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A new *Acanthocyclops* Kiefer, 1927 (Cyclopoida: Cyclopinae) from an ecological reserve in Mexico City

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A new species of *Acanthocyclops* is decribed from an Ecological Reserve in Mexico City. *Acanthocyclops eduardoi* sp. nov. was assigned as a member of the *Acanthocyclops vernalis–robustus* complex and it differs from its congeners by a combination of characters including 17 segmented antennules, the ornamentation of spinules on the ventral and dorsal surface of caudal ramus, a short dorsal seta (0.47–0.56), an elongated third segment of endopodite of fourth leg (length/width 3.10–3.80) and, the length/width ratio of caudal ramus ranging from 4.30 to 4.35. The male of *A. eduardoi* sp. nov. shows a unique ornamentation pattern on the coxal plate of the fourth leg. The new species resembles other species such as *Acanthocyclops marceloi*, *Acanthocyclops caesariatus*, *Acanthocyclops brevispinosus*, *Acanthocyclops trajani* and *Acanthocyclops einslei.* The number of species of the genus in the Mexican Plateau is increased so the diversity of the genus in this biogeographic province may be underestimated and deserves further study.

http://www.zoobank.org/urn:lsid:zoobank.org:pub:32A9F42E-5C7F-4149-920E-E14A91C719FD

Keywords: Mexican Plateau; freshwater; limnology; Copepoda

Introduction

The genus *Acanthocyclops* (Kiefer, 1927) contains more than 75 nominal species and subspecies (Boxshall and Halsey 2004; Dussart and Defaye 2006) and has a worldwide distribution (Mirabdullayev and Defaye 2004). The morphological variability of some of the nominal species has motivated numerous publications, especially in the case of species contained in the *Acanthocyclops vernalis–robustus* complex (Mirabdullayev and Defaye 2004). The high variability of the characters used to separate *A. vernalis* (Fisher, 1853) and *A. robustus* (G.O. Sars, 1863) has resulted in a long history of synonymizations, redescriptions and taxonomic confusion. It has been shown that both species have an Old World origin and are also found in the Americas, but morphologically similar forms occurring in the continent have been assigned to either of these taxa without a complete taxonomic analysis (Dahms and Fernando 1997; Dodson et al. 2003). Hence, many recently described or redescribed species such as *Acanthocyclops trajani* Mirabdullayev and Defaye, 2002, *Acanthocyclops brevispinosus* (Herrick. 1884), *Acanthocyclops pennaki* Reid, 1992 and *Acanthocyclops einslei* Mirabdullayev and Defaye, 2004 were first identified as *A. robustus* or *A. vernalis*. New morphological

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characters have provided sound tools to separate species within the complex (Reid 1992; Dodson 1994; Dahms and Fernando 1997; Mirabdullayev and Defaye 2002, 2004).

In the Americas, the genus includes 14 species distributed in North America (Yeatman 1959; Reid 1998; Williamson and Reid 2001; Mercado-Salas et al. 2006, 2009; Mercado-Salas and Suárez-Morales 2011) and seems to be less diverse in South America, where only four species have been recorded (Reid 1985; Rocha and Botelho 1998). In Mexico seven species are currently known, most of their records are from northern and central regions of the country, especially from semi-arid environments. The recent discovery of new species suggests that the diversity of the genus in the country might be underestimated (Reid and Suárez-Morales 1999; Fiers et al. 2000; Mercado-Salas et al. 2006, 2009, Mercado-Salas and Suárez-Morales 2011).

Eastern Quarry is part of the Ecological Reserve of San Angel Pedregal, adjacent to Ciudad Universitaria, Mexico City. In April 1970, the university issued a permit for the extraction of basaltic material (*c*.5,500,000 m^3). During the drilling the local aquifers were disrupted and water surfaced to form small reservoirs. Several studies have revealed an amazing diversity of phytoplankton, protozoa, insects, macrocrustaceans, amphibians, reptiles and birds; these were recorded as native, endemic forms, with a restricted distribution and, in some cases, were considered relict or rare elements in Mexico Valley (Lot 2007). Copepods have not been studied in the area; there is only one record of *Macrocyclops* (Villalobos-Hiriart et al. 2007). From a recent survey of the zooplankton of the Eastern Quarry several specimens of *Acanthocyclops* were obtained and tentatively identified as *A. robustus*; these specimens were taxonomically re-examined and recognized as belonging to an undescribed taxon.

Material and methods

Zooplankton samples were collected during September and December of 2010 in the small lakes of the Eastern Quarry, Ecological Reserve of San Angel Pedregal (Figure 1). For qualitative studies samples were collected using a 200-μm mesh hand net to sample the surface layer; for quantitative studies 16 litres of water were filtered using a bucket and a spoon-like net with a 54-μm mesh in each of seven sampling sites. For this study we used the samples collected on 3 December 2010. The biological material was fixed and preserved in 4% formalin. Copepods were sorted from the entire original samples and kept in 70% ethanol with glycerine. Several female and male specimens of *Acanthocyclops* were collected. A close examination of these specimens was performed in the laboratory and differences were found with respect to previously known species of the genus, motivating a deeper analysis. Specimens were dissected and examined following the techniques described by Williamson and Reid (2001) and Reid (2003). Dissected specimens were mounted in semi-permanent slides with glycerine sealed with Entellan®. Scale drawings were made at 100 × magnification with a camera lucida mounted on a standard Olympus CX31 compound microscope. This hitherto unknown species was described and illustrated following the current standards for the taxonomic study of the genus (Einsle 1996; Fiers et al. 2000). The specimens of the typical series of the new species were deposited in the collection of zooplankton held at El Colegio de la Frontera Sur (ECO-CH-Z), in Chetumal, Mexico. Original samples are in the Laboratory of C. Álvarez-Silva at Universidad Autónoma Metropolitana Campus Iztapalapa, Mexico City.

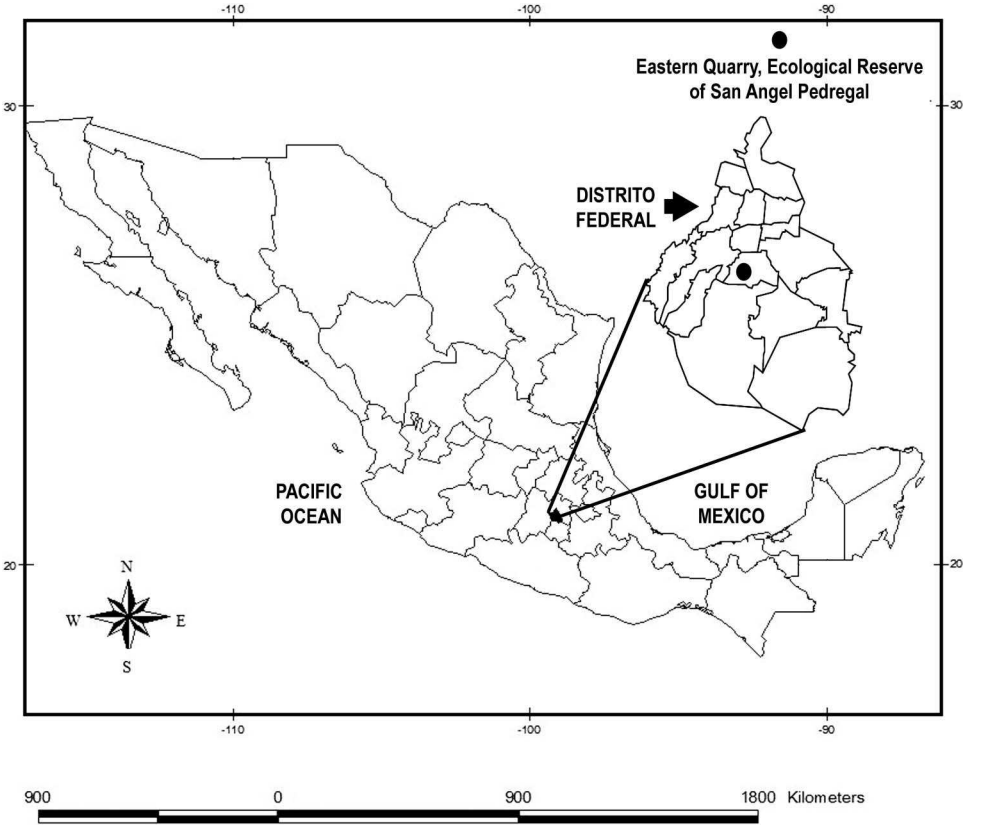

Figure 1. Map of Mexico; the sampled sites where *Acanthocyclops eduardoi* sp. nov. were collected.

Systematics

Order **CYCLOPOIDA** G. O. Sars, 1886
Family **CYCLOPIDAE** Burmeister, 1834
Subfamily **CYCLOPINAE** Burmeister, 1834
Genus ***Acanthocyclops*** Kiefer, 1927
Acanthocyclops eduardoi Mercado-Salas and Álvarez-Silva n. sp.
(Figures 2–5)

Material examined

Holotype. Adult female, dissected, mounted in glycerine sealed with Entellan (ECO-CH-Z-07510), Station 3 December 2010 Eastern Quarry, Ecological Reserve of San Angel Pedregal (19°19′4.42″ N, 99°10′21.4″ W) coll. 3 December 2010 by Carlos Álvarez-Silva.

Allotype. Adult male, dissected, semi-permanent slide (ECO-CH-Z-07511), same site, date and collector.

Paratypes. (ECO- CH-Z-07512), 20 adult females, three undissected copepodites, same locality and date of collection; ethanol-preserved. Original samples containing several adult males and females and also copepodites are deposited in C. Álvarez-Silva's laboratory at the Universidad Autónoma Metropolitana Campus Iztapalapa, Mexico City.

Type locality

Station 3 December 2010, Eastern Quarry, Ecological Reserve of San Angel Pedregal, Mexico City, Mexico (19°19′4.42″ N, 99°10′21.4″ W); temperature of water at time of collection 15.1°C, pH 9.1. Average density of individuals in the sample was 99.7 adult copepods per litre (females 60.2 per litre; males 39.5 per litre).

Etymology

The species is warmly dedicated to Dr Eduardo Suárez-Morales for his many contributions to the knowledge of the copepod fauna in Mexico and Latin America and his commitment to training Latin American taxonomists.

Description – adult female holotype

Total body length 1.62 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 1.084 mm, representing 66.66% of total body length. Dorsal surface smooth. Urosome relatively slender, formed by five somites: fifth pediger plus four succeeding somites. Genital double-somite moderately expanded at proximal half. Anal and preanal somites equally sized.

Antennule (Figure 2D). Seventeen-segmented in all specimens examined; armature per segment as follows (s = seta, ae = aesthetasc, sp = spine): 1(8s), 2(3s), 3(1s), 4(6s), 5(3s), 6(1s + 1sp), 7(1s), 8(1s), 9(1s), 10(0s), 11(2s), 12(1s +1ae), 13(0s),14(1s), 15(2s), 16(2s), 17(7s). Antennules reaching middle of second thoracic somite. Dorsal surface of first segment without row of spinules.

Antenna (Figure 2E,F). Four-segmented, basis with three groups of spines on caudal surface and three groups on frontal surface. Eight largest spines arranged longitudinally close to inner margin, additional group adjacent to first one, with four spines of the same size, third row of spines present on outer margin of basis with five small spines. Basis with long exopodal seta biserially pinnate plus two equally long basipodal setae. First segment of endopodite with single outer seta and inner row of small spinules. Second endopodal segment with five lateral and four terminal outer setae; inner margin with row of short spinules. Third endopodal segment with seven terminal setae, inner margin with row of spines.

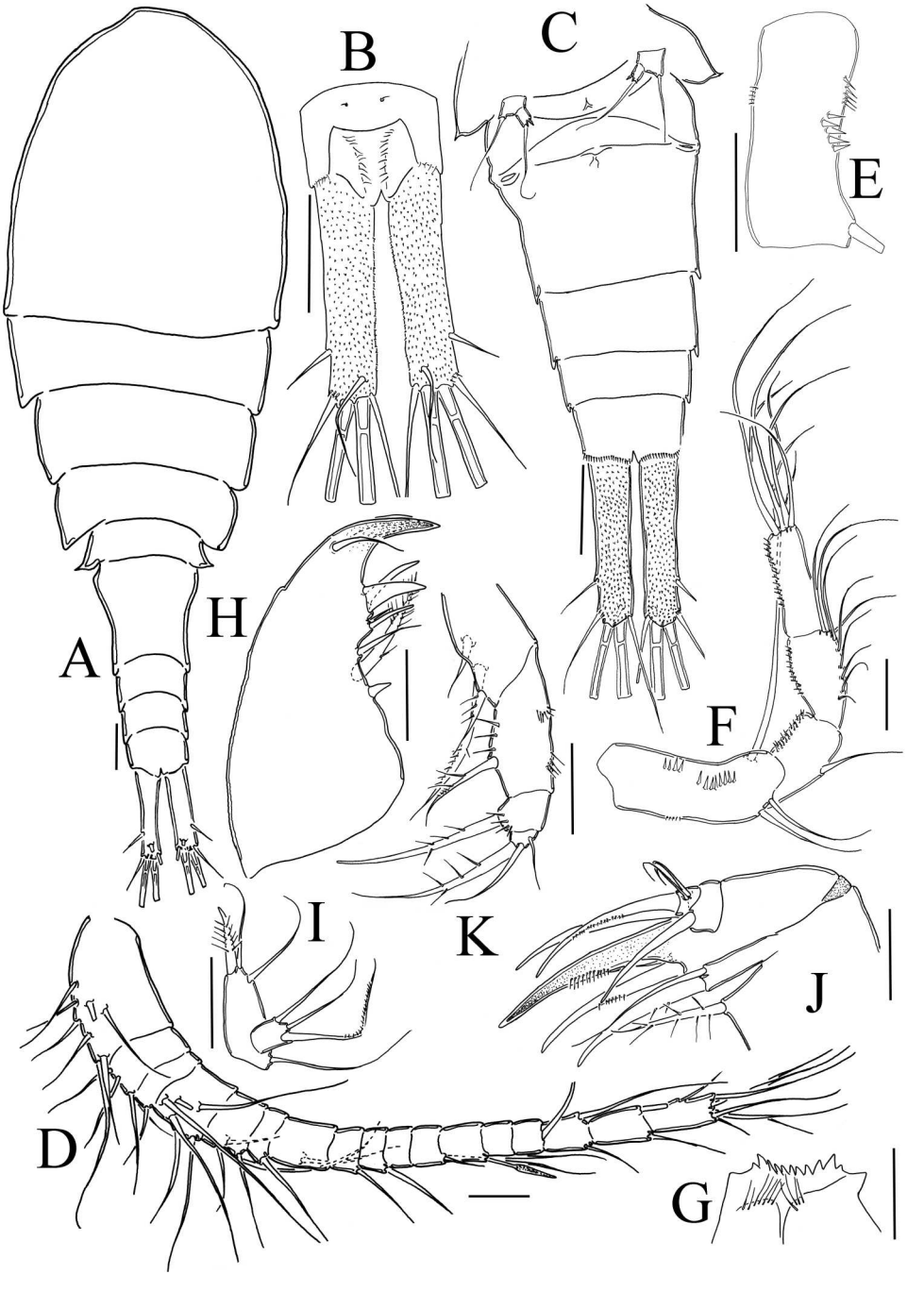

Figure 2. *Acanthocyclops eduardoi* sp. nov. from Mexico, holotype adult female. (A) Habitus, dorsal view; (B) caudal ramus, dorsal view; (C) urosome with fifth pedigerous and genital somites, ventral view; (D) antennule; (E) antenna basipodite, frontal; (F) antenna, caudal; (G) labrum; (H) maxillule; (I) maxillule palp; (J) maxilla; (K) maxilliped. Scale bars: A–C, 100 μm; D–K, 50 μm.

Labrum (Figure 2G). Distal margin with 11 blunt teeth between rounded lateral protuberances; two rows of long, slender spinules on ventral surface.

Maxillule (Figure 2H,I). Precoxal arthrite with naked surface, with three strong chitinized distal claws and one spiniform seta on frontal side. Basis of palp furnished apically with one biserially pinnate seta and two simple setae. Endopod subquadrate, with three unequally long apical setae.

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

Maxilliped (Figure 2K). Four-segmented. Syncoxa with three spiniform setae along inner margin. Basis with strong setulated setae, one longitudinal row of long spines on inner margin, and two transverse rows of spines on outer margin. Endopod two-segmented, first segment with wide-based, stout basal spine sparsely spinulated; longitudinal row of four spines, close to the insertion of seta. Second endopodal segment armed with three elements: one proximal strong, spiniform sparsely spinulated seta plus two shorter, naked setae.

Leg 1 (Figure 3A). Intercoxal sclerite with row of four spinules on each side of anterior surface, distal margin with two rounded chitinized projections. Coxa with strong biserially setulated inner coxal seta. Basis with long basipodal seta on outer margin, inner margin moderately expanded, with strong spiniform seta reaching midlength of third endopodal segment; small spines along insertion of endopod. Endopod and exopod three-segmented. Armature as in Table 1.

Leg 2 (Figure 3B). Intercoxal sclerite naked, with two rounded chitinized projections. Coxa with row of spinules along outer margin. 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 three-segmented. Armature as in Table 1.

Leg3 (Figure 3C). Intercoxal sclerite naked, with slightly rounded chitinized projections. Coxa with inner coxal seta biserially setulated 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 expansions. Endopod and exopod three-segmented. Small spines along insertion of endopod. Endopod as long as exopod. Armature as in Table 1.

Leg 4 (Figure 3D, Table 2). Intercoxal sclerite with single row of 11 spinules on anterior surface; distal margin smooth, not expanded. Coxal surface with one row of five spines close to proximal margin, one row of 10 spines along proximal margin and one row of spinules along outer margin; inner coxal seta biserially setulated, reaching distal margin of first endopodal segment. Basis with seta on outer margin and row of

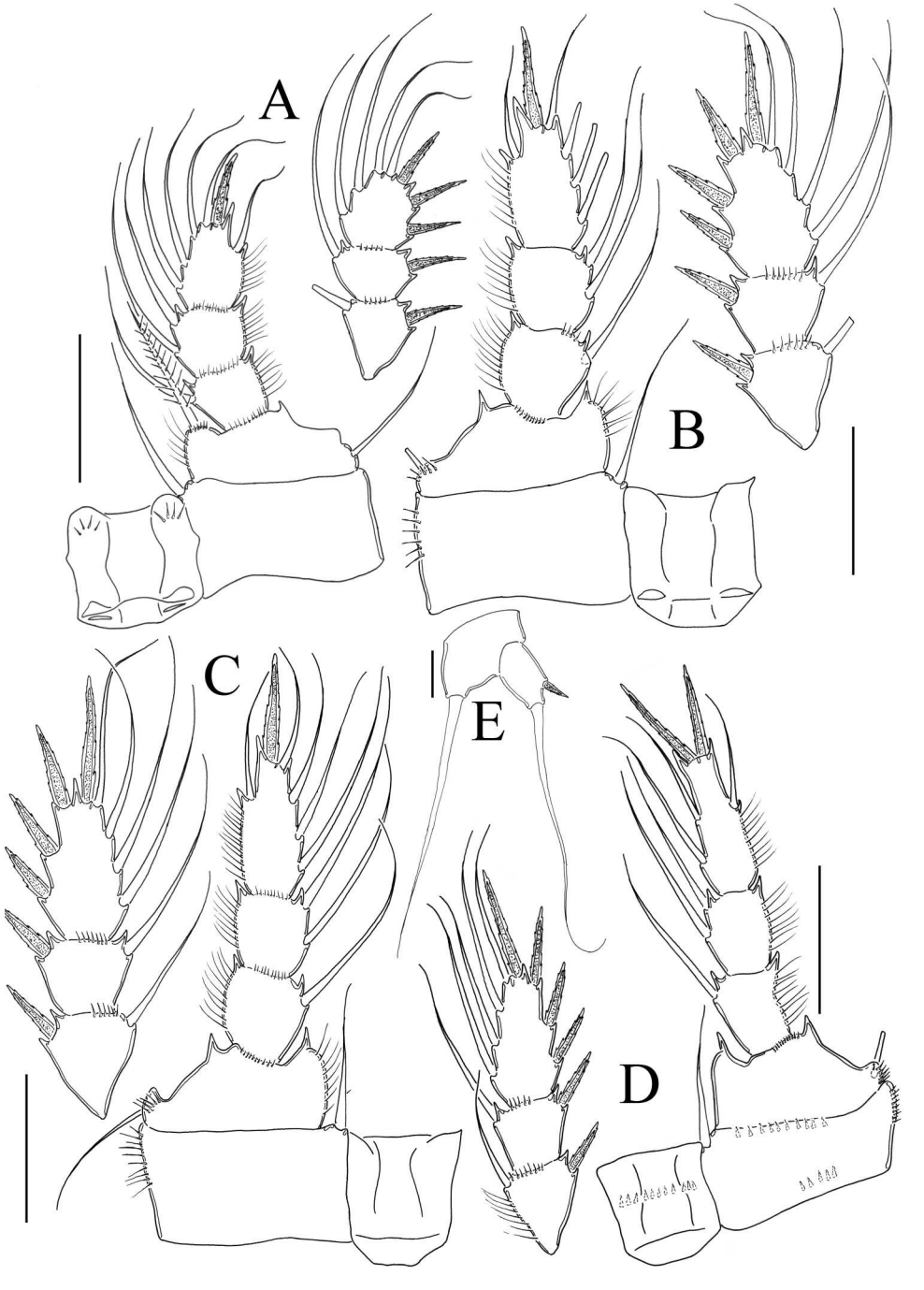

Figure 3. *Acanthocyclops eduardoi* sp. nov. from Mexico, holotype adult female. (A) First leg; (B) second leg; (C) third leg; (D) fourth leg; (E) fifth leg. Scale bars: A–D, 100 μm; E, 50 μm.

Table 1. Armature of swimming legs 1–4 (spines in Roman numerals, setae in Arabic) of *Acanthocyclops eduardoi* sp. nov. Sequence follows external to internal positions.

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

Table 2. Measurements of *Acanthocyclops eduardoi* sp. nov. (adult females).

	Min.–Max.	Mean
Caudal ramus ($n = 20$)		
Fu L/W	4.30–4.95	4.73
Ti/Fu L	0.80–0.97	0.90
Ti/Te	1.30–1.72	1.63
Ti/Sd	1.50–2.03	1.81
Sd/Fu L	0.47–0.56	0.49
End 3 P4 ($n = 10$)		
L/W	3.10–3.80	3.50
Inner Sp./L	0.68–0.76	0.72
Inner Sp./W	2.40–2.70	2.52
Outer Sp./Inner Sp.	0.84–0.92	0.89
Lat. Set. Position	0.57–0.60	0.58

Abbreviations: Fu, furca; L, length; W, width; Ti, innermost apical seta; Te, outermost apical seta; Sd, dorsal caudal seta; Inn. Sp, inner spine; Outer sp, outer spine.

spinules on the insertion of seta; row of small spinules on the insertion of endopod. Endopod and exopod three-segmented. Endopod slightly longer than exopod. Inner spine slightly longer than outer spine; length ratio of outer/inner terminal spines of third endopodal segment (Enp 3) 0.97. Length/width ratio Enp 3 = 3.1. Insertion point of seta on outer margin of Enp 3 = 0.56 of the length of segment. Length ratio of inner endopodal spine/Enp 3 = 0.75. Armature as in Table 1.

Leg 5 (Figure 3E). Leg consisting of two free segments, first (proximal) subrectangular, with moderate lateral expansion bearing long regular seta; second (distal) segment about 1.63 times longer than broad, bearing long seta inserted distally. Short spiniform element inserted subdistally; spiniform element slightly longer than distal margin of segment.

Urosome (Figure 2C). Posterior margins of genital double somite, urosomites and anal somites smooth both dorsally and ventrally; relative ratio of each urosomite as: 52 : 14 : 14 : 20 = 100. Genital double-somite representing 17.5% 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 margin with rows of 18–20 stout spines along insertion of caudal rami of ventral surface and ascending along the flanks and reaching dorsal margin.

Caudal ramus (Figure 2B, Table 2). Ramus 0.33 times as long as urosome. Length/width ratio = 4.92. Inner margin, ventral and dorsal surfaces with small spinules not showing an established pattern. Lateral seta short, 0.29 times as long as caudal ramus, inserted at about three-quarters of the outer margin of ramus. Dorsal seta 0.56 times as long as caudal ramus. Innermost terminal seta 0.97 times as long as caudal ramus and longer than dorsal seta. Outermost terminal seta about 0.58 times as long as caudal ramus.

Description – adult/male allotype

Total body length 1.25 mm from anterior end of cephalothorax to posterior margin of caudal rami.

*Antennule (*Figure 4C,D). Geniculate, 15-segmented.

Antenna (Figure 4E,F). As in female except for the lack of row of tiny spinules on outer margin of basis.

Mouth parts. As in female.

Leg 1 (Figure 5A). As in female except for the number of spinules on intercoxal sclerite being seven instead of four on each side of anterior surface.

Leg 2 (Figure 5B). As in female except for the ornamentation of intercoxal sclerite, the male presents a row of seven spinules on medial margin.

Leg 3 (Fig 5C). As in female except for the ornamentation of intercoxal sclerite, the male presents a row of six spinules on each side of anterior surface.

Leg 4 (Fig 5D,E). As in female except for two characters: (1) the ornamentation of intercoxal sclerite stronger than in female, the male presents an additional row of spinules on anterior surface and a group of strong spinules above the normal row of spinules present on medial margin; and (2) lateral outer seta of male is modified into a tubular spine.

Leg 5. As in female.

Leg 6. Small low plate at distal corner of genital somite with one strong inner spine, one medial seta as long as inner spine and one outer seta about two times longer than inner spine.

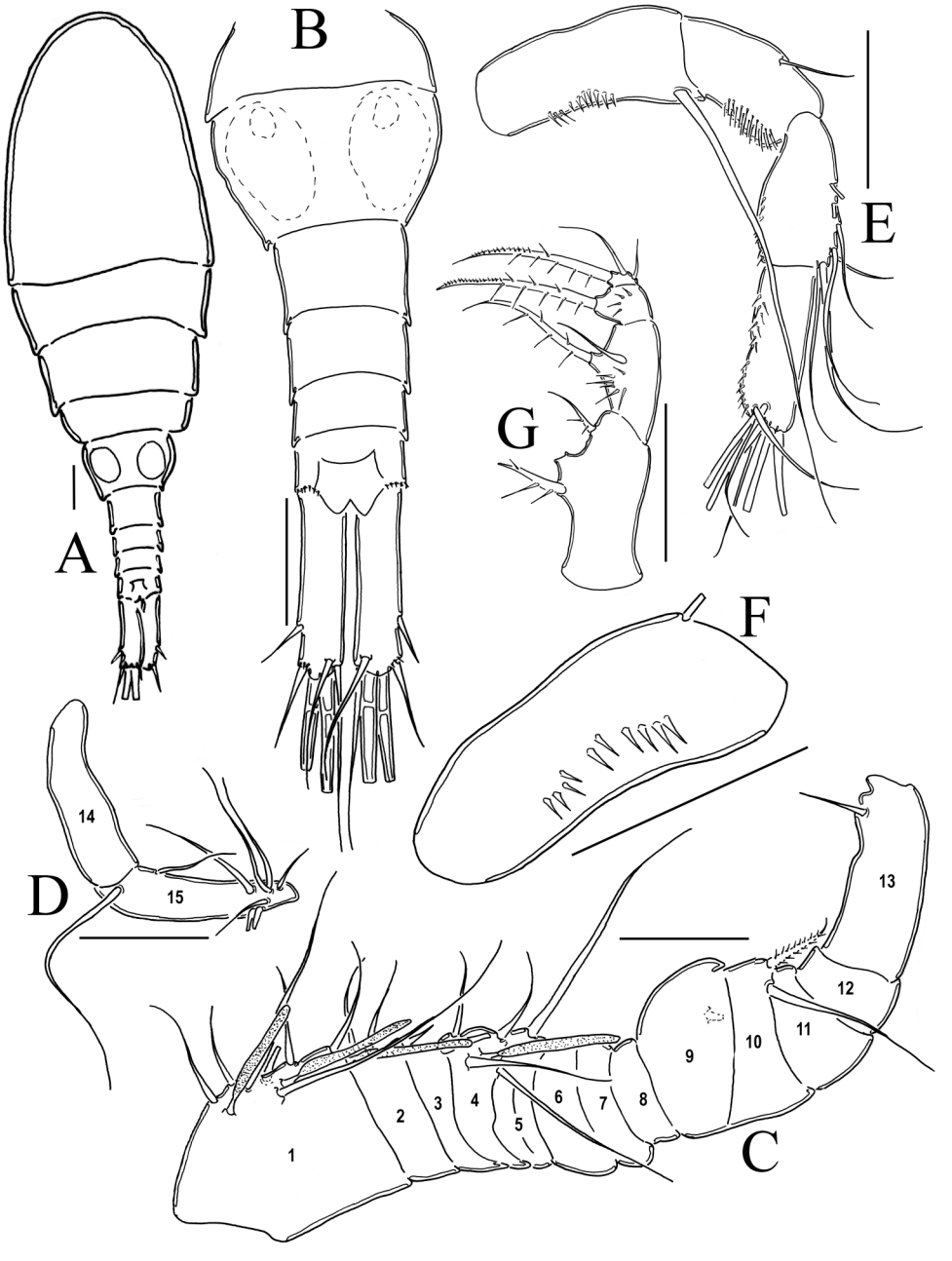

Figure 4. *Acanthocyclops eduardoi* sp. nov. from Mexico, allotype adult male. (A) Habitus, dorsal view; (B) urosome, dorsal view; (C) antennule; (D) antennule, segments 14 and 15; (E) antenna, caudal; (F) antenna basipodite, frontal; (G) maxilliped. Scale bars: A, B, 100 μm; C–G, 50 μm.

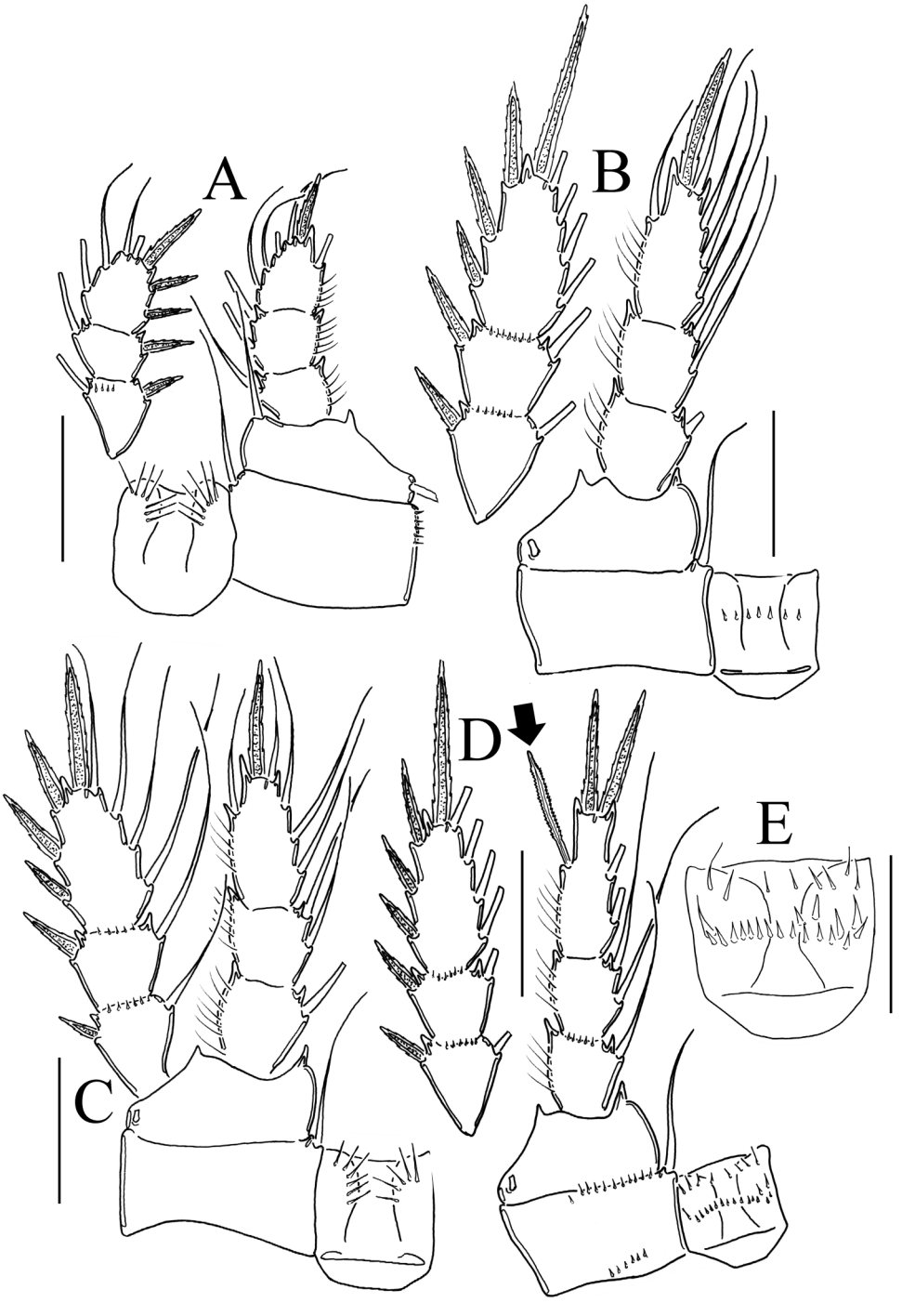

Figure 5. *Acanthocyclops eduardoi* sp. nov. from Mexico, allotype adult male. (A) First leg; (B) second leg; (C) third leg; (D) fourth leg; (E) coxal plate of fourth leg. Scale bars: A–D, 100 μm; E, 50 μm.

Urosome (Figure 4B). Genital somite subrectangular, length/width ratio = 0.625. Genital somite and succeeding three urosomites without ornamentations. Distal dorsal margin of anal somite with rows of five stout spines.

Caudal ramus (Figure 4B). Length/width ratio = 3.93, and not ornamented with spinules as female. Lateral spiniform seta short, 0.31 times as long as caudal ramus, inserted at about three-quarters of the outer margin of ramus. Dorsal seta 0.74 times as long as caudal ramus. Innermost terminal seta slightly longer than caudal ramus (1.04 times) and longer than dorsal seta. Outermost terminal seta about 0.50 times as long as caudal ramus.

Remarks

The characters that allowed us to include *A. eduardoi* sp. nov. in the genus *Acanthocyclops* are: (1) the general body shape with the fifth somite broader than the genital somite and lateral margins triangular; (2) fifth leg represented by two segments, the distal one armed with a small subapical spine reaching the distal end of basal segment; (3) female antennule with 17 segments; (4) endopodal and exopodal rami of legs 1–4 all with three segments (Reid 1985; Einsle 1996; Dussart and Defaye 2001).

The new species was assigned as a member of the *A. vernalis–robustus* complex because of 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. The main character to separate all the species of this complex from the strict *A. robustus* is through differences in the ornamentation of the antennal basipodite, which bears spinules near the insertion of the exopodal seta, a character lacking in the new species and its congeners of the complex. As in *A. marceloi* Mercado-Salas and Suárez-Morales, 2009, *A. caesariatus* Mercado-Salas and Suárez-Morales, 2009, *A. robustus*, *A. trajani*, *A. einslei* and *A. brevispinosus*, *A. eduardoi* sp. nov. has 17 segmented antennules. In all of these species with exception of *A. marceloi* the distal end of the long aesthetasc on segment 12 reaches the distal margin of segment 14 (Mercado-Salas et al. 2009). One of the main differences between *A. trajani* and *A. eduardoi* sp. nov. is the absence of spinules on inner side of the claw-like seta of the basipodite of maxilla. The length/width ratio of the caudal ramus in *A. eduardoi* sp. nov. is 4.3–4.95, this proportion is within the range of variation of *A. robustus* (4–5.8), *A. trajani* (4.15–5.8) and *A. einslei* (4.15–6.40), but differs from *A. brevispinosus* (5.20–6.85), *A. marceloi* (2.8) and *A. caesariatus* (3.79). A distinctive character of *A. eduardoi* sp. nov. is the ornamentation of the ventral and dorsal surface of caudal ramus of the female, it has an extended field of tiny spinules, a similar pattern was previously reported in *A. einslei* and *A. marceloi*, but it differs among these species. In *A. marceloi* the spinules are arranged in symmetrical patches on the ventral surface and irregular ones on the dorsal surface. In the new species spinules are irregularly distributed both dorsally and ventrally, the pattern in *A. einslei* has not been described.

A useful character to separate *A. eduardoi* sp. nov. from its congeners is the length ratio of the dorsal caudal seta/caudal ramus (0.47–0.56), which is similar to *A. brevispinosus* (0.53). A longer seta is present in *A. marceloi* (0.63), *A. trajani* (0.64), *A. einslei* (0.71) and in *A. caesariatus* (0.75). In *A. eduardoi* sp. nov. the innermost terminal caudal seta is slightly shorter than the caudal ramus (0.80–0.97) as in *A. caesariatus* (0.9), *A. robustus* (0.50–0.88) and *A. einslei* (0.90), whereas in *A. brevispinosus*

it is much shorter (0.4–0.5) and slightly longer in *A. marceloi* (1.15) and *A. trajani* (0.84–1.04). Most of the species belonging to the *A. robustus–vernalis* complex, including the new species, have a 3444 spine formula, with the exception of some populations of *A. robustus* (2334 also) (Mirabdullayev and Defaye 2002) and *A. marceloi* (3443) (Mercado-Salas et al. 2009). Another important character to separate *A. eduardoi* sp. nov. from its congeners is the ornamentation of the first leg coupler; in this species it has two groups of spinules, four on each side of the coupler (Figure 2A) as in *A. caesariatus* (Mercado-Salas et al. 2009). In *A. trajani* this structure is armed with two groups of five spinules, in *A. marceloi* with two rows of 8–10 spinules, and in *A. robustus*, *A. brevispinosus* and *A. einslei* this ornamentation is absent. Couplers of second and third legs in *A. eduardoi* sp. nov. are naked as in *A. marceloi*, *A. caesariatus*, *A. einslei* and *A. brevispinosus*; *A. trajani* is the only species with an ornamentation represented by a single row of six spinules at each side of coupler of the second leg. It also has one row with six spinules on each side, close to the anterior margin, and one transversal row of approximately 20 tiny spinules on medial margin of the coupler of the third leg, so diverging from the pattern observed in the new species. In *A. eduardoi* sp. nov., the ornamentation of the fourth leg coupler consists of one transverse row of 11 strong spinules on medial margin as in *A. marceloi*, *A. brevispinosus* and *A. caesariatus* but differs from *A. trajani* with a row of 15 strong spinules, from *A. robustus* with a row of 18 tiny spinules and from *A. einslei*, bearing 11 small spinules. All endopodal and exopodal setae of swimming legs 1–4 in females of *A. eduardoi* sp. nov. are normal as in *A. marceloi* and *A. caesariatus*. In *A. robustus* and *A. trajani* modified setae are present on legs 2–4; also, *A. einslei* and *A. brevispinosus* have modified setae on legs 3 and 4. An additional distinguishing character of *A. eduardoi* sp. nov. is the length/width ratio of third segment of endopodite of fourth leg (3.1–3.8), which is shorter in its congeners; in *A. trajani* it ranges from 2.25 to 3.10 and in the rest of the species it varies between 2.2 and 2.5. The length ratio of inner spine/length of End 3 of fourth leg of *A. eduardoi* sp. nov. (0.68–0.76) is similar to *A. einslei* (0.72–0.77) and differs from *A. trajani*, *A. marceloi* and *A. caesariatus* (0.82–0.88), *A. robustus* and *A. brevispinosus* present a wider range than the rest of species (0.71–0.95). In *A. eduardoi* sp. nov. the insertion point of the outer seta on End 3 of fourth leg is 0.57–0.60, whereas it is 0.56–0.66 in *A. trajani*, 0.60–0.71 in *A. robustus*, in 0.61 in *A. marceloi*, 0.67 in *A. caesariatus* and in *A. einslei* and *A. brevispinosus* the value ranges between 0.75 and 0.82.

The male of *A. eduardoi* sp. nov. shows a unique ornamentation pattern on the coxal plate of the fourth leg, with one transversal row of 13 strong spinules equal in size on medial margin, one group of strong spinules not equal in size at each side above the transversal row and a third row of slender spines of different size close to the anterior margin of coupler (Figure 4E). Finally, the lateral seta of outer margin of End 3 of fourth leg is modified in *A. eduardoi* sp. nov. as in *A. einslei* and *A. brevispinosus* whereas in *A. robustus* and *A. trajani* this seta is normal; males of *A. marceloi* and *A. caesariatus* have not been described.

Discussion

Until recently it was considered that Cyclopoida species tended to be more widespread (cosmopolitan) than Calanoida (Dussart and Defaye 1995). This concept seems to have less validity nowadays when the detailed observations of taxa have revealed

new species that may have restricted distributions that are related to local speciation processes (Fiers et al. 1996; Reid 1998; Mirabdullayev and Defaye 2002, 2004; Suárez-Morales and Reid 2003; Suárez-Morales et al. 2004; Boxshall and Defaye 2008). A clear example is the *A. robustus–vernalis*, complex which after a closer, updated morphological analysis has revealed at least eight distinct species: *A. robustus*, *A. vernalis*, *A. trajani*, *A. brevispinosus*, *A. marceloi*, *A. dodsoni* and *A. caesariatus* (Dahms and Fernando 1997; Mirabdullayev and Defaye 2002, 2004; Dodson et al. 2003; Mercado-Salas et al. 2006, 2009; Mercado-Salas and Suárez-Morales 2011).

Most of the known species of *Acanthocyclops* occur mainly in temperate and subarctic latitudes in Eurasia and North and South America; only *A. smithae* and *A. rebecae* both from the Yucatan Peninsula are considered as Neotropical forms. Recently described species (*A. dodsoni*, *A. marceloi* and *A. caesariatus*) and the species described herein are distributed in the Mexican Plateau biogeographic province (stretching from southern USA to central Mexico), which is considered by some authors as part of the Nearctic biogeographic region (Morrone 2006) and by others as a transition zone between the Nearctic and Neotropical regions (Darlington 1957; Halffter 1962, 1964, 1976, 1987; Arriaga et al. 1999), in which many taxa have radiated. The study of the copepod fauna in this area in Mexico is still limited, but has revealed a mixture of fauna from both regions and fauna that seems to be endemic or have restricted distributions (Silva-Briano and Suárez-Morales 1998; Granados-Ramírez and Suárez-Morales 2003; Mercado-Salas et al. 2006, 2009; Mercado-Salas 2009; Mercado-Salas and Suárez-Morales 2009).

The history of the Mexican Plateau is complex and includes different events at different times that have favoured regional speciation processes. (1) The uplift of the Sierra Madre Occidental and Sierra Madre Oriental during the Eocene and middle Miocene, which stopped the atmospheric flow from the Pacific Ocean and the Gulf of Mexico so causing a major drought and aridity in the area. Many species were segregated along latitudinal and longitudinal gradients, generating radiation of new lineages. (2) The transition from tropical and warm conditions to much colder conditions during Pleistocene glaciation periods allowing the expansion of northern taxa to areas previously occupied by deserts and arid areas where pluvial lakes were formed. Speciation processes were active after the end of the glacial period (Granados-Ramírez and Suárez-Morales 2003). At the beginning of the Holocene, isolation of Nearctic lineages in desert habitats favoured new radiations (Devitt 2006).

Considering its morphological characters, habitats and geographical distribution, the new species seems to be related to the *A. robustus–vernalis* group (Reid et al. 1991; Einsle 1996; Dahms and Fernando 1997; Reid and Suárez-Morales 1999; Mirabdullayev and Defaye 2002; 2004; Iepure and Defaye 2008; Mercado Salas et al. 2009). This is the eighth confirmed record of species of *Acanthocyclops* in Mexico after *A. dodsoni*, *A. vernalis*, *A. robustus*, *A. smithae*, *A. rebecae*, *A. marceloi* and *A. caesariatus* (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, 2009). Dodson and Silva-Briano (1996) reported *A. exilis* from a reservoir in Aguascalientes state, central Mexico, but this record has not been confirmed.

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