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Original Article

A new and rare epigean asellid from western Mexico *Caecidotea contrerasbalderasi* sp. nov. (Isopoda: Asellidae) with a new suture pattern in pleopod IV for the Mexican epigean species

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ABSTRACT

A new epigean asellid isopod, *Caecidotea contrerasbalderasi* sp. nov. is described from Nayarit, northwestern Mexico. This new species has morphological characters belonging to two different types of environments, both depigmentation and anophthalmia, indicators of organisms adapted to live in constant darkness as cavernicolous species. Despite showing characteristics of hypogean species, the new taxon does not show elongation of appendages, such as pereiopods, antennae or uropods. Its pleopod IV exopod lacks false sutures. This is a new pattern type "C", and differs from that observed in types A and B. The description of this new species brings a new total of 101 species and three subspecies, for the genus *Caecidotea* in North America all morphologically poorly differentiated and with a restricted distribution.

KEYWORDS

Crustacea, dual lifestyle, freshwater isopod, Nayarit, Peracarida

INTRODUCTION

The Mexican state of Nayarit lies within four physiographic provinces known as 1) the Northwest Coastal Plain lowland region, 2) the Sierra Madre Occidental biogeographic province, 3) the Duranguense province, and 4) the Trans-Mexican Volcanic Belt (TMBV) (Campbell, 1999; Morrone,

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2019). The rugged topography of the TMVB gives rise to many basins with unique climatic traits (Espinosa and Ocegueda, 2007), which influence the high rate of endemism of various groups of freshwater crustaceans (Alvarez et al., 2014; Alvarez and Villalobos, 2016; García-Vázquez et al., 2019; García-Vázquez et al., 2021; Pedraza-Lara et al., 2012; Pedraza-Lara and Doadrio, 2015; Pedraza-Lara et al., 2021).

In Mexico, the genus *Caecidotea* Packard, 1871 comprises 16 species that have been recorded in a wide variety of freshwater ecosystems, both lentic and lotic. The information about their distribution and habitat is provided in Tab. 1.

The species *Caecidotea contrerasbalderasi* sp. nov. represents the first record for the genus in the Mexican state of Nayarit. The updated number of species in the genus *Caecidotea* in North America is 101: 74 from hypogean habitats and 27 from surface waters, including three subspecies, *C. bicrenata whitei* Lewis and Bowman, 1981, *C. racovitzai australis* (Williams, 1970), *C. r. racovitzai* (Williams, 1970) (García-Vázquez et al., 2021), with morphological differences of taxonomic importance that guarantee their reassignment to a full species rank (García-Vázquez, unpubl. data).

MATERIAL AND METHODS

During an ecological survey near the municipality of Xalisco, Nayarit, Mexico (Fig. 1), nine specimens of an unidentified epigean isopod in the genus *Caecidotea* were hand collected from a crystalline shallow pond supplied by upwelling spring water, with a bottom of mud and gravel. The pond lacked aquatic vegetation with a temperature of 24–26 °C. The collected specimens were preserved in 70% ethanol and were subsequently analyzed at the Laboratorio de Entomología y Artrópodos of the Facultad de Ciencias Biológicas, Universidad Autónoma de Nuevo León (FCB-UANL). After morphological examination, the specimens were recognized to belong to a new species of *Caecidotea* that is hereby described and compared with other congeneric epigean and hypogean species. The specimens were measured and drawn using a stereomicroscope Olympus-SZX12 equipped with a camera lucida, then dissected and mounted in Entellan® in permanent slides; the limbs were illustrated using a Carl Zeiss compound microscope with camera lucida. Anatomical details of the male appendage follow the nomenclature of García-Vázquez et al. (2019).

Table 1. Checklist of species of the genus *Caecidotea* recorded in Mexico.

Species and author	Distribution	Habitat
C. alvarezi García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021	Jalisco	Epigean, lake
C. buzwilsoni García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021	Guanajuato	Epigean, freshwater lagoon
C. camaxtli García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2019	Tlaxcala	Epigean, freshwater spring
C. chiapas Bowman, 1975	Chiapas	Hypogean, subterranean waters
C. chicoensis García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021	Hidalgo	Epigean, freshwater spring
C. communis (Say, 1818)	Puebla, Mexico City, Michoacán, and Veracruz	Epigean and freshwater habitats as lakes and lagoons
C. contrerasbalderasi sp. nov.	Nayarit	Epigean, groundwater hot spring
C. mintzita García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021	Michoacán	Epigean, freshwater spring
C. pasquinii Argano, 1972	Veracruz	Hypogean, subterranean waters
C. puebla (Cole and Minckley, 1968)	Puebla	Epigean, river
C. villalobosi García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021	Veracruz	Epigean, lake
C. vomeroi Argano, 1977	Chiapas	Hypogean, subterranean waters
C. williamsi Escobar-Briones and Alcocer, 2002	Puebla	Epigean, saline crater-lake
C. xochimilca Rocha-Ramírez and Peñaloza-Daniel, 2011	Mexico City	Epigean, lake
C. zacapuensis García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021	Michoacán	Epigean, freshwater lagoon
C. zullini Argano, 1977	Chiapas	Hypogean, subterranean waters

Figure 1. Type locality of *Caecidotea contrerasbalderasi* sp. nov., Pantanal, municipality Xalisco, Nayarit, México.

The specimens were deposited in the Colección Carcinológica (FCB-UANL) and the National Museum of Natural History, Smithsonian Institution, Washington DC (USNM).

A review of the literature regarding the suture pattern in pleopod IV was done for all the 12 Mexican epigean species of *Caecidotea* (see Cole and Minckley, 1968; Escobar-Briones and Alcocer, 2002; García-Vázquez et al., 2019; García-Vázquez et al., 2021; Rocha-Ramírez and Peñaloza-Daniel, 2011; Say, 1818), following the classification in types by Lewis and Bowman (1981).

SYSTEMATICS

Order Isopoda Latreille, 1817

Family Asellidae Rafinesque, 1815

Genus *Caecidotea* Packard, 1871

***Caecidotea contrerasbalderasi* sp. nov.**
(Figs. 2–4)
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Material examined. Holotype: 1 male (UANL-FCB-C-6240), length 7 mm, in freshwater pond, clear water and bottom of mud and gravel; Pantanal, municipality Xalisco, Nayarit, Mexico, 21°25'38.29"N 104°51'29.67" W, elev. 927 m, 15 February 1988, coll. Gabino A. Rodríguez-Almaraz. Paratypes: 4 females and one male (UANL-FCB-C-6241); one specimen, unsexed (USNM 1014039).

Diagnosis. Male body length 7.0 mm, width 1.6 mm. Head trapezoidal, anterior margin concave, postmandibular lobes protruding. Pereionites I–II with concave margin. Pleotelson subquadrate, lower caudomedial lobe bilobed. Pleopod I length 1.4 × width; distal article length 1.4 × protopod length, distal article length 1.9 × width, external margin proximally concave with 4 small setae as long as retinacula. Pleopod III transverse suture with 7 presutural simple setae. Pleopod IV protopod with fringe of small setae plus 2 long simple setae. Pleopod V with 2 sinuous sutures. Uropod half as long as pleotelson.

Description. Male (UANL-FCB-C-6240) 7 mm (Figs. 2A–4). Body length 4.2 width; surface covered by scattered setae; head width 1.5 × length, anterior

margin concave; without eyes; postmandibular lobes poorly developed. Pereionites subrectangular, lateral margins rounded with setae, pereionites I–II similar in length with frontal margin medially concave, pereionite I symmetrical, pereionite II with anterolateral margin front projecting, pereionites III–IV with frontal margin straight, pereionites V–VII with frontal margin convex, posterolaterally back projecting (Fig. 2A).

Antennula not overreaching protopodal article 3 of antenna; flagellum with 7 articles, aesthetascs in formula 1-1-1-1; articles tapering distally, first article 1.5 and 2.6 times longer than second and third segments; 1–3 longer than flagellum. First article 1.5 and 2.6 times longer than second and third articles.

Antenna, flagellum broken in all specimens except a paratype female in which it reaches posterior margin of pleotelson, with 4 protopodal articles, and flagellum of 19 articles.

Pereiopod I (Fig. 2A), subchelate, propodus length 1.4 × width, shorter than pereiopod II; palm outer margin convex, proximally with 2 articulated strong setae; mesial process unicuspidate, large, triangular with pointed apex not surpassing dactylus width; distal process absent; proximal process with 2 strong setae, one as long as medial process; dactylus flexor margin with 9 setae increasing in size distally, outer margin with 5 simple setae, 1 distally plumose seta; dactylus as long as inner margin of propodus. Pereiopod II (not figured) longer not as robust as pereiopod I; not subchelate; dactylus as long as propodus length. Pereiopod III (Fig. 3C) propodus with 6 strong setae as long as dactylus unguis. Pereiopod IV (Fig. 3D) slightly longer than pereiopod II; dactylus with 2 setae on inner margin with 1 terminal setae, outer margin with 4 setae; propodus length 3.0 dactylus length, propodus length 4.0 width, outer and inner margin bearing

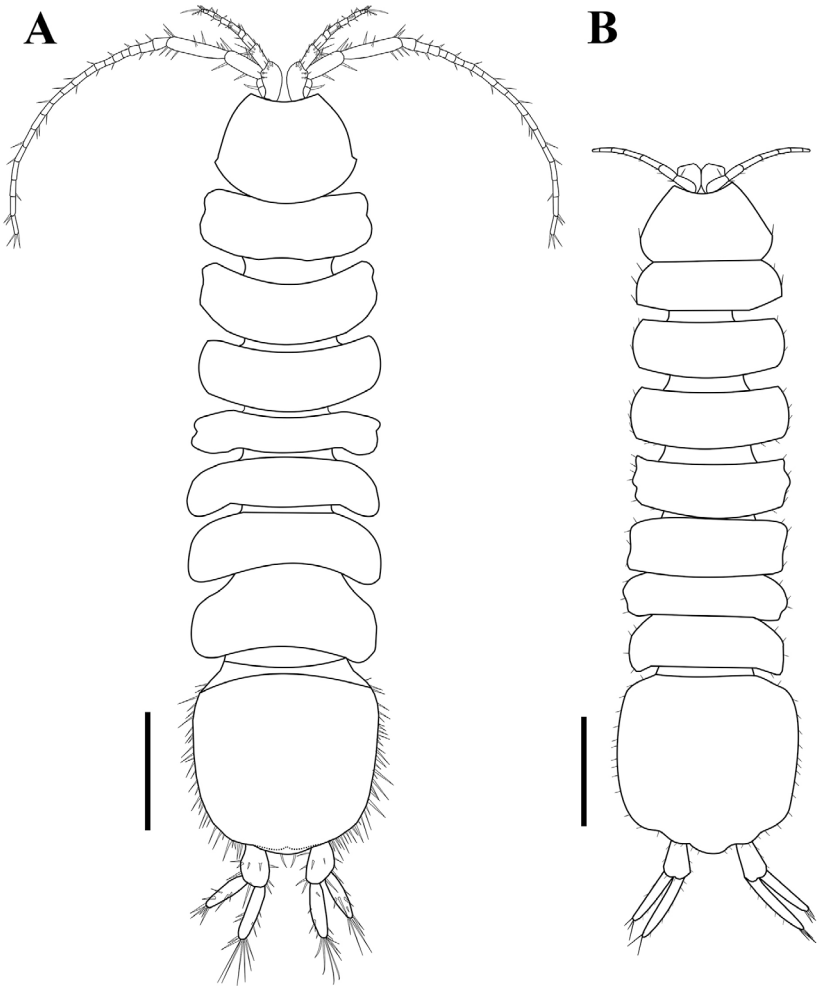

Figure 2. *Caecidotea contrerasbalderasi* sp. nov., Pantanal, municipality Xalisco, Nayarit, Mexico. **A**, Holotype male (UANL-FCB-C-6240), 7.0 mm. **B**, Paratype female (UANL-FCB-C-6241) 6.0 mm. **A**, male habitus. **B**, female habitus. Scale bars = 1.0 mm.

scattered setae; with single subtriangular projection on distal margin; carpus subtrapezoidal length 2.4 × width; outer margin with 1 setae centrally placed plus 3 on posterodistal margin, inner margin with 7 spines; merus triangular, subequal as wide as long, with long, robust setae of different sizes at anterodistal angle; ischium rectangular, length 1.4 × width and about 1.1 × merus length; basis subrectangular length 1.7 × ischium length; inner margin with 2 proximal spines plus one distal spine, outer margin with 10 spines. Pereiopod V (not figured) similar in length to pereiopod VI. Pereiopod VI (Fig. 3H) similar to pereiopod IV; dactylus about third as long as propodus. Pereiopod VII (not figured) 1.1 pereiopod VI length.

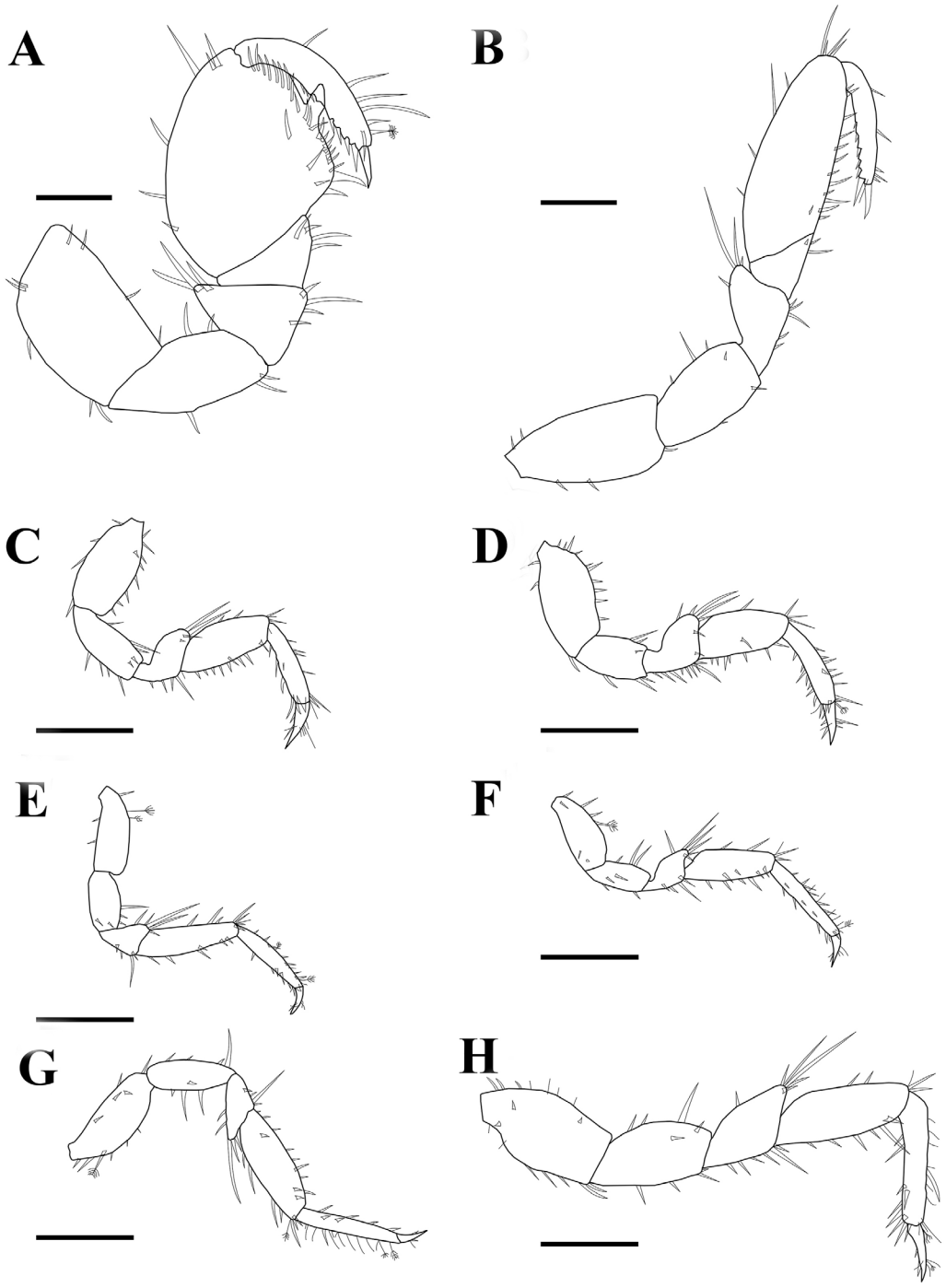

Figure 3. *Caecidotea contrerasbalderasi* sp. nov., holotype male (UANL-FCB-C-6240), 7.0 mm, paratype female (FCB-UANL-6241), Pantanal, municipality Xalisco, Nayarit, Mexico. **A**, male pereiopod I; **B**, female pereiopod I; **C**, male pereiopod II; **D**, male pereiopod III; **E**, female pereiopod IV; **F**, pereiopod V; **G**, female pereiopod VI. **H**, pereiopod VII. Scale bar: **A**, **B** = 0.15, **C**-**H** = 0.2 mm.

Pleopod I (Fig. 4A), longer than pleopod II; basal protopod with 4 retinacula, length 1.4 × width; distal article length 1.4 × protopod length, distal article length 1.9 × width, bearing rounded apex, mesial margin proximally concave with 4 small setae; inner margin without setae; apex with 7 simple longer setae, distally with 3 additional simple and smaller setae.

Pleopod II (Fig. 4B), protopod subquadrate, width 0.8 × length, with 1 medial seta; exopod proximal segment with 3 lateral setae, distal segment oval, length 1.3 × width, with 11 lateral and distal setae, with numerous minute simple setae on inner distal margin; endopod narrow, length 4.0 × width, with rounded prominent lateral basal inner and outer apophyses, tip produced into terminal process, tapering and slightly curving latero-distally, cannula long simple; caudal process simple, rounded, armed with 7 cuticular scales, ventral groove simple length 4.3 × width; mesial process simple, acute; lateral process not evident (Fig. 4C, D).

Pleopod III (Fig. 4E), protopod small; exopod ovate forming large operculum for remaining pleopods; distal article length 1.3 proximal article length, transverse suture with 7 presutural simple setae, external margin with 4 small simple setae, distal margins with 9 postsutural simple setae, apex with 10 plumose setae.

Pleopod IV (Fig. 4F), protopod small bearing a basal fringe of small setae plus 2 long simple setae; exopod type B after Lewis and Bowman (1981), ovate, with single transverse suture on median margin; protopod distal article length 1.2 × proximal article length.

Pleopod V (Fig. 4G), with 2 sinuous sutures arising near to distal third length; external margin with 3 setae; exopod ovate, length 1.9 × width.

Pleotelson, subquadrate, as long as wide, lateral margins parallel with several setae, caudomedial lobe wide protruding; lower caudomedial lobe emarginate, with 1 simple setae on each lobe; apex rounded.

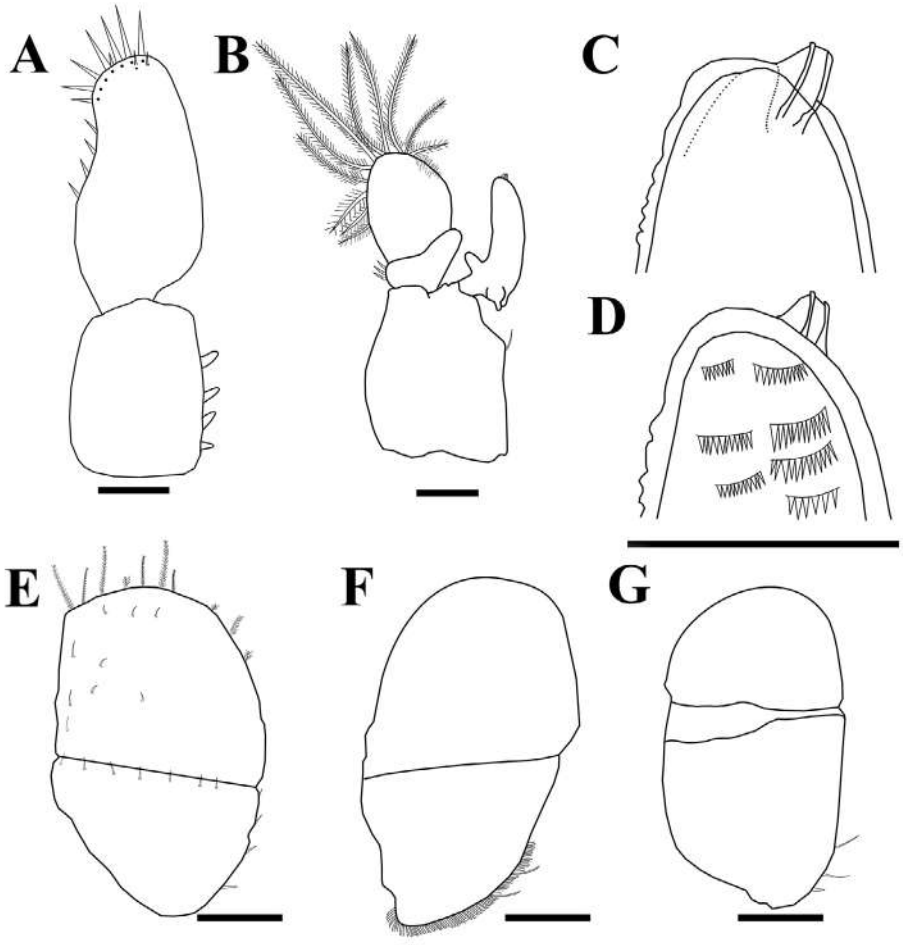

Figure 4. *Caecidotea contrerasbalderasi* sp. nov., holotype male (UANL-FCB-C-6240), 7.0 mm, left pleopods, Pantanal, Municipality Xalisco, Nayarit, Mexico. **A**, pleopod I; **B**, pleopod II; **C**, **D**, dorsal and ventral view of the apex of the endopodite; **E**, pleopod III; **F**, pleopod IV; **G**, pleopod V. Scale bars: **A**, **B** = 0.1 mm, **C**, **D** = 0.054 mm, **E-G** = 0.2 mm.

Uropods half as long as pleotelson length; endopod length 1.6 × protopod length, endopod length 1.2 × exopod length.

Female paratype (UANL-FCB-C-6241) 6 mm (Fig. 2B) (only features differing from male are illustrated and described, Fig. 3).

Pereiopod I (Fig. 3B) slender; propodus length 2.5 × width; palm without process and with unequal simple setae; dactylus with 5 setae on flexor margin. Pereiopod II (Fig. 3E) longer than pereiopod I; not subchelate; dactylus length 3.3 × propodus length, with 1 seta on inner margin plus 1 terminal setae; propodus length 6.0 × width; inner and outer margin with 7 simple setae bearing scattered smaller ones, inner margin with 5 simple setae bearing distally a sclerotized triangular process. Pereiopod IV (Fig. 3F) slightly longer than pereiopod II; dactylus with 1 seta on inner margin and a larger terminal setae, outer margin with 3 simple setae; propodus length 2.4 × dactylus length, outer margin with 6 large setae with smaller setae intercalated, inner margin with 4 setae with single subtriangular projection on their distal margin; carpus subtrapezoidal length 3.0 × width; outer margin with 2 setae centrally placed, 2 on posterodistal margin, inner margin with 4 setae; merus triangular, length 1.3 × width, with 2 strong setae at anterodistal angle; ischium rectangular, length 2.2 width, 1.2 times as long as merus; basis subrectangular length 1.4 × ischium length, 2.3 times as long as wide; inner margin without setae, outer margin with 3 simple setae plus 1 plumose seta. Pereiopod VI (Fig. 3G) longer and more robust than pereiopod II and IV; dactylus with 1 spine on inner marginal plus a greatest terminal spine; outer margin with 1 simple seta plus 1 short seta; propodus length 6.0 × width.

Etymology. The present species is named in honor of Dr. Salvador Contreras-Balderas, as a posthumous tribute to his important and successful career as a taxonomist of fishes and crustaceans, as well as Professor of Systematics and Evolution in the Facultad de Ciencias Biológicas of the Universidad Autónoma de Nuevo León.

Habitat. The species was collected in a crystalline, freshwater shallow pond at 20 cm deep (temperature 24–26 °C) under submerged rocks and between the decaying organic matter (willow leaves), with muddy and gravelly bottom.

Distribution. Only known from the type locality.

Remarks. Morphologically, the eyes in the type series of *Caecidotea contrerasbalderasi* sp. nov. are absent, as well as body pigmentation, features usually associated with a subterranean lifestyle (Rudy et al., 2018). In contrast, this species does not present elongation of appendages such as pereiopods, antennae or uropods. A similar situation is found in some Eastern Australian phreatoicidean isopods belonging to the genus *Crenoicus* and in the New Zealand genus *Notamphisopus*, in which epigean species lack functional eyes and pigmentation (Fenwick et al., 2009; Wilson and Ho, 1996).

DISCUSSION

Caecidotea contrerasbalderasi sp. nov. shares with its congeneric Mexican hypogean species a pleopod IV type B (sensu Lewis and Bowman, 1981; see Tab. 2, Fig. 4F). However, the species can be easily separated from the rest of their epigean congeners by the presence of a pleotelson with a caudomedial lobe emarginate and the absence of eyes.

Table 2. Pleopod IV suture pattern for the *Caecidotea* species of Mexico (data compiled from the literature).

Species	Pleopod IV type	Eyes
C. alvarezi	C	Present
C. buzwilsoni	C	Present
C. camaxtli	C	Present
C. chiapas	B	Blind
C. chicoensis	C	Present
C. communis	A	Present
C. contrerasbalderasi sp. nov.	B	Present
C. mintzita	C	Present
C. pasquinii	B	Blind
C. puebla	*	Present
C. villalobosi	C	Present
C. vomeroi	*	Blind
C. williamsi	B	Present
C. xochimilca	B	Present
C. zacapuensis	C	Present
C. zullini	B	Blind

*The *C. puebla* and *C. vomeroi* species must be collected to obtain additional information on the pleopod IV suture pattern.

Another character of taxonomic importance is the shape of the endopod apex of pleopod II (Fleming, 1973); in subterranean species such as *Caecidotea chiapas* Bowman, 1975, *Caecidotea vomeroi* Argano, 1977, and *Caecidotea zullini* Argano, 1977, the endopod apex presents an abrupt elongation, while in *Caecidotea contrerasbalderasi* sp. nov. and *Caecidotea pasquinii* (Argano, 1972) (subterranean species) the apex does not present this abrupt elongation. This is more similar to that of epigean species with the presence of a caudal process, and the cannula is short and with a mesial process (see García-Vázquez et al., 2021, p. 46, Fig. 1). For this reason, a dual epigean/hypogean lifestyle cannot be discounted in *Caecidotea contrerasbalderasi* sp. nov.

As is shown in Tab. 2, the pleopod IV lacks a suture (Fig. 5) in seven epigean species: *Caecidotea alvarezi* García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021, *Caecidotea buzwilsoni* García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021, *Caecidotea camaxtli* García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2019, *Caecidotea chicoensis* García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021, *Caecidotea mintzita* García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021, *Caecidotea puebla* (Cole and Minckley, 1968), and *Caecidotea zacapuensis* García-Vázquez, Rodríguez-Almaraz and Pedraza-Lara, 2021; while in *Caecidotea contrerasbalderasi* sp. nov., García-Vázquez, Campos and Rodríguez-Almaraz, *Caecidotea williamsi* Escobar-Briones and Alcocer, 2002, *Caecidotea xochimilca* Rocha-Ramírez and Peñaloza-Daniel, 2011, and the hypogean species *Caecidotea pasquinii* (Argano, 1972), *Caecidotea chiapas* Bowman, 1975, *Caecidotea zullini* Argano, 1977 and *Caecidotea vomeroi* Argano, 1977, the pattern B is present (Fig. 5B); only *Caecidotea communis* (Say, 1818) shows pattern A (Fig 5A). These results allow us to propose the existence of a new pattern, termed type C (Fig. 5C), which corresponds to the absence of sutures on pleopod IV. The presence of this new pattern will be the subject of future studies aiming to find out if it is a phylogenetic signal among the epigean and hypogean species distributed from Canada to Guatemala.

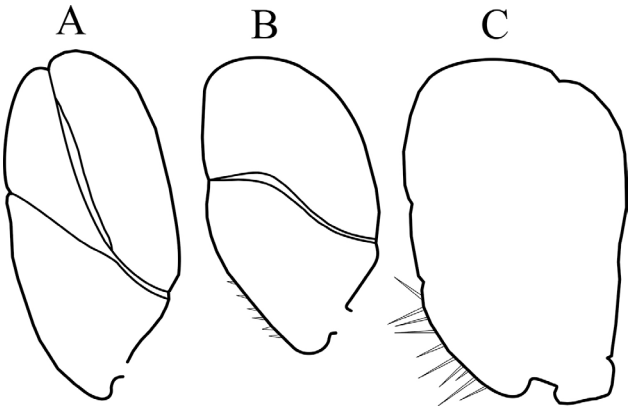

Figure 5. Suture patterns of pleopod IV: **A**, Pattern A, with 2 false sutures and apical incision; **B**, Pattern B, with single sigmoid false suture; **C**, Pattern C, without sutures. Figures **A** and **B** taken and redrawn from Lewis and Bowman (1981: 6, fig 7).

Caecidotea contrerasbalderasi sp. nov. was collected in a well-preserved, crystalline freshwater shallow pond. The type locality was recently visited, and it has been transformed into a recreational area which is constantly cleaned by removing decaying organic matter (mostly willow leaves) by a dredging system; no additional specimens of this new taxon were found. This is an extremely alarming situation, since the transformation of the habitat by anthropogenic actions compromises the existence of the species at the site. Thus, it is urgent to take conservation and water management actions in the region to avoid the loss of this species.

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ADDITIONAL INFORMATION AND DECLARATIONS

Author Contributions

All authors have contributed equally.

Consent for publication

We give our full consent of publication of this paper including images and free distribution on the internet to the journal Nauplius and the Brazilian Crustacean Society.

Competing interests

The authors state that they have no known competing financial interests or personal relationships that may have influenced the work reported here.

Data availability

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Study permits

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