

A new species and illustrated records of *Paracyclops* Claus, 1893 (Copepoda: Cyclopoida: Cyclopinae) from Mexico

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A new species of the freshwater cyclopoid genus *Paracyclops* Claus, 1893 collected from the state of Aguascalientes, Mexico is described based on female and male specimens. It has affinities with other forms with profusely ornamented caudal rami, such as *Paracyclops carectum* Reid and *Paracyclops pilosus* Dussart, but it can be distinguished by a combination of characters including details of the ornamentation of the coxa of leg 1, third antennular segment with incomplete suture line, inner margin of the caudal rami with scattered hair-like elements, and relatively long caudal rami, among other characters. The male is distinguished mainly by having the caudal rami completely covered by pilosity, which differs from all other known *Paracyclops*, including *Paracyclops carectum*. The new species has affinities with neotropical *Paracyclops*. Illustrated records and a morphological analysis of two more species of *Paracyclops* from Mexico, *Paracyclops poppei* and *Paracyclops chiltoni*, are also included in this contribution.

Keywords: Cyclopidae; zooplankton; biodiversity; freshwater crustaceans

Introduction

The genus *Paracyclops* belongs to the diverse subfamily Eucyclopinae and comprises 28 nominal species (Karaytug 1999; Dussart and Defaye 2006). The taxonomy of the genus is still problematic because of the lack of complete early descriptions of widely distributed nominal species such as *Paracyclops chiltoni* (Thomson, 1882) and *Paracyclops fimbriatus* (Fischer, 1853) (Karaytug 1999; Karaytug and Boxshall 1998a; Dussart and Defaye 2006).

Species of *Paracyclops* have been recorded from different types of freshwater habitats, including estuaries and semi-terrestrial habitats such as bromeliads (Karaytug and Boxshall 1998b); however, most are benthic forms (Karaytug 1999). The genus is distributed worldwide, including cold temperate latitudes and fully tropical areas, where the genus tends to be most speciose.

Following the comprehensive revision of the genus by Karaytug (1999), the records of *Paracyclops* from the Americas include only 13 species, most of them from South America and only four from North America. Karaytug (1999) concluded that, because of the complexity of the genus, its poorly developed taxonomy, and the need to revise unreliable or doubtful records, it is likely that many species are yet to be described from different geographical regions. Records should be confirmed based

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on the updated taxonomic standards for the genus; this process will strengthen regional and local approaches to reveal biodiversity and biogeography patterns. During a survey of the copepod fauna from aquatic habitats of semi-desert areas in the state of Aguascalientes, north-central Mexico, one male and several female specimens of an undescribed species of *Paracyclops* and females of *Paracyclops poppei* (Rehberg, 1880) were recorded. The new species is described in full and compared with its congeners. An illustrated record of *P. poppei* from the same area is also presented together with a record of *P. chiltoni* from the state of Campeche, in southeast Mexico. Both species are analysed and compared in the light of recent redescriptions and upgraded taxonomic criteria (Karaytug 1999) to provide data about the range of variation of these species.

Material and methods

During the course of a long-term project to determine the diversity of the cyclopoid copepods in the Mexican state of Aguascalientes, zooplankton samples were collected between 1989 and 2003 in more than 500 water bodies covering the whole

state (see Dodson and Silva-Briano 1996). Samples were collected using a standard plankton net hauled near the shoreline of different aquatic habitats including ponds, reservoirs, ephemeral springs and large dams. The biological material was then fixed and preserved in 4% formalin. Copepods were sorted from the entire original biological samples and maintained in 4% formalin with a drop of glycerine. Several male and female specimens of a species of *Paracyclops* were collected during this survey at one of the localities (La Chica Dam); based on a preliminary taxonomic analysis, these copepods were tentatively identified as *Paracyclops pilosus* (Mercado-Salas 2007). A second, closer examination of these specimens was performed later and differences found in respect to *P. pilosus* motivated a deeper analysis. Two females and one male were dissected entirely and mounted in semi-permanent slides in glycerine sealed with Entellan®, a commercial, fast-drying mounting medium and sealant. Scaled drawings were made at 100 $\times$ magnifications with a drawing tube mounted on a standard Olympus CX31 microscope. Additional specimens of Mexican *Paracyclops* were collected from another locality in Aguascalientes and from the Yucatan peninsula. These were also processed for taxonomic examination.

Taxonomy

Order **CYCLOPOIDA** Burmeister, 1835

Family **CYCLOPIDAE** Rafinesque, 1815

Subfamily **EUCYCLOPINAE** Kiefer, 1927

Paracyclops hirsutus sp. nov.

(Figures 1–5)

Material examined

Adult female holotype specimen from La Chica Dam (22°22' N, 102°18' W), state of Aguascalientes, central Mexico, coll. Marcelo Silva-Briano, 21 July 1990. Specimen dissected, slide in collection of Zooplankton at ECOSUR-Chetumal (ECO-CHZ-03989).

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Allotype adult male from La Chica Dam, Aguascalientes, central Mexico, coll. Marcelo Silva-Briano, 21 July 1990, specimen dissected, slide in collection of Zooplankton at ECOSUR-Chetumal (ECO-CHZ-03990). Paratypes: three adult females, same site and date of collection, ethanol-preserved, vial deposited at ECOSUR (ECO-CHZ-03991).

Description – adult female holotype

Body length 0.794 mm from anterior end of cephalothorax to posterior margin of anal somite. Average length of type specimens: 0.810 mm. Habitus compact, with prosome longer than urosome, cephalothorax widely rounded anteriorly, 1.4 times longer than wide.

Antennule (Figure 1A). Eight-segmented, armature per segment as follows (s, seta; ae, aesthetasc): 1(8s), 2(10s), 3(5s), 4(3s), 5(2s+ae), 6(2s), 7(2s+ae), 8(5s+ae). Ventral surface of first antennular segment with row of six to eight spinules on proximal half.

Third segment with incomplete suture line.

Antenna (Figure 1B). Four-segmented, comprising coxobasis and three-segmented endopod. Coxobasis with five groups of spinules on proximal half, with two biserially spinulated basipodal setae and long exopodal seta. First segment of endopod without outer setae, but ornamented with a transversal group of hair-like setules and with one group of hair-like setules on inner surface, close to the insertion. Second segment of endopod with four lateral and four terminal outer setae; inner margin with row of spinules. Third endopodal segment with seven terminal setae, inner margin with row of spinules.

Mandible (Figure 1C). Gnathobase with five strongly chitinized teeth and long dorsal seta armed with inner row of spinules, fifth tooth tricuspidal. Coxa with row of spinules on outer margin between palp and gnathobase. Palp with 2 long biserially setulated setae.

Maxillule (Figure 1D). Precoxa with surface armed with spiniform process on proximal half; distal half with three strong chitinized claws, five spiniform setae and one strong setulated seta on frontal side. Proximal segment of palp with three subequally long apical setae and long, biserially setulated seta on dorsal surface. Distal segment of palp with three apical setae.

Maxilla (Figure 1E). Precoxa with row of strong spinules on dorsal surface; precoxal

endite with two biserially setulated setae, one clearly shorter. Coxa with single stout seta, coxal endite armed with two setae, one strongly spinulated, one naked. Basis with usual claw and strong spine, both elements bearing spinules on outer margin. First endopodal segment armed with two subequal setae; second segment bearing three setae.

Maxilliped (Figure 1F). Four-segmented. Syncoxa with three equally long setulated setae along inner margin with transverse row of spinules near insertion of setae. Basis with two subequal setulated setae and two transverse rows of spinules on outer

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Figure 1. *Paracyclops hirsutus* sp. nov., holotype female from Aguascalientes, Mexico. (A) Antennule; (B) coxobasis of antenna; (C) mandible; (D) maxillule; (E) maxilla; (F) maxilliped.

Scale bars: A, 50 μ m; B–F, 25 μ m.

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margin. Endopod two-segmented, first segment with one stout spine with strong spinules along inner margin. Second endopod armed with three elements, two strong spiniform spinulated setae plus a slender, naked seta.

Swimming legs 1–4 biramous, all endopodal and exopodal rami three-segmented; armature is described in Table 1.

Leg 1 (Figure 2A). Coupler (not illustrated) with two groups of hairs on each side of anterior surface, distal margin with two rounded chitinized projections. Coxa with one group of long spinules close to outer margin, row of 10–12 long spiniform elements perpendicular to medial margin of coxa. Basis with one slender basipodal seta on outer margin, inner margin with one strong, spiniform basipodal seta reaching proximal onethird of third endopodal segment; group of spinules at insertion of seta. Endopod slightly longer than exopod. Three segments of exopod armed with long spines.

Leg 2 (Figure 2B). Coupler with one row of spinules on each side of anterior surface, row of hair-like elements along anterior margin, with two rounded chitinized projections. Coxa with one row of 9–11 spinules on outer margin. Coxal spiniform seta long, strong, spinulated. Basis with one row of hair-like elements on inner margin; outer margin with cluster of spinules close to insertion of basipodal seta. Endopod as long as exopod.

Leg 3 (Figure 2C). Coupler with two rows of spinules on middle anterior surface, one tight row of long spinules and one of short spinules; distal margin with row of hairlike elements. Coxa with two groups of spinules, one row on outer margin and short, diagonal row of long spinules close to proximal outer corner; strong spiniform, spinulated coxal seta. Basis with row of hair-like elements on inner margin; outer margin with basipodal seta, group of four spinules on insertion of basipodal seta. Endopod slightly longer than exopod.

Leg 4 (Figure 3A). Coupler with three rows of small spinules, two on middle anterior surface and one on distal margin. Coxa with row of spinules on outer margin and strong, relatively short coxal spinulated seta on inner margin. Basis with row of four spinules on outer margin close to insertion of basipodal seta. Exopod slightly longer than endopod. Outer and inner terminal endopodal spines serrate. Outer spine reaching about half the length of inner spine. Length ratio of outer/inner terminal spines of Enp 3 = 0.52. Length : width ratio Enp 3 = 1.73.

Leg 5 (Figure 3C). Leg consisting of one free subquadrate segment, bearing one strong inner bilaterally serrate spine, one slender seta and one biserially setulated Table 1. Armature of swimming legs in *Paracyclops hirsutus* sp. nov.

Coxa Basis Exopod Endopod

Leg 1 0-1 1-1 I-1, I-1, III-5 0-1, 0-1, 1-I-4

Leg 2 0-I 1-0 I-1, I-1, III-I-5 0-1, 0-2, 1-I-4

Leg 3 0-I 1-0 I-1, I-1, III-I-5 0-1, 0-2, 1-I-4

Leg 4 0-I 1-0 I-1, I-1, II-I-5 0-1, 0-2, 1-II-2

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Figure 2. *Paracyclops hirsutus* sp. nov., holotype female from Aguascalientes, Mexico. (A) Leg 1; (B) leg 2; (C) leg 3 with separated endopod and exopod. Scale bars A–C, 50 μ m.

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outer seta. Outer seta slightly longer than inner spine. Row of three to four spinules at insertion of inner spine.

Urosome (Figure 3C). Consisting of fifth pediger, genital-double somite plus three

free somites. Posterior margins of genital double somite and succeeding urosomites crenulated both dorsally and ventrally; relative ratio of each urosomite as: 17.7 : 36.7 : 14.4 : 16.7 : 14.5 = 100. Anterior half of genital double-somite not expanded laterally; Figure 3. *Paracyclops hirsutus* sp. nov., holotype female from Aguascalientes, Mexico. (A) Leg 4 with separated exopod; (B) habitus, dorsal view; (C) urosome showing fifth legs, ventral view; (D) caudal rami, dorsal view. Scale bars: A, D, E, 50 μ m; C, 100 μ m;

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somite ornamented on ventral surface with short rows of spiniform cuticular projections on distal half. First and second postgenital somites with two ventral rows of spinules on ventral surface and three on dorsal surface. Anal somite with distal row of strong spinules close to the insertion of caudal rami. Anal operculum with longitudinal row of small spinules on each side.

Caudal rami (Figure 3C,D). Rami representing 34% of urosome length. Length : width ratio = 3.8. Inner margin weakly hairy. Row of transversal spinules near insertion of lateral setae. Cluster of strong spinules at base of lateral spiniform seta and near base of outer terminal seta. Ramus armed with six setae. Lateral seta short, 0.5 times as long as caudal ramus, inserted at about 70% of outer margin of ramus. Dorsal seta short, 0.35 times as long as caudal ramus. Inner terminal seta 0.64 times as long as caudal ramus, longer than dorsal seta.

Description – adult male

Antennule (Figure 4A–C). Geniculate, 11-segmented, armature per segment as follows (s, seta; ae, aesthetasc): 1(12s), 2(2s), 3(5s), 4(5s+ae), 5(0), 6(1s), 7(1s), 8(3s), 9(2s), 10(1s), 11(5s+ae). First segment with one modified seta, dorsal surface of same segment with two rows of spinules.

Antenna. As in female except for relatively longer coxobasis.

Mandible. As in female, except for larger cluster of spinules near palp.

Maxillule. As in female.

Maxilla. As in female.

Maxilliped. As in female except for additional row of spinules on outer surface of syncoxa.

Legs 1–4. Biramous, all endopodal and exopodal rami three-segmented, ramal armature as in female.

Leg 1 (Figure 4D,E). As in female except for looser arrangement of row of spinules on middle surface of coxa.

Leg 2 (Figure 4F,G). As in female except for additional row of spinules along distal margin of coxa.

Leg 3 (Figure 5A). As in female except for longer hair-like elements on distal margin of coupler and distal row of short spinules on coxa.

Leg 4 (Figure 5B). As in female except for weaker ornamentation of coupler.

Leg 5 (Figure 5D). As in female.

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Figure 4. *Paracyclops hirsutus* sp. nov., allotype male from Aguascalientes, Mexico. (A) Antennule, anterior view; (B) same, posterior view; (C) same, distal segments; (D) leg 1 with separated endopod; (E) coupler of leg 1; (F) coupler, coxa and basis of leg 2; (G) exopod of leg 4. Scale bars: A, B, 100 μ m; C–G, 50 μ m.

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Figure 5. *Paracyclops hirsutus* sp. nov., allotype male from Aguascalientes, Mexico. (A) Leg 3 with separated endopod; (B) leg 4 with separated endopod and coupler; (C) urosome, dorsal view; (D) same, ventral view. Scale bars: A, B, 50 μ m; C, D, 100 μ m.

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Leg 6 (Figure 5D). Small, low plate at distal corner of genital somite with one long, strong spine, one short middle seta and one outer seta as long as inner spine. Row of strong spinules at insertion of leg.

Urosome (Figure 5C,D). Genital somite subrectangular, length : width ratio = 0.71. Posterior margins of genital somite and succeeding three urosomites crenulated both dorsally and ventrally. Genital somite ornamented on dorsal surface, with rows of spiniform cuticular projections. Postgenital urosomites with ventral and dorsal rows of spiniform projections. Anal somite with patch of short hair-like elements on ventral and dorsal surfaces; anal operculum with row of small spinules at each side. Row of spinules close to insertion of caudal rami.

Caudal rami (Figure 5C,D). Rami representing 24% the length of urosome. Length : width ratio = 2.3. Inner margin, dorsal and ventral surfaces hirsute. Row of transverse spinules close to insertion of lateral setae. Cluster of strong spinules at base of lateral spiniform seta and near base of outer terminal seta. Lateral terminal spiniform seta short, 0.34 times as long as caudal ramus, inserted at about three-quarters of the outer margin of ramus. Dorsal seta 0.72 times as long as caudal ramus. Inner terminal seta 0.87 times as long as caudal ramus; seta longer than dorsal seta.

Type locality

La Chica Dam (22°22' 19.63' ' N, 102°18' 46.69' ' W), Cosío Municipality, Aguascalientes, central Mexico. This is a small reservoir (surface ca. 26,000 m²) in a high-altitude (2021 m) semi-desert area with scarce vegetation.

Etymology

The specific name is the Latin adjective *hirsutus* meaning hairy; it makes reference to the unique condition of the caudal rami of the male, completely covered with pilosity.

Remarks

These specimens were included in the genus *Paracyclops* for having the diagnostic characters described by Karaytug (1999) including the presence of a fringe of long setules along the posterolateral margin of the fifth pedigerous somite, caudal rami with transverse rows of spinules on the dorsal surface at base of lateral seta, female antennules with eight segments, antennae with exopodal seta, fifth legs with one strong inner spine and two setae, first segment of male antennules with one modified seta. Following the comprehensive key of the known species of *Paracyclops* (Karaytug 1999), both our female and male specimens key down to *Paracyclops carectum* because this shares several characters with the new species. In the female these characters include the presence of eight antennular segments, the structure and armature of legs 1–4 and fifth legs, but mainly by the caudal rami bearing ornamented inner margins.

The female of the new species has an ornamentation pattern of the caudal rami that clearly diverges from that known in *P. carectum* (Reid 1987; Karaytug and Boxshall 1998b); it has sparsely arranged long setules along the inner margin of the caudal rami and the dorsal and ventral surfaces are naked. The ornamentation of

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P. carectum has a denser, uniform pattern on the inner margin of rami and also scattered clusters of short spinules on the dorsal surface (see Karaytug and Boxshall 1998b), which are absent in the new species. The innermost terminal caudal seta is clearly shorter in female *P. carectum* (0.55 times as long as ramus) than in the new species (0.8). The outermost caudal seta is a stout spiniform element armed with an inner row of setules whereas it is a slender, naked seta in the new species. Furthermore, in *P. carectum* this seta is 0.67 times as long as ramus compared with 0.60 in the new species.

Other differences of the females of *P. carectum* with respect to the new species include a more compact body and a shorter cephalothorax, almost equally wide as it is long length : width ratio = 1.1 (see Reid 1987); in the new species the cephalothorax is narrower, 1.7 times longer than wide. Both species have a different ornamentation pattern on the dorsal and ventral surfaces of the genital and postgenital somites; the surface of these somites is naked in *P. carectum* (see Karaytug 1999), whereas it has rows of spinules in the new species. Additional differences in the females of these species include relatively longer caudal rami (length : width ratio = 3.2 in *P. carectum* compared with 4.1 in *P. hirsutus* sp. nov.). The legs 1–4 show some additional differences; based on the illustrations by Reid (1987), the ornamentation of all couplers diverges; patterns are weaker in *P. carectum*. Also, the exopodal spines of legs 2–4 are clearly shorter than in the new species (see Reid 1987, figs 10–12). The length ratio of outer : inner terminal spine of leg 4 endopod is different: 0.37 in *P. carectum* versus 0.52 in the new species. The new species has a weak distal spinulation of the fifth leg, whereas *P. carectum* has strong, wide-based spinules near the insertion of the fifth leg setae.

In the new species the ornamentation of the caudal rami is much stronger in the male than in the female, whereas the pattern is similar in males and females of *P. carectum*. Males of *P. hirsutus* diverge from *P. carectum* by having the inner margin and the dorsal and ventral surfaces covered with short hair-like elements, whereas the male of *P. carectum* has only the inner margin ornamented differently

with relatively strong spinules arranged in clusters, but the dorsal and ventral surfaces are otherwise naked. Further, in the new species the anal somite has an extended hairy field on both the dorsal and ventral surface, whereas, aside from the usual ornamentation, this somite is naked in *P. carectum* (Karaytug and Boxshall 1998b; Karaytug 1999). Another species with ornamented caudal rami is *P. pilosus*; the female of this species has four rows of two to four small spinules on the ventral surface, but the inner margin is naked (Dussart 1984); the male lacks even this weak ornamentation. As described by Reid (1987) and Karaytug (1999), the caudal rami of the male *P. carectum* is shorter than in the female (length : width ratio = 3.2 in the female compared with 2.1 in the male); the same pattern is true in the new species (4.1 in the female, 2.25 in the male). Hence, these proportions are additional differences between these two species.

The sixth leg of the male *P. carectum* is different from that of *P. hirsutus* sp. nov. In the former species the spiniform seta is longer, reaching well beyond the distal margin of the first postgenital somite, whereas it does not reach this margin in the new species (Figure 5D). The spinules at the insertion of the sixth legs are arranged differently and are smaller in the new species (see Reid 1987; Karaytug and Boxshall 1998b; Karaytug 1999). The antennules have the same general segmentation pattern of male *Paracyclops* (see Karaytug and Boxshall 1999).

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Paracyclops hirsutus sp. nov. can be distinguished from the other known neotropical species (*Paracyclops andinus* Kiefer, 1957, *P. pilosus* Dussart, 1984, *P. carectum* Reid, 1987, *P. novenarius* Reid, 1987, *P. hardingi* Karaytug and Boxshall, 1998b, *P. reidae* Karaytug and Boxshall, 1998b, *P. bromeliacola* Karaytug and Boxshall, 1998b, *P. punctatus* Karaytug and Boxshall, 1998b, *P. rochai* Karaytug and Boxshall, 1998b) by the peculiar ornamentation on the caudal rami and the anal somite.

Another relevant distinguishing character is the presence of a mid-distal row of long spinules arranged midway along the coxa of leg 1 both in males and females (Figures 2A, 4E). This character is present only in *P. imminutus* Kiefer, 1929 (Karaytug 1999), but the row is shorter in the new species.

Additional distinguishing characters include the outer seta of the fifth leg; in *P. hirsutus* sp. nov. it is slightly longer than the inner spine, this proportion is shared with *P. hardingi* and *P. carectum* and differs from *P. reidae*, *P. bromeliacola* and *P. punctatus*, in which the length ratio of these elements is close to 1.3; differences are greater in the remaining species: *P. rochai* (1.45), *P. pilosus* (1.7) and *P. novenarius* (2.8). Further differences include the length : width ratio of the caudal ramus of the male; in the new species it is 2.25. This proportion differs from *P. punctatus* (2.7), *P. pilosus*, *P. novenarius* and *P. rochai* (2.5), *P. carectum* and *P. reidae* (both with 2.1), *P. bromeliacola* (2.0) and *P. hardingi* (1.9). In the male of *P. hirsutus* sp. nov. the length ratio of the medialmost terminal caudal setae : caudal ramus is 0.87, similar to this ratio in *P. rochai* (0.84), but different from the ratios in *P. pilosus* (0.66), *P. carectum* (0.63), *P. andinus* (1.26), *P. novenarius* (1.0), *P. hardingi* (1.2), *P. reidae* (1.45), *P. bromeliacola* (1.08) and *P. punctatus* (1.1).

The male of the new species shares with all its neotropical congeners the presence of one modified seta on the first antennular segment of the antennules (Karaytug 1999). But the number of segments of the male antennule in *P. hirsutus* sp. nov. differs from *P. bromeliacola* and *P. hardingui* (both with 14 segments) and *P. novenarius* with 12 segments; only *P. carectum* shares an 11-segmented antennule with the new species. The spine formula in *P. hirsutus* sp. nov. is 3443 as in its neotropical congeners, except *P. novenarius* (3433) (Reid 1987; Karaytug 1999). The length ratio of outer : inner spine of third segment of leg 4 is 0.53 in the new species; which is similar to that of *P. rochai* (0.54) and *P. hardingi* (0.50) and differs from those of *P. reidae* (0.61), *P. andinus* (0.41), *P. pilosus* (0.42), *P. bromeliacola* (0.44), *P. novenarius* (0.40) and *P. carectum* (0.37).

The new species seems to be most closely related to *P. carectum*, but has affinities with the neotropical *P. rochai*, *P. bromeliacola* and *P. punctatus* by the lack of a distal row of spinules from the coxa of legs 2 and 3 and the absence of spinules at the base of the two inner setae on the antennal coxobasis. Furthermore, females of all these species have eight-segmented antennules, whereas the known Nearctic forms have 11 (*P. yeatmani*, *P. affinis*, *P. canadensis*) or 12-segmented (*P. smileyi*) antennules (Karaytug 1999).

Paracyclops chiltoni (Thomson, 1882)

(Figures 6, 7)

Material examined

Two adult female specimens from a water reservoir in the lagoon of Silvituc (18°37' 37.44' ' N, 90°16' 44.12' ' W), state of Campeche, southeast Mexico, coll. Downloaded By: [Suárez-Morales, Eduardo] At: 18:20 25 November 2009

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Martha Gutiérrez-Aguirre, 13 October 1998. One specimen dissected, slide in collection of Zooplankton at ECOSUR-Chetumal (ECO-CHZ-02380). One undissected specimen in vial, ethanol-preserved (ECO-CHZ-02380).

Remarks

The main morphological characters stated as diagnostic by Karaytug (1999) for this presumably cosmopolitan species are present in the Mexican specimens; these include: eight antennular segments (Figure 6A), genital double-somite about as long as broad, a relatively short outer seta of the fifth legs, which is as long as the inner spine or slightly longer, the absence of a cluster of spinules on the insertion of two coxobasal setae of the antennae in the female (which is present in the male), and cuticular depressions on the ventral surface of the caudal rami. The specimens from Campeche, Mexico, show some variation with respect to the description of *P. chiltoni* from New Zealand, the country from where this species was originally described. Our specimens exhibit differences in several characters, including the presence of only two cuticular pits on the ventral surface of the caudal rami (Figure 6G); according to Karaytug and Boxshall (1998b) and Karaytug (1999), this character is weaker or less defined in specimens from outside the Palaearctic region. In the Campeche material, the relative length of the outer seta of the fifth leg is distinctly longer than the inner spine (Figure 7D); according to Karaytug and Boxshall (1998b), this character was found only in some specimens from New Zealand, whereas in most other specimens both elements are equally long. The spinulation of the anal somite was most similar to the specimens from Brazil depicted by Karaytug and Boxshall (1998b), with a denser array of the longitudinal row of spinules on the anal cleft (see Figure 6F), but with a shorter transverse row, covering only half of the insertion margin of the caudal rami. The caudal rami (Figure 6F,G) are relatively shorter in both the Mexican (length : width ratio = 3.1) and the New Zealand (2.9) specimens than in those from Brazil (3.5) (Karaytug 1999). As in the New Zealand specimens, the Campeche females have an innermost terminal caudal seta slightly longer than the posterolateral seta, but in our specimens it is 70% as long as caudal ramus versus 63% in the New Zealand females. In the specimens of *P. chiltoni* examined by Karaytug (1999), the diagonal dorsal row of spinules on the caudal rami continues ventrally and is observable in this position, but in the Mexican specimens, spinules are absent from the ventral surface (Figure 6G). Dorsally, this row is slightly curved anteriorly, as in the specimens from Brazil (see Karaytug and Boxshall 1998b). In leg 1 (Figure 7B) there is some variation in the ornamentation of the coxa and the basipod (i.e. distal row with longer and fewer elements in the Mexican specimens, denser cluster on the outer edge of coxa, row of spinules absent on insertion of exopod), but the main difference is in the heavier and denser spinulation of the outer margins of the endopod and exopod. The same is true for legs 2–4 (Figures 6D,E, 7A,C). The coxal ornamentation of leg 4 is similar to that of the New Zealand specimens, with two rows of small spinules versus strong, longer elements in the Brazilian specimens (see Karaytug 1999). The ornamentation of the antennal coxobasis is almost identical to that depicted by Karaytug and Boxshall (1998b), except for shorter semi-circular row on middle surface of segment, denser field of spinules on proximal outer surface and inner distal row of spinules (Figure 6B,C). Downloaded By: [Suárez-Morales, Eduardo] At: 18:20 25 November 2009

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Overall, the morphological variations observed in the Mexican specimens from Campeche are within the range of variability of this species, as demonstrated by Karaytug and Boxshall (1998b) and Karaytug (1999); hence, they are clearly assignable to this species. This is the first illustrated record and morphological comparison of *P. chiltoni* from Mexico.

Figure 6. *Paracyclops chiltoni*, adult female from Campeche, Mexico. (A) Antennule; (B) antenna; (C) coxobasis of antenna, frontal view; (D) leg 4 with separated endopod and exopod; (E) coupler of leg 4; (F) urosome, dorsal view; (G) same, ventral view showing fifth legs. Scale

bars A, D–G, 50 μ m, B, C, 25 μ m.
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Paracyclops poppei (Rehberg)

(Figures 8, 9)

Material examined

Two adult female specimens from water reservoir in San Miguel de los Sandoval, El Llano, (21°53' 10.66' ' N, 102°06' 26.69' ' W), state of Aguascalientes, central Mexico, Figure 7. *Paracyclops chiltoni*, adult female from Campeche, Mexico. (A) Leg 2 with separated endopod and exopod; (B) leg 1 with separated endopod; (C) leg 3 with separated exopod; (D) fifth leg. Scale bars A–D, 50 μ m.

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altitude 1998 m, coll. Marcelo Silva-Briano, 13 October 1991. One specimen dissected, slide in collection of Zooplankton at ECOSUR-Chetumal (ECO-CHZ-03988). One specimen in vial, ethanol-preserved (ECO-CHZ-03988).

Remarks

The morphology of the specimens examined agrees in most respects with the descriptive study of the species by Karaytug (1999). There are, however, some characters that reflect some of the morphological variability described by Karaytug (1999). In the Mexican specimens examined, the length : width ratio of the caudal rami is 5.0, versus 3.6 in European specimens; Karaytug and Boxshall (1999) recognized that the range of variation of the length of the caudal rami is greater in American specimens (2.1–3.9); however, the proportions of these Mexican specimens allows a considerable expansion of this range. Caudal seta II (*sensu* Karaytug 1999, arrowed in Figure 8D) is also longer than in the European forms (as illustrated by Karaytug 1999). The exopodal spines and the terminal endopodal spine of leg 1 (Figure 9A) are relatively longer in the Mexican females of *P. poppei* than in the depictions by Karaytug and Boxshall (1998b). The ornamentation of the coxa of leg 4 is heavier in the European specimens than in the Mexican ones (Figure 9D). The inner spine of the terminal endopodal segment of leg 4 is relatively longer in the Mexican specimens (1.74 versus 1.30 times as long as segment).

Paracyclops poppei is a very common and widespread species in North America (Karaytug 1999), but in Mexico it has been reported from only two sites in central Mexico (Suárez-Morales and Reid 1998), including Aguascalientes (Dodson and Silva-Briano 1996).

Discussion

This is the third confirmed record of species of *Paracyclops* in Mexico, after *P. poppei* from the same state (Aguascalientes) and the state of Mexico, and *P. chiltoni* from several states in southeast and central Mexico (Quintana Roo, San Luis Potosí, Yucatan, Tabasco) (Dodson and Silva-Briano 1996; Suárez-Morales et al. 1996; Suárez-Morales and Reid 2003; Dussart and Defaye 2006). In Mexico there are records of *P. fimbriatus* from several states (Suárez-Morales and Reid 1998); according to Karaytug (1999), the American records of *P. fimbriatus* should be revised because the distribution of this species is restricted to Asia and Europe. Hence, the records from Mexico should be revised following the upgraded morphological criteria and the redescription of *P. fimbriatus* (Karaytug and Boxshall 1998b); some of these might represent undescribed species.

Most of the known American species of *Paracyclops* occur in tropical latitudes, some in North America and some others, like *P. bromeliacola*, *P. chiltoni* and *P. poppei*, occur in both geographic areas (Dussart and Defaye 2006). *Paracyclops affinis*, *P. canadensis*, *P. yeatmani* and *P. smileyi* have been reported from the Nearctic region only, but it is clear that the genus is most diverse in the Neotropics, with eight known species: *P. andinus*, *P. pilosus*, *P. carectum*, *P. novenarius*, *P. hardingui*, *P. punctatus*, *P. reidae* and *P. rochai* (Karaytug and Boxshall 1998b; Karaytug 1999; Dussart and Defaye 2006). The surveyed area, in northern-central Mexico, lies in a transitional fringe between these two biogeographic regions. Because of its morphological similarity with *P. carectum* and with other neotropical species, *P. hirsutus*

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seems to be more closely related to the neotropical forms than to the Nearctic species. The occurrence of a species with such clearly neotropical links like *P. hirsutus*, together with *P. poppei*, a Nearctic species in central Mexico, results from the effect of this transitional biogeographical region on the composition of the local copepod

fauna. Furthermore, some of the morphological details found in specimens of *P. chiltoni* from Campeche show affinities with Brazilian forms. A mixture of cosmopolitan, Nearctic, neotropical and endemic elements occurring in varying proportions is characteristic of different regions of Mexico (Suárez-Morales et al. 1996; Suárez-Morales and Reid 1998; Mercado-Salas 2007). So far, the new species was recorded from a single locality out of more than 500 sampled in the state of Figure 8. *Paracyclops poppei*, adult female from Aguascalientes, Mexico. (A) Antennule; (B) antenna; (C) urosome, ventral view; (D) same, dorsal view. Scales A–D, 50 μ m.

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Figure 9. *Paracyclops poppei*, adult female from Aguascalientes, Mexico. (A) Leg 1; (B) leg 2 with separated endopod and exopod; (C) leg 3; (D) leg 4 with separated endopod. Scales A–D, 50 μ m.

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Aguascalientes. This presumably restricted distributional range allows us to advance this species as potentially endemic to this area. Other supposedly endemic neotropical species, hitherto recorded from a single locality include: *P. andinus*, *P. rochai*, *P. bromeliacola*, *P. punctatus*, *P. reidae* and *P. novenarius*. The nearctic *P. smileyi* is known also only from the type locality in the United States (Karaytug and Boxshall 1998; Karaytug 1999; Dussart and Defaye 2006).

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