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A new species of *Cletocamptus* Schmankewitsch, 1875 (Crustacea, Copepoda, Harpacticoida) from a high altitude saline lake in Central Mexico

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ABSTRACT

During the analysis of littoral samples collected from a high-altitude saline crater lake in Central Mexico, several female and male specimens of harpacticoid copepods were recovered and taxonomically examined. They were found to represent an undescribed species of the canthocamptid genus Cletocamptus *Schmankewitsch, 1875. The new species,* C. gomezi *n. sp. is described herein based on specimens of both sexes. It resembles* C. stimpsoni *Gómez, Fleeger, Rocha-Olivares and Foltz, 2004 from Louisiana but also* C. trichotus *Kiefer, 1929. The new species differs from* C. stimpsoni *and from other congeners by details of the maxillular armature, the setation of the endopodal segments of legs 2 and 3, and the armature of the third exopodal segment of legs 3 and 4. Also, the dorsal (VII) and the outer (IV) caudal setae are both relatively shorter than in* C. stimpsoni*. This is the second species of the genus known to be distributed in Mexico. The occurrence of the new species in a high-altitude saline lake, the isolation of the type locality, and its absence from adjacent freshwater lakes suggest that this species is endemic to this site.*

Key words: saline lakes, crustacean fauna, copepods, Neotropics, meiobenthos.

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INTRODUCTION

The epicontinental free-living copepod fauna of Mexico, Central America and the insular Caribbean has been surveyed for decades (Reid, 1990; Suárez-Morales *et al.*, 2000), and the group contains many endemic and cryptic forms in peculiar or restricted habitats (Suárez-Morales and Reid, 2003; Montiel-Martínez *et al.*, 2008; Suárez-Morales *et al*., 2010; Mercado-Salas *et al.*, 2009). Among the freshwater copepod taxa of this region, harpacticoids are the least known. Many records of purportedly cosmopolitan species must be revised as they probably represent undescribed species, thus concealing a biodiversity that is yet to be revealed (Reid, 1990; Suárez-Morales and Reid, 1998). Overall, there is a lack of information on these benthic copepods in extensive areas of this region and particularly in most of the largest water bodies in Central and Northern Mexico, where only a few species have been recorded (Suárez-Morales and Reid, 1998; Suárez-Morales *et al.,* 2010; Gutiérrez-Aguirre *et al.,* 2011).

The crater lake of Alchichica is a high altitude aquatic system located in the endorheic eastern basin in the SE sector of the Mexican plateau (Alcocer *et al.*, 2000; Filonov *et al*., 2006). Geologically, this area originated during the quaternary, *ca.* 1MYA (Gasca, 1981). This peculiar and largely isolated system hosts several endemic species including the atherinid fish *Poblana alchichica* (Good, 1945), the ambystomatid amphibian *Ambystoma taylori* (Brandon *et al*., 1982), the corixid insect *Krizousacorixa tolteca* (Jansson, 1979), the isopod crustacean *Caecidotea williamsi* (Escobar-Briones and Alcocer, 2002), the diatom *Cyclotella alchichicana* (Oliva *et al*., 2006), the diaptomid copepod *Leptodiaptomus garciai* Osorio-Tafall, 1941 (Montiel-Martínez *et al*., 2008), and an undescribed rotifer of the *Brachionus plicatilis* group (*Brachionus* Mexico) that is known only from this and other two nearby lakes (Alcántara-Rodríguez *et al*., 2012).

The knowledge of the copepod fauna in Alchichica is largely limited to calanoid species dwelling in the water column (Montiel-Martínez *et al*., 2008); the cyclopoid copepod fauna is being examined. During a survey of the local meiofauna, harpacticoid copepods were briefly treated by Hernández (2001), who reported the occurrence of a species of *Bryocamptus* Chappuis, 1928 without further comments. Recent sampling of littoral habitats of Alchichica yielded several specimens of an harpacticoid copepod that belongs to a previously undescribed species of the canthocamptid genus *Cletocamptus* Schmankewitsch, 1875. In this work the new species is described based on female and male specimens and comments on the relevance of this finding and the distribution of the genus in Mexico are given.

Study area

Lake Alchichica is a saline, high altitude (2345 m asl) crater lake located at 19° 24’ N, 97° 24’ W in the central Mexico plateau (Fig. 1). The climate of the region is semi-arid with an average temperature of 12.9°C, and low values of precipitation (Adame *et al*., 2008; Alcocer *et al*., 2000). It is a perennial system with oligotrophic and saline conditions [total dissolved solids (TDS)=8.3-9.0 g L^{-1}; pH 8.7-9.2; specific conductivity at 25°C, K_{25}=12676-13727 µS cm^{-1}]. It has a maximum depth of 62 m and a mean depth of 40.9 m (Ortega-Mayagoitia *et al*., 2011), almost cylindrical in shape with steep cliff-like slopes, and surrounded by an asymmetric ring of stromatolites which allows a reduced littoral zone only (Alcocer *et al.*, 1998). This lake is warm monomictic, mixing during the cold-dry season (usually from December to March), it remains stratified the rest of the year, thus generating a permanent anoxic hypolimnion for several months (Bautista-Reyes and Macek, 2012).

METHODS

A biological survey of the littoral habitats of lake Alchichica was performed in September 2010. Qualitative samples were taken with a plankton net (50 µm mesh size) from the pools between the shore and the emerged microbialites surrounding the lake (Couradeau *et al*., 2011), a habitat characterised for being shallow and having submerged seagrass beds of *Ruppia maritima* (Ramírez-García and Vázquez-Gutiérrez, 1989) and *Chara* sp. Fractions of the sample were fixed either with

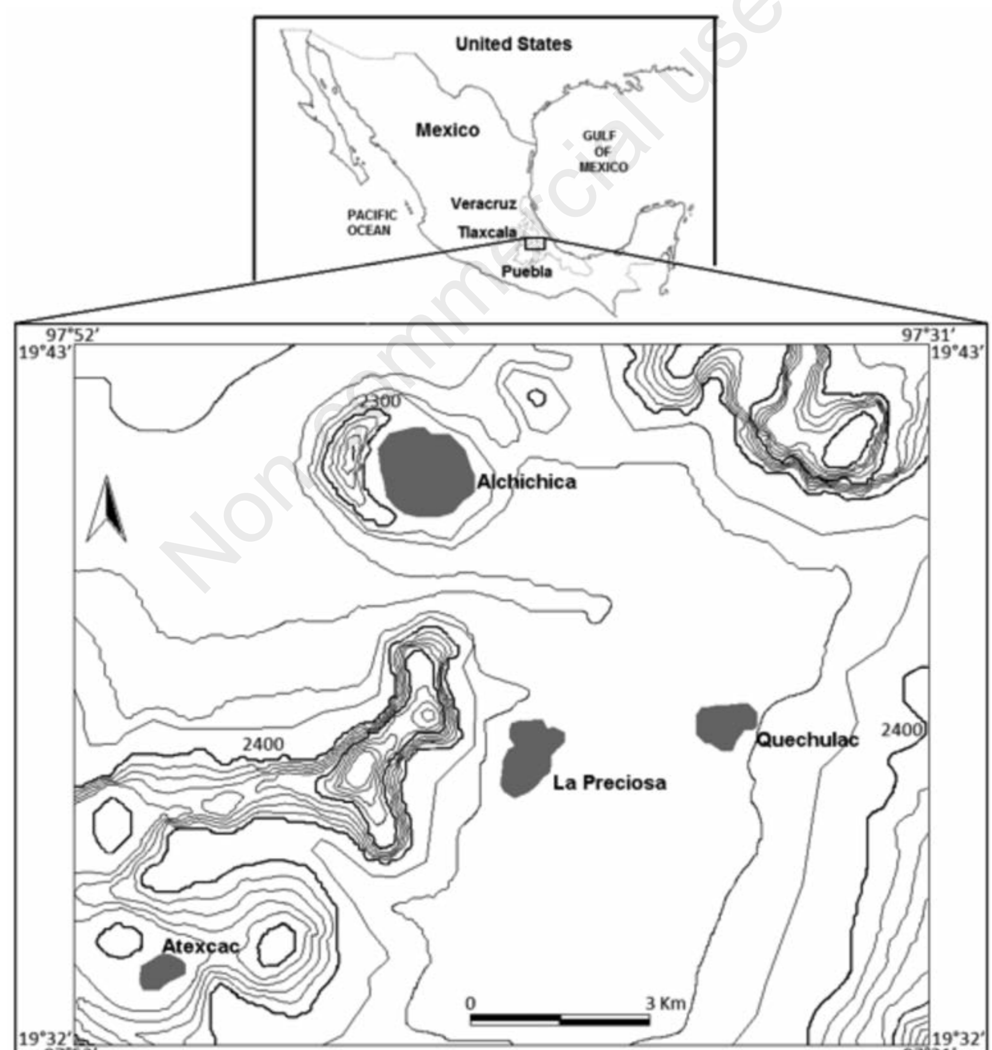

Fig. 1. Location of the high-altitude lake Alchichica in Puebla, Central Mexico, the type locality of *Cletocamptus gomezi* n. sp.

a 4% formaldehyde solution or with 100% ethanol. Copepods were sorted from the original samples and transferred to 70% ethanol for long-term preservation. Specimens were then placed in glycerol for taxonomical examination and dissection. The dissected appendages were mounted on slides using glycerol as mounting medium and sealed with nail varnish or with Entellan®. Figures were drawn with the aid of a drawing tube. Observations on dissected specimens were made with an Olympus BX51 with Nomarski DIC microscope (Olympus America Inc., Center Valley, PA, USA). Morphological terminology followed Huys and Boxshall (1991). Some specimens were prepared for scanning electron microscope (SEM) examination which was performed with a JEOL LV-5900 microscope (JEOL Ltd., Tokyo, Japan) at facilities of the University of Aguascalientes, Mexico. This process included dehydration of specimens in progressively higher ethanol solutions (60, 70, 80, 96, and 100%), critical-point drying, and gold-coating following standard methods. Morphological terminology followed Huys and Boxshall (1991). Type specimens were deposited in the Collection of Zooplankton at *El Colegio de la Frontera Sur*, Chetumal, Mexico (ECO-CHZ) and in the National Museum of Natural History, Smithsonian Institution, Washington, USA. Original samples are deposited in the Laboratory of Tropical Limnology, *Facultad de Estudios Superiores Iztacala*, *Universidad Nacional Autónoma de México*, Mexico.

RESULTS

Systematics

The new species (Figs. 2-8) is classified as follows:
Order Harpacticoida Sars, 1903
Family Canthocamptidae Brady, 1880 (*incertae sedis*) *sensu* Por, 1986
Genus *Cletocamptus* Schmankewitsch, 1875
Cletocamptus gomezi n. sp.

Type of material: adult female holotype (ECO-CHZ-08963) partially dissected; adult male allotype (ECO-CHZ-08964) partially dissected, four adult female paratypes preserved in ethanol (ECO-CHZ-08966), one undissected adult female and one undissected male (USNM-1201777), two undissected females mounted on semi-permanent slides (USNM-1201778, USNM-1201779), and three undissected female paratypes on slides (ECO-CHZ-08965). Littoral samples collected 3 September 2010 by Omar A. Barrera.

Type locality: lake Alchichica (19° 24' N, 97° 24' W; 2,345 m asl), Puebla, Central Mexico.

Etymology: the species is named *Cletocamptus gomezi* n. sp. after Dr. Samuel Gómez (*Instituto de Ciencias del Mar y Limnología*, *Universidad Nacional Autónoma de México*, Mexico) for his efforts and relevant contributions to the taxonomic knowledge of this complex genus of harpacticoid copepods.

Description

Female (holotype)

Body (Fig. 2A) almost cylindrical, cephalosome wide, tapering posteriorly; length 0.47 mm measured from tip of rostrum to posterior margin of anal somite. Length range of females from 0.39 to 0.55 mm, average length 0.44 mm, *n*=22. Rostrum confluent with cephalosome, widest at base. Rostrum with lateral margins smooth, tapering distally; rostral tip bent downwards, not prominent, with two lateral sensilla, with over 25 short spinules arranged in single curved row (Fig. 6B).

Cephalosome with small, sparsely distributed spinules dorsally and with denser pattern laterally (Figs. 2A, 8A, and 8B); posterior margin with row of spinules. Succeeding three prosomites, bearing legs 2-4, with field of short hair-like spinules and with similar row of spinules on distal margin, the third with short additional row. First urosomite bearing leg 5 with two short rows of spinules on distal margin. Anterior half of genital double somite with two rows additional to one along posterior margin; posterior half of genital somite with two short rows of spinules on medial surface plus distal row on posterior margin. Free urosomites with straight lateral margins, urosome cylindrical. Genital double somite with distinct mediodorsal transversal suture. Succeeding three free urosomites with row of spinules ventrally and laterally, first free urosomite also with sparse spinular patches dorsally. Anal somite with parallel lateral margins, smooth dorsally; anal area moderately deep, with two parallel rows of short setules along margin of rounded anal operculum. Distal margin of anal somite with row of 8-10 spines dorsally close to insertion site of caudal rami (Figs. 2E and 2F). Caudal rami subrectangular, twice longer than wide, measuring between 0.030 and 0.035 mm (average=0.033 mm, *n*=9). Ramus tapering slightly towards the posterior margin and about 1.55 times as long as wide, with two diagonal rows of spinules dorsally. Caudal rami with 6 setae. Middle caudal apical seta (V) longest, between 70 and 85% of total body length (0.26-0.39 mm), partially fused with outer seta (IV). Outer terminal seta (III) as long as caudal ramus. Outer lateral setae (I, II) inserted on proximal third of ramus, anteriormost (I) being less than half the length of the other (II). Dorsal seta (VII) as long as ramus.

Antennule (Figs. 3A, 7B) six-segmented; first segment about as long as second, ornamented with one medial and one distal rows of spinules (Figs. 6D and 6E). Armature of antennulary segments (s, setae; ae, aesthetasc) as: 1(1), 2(8s), 3(5), 4(1s+), (1s+1ae), 5(1s), 6(10s+1ae). Aesthetasc on fourth segment relatively short, barely reaching distal half of outer margin of last antennular segment, and fused to a seta.

Antenna (Fig. 3B). Coxa ornamented with patch and rows of spinules. Allobasis about two times as long as coxa, with single abexopodal seta. Exopod one-segmented, somewhat elongated, bearing three subequal setae, lateral outer margin with row of short setules. Free endopodal segment with two lateral strong spines and six distal elements, segment ornamented with proximal and medial spinular rows (Fig. 6C). Variant pattern on one side of some specimens, with both rows on distal half of segment (Fig. 7C).

Mandible (Fig. 3D) elongate, robust, tapering distally. Gnathobasis with 6 monocuspidate teeth. Palp present, cylindrical, about twice as long as wide, one-segmented, armed with two slender apical setae, with patch of spinules on gnathobasis near articulation with palp.

Maxillule (Figs. 3E, 7D). Praecoxa with proximal row of spinules; praecoxal arthrite with two proximal rows of 3-4 spinules, with four distally bifurcate strong spiniform elements, plus one serrate terminal spine and one short,

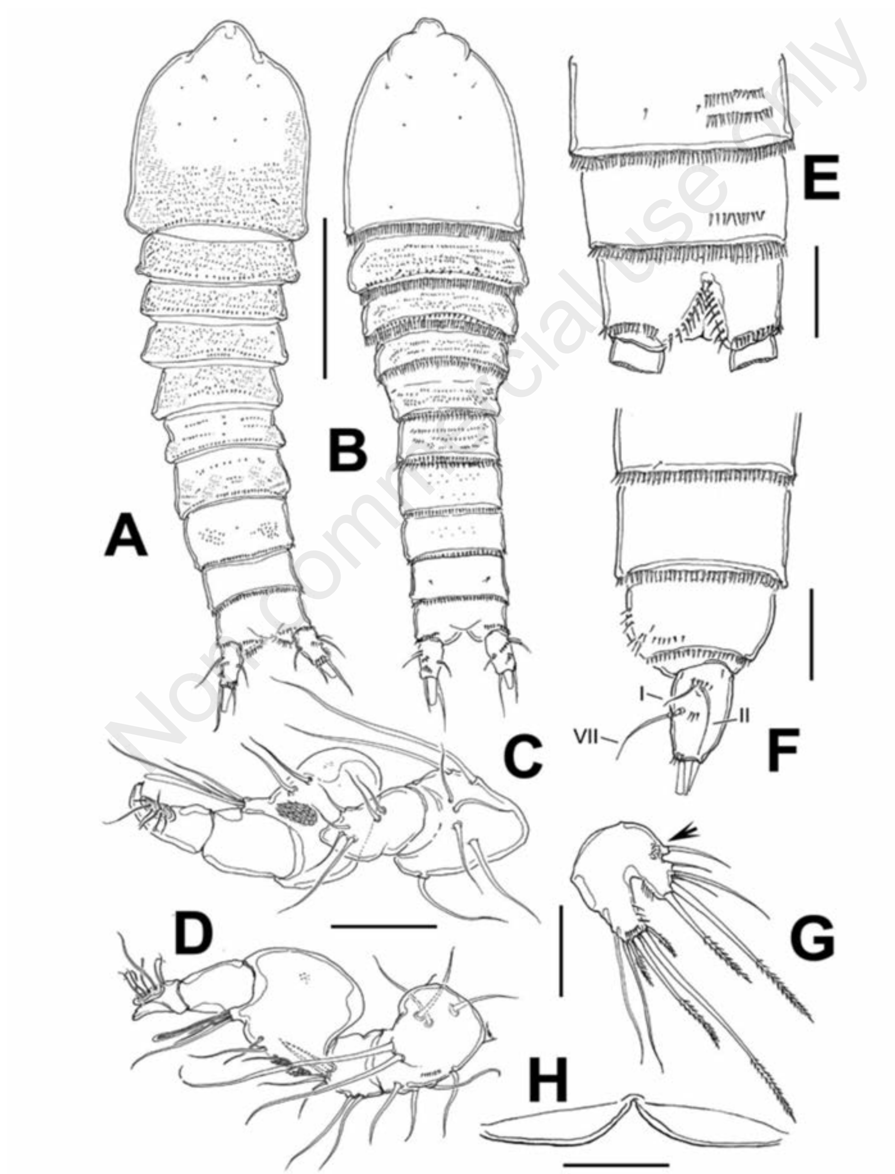

Fig. 2. *Cletocamptus gomezi* n. sp., from lake Alchichica, Central Mexico. A, adult female, habitus, dorsal view; B, adult male, habitus, dorsal view; C, male antennule, caudal view; D, male antennule, frontal view; E, female anal somite, ventral view; F, female anal somite, lateral view; G, female fifth leg, ventral; H, male sixth leg plate, ventral. Scale bars: A, B=100 μm; C-G=20 μm; H=10 μm.

robust spine-like lateral seta ornamented with long naked setules (two arrows in Fig. 3E). Coxa cylindrical, with two terminal setae (each marked with a dot in Fig. 3E). Basis with or without surface setules, with three apical, distally branched setae (single arrow in Fig. 3E). Exopod and endopod represented by three setae each.

Maxilla (Figs. 3F, 6F, 7E). Syncoxa ornamented with outer row of spinules and with inner setulose patch; with two endites, each armed with three setae, one of them stronger and shorter, another one bifid at its tip. Allobasis smooth, drawn into distal strong claw bearing slender basal seta and three adjacent endopodal setae.

Maxilliped (Fig. 3G) slender, subchelate. Syncoxa with curved row of small spinules along medial outer margin and armed with one long seta on distal third of segment. Basis slightly longer than syncoxa, with two longitudinal and one transverse spinular rows, as depicted. Endopodal claw slender, slightly curved, about 1.3 times as long as basis, with one accompanying seta.

Leg 1 (Fig. 4A). Coxa with row of small spinules on anterior and posterior outer margins, plus additional spinular row on middle of segment. Basis with inner spine reaching half-length of first endopodal segment and with outer seta ornamented with spinules at its base; with spinules between insertion site of endopod and exopod, and in the middle of the segment. Exopod three-segmented, slightly shorter than the two-segmented endopod.

Leg 2 (Fig. 4B). Coxa as in P1, except for lack of spinules near proximal outer margin. Basis with short outer seta. Endopod two-segmented, 2.3 times shorter than exopod, endopod not reaching distal margin of second exopodal segment, with four elements on distal segment, three of them

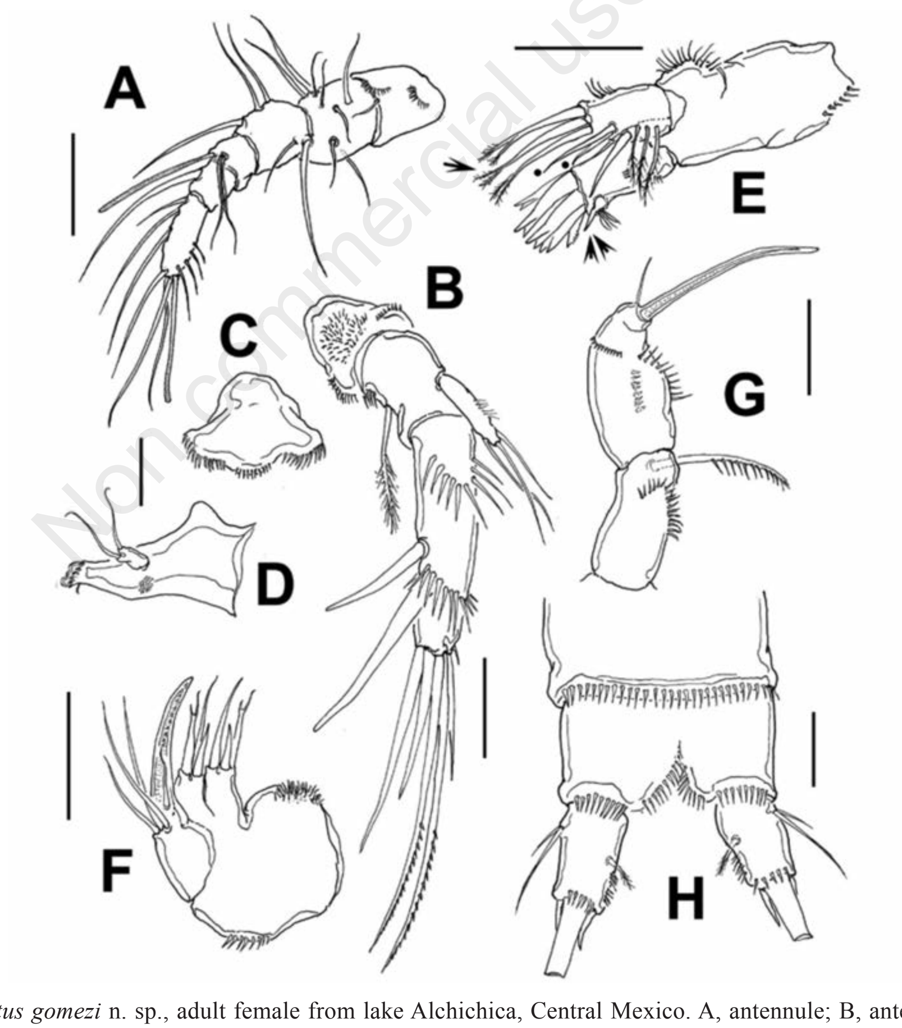

Fig. 3. *Cletocamptus gomezi* n. sp., adult female from lake Alchichica, Central Mexico. A, antennule; B, antenna; C, labrum; D, mandible; E, maxillule with lateral precoxal seta (two arrows), branched basipodal setae (single arrow), and two coxal setae (dots); F, maxilla; G, maxilliped; H, anal somite and caudal rami, dorsal view, another specimen. Scale bars: A,B, E-H=20 µm; C,D=10 µm.

short, less than half the length of the segment. All three short setal elements on subdistal position, two on outer margin, one on inner margin of segment. Exopod three-segmented, with spinules on outer and distal margins of all segments.

Leg 3 (Fig. 4C). Coxa and basis as in leg 2 except for longer outer seta of basis. Endopod two-segmented, 2.3 times shorter than exopod, barely reaching beyond distal margin of first exopodal segment. Second endopodal segment longest of ramus, representing 70% of endopod, with five setal elements, four of them short, inner margin with long spinules. All four short setal elements on subdistal position, three on outer margin, one on inner margin of segment. Exopod three-segmented, with one inner seta on third exopodal segment.

Leg 4 (Fig. 4D). Coxa and basis as in leg 3. Exopod three-segmented, third segment with 4 setal elements and inner margin without setae. Endopod two-segmented, much shorter than exopod, barely reaching middle of first exopodal segment. Second endopodal segment with two apical setae, inner apical one about half the length of the other.

Armature of swimming legs is presented in Tab. 1.

Leg 5 (Fig. 2G) exopod and baseoendopod fused. Baseoendopodal lobe longer than exopodal lobe, with four apical and two inner setae; relative length of setae as shown. Exopodal lobe with five setae plus outer seta of basis; basal seta with patch of spinules at insertion site (arrowed in Fig. 1G).

Leg 6 (Fig. 4E) represented by short, ventral expansion and short rounded segment armed with short, pinnate seta.

Male

General body shape (Fig. 2B) as in female except for separate urosomites. Cephalosome as in female but with

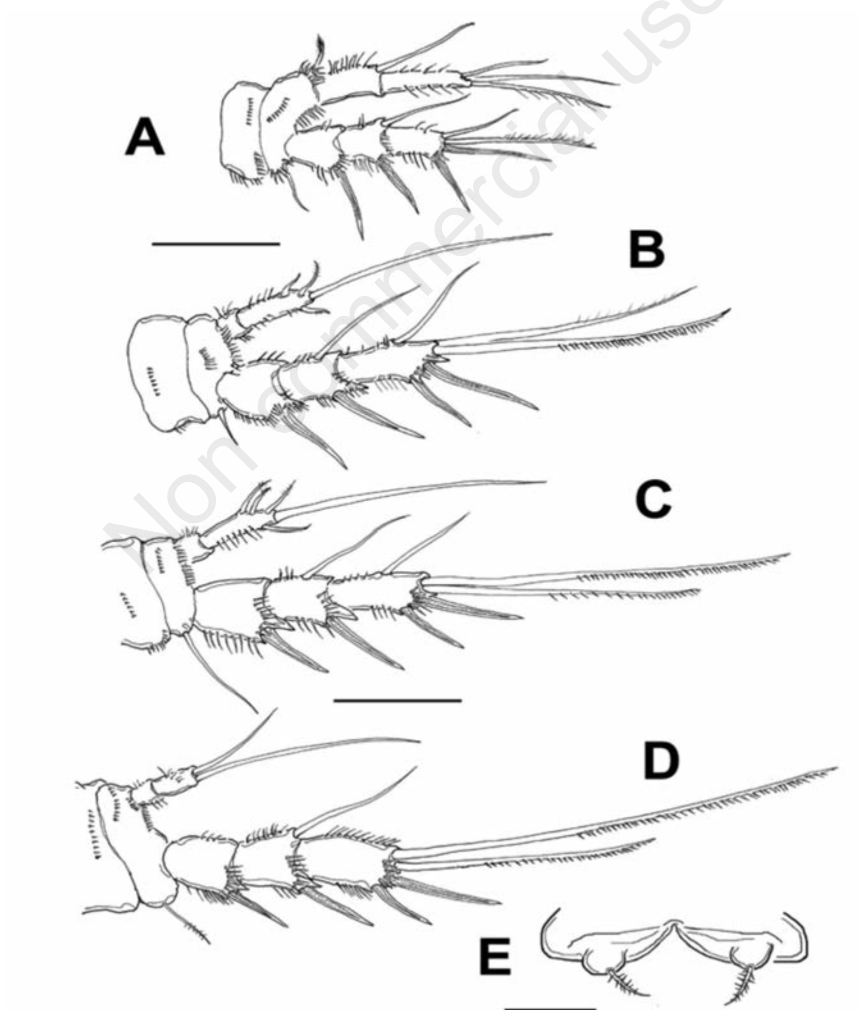

Fig. 4. *Cletocamptus gomezi* n. sp., adult female from lake Alchichica, Central Mexico. A, first leg; B, second leg; C, third leg; D, fourth leg; E, sixth leg. Scale bars: A-D=50 μm; E=20 μm.

denser ornamentation on dorsal surface including long spinules along posterior margins and additional rows and clusters of minute spinules in all prosomites (Fig. 2B). Urosomites with spinulation pattern as in female, but anal somite with fewer spinules dorsally (Fig. 2B); anal operculum with comparatively smaller spinules along posterior margin. Caudal rami as in female.

Antennule (Figs. 2C and 2D) geniculate, six-segmented, subchirocer. Fourth segment with aesthetasc and patch of low, wide-based spinules. Last segment curved, with two distal rounded processes. Antenna, mandible, maxillule, maxilla and maxilliped (not shown) as in female.

Leg 1 (Fig. 5A) as in female, except for acute inner process of basis and stout outer basipodal seta.

Tab. 1. Armature of the swimming legs.

	Basis*	Endopod*	Exopod*
Leg 1	1-I	0-1;0,2,I	I-0;I-1; I,I,2
Leg 2	1-0	0-0;1,1,2	I-0;I-1;II,2,1
Leg 3	1-0	0-0;1,1,3	I-0;I-1;II,2,1
Leg 4	1-0	0-0;0,2,0	I-0; I-1; II,2,0

**Spines are expressed in Roman numerals, setae in Arabic numerals.*

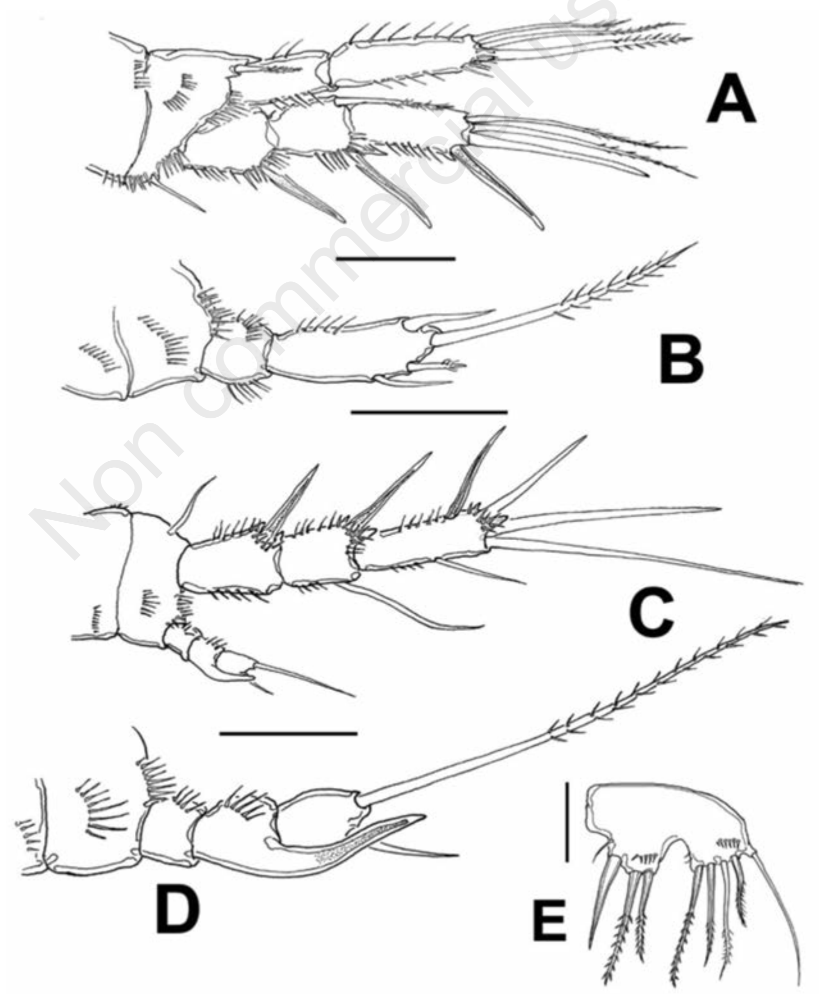

Fig. 5. *Cletocamptus gomezi* n. sp., adult male from lake Alchichica, Central Mexico. A, first leg; B, endopodal ramus of second leg; C, third leg; D, modified endopodal ramus of third leg, enlarged; E, Leg 5. Scale bars: A=25 µm; B, C=50 µm; D=20 µm.

Leg 2 (Fig. 5B) as in female except for dimorphic, shorter and stouter apical seta and relatively shorter inner spines on second endopodal segment.

Leg 3 (Figs. 5C and 5D). Exopod as in female except for shorter apical setae and shorter basipodal seta. Endopod three-segmented, first segment with outer row of spinules; second segment with spinules and with inner apophysis barely reaching beyond distal end of third endopodal segment, the latter with short and naked subdistal inner seta and long pinnate distal seta.

Leg 4 as in female.

Leg 5 (Fig. 5E) with exopodal and baseoendopodal lobes fused. Outer seta of basis long, naked. Endopodal expansion of baseoendopod wide, armed with two distal, one subdistal and one lateral seta, and ornamented with row of 4-6 spinules at insertion of distal setae. Exopodal lobe with four setal elements. Leg 6 (Fig. 2H) represented by low curved plate, unarmed.

Remarks

The number of species assigned to the genus *Cletocamptus* has been variable in the literature because of successive modifications of the morphologic definition of this taxon: Lang (1948) included only a few species, Fleeger (1980) listed 12 species, Bodin (1997) 5 and Wells (2007) increased the number to 23. This variability

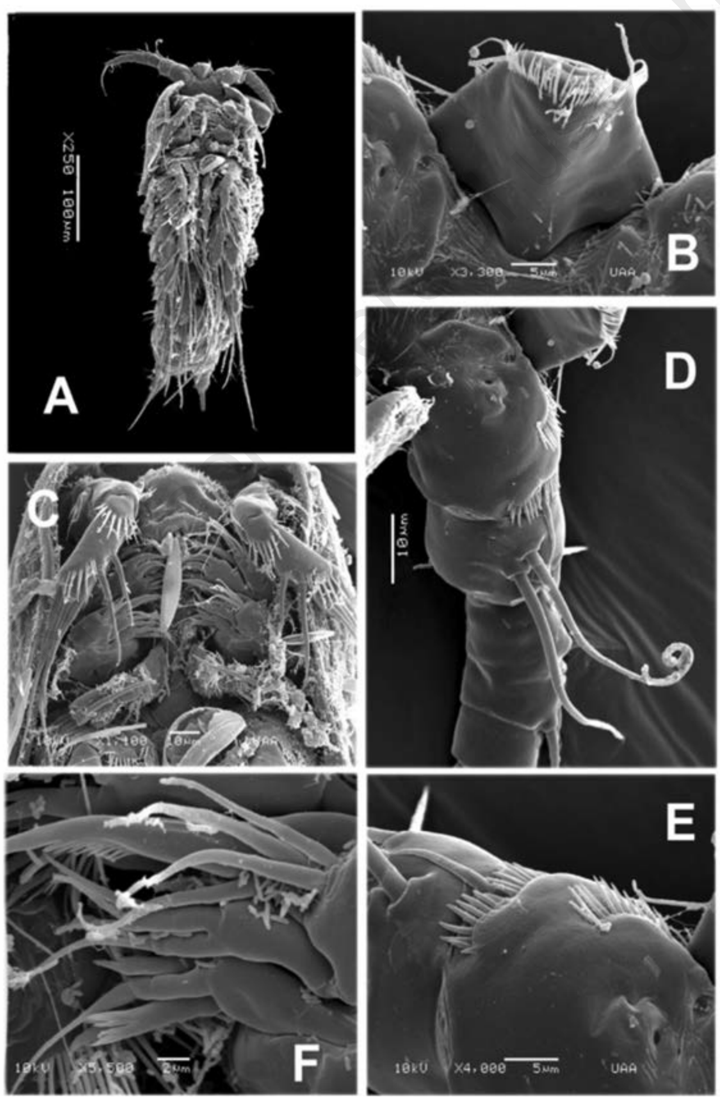

Fig. 6. *Cletocamptus gomezi* n. sp., adult female from lake Alchichica, central Mexico; SEM-prepared specimen. A, female body, ventral view; B, rostrum, ventral view; C, mouthparts, ventral view; D, anterodistal margin of first antennular segments; E, anterodistal margin of first antennular segments showing detail of rows of spinules; F, medial part of maxilla, caudal surface.

reflects the inconsistent taxonomical situation and definition of the genus (Mielke, 2000). Recent revisionary works by Mielke (2000), Gómez *et al.* (2004), and Gómez (2005), proved that the genus is more diverse than previously known, containing several cryptic species historically assigned to supposedly cosmopolitan species like *C. deitersi* (Richard, 1897). Gómez *et al.* (2007) and Gómez and Gee (2009) concluded that there are currently 23 valid species in *Cletocamptus*.

Overall, the lack of information on key characters for many species and the morphological variability of some of them have generated hesitation among taxonomists, particularly in classifying closely related forms (Gómez and Gee, 2009). According to Gómez *et al.* (2004), there are several examples of erroneous records attributed to *C. deitersi*. They argue that this nominal species contains morphologically indistinguishable sibling species. This species, originally described from the Naposta Grande river, Argentina, is currently considered as a *species inquirenda* (Gómez *et al*., 2004) as well as records attributed to *C. deitersi* by some other authors. Other American species recently differentiated from this nominal species are: *C. fourchensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, *C. stimpsoni* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, *C. deboradexterae* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, and *C. sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004 (Gómez *et al*., 2004).

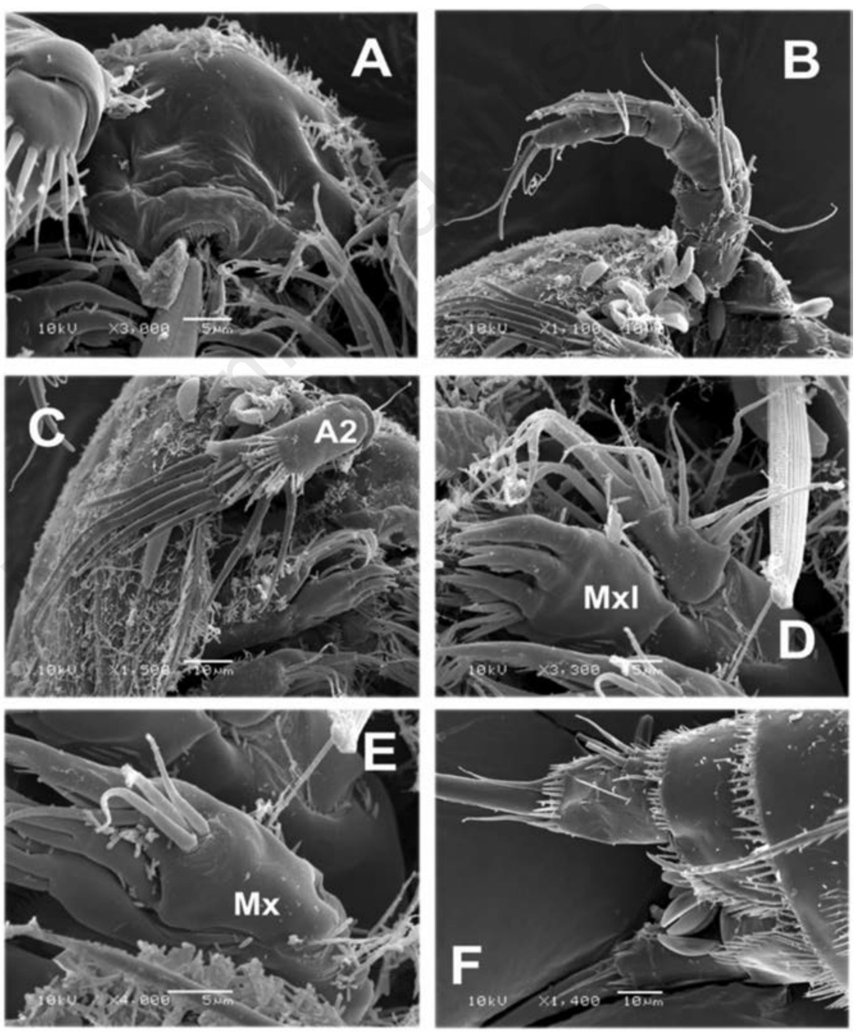

Fig. 7. *Cletocamptus gomezi* n. sp., adult female from lake Alchichica, Central Mexico, another scanning electron microscope-prepared specimen. A, oral field and labrum, ventral view; B, antennule; C, antenna (A2) showing variant spinulation pattern, ventral view; D, maxillule, caudal view (Mxl); E, maxilla (Mx); F, anal somite, ventral, semi-lateral view.

Following Gómez and Gee's (2009) key for the identification of the known species of *Cletocamptus*, our specimens from Alchichica key down to *C. stimpsoni* by their sharing the following characters as indicated in the key sequence: one-segmented mandibular palp, second endopodal segment of female leg 3 with five setae, caudal rami about 1.5 times as long as wide, and reduced ornamentation of female prosomites. Hence, the new species *C. gomezi* n. sp. resembles *C. stimpsoni* but also *C. trichotus* Kiefer, 1929 from South Africa and *C.* cf. *deitersi* from Patagonia as illustrated by Daday (1902). The new species differs from *C. stimpsoni* in several characters; the second endopodal segment of the female leg 2 bears three setal elements in *C. stimpsoni* (Fig. 18B in Gómez *et al*., 2004) *vs* four in the new species. Also, the female leg 4 exopod has five elements including two spines and three setae in *C. stimpsoni vs* four setal elements (two spines and two setae) in the new species. In addition, the third exopodal segment of male and female leg 3 bears five setal elements in the new species *vs* six such elements in *C. stimpsoni*, which has an additional seta on the inner margin (Figs. 19A and 23A in Gómez *et al*., 2004). In *C. stimpsoni* there are five setal elements on the third exopodal segment of the female and male leg 4 (three setae, two spines) (Figs. 19B and 23B in Gómez *et al*., 2004), whereas the new species count four elements (two setae, two spines). Other differences can be found in the relative length of the dorsal (VII) and two outer caudal setae (I, II): these are shorter in the new species. The former is about 0.9 times as long as the ramus and the second about 1.2 *vs* values of 1.5 and 1.3 (at least) in *C. stimpsoni*, respectively (Fig. 15 in Gómez *et al*., 2004). With an average size of 0.44 mm, the new species appears to be smaller than *C. stimpsoni*, whose average size range is 0.55 mm. These differential characters are not within the variability range of *C. stimpsoni* (Gómez *et al*., 2004). Also, the new species has some unique features in the maxillular armature, with distally bifid praecoxal spines and branched basipodal distal setae. Also, the basally robust lateral coxal seta (two arrows in Fig. 3E) of the new species differs from that of *C. stimpsoni*; it resembles more that of *C. deborahdexterae*, although it is relatively smaller and stouter, not distally slender or curved as in *C. deborahdexterae* (Fig. 5E in Gómez *et al*., 2004).

The new species differs from *C. trichotus* in having a lighter cuticular ornamentation on the dorsal surface of the urosomites, the armature (four setae) of the distal segment of leg 2 endopod, with three short and one long setal elements *vs* two short and two longer elements in *C. trichotus*. The armature of the same segment of leg 3 shows additional differences: four short and one long setal elements are present in the new species *vs* three short and two long in *C. trichotus* (Kiefer, 1929; Lang, 1948). Also the process of the second endopodal segment of the male leg 3 is relatively shorter in the new species, surpassing the distal segment by half the length of segment whereas in *C. trichotus* the process is twice this length. The armature of the male leg 2 second endopodal segment, with

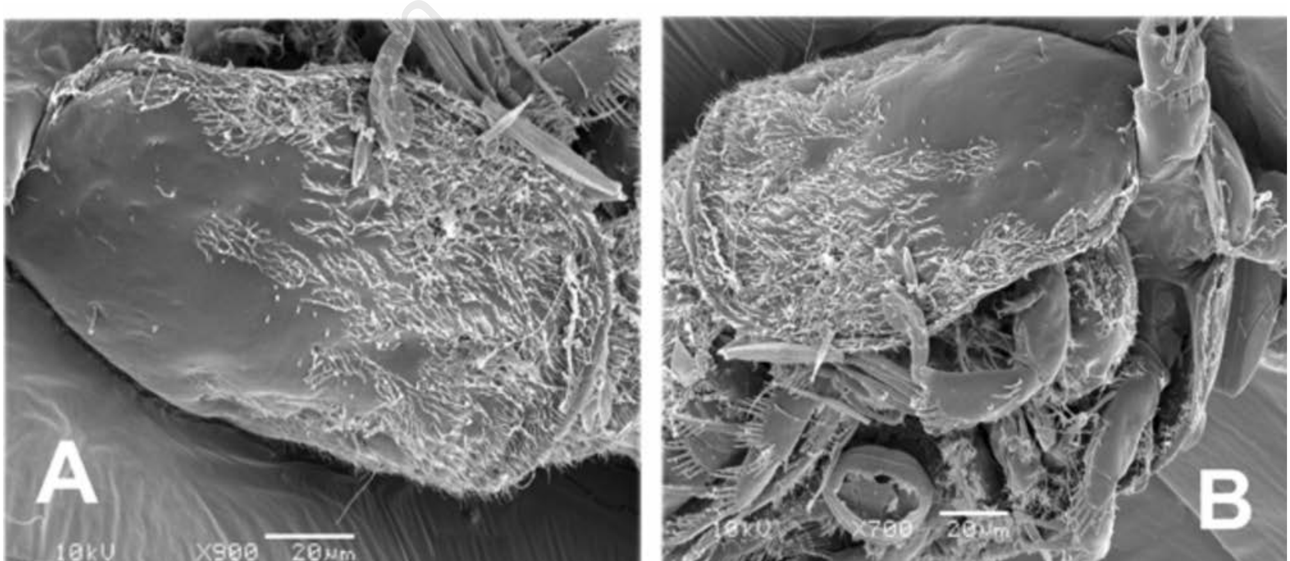

Fig. 8. *Cletocamptus gomezi* n. sp., adult female from lake Alchichica, Central Mexico, scanning electron microscope-prepared specimen. A, cuticular ornamentation of cephalosome, semi-lateral view; B, cuticular ornamentation of cephalosome, lateral view.

four elements in both cases, diverges in these two species: in *C. trichotus*, all elements are long, the shortest one being as long as bearing segment, whereas in *C. gomezi* n. sp., only the apical seta is this long, the remaining three elements are short and spiniform (Fig. 5B). The female fifth leg has some additional differences, including distinct proportional lengths of the exopodal and baseoendopodal setae, a relatively longer basal seta and stronger, and a shallower cleft between the baseoendopod and exopodal lobes in *C. trichotus* (Kiefer, 1929; Lang, 1948) when compared with the new species.

The new species differs from Daday's (1902) *C. deitersi* from Patagonia in the armature of the female leg 1 exopod; this segment has four elements in the new species (Fig. 4A) *vs* only three in *C.* cf. *deitersi* (Lang, 1948). In addition, the new species has three setae on the second endopodal segment of leg 1 *vs* four in Daday's *C. deitersi* (Lang, 1948). The armature of the leg 2 endopod of leg 3 is strikingly similar in both species, but in the new species the third exopodal segment has five setal elements *vs* six in Daday's *C. deitersi*. Also, *C. gomezi* n. sp. has four elements on the leg 4 third exopodal segment, whereas five such elements are present in *C.* cf. *deitersi* (Daday, 1902; Lang, 1948). The male leg 3 inner apophysis is relatively longer in the new species, reaching beyond the distal margin of the third endopodal segment; the same structure is shorter in Daday's *C. deitersi*, not reaching the distal margin of third endopodal segment.

DISCUSSION

Cletocamptus is a very widely distributed genus with records of the previously presumed cosmopolitan *C. deitersi* from different regions of the world. Because of the many Neotropical populations of *Cletocamptus* mistakenly attributed to *C. deitersi*, it is now assumed that the genus diversity remains largely underestimated in the region (Gómez *et al*., 2004). There are only a few records of species of *Cletocamptus* from Mexico, Central America and the Caribbean: *C. albuquerquensis* (Herrick, 1895), *C. deitersi* (Richard, 1879) – a *species inquirenda* that has been proved to be different from other American species –, and *C. bermudae* Willey, 1931, reported in regional listings (Reid, 1990; Suárez-Morales *et al*., 1996; Suárez-Morales and Reid, 1998) but also treated as a *species inquirenda* by Gómez *et al*. (2004). Recently, Gómez *et al.* (2004) added *C. sinaloensis* from North-West Mexico. These authors also suggested that a record of *C. deitersi* from a sinkhole in the Yucatan peninsula (Suárez-Morales *et al.*, 1996) could refer to either *C. sinaloensis* or *C. deborahdexterae*. Gómez and Gee (2009) relegated the nominal *C. albuquerquensis* as *species inquirenda*, so the Mexican records from the states of Coahuila and Guerrero (Suárez-Morales and Reid, 1998; Suárez-Morales *et al*., 2000) are yet to be clarified. The finding of the new species *C. gomezi* n. sp. represents the second confirmed species of *Cletocamptus* known from Mexico (Gómez *et al*., 2004; Gómez and Gee, 2009).

Apparently, the new species is common in the lake and, as far as we know, restricted to the littoral zone, where the microbialites allow the formation of shallow pools around the lake, especially in its eastern sector, which has some connections but a reduced water flow with the deep limnetic zone. These microhabitats are mostly covered by submerged *R. maritima*, and *Chara* sp. accompanied with littoral debris and benthic algae (diatoms and filamentous chlorophytes and cyanobacteria), where, according to Alcocer *et al*. (1998), sediments, although covered by a superficial mud layer, are composed of sand and gravel, with low to medium concentrations of carbonate (1.9-29%) and medium to high concentrations of organic matter (2.8-8.4%). By contrast, these copepods were absent in the sediment samples that we obtained from the deep zone of the lake, which indicates that its vertical distribution should be limited to the upper aerated zones, as it has been described in the reports on the zooplanktonic and benthic species (Hernández *et al*., 2010) of this lake.

Members of this genus are usually related to estuaries, coastal and beach lagoons, but they are also known from brackish water and even hypersaline habitats (Mielke, 2000; Gómez *et al.*, 2004, 2007). There is only one species known from a full freshwater habitat, (*i.e.* a freshwater stream in Chile): *C. cecsurirensis* Gómez, Sheihing and Labarca, 2007 (Boxshall and Defaye, 2008; Gómez *et al*., 2007). In Mexico, *Cletocamptus* has been reported from a freshwater sinkhole in the Yucatan peninsula, with a limited marine influence (Suárez-Morales *et al.*, 1996) and from a coastal lagoon and estuarine areas of Sinaloa (Gómez *et al.,* 2004). The finding of a species of *Cletocamptus* in a high-altitude lake in Central Mexico (>2300 m) and more than 100 km inland is noteworthy; only *C. cecsurirensis* is known from high altitude, more than 4000 m asl (Gómez *et al.*, 2007). *Cletocamptus deboradexterae* is known from lake Salton (Gómez *et al.*, 2004), a shallow, saline endorrheic flood lake in Southern California; general conditions are similar to Alchichica, although salinity is much higher in Salton sea (40 g L^{-1} *vs* 8-9 g L^{-1}) and its altitude is below the sea level. It is not easy to explain the occurrence of *C. gomezi* n. sp. in Alchichica or at 4000 m in Salar de Surire, Northern Chile. Gómez *et al*. (2007) did not comment on the habitat features related to *C. cecsurirensis* or on its unexpected presence in these conditions. In Alchichica, it could represent a derivate of a relict population stranded after glaciation periods as other freshwater copepods in the central region of Mexico (Granados-Ramírez and Suárez-Morales, 2003). Passive transportation by migratory birds feeding or breeding in coastal areas is yet another possibility. However, the known migratory routes in this region are North-South and vice versa, but not East-West (Alcántara-

Rodríguez *et al.*, 2012). Other primarily coastal copepods with a high genetic variability have been able to invade brackish or freshwater habitats and expand their distributional range well inside the continent (Lee and Petersen, 2003; Suárez-Morales *et al.*, 2010).

CONCLUSIONS

Salinity is one of the most important factors affecting the distribution and performance of aquatic organisms and it probably determines the distributional patterns of copepods and other aquatic organisms. Their ability to colonise new habitats relies on their differential adaptive capabilities to higher salinities (Nielsen *et al.*, 2003; Alcántara-Rodríguez *et al.*, 2012). As predominantly coastal and brackish water forms, harpacticoids like *C. gomezi* n. sp. would be able to successfully colonise this saline environment and has now become a common and widespread form in the local meiofauna; no other species of harpacticoid was observed in our samples. According to the observations by Montiel-Martínez *et al.* (2008) it is unlikely that populations of the endemic diaptomid copepod *L. garciai* from Alchichica, restricted to local conditions of relatively high salinity, interact with those from adjacent water bodies as they have a lower salinity range. Consequently, colonisation of other lakes by this species is improbable. We have analysed the littoral fauna from the neighbour saline lake Atexcac, and the other freshwater waterbodies of the eastern basin, but the new species has not been observed. In addition, we cannot disregard the possibility that *C. gomezi* n. sp. would be able to dwell at lower salinity conditions, but this should be determined experimentally (Montiel-Martínez *et al.*, 2008; Barrera-Moreno, 2010). This and the peculiar physiographic and hydrologic features of Alchichica considered, the local population of *Cletocamptus gomezi* n. sp. is presumed to be endemic to this lake.

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