic *A. carolinianus* confirms the strong influence of these forms in Middle America.

Boxshall and Defaye (2008) observed that the highest diversity of freshwater copepods occurs in the Palaearctic region, followed by the Neotropics; they also estimated that up to 90% of the diversity is represented by species restricted to a single zoogeographic region. These new data are important in reexamining the copepod diversity of the Neotropical Region in which the habitat diversity provides favorable conditions for local speciation processes (Fiers et al. 1996, Suárez-Morales et al. 2004). Due to their high variability and complex taxonomy (Dodson et al. 2003), our results further suggest that the *vernalis-robustus* species group should be revised in greater detail in the region.

Species with pilose caudal rami have been recorded from different environments, including marshy meadows (*A. venustoides* and *A. pilosus*), groundwater (*A. venustus* and *A. gordani*), and ponds (*A. carolinianus*, *A. caesariatus*, and *A. marceloi*) (Einsle 1996). However, some of these species are in need of taxonomic revision. If Einsle's (1996) assumptions of (1) *A. gordani* being a species of *Megacyclops* and (2) *A. pilosus* a synonym of *A. venustoides* hold true, then the number of *Acanthocyclops* with pilose caudal rami would decrease to only 5 species. *Acanthocyclops caesariatus* sp. nov. and *A. marceloi* sp. nov. are the only species of the genus with pilose caudal rami reported from the Neotropical region.

This work increases the number of species of *Acanthocyclops* known from Mexico, from 5 to 7. Previous records include *A. vernalis*, *A. robustus*, *A. smithae*, *A. rebecae*, and *A. dodsoni* (Lindberg 1955, Dodson and Silva-Briano 1996, Suárez-Morales and Reid 1998, Grimaldo-Ortega et al. 1998, Reid and Suárez-Morales 1999, Fiers et al. 2000, Mercado-Salas et al. 2006).

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