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## New species of *Cletocamptus* and a new and fully illustrated record of *C. sinaloensis* (Copepoda: Harpacticoida) from Brazil

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### Abstract

Two new species of harpacticoid copepods, *Cletocamptus levis* sp. nov. and *Cletocamptus nudus* sp. nov. are described from Brazil. *Cletocamptus nudus* sp. nov. seems to be closely related to *C. schmidti* based on the armature formula of mouth parts, P3 and P4, but can be separated based on the ornamentation of the anal operculum, relative length of exopodal and baseopodal setae of the female P5, and length ratio of the female P1 EXP:ENP. *Cletocamptus levis* sp. nov. seems to be more closely related to *C. axi* by the combination of a P1 ENP shorter than the P1 EXP, the armature formula of the mandibular palp, length: width ratio of caudal rami, and relative length of the female P3 ENP 2, male P2–P4 EXP 1, and number of segments of the male P3 ENP. It can be separated by the spinule ornamentation on the anal operculum, shape of female rostrum, relative length of outer spinules of female P2–P4 EXP, relative length of the setae on the male P5 EXP, armature of male P6, and by the dimorphic male rostrum of *C. levis* sp. nov. which is similar to that observed for *C. retrogressus* and *C. albuquerquensis*. Additionally, a fully illustrated record of the Mexican *C. sinaloensis* is reported for the first time from Brazilian waters, and *C. affinis mongolicus* Stérba, 1968 is given full species status.

**Keywords:** *Cletocamptus*, *Copepoda*, *Harpacticoida*, *taxonomy*, *new species*

### Introduction

*Mesochra* (= *Cletocamptus*) *deitersi* was originally described by Richard (1897) from the Naposta Grande River (Argentina). Since Richard's description, *C. deitersi* has been reported from inland brines as well as coastal estuaries and mangroves from several sites in North, Central, and South America as well as in India, China, Ethiopia, Hawaii, Australia, Iran, and Malaysia (Gómez et al. 2004). Nevertheless, the cosmopolitanism of *C. deitersi* is best explained by the intraspecific variability of the species, and above all, by the fact that virtually all specimens attributed to *C. deitersi* around the globe are morphologically similar and cannot be differentiated on the basis of Richard's (1897) original description (Gómez et al. 2004).

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Several authors (Dexter 1995; Suárez-Morales et al. 1996; Gee 1999; Mielke 2000a, 2001) have suggested that *C. deitersi* consists of a number of morphologically indistinguishable sibling species. This was partially confirmed by Rocha-Olivares et al. (2001) and Castro-Longoria et al. (2003). Their findings instigated the morphological analysis of the known populations of *Cletocamptus* previously identified with the Argentinian *C. deitersi*. After thorough examination of the available literature, Gómez et al. (2004) decided to consider as *species inquirendae* *C. deitersi* (Richard, 1897), *C. dadayi* (Delachaux, 1917), *C. brehmi* Kiefer, 1933, *C. bermudae* Willey, 1930, *C. cfr. bicolor*, Herbst, 1960, *C. gabrieli* Löffler, 1961, *C. ecuadorianus* Löffler, 1963, *C. kummleri* (Delachaux, 1917), and the *C. deitersi* material of Daday (1902), Kiefer (1936), Herbst (1960), Hamond (1973), Dussart (1974), Tai and Song (1979), and Suárez-Morales et al. (1996). Gómez et al. (2004) considered Ranga Reddy and Radhakrishna's (1979), Dussart and Frutos' (1986), Sitjar's (1988), and Zamudio-Valdéz's (1991) records of the species as doubtful. They also suggested a more detailed description of dorsal and ventral ornamentation of body somites of *C. axi* Mielke, 2000, which following Gómez et al. (2004) is a valid species. They also considered *C. schmidti* Mielke, 2000 as a valid species different from *C. deitersi* based on the fact that this species resembles *Cletocamptus* specimens (previously identified with *C. deitersi*) from São Luis Island (Maranhao, Brazil) (USNM 250011) in the armature formula of female P1–P5, but suggested a detailed redescription of the dorsal and ventral ornamentation of body somites of *C. schmidti*. Additionally, Gómez et al. (2004) noticed that the small seta on the male P6 of some specimens of *C. axi* and *C. schmidti* was found also in specimens from São Luis Island (Jansen lagoon, Maranhao, Brazil) (USNM 242172), suggesting that this character may provide useful phylogenetic information.

The present contribution deals with the description of two new species of *Cletocamptus* and a new and fully illustrated record of *C. sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, from Cananéia (São Paulo, Brazil) and São Luis Island (Maranhao, Brazil).

## Material and methods

Specimens of *C. nudus* sp. nov. and *C. sinaloensis* analysed in this study were borrowed from the USNM collection. The vials were labelled and contained a number of specimens as follows:

*Cletocamptus deitersi*, USNM 250011; Brazil; Maranhao; Ilha de São Luis, near Raposo, in mangroves. This vial contained 13 *Cletocamptus* specimens and three specimens of an unidentified Laophontidae. The *Cletocamptus* specimens were shown to belong to two different species: 11 specimens are herein attributed to *C. sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, and two specimens were attributed to *C. nudus* sp. nov. described below.

*Cletocamptus deitersi*, USNM 242172; Brazil; Maranhao; Ilha de São Luis; Lagoa Jansen. This vial contained five *Cletocamptus* specimens that were attributed to *C. sinaloensis*.

*Cletocamptus deitersi*, USNM 278124; Brazil; Rio de Janeiro, Lagoa de Freitas; P. S. Young, June 1996; J. W. Reid, 1 July 1996; 2f; Acc. #41. This vial contained only one CIII (third copepodid) and was not included in the present study.

Specimens of *C. levis* sp. nov. from Cananéia, São Paulo (Brazil) were provided by Dr Guilherme R. Lotufo.

Morphological observations and drawings were made from whole and dissected specimens. Intraspecific variability in armature formulae of P1–P6 was assessed only from

dissected specimens. Aberrations, deformed setae/spines and/or segments were not considered as intraspecific variability. Only the presence or lack of well-developed and/or reduced setae/spines, and different patterns of spinular ornamentation of body somites were considered as intraspecific variability. Observations and drawings were made using a Leica compound microscope equipped with drawing tube at a magnification of  $1000\times$ . Additional observations were made also at  $1250\times$ . The type material has been deposited in the National Museum of Natural History (Smithsonian Institution) (USNM) and in the Copepoda collection of the Museu de Zoologia, Universidade de São Paulo (MZUSP).

The terminology proposed by Huys and Boxshall (1991) for morphological descriptions was adopted. The following abbreviations are used in the text and tables: P1–P6, first to sixth swimming legs; EXP, exopod; ENP, endopod; P1(P2–P4) EXP(ENP) 1(2, 3) denotes the proximal (middle, distal) exopodal (endopodal) segment of P1, P2, P3, or P4.

### Taxonomic account

**Family CANTHOCAMPTIDAE** Sars, 1906 (*incertae sedis*) *sensu* Por, 1986

**Genus *Cletocamptus*** Schmankewitsch, 1875

***Cletocamptus nudus*** sp. nov.

(Figures 1–5)

#### *Type material*

One female holotype (USNM 250011) preserved in alcohol and one dissected female paratype (USNM 1010094).

#### *Type locality*

São Luis Island, Maranhao, Brazil ( $2^{\circ}31'S$ ,  $44^{\circ}16'W$ ).

#### *Etymology*

The specific epithet refers to the bare anal operculum of the species.

#### *Description*

*Female.* Habitus (Figure 1A, B) tapering posteriorly; total body length measured from tip of rostrum to posterior margin of caudal rami ranging from 675 to 740  $\mu\text{m}$  (mean 707.5  $\mu\text{m}$ ,  $n=2$ ; holotype 740  $\mu\text{m}$ ). Rostrum defined at base, triangular, with pair of setules subapically and ornamented with small spinules distally. Cephalic shield (Figure 1A, B) with small, fine spinules along margin dorsally and with comparatively longer spinules laterally. Dorsal and lateral surface of free thoracic somites (P2–P4-bearing somites) with transverse rows of minute spinules, with longitudinal row of small spinules close to posterior margin and with long spinules along posterior margin. Dorsal and lateral surface of first urosomite (P5-bearing somite) with transverse rows of minute spinules, with row of small spinules close to posterior margin and with long spinules along posterior margin. Genital somite with subcuticular rib dorsally and laterally indicating former division between first and second genital somites (Figure 1A, B), but completely fused ventrally (Figure 2A); dorsal and lateral surface of first and second genital somite with transverse

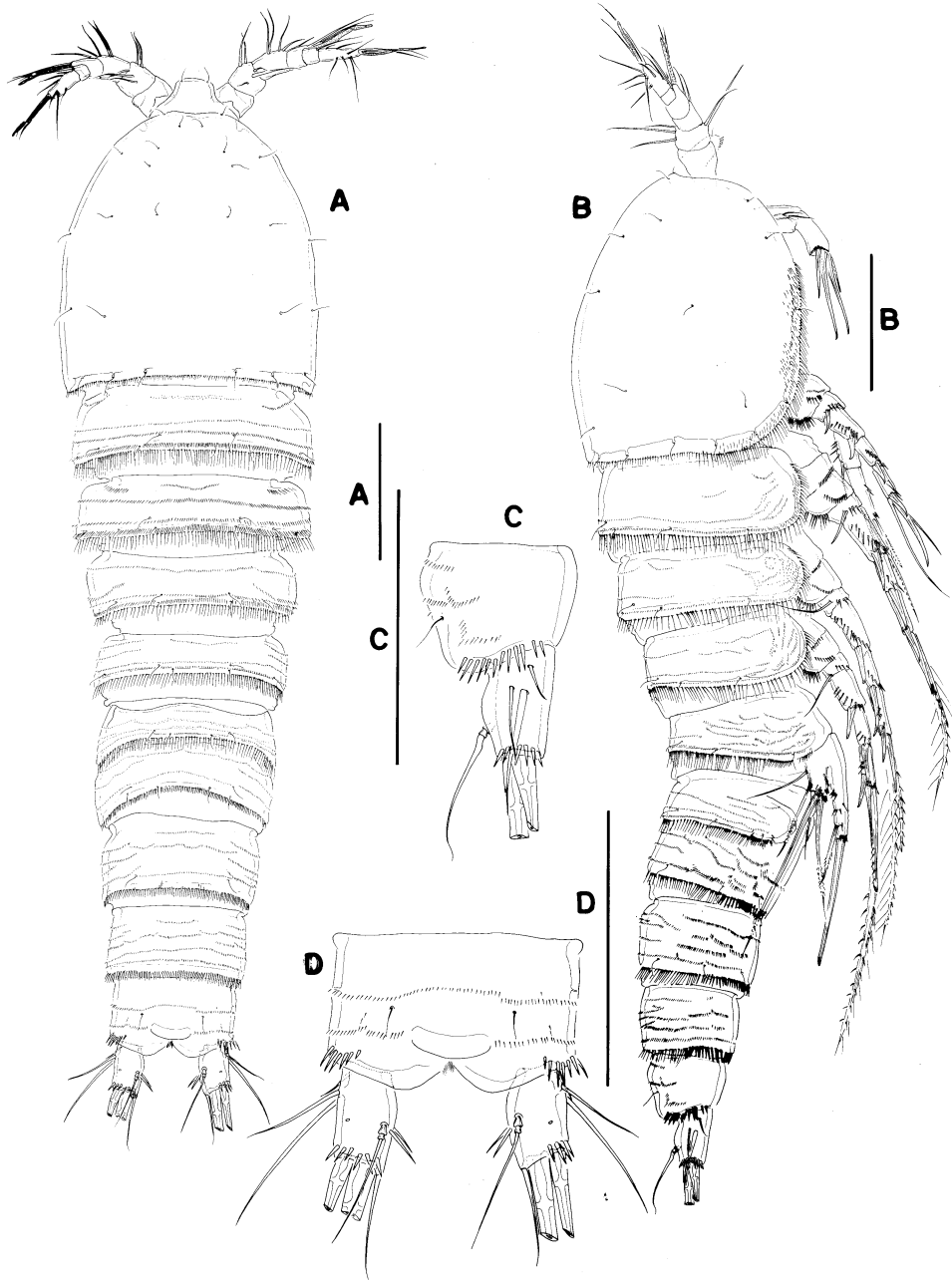


Figure 1. *Cletocamptus nudus* sp. nov., female. (A) Habitus, dorsal; (B) habitus, lateral; (C) anal somite and right caudal ramus, lateral; (D) anal somite and caudal rami, dorsal. Scale bars: 100  $\mu$ m.

rows of minute spinules, with row of long spinules along posterior margin of both somites, and with relatively longer spinules laterally, ventrally with spinules. Fourth and fifth urosomite as in second genital somite dorsally, ventral surface with short transverse spinule rows.

Dorsal surface of anal somite (Figure 1A, D) with transverse rows of minute spinules and with dorsolateral strong spinules close to joint with caudal rami; rounded anal operculum

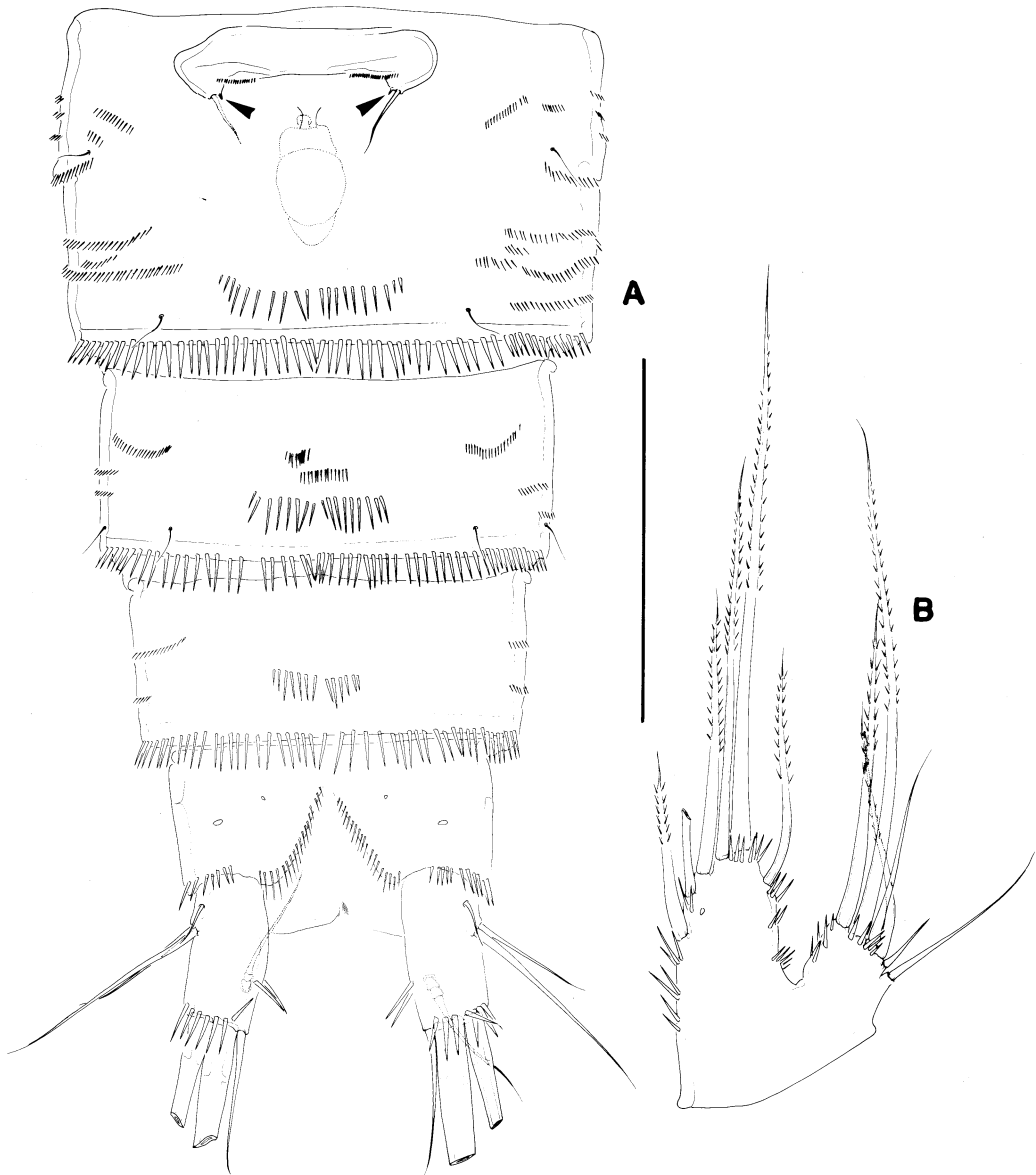


Figure 2. *Cletocamptus nudus* sp. nov., female. (A) Urosome, ventral (P5-bearing somite omitted); (B) P5. Scale bar: 100  $\mu$ m.

without ornamentation. Caudal rami (Figures 1A–D, 2A) about 1.5 times longer than wide; dorsal and ventral surface smooth, except for inner set of spinules close to insertion site of seta VII and close to posterior margin dorsally and ventrally; with seven elements.

Antennule (Figure 3A) six-segmented; surface of segments smooth except for two rows of spinules on first segment. Armature formula, 1-(1), 2-(8), 3-(6), 4-(1 + [1 + ae]), 5-(1), 6-(9 + [1 + ae]).

Antenna (Figure 3B) with small coxa. Allobasis armed with two abexopodal setae. Free endopodal segment ornamented with inner strong spinules proximally and subdistally; with

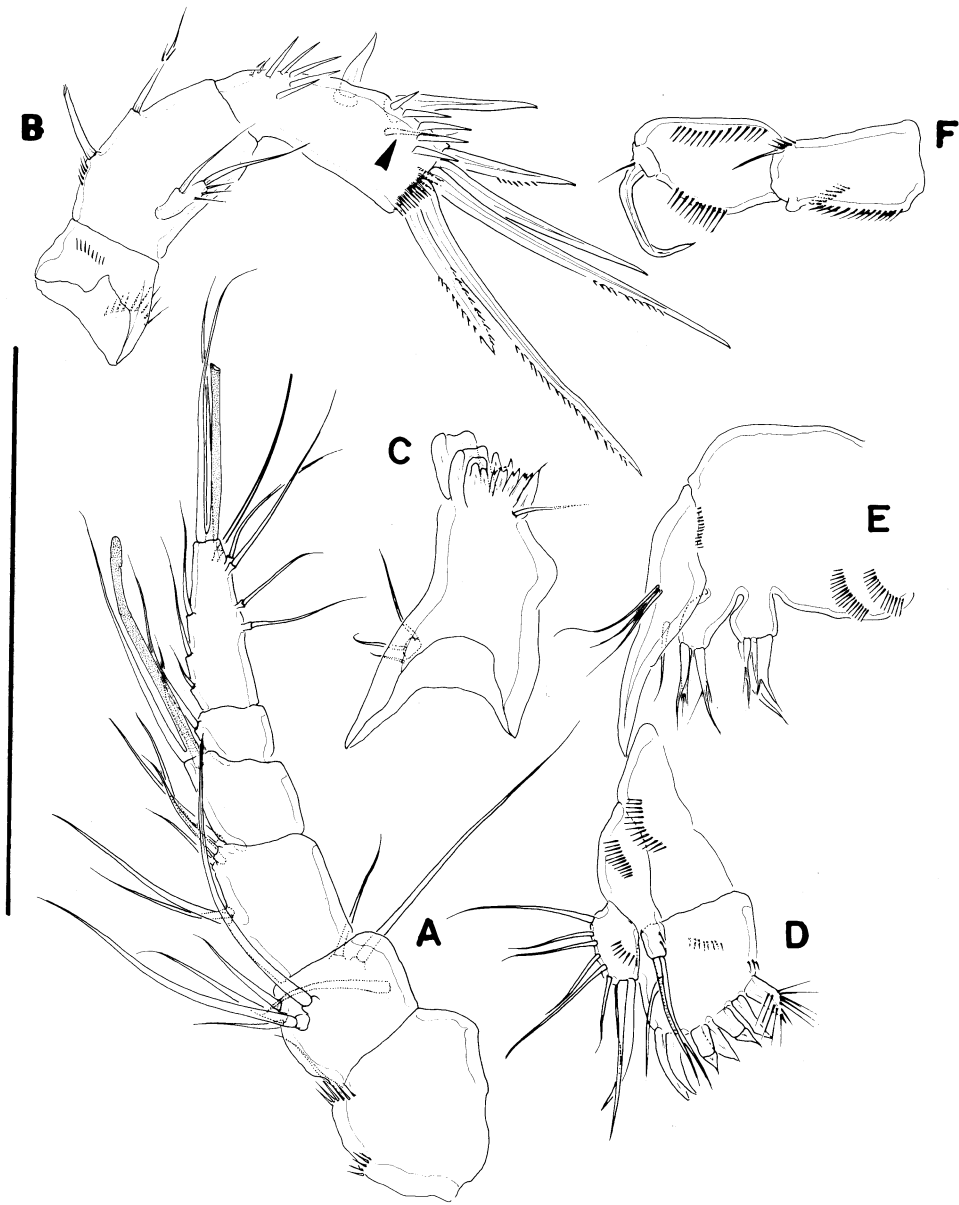


Figure 3. *Cletocampus nudus* sp. nov., female. (A) Antennule; (B) antenna; (C) mandible; (D) maxillule; (E) maxilla; (F) maxilliped. Scale bar: 10  $\mu$ m.

two lateral inner spines and a slender seta (the latter indicated in Figure 3B), and five distal elements. Exopod one-segmented; about seven times longer than wide; with few spinules, and with one lateral and one apical smooth seta.

Mandible (Figure 3C) robust; chewing edge with bicuspidate teeth, four (or five?) multicuspidate teeth, one pyriform element and one lateral seta. Palp one-segmented, with two setae unequal in length and one small seta arising nearby.

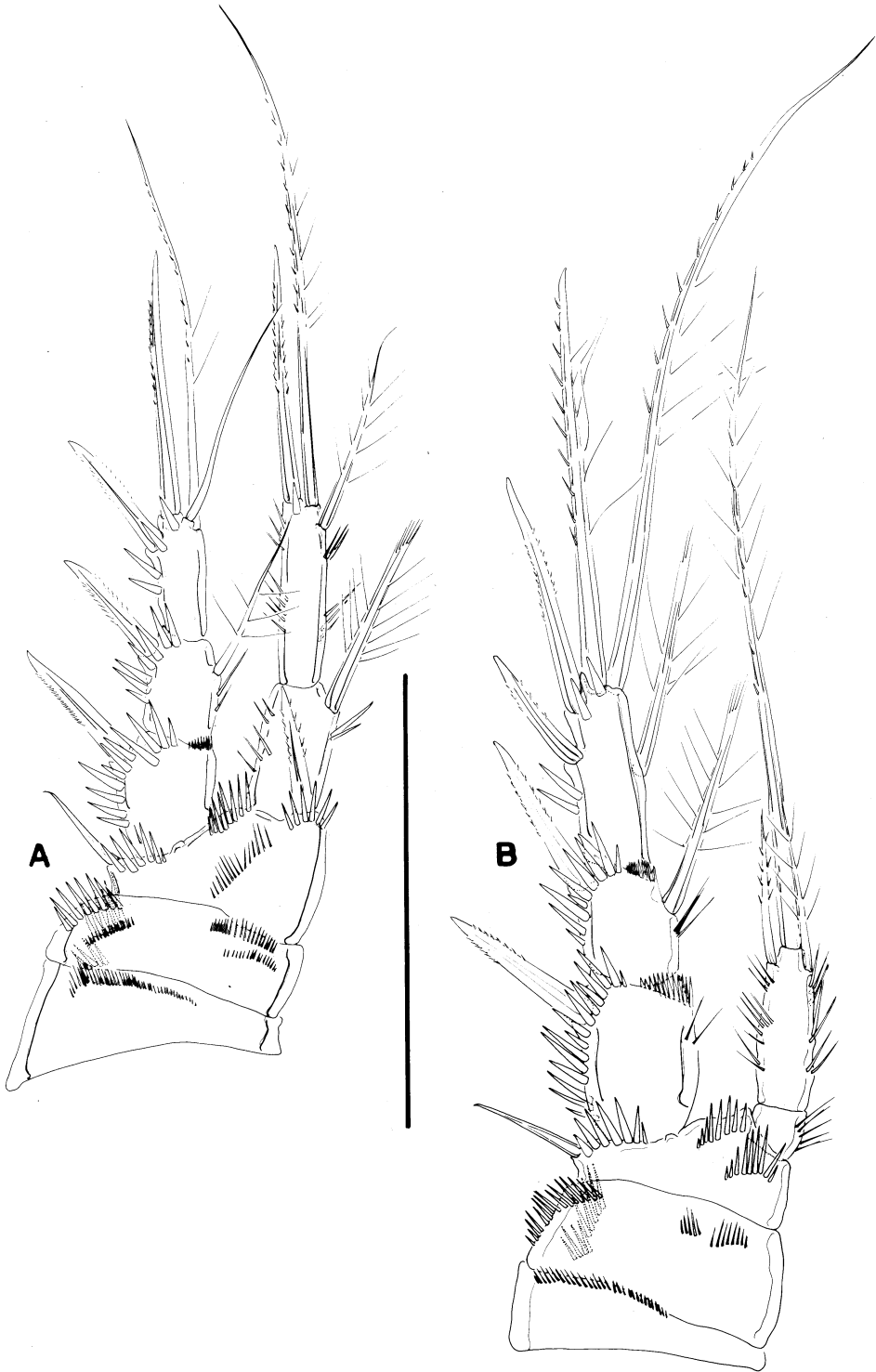


Figure 4. *Cletocamptus nudus* sp. nov., female. (A) P1; (B) P2. Scale bar: 100  $\mu$ m.





Figure 5. *Cletocamptus nudus* sp. nov., female. (A) P3; (B) P4. Scale bar: 100  $\mu$ m.

Maxillule (Figure 3D) robust; arthrite of praecoxa with few spinules, with one surface seta, six (or seven?) distal spines and one lateral strong seta, the latter spinulose. Coxa with some spinules and with two slender setae. Basis with some median spinules and with two apical setae; exopod and endopod represented by three setae each.

Maxilla (Figure 3E): syncoxa with minute spinules along inner margin and close to joint with allobasis; with two endites, each bearing three setae. Allobasis drawn into strong claw bearing one accompanying seta. Endopod represented by three setae.

Maxilliped (Figure 3F) subchelate. Syncoxa with row of spinules and with a small seta on inner distal corner. Basis without armature and with one anterior and one posterior longitudinal row of spinules. Endopod drawn into long and slender claw with one accompanying small seta. The shape of the maxilliped shown in Figure 3F is an artefact of mounting.

P1 (Figure 4A): praecoxa with spinules close to joint with coxa. The latter with four transverse spinule rows on anterior face, and with spinule row near outer distal corner on posterior face. Basis with median spinule row, and with stronger spinules at base of exopod, between rami and at base of inner basal spine. Exopod three-segmented. Endopod two-segmented, of about the same length as exopod.

P2 (Figure 4B): praecoxa as in P1. Coxa with median row of small spinules and with strong spinules close to outer distal corner anteriorly, and with some spinules close to outer distal corner posteriorly. Basis with spinules between rami and at base of endopod, and with stronger spinules at base of exopod; outer element spine-like. Exopod three-segmented and ornamented as figured. Endopod two-segmented, reaching proximal quarter of EXP 2; ENP 1 small, slightly wider than long and with outer spinules; ENP 2 with long spinules as shown, and with one outer spine, one apical and one inner seta.

P3 (Figure 5A): praecoxa and coxa as in P2. Basis as in P2 except for seta-like outer element. Exopod as in P2 except for two inner setae on P3 EXP 3. Endopod as in P2 except for comparatively shorter ENP 2.

P4 (Figure 5B): coxa and basis as in P2. Exopod as in P2, except for location of inner seta on P4 EXP 3. Endopod two-segmented, barely reaching the middle of P4 EXP 1; ENP 1 small, slightly wider than long; ENP 2 with inner and outer slender spinules and with two apical setae.

P5 (Figure 2B): exopod and baseoendopod fused. Baseoendopodal lobe about two times longer than exopod, with sets of spinules along inner and outer margin, with spinules at base of apical seta; with one outer, one apical, and four inner setae; relative length of setae as figured. Exopod with spinules as figured, with five setae plus outer seta of basis.

Armature formula of female P1–P5 as in Table I.

P6 (Figure 2A) represented by median plate in anterior half of first genital somite, each vestigial leg represented by an outer long and slender seta, and an inner minute element (indicated in Figure 2A). Copulatory pore in the middle of genital double somite.

*Male.* Unknown.

***Cletocamptus sinaloensis*** Gómez, Fleegeer, Rocha-Olivares and Foltz, 2004  
(Figures 6–13)

*Material examined*

Four females and one male preserved in alcohol, one dissected male and one dissected female, and two males and two females prepared for SEM (USNM 1010091), and one

Table I. Armature formula of female P1–P5 of *Cletocamptus nudus* sp. nov.

	P1	P2	P3	P4	P5
EXP	I-0; I-1; I,II,1	I-0; I-1; II,II,1	I-0; I-1; II,II,2	I-0; I-1; II,II,1	5
ENP	0-1; 0,II,1	0-0; I,1,1	0-0; I,1,1	0-0; 0,2,0	6

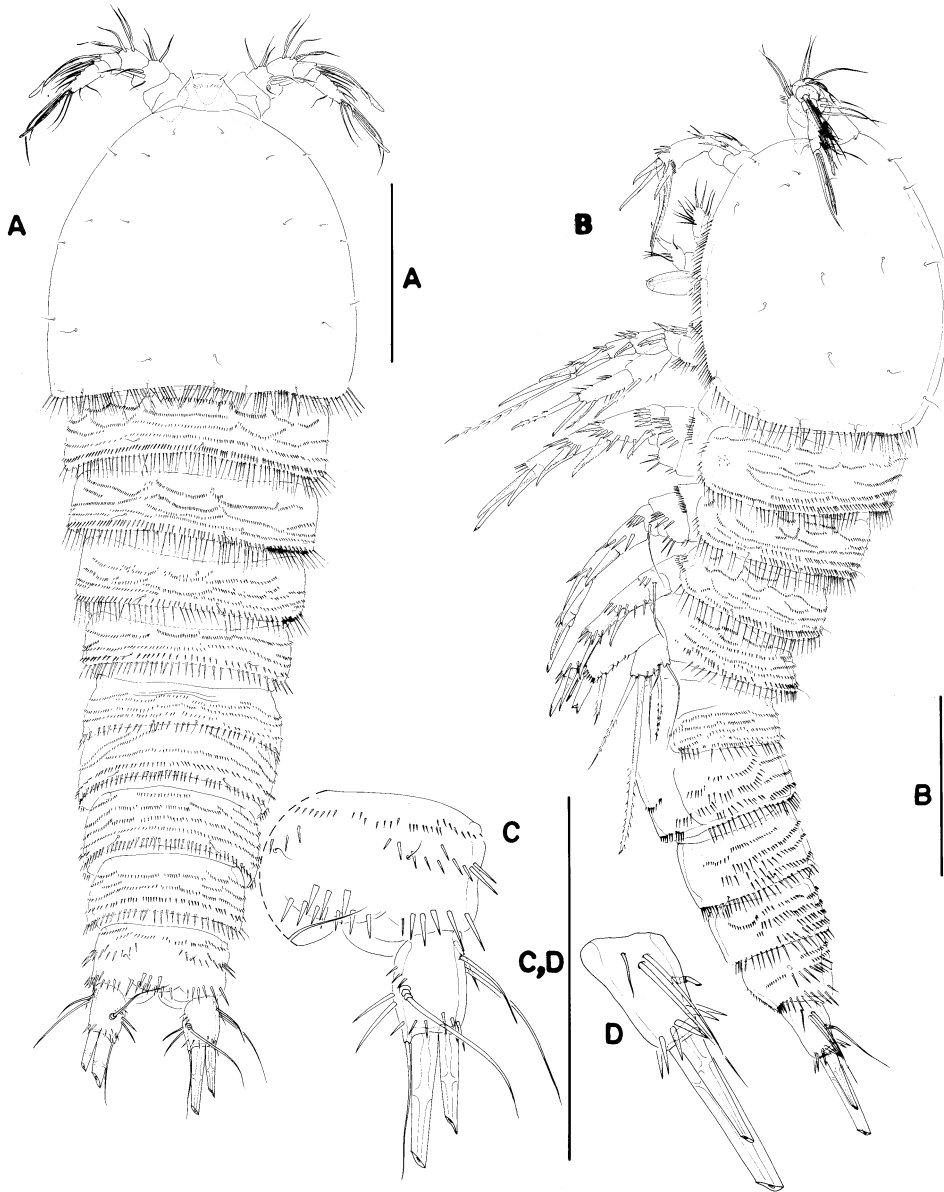


Figure 6. *Cletocamptus sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, female. (A) Habitus, dorsal; (B) habitus, lateral; (C) anal somite and right caudal ramus, dorsal; (D) left caudal ramus, lateral. Scale bars: 100  $\mu$ m.

male preserved in alcohol, one dissected female and three dissected males (USNM 242172).

#### *Distribution*

Mexico: Ensenada del Pabellón lagoon, Sinaloa ( $24^{\circ}19' - 24^{\circ}35'N$ ,  $107^{\circ}28' - 107^{\circ}45'W$ ), El Yugo estuary, Sinaloa ( $23^{\circ}18'14''N$ ,  $106^{\circ}29'W$ ), Urías system, Sinaloa ( $23^{\circ}11'06''N$ ,  $106^{\circ}25'06''W$ ); Brazil: Jansen lagoon, São Luis Island, Maranhao ( $2^{\circ}31'S$ ,  $44^{\circ}16'W$ ).

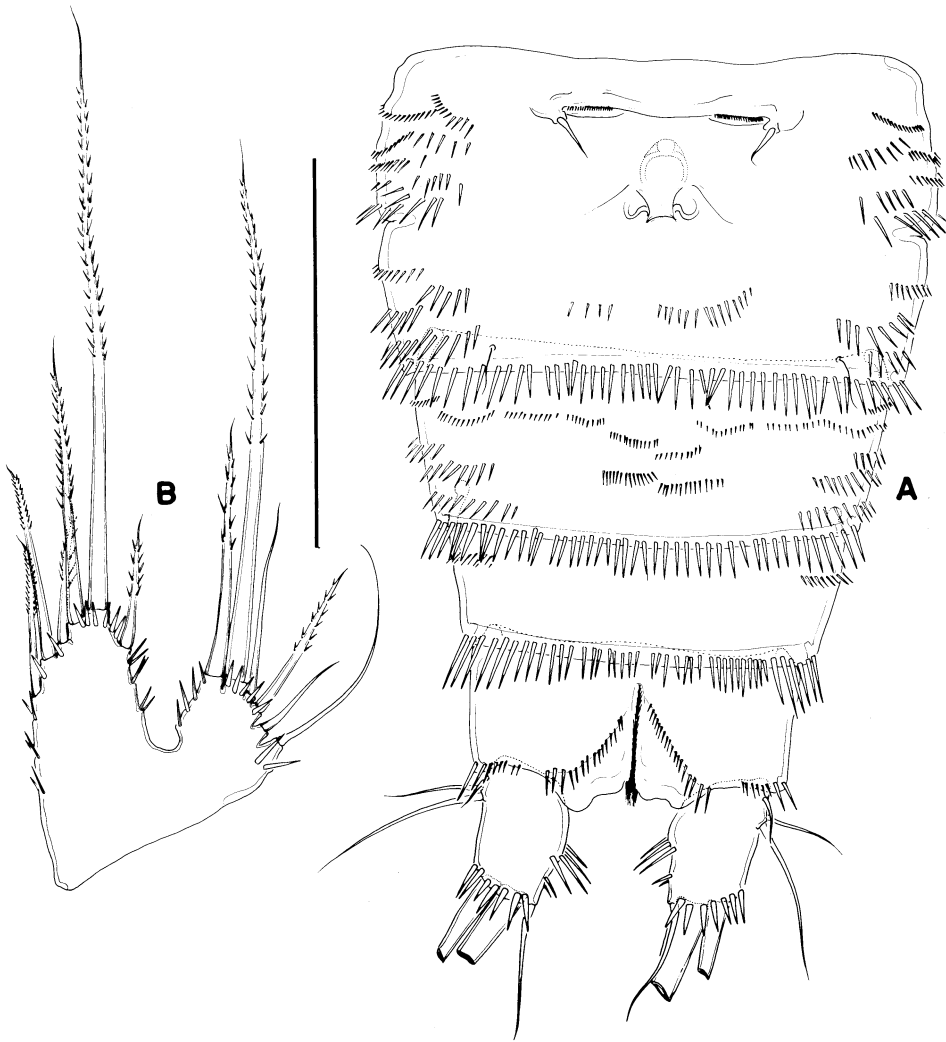


Figure 7. *Cletocamptus sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, female. (A) Urosome, ventral (P5-bearing somite omitted); (B) P5. Scale bar: 100  $\mu\text{m}$ .

### Description

The material presented herein matches the description of *C. sinaloensis* given by Gómez et al. (2004). The body length of the Brazilian material (from 450 to 640  $\mu\text{m}$ ; mean 569  $\mu\text{m}$ ,  $n=7$ ) falls within the range reported earlier by Gómez et al. (2004) (from 510 to 750  $\mu\text{m}$ ; mean 658  $\mu\text{m}$ ,  $n=11$ ). The detailed description of *Cletocamptus* specimens is necessary for a correct identification and species separation. Lack of detail and careless descriptions of *Cletocamptus* species attributed to *C. deitersi* worldwide have obliged several authors to establish synonymies based on poor descriptions. In order to strongly support the assignation of the Brazilian material to *C. sinaloensis*, the female (Figure 6A, B) and male habitus (Figure 11A, B), female (Figure 6C, D) and male caudal rami (Figure 11A, B,

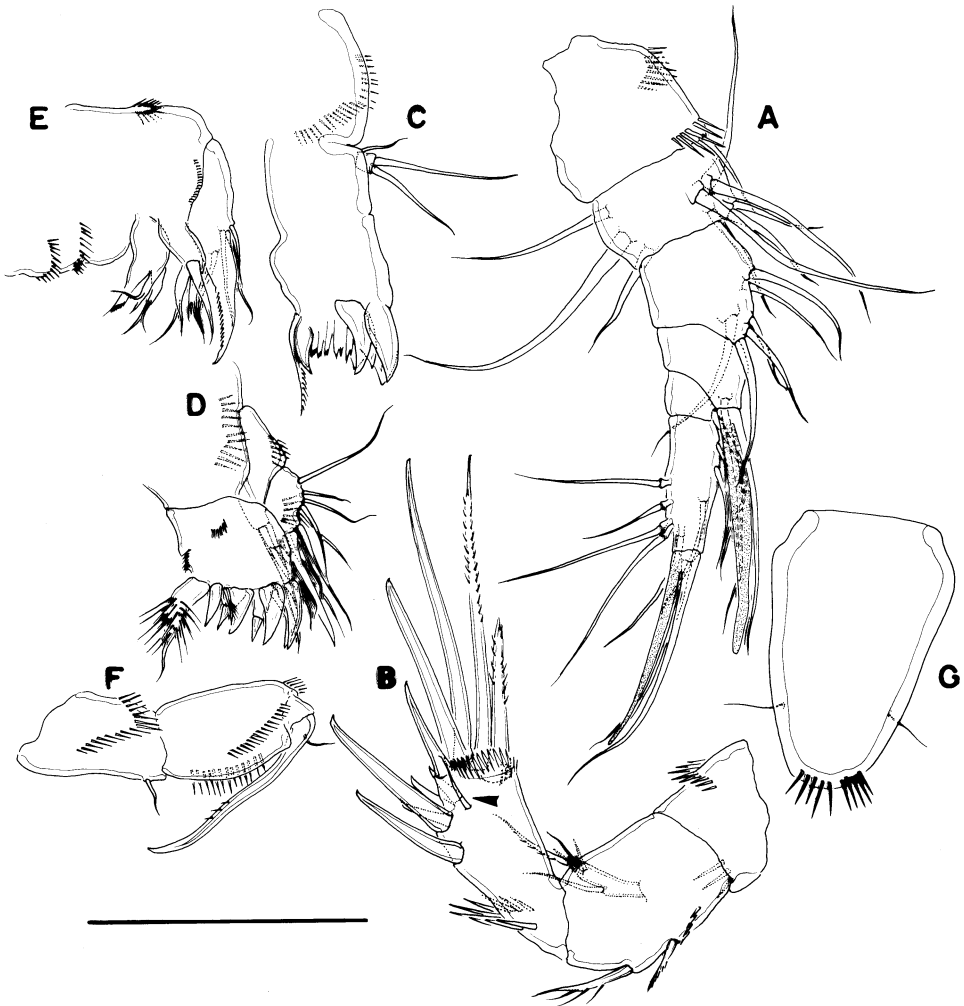


Figure 8. *Cletocamptus sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, female. (A) Antennule; (B) antenna; (C) mandible; (D) maxillule; (E) maxilla; (F) maxilliped; (G) rostrum. Scale bar: 100  $\mu$ m.

D), ventral view of the female (Figure 7A) and male urosome (Figure 11D); female mouth parts (Figure 8A–F), male A1 (Figure 12A), female P1–P5 (Figures 7B, 9A, B, 10A, B), and male P1–P6 (Figures 11C, D, 12B, C, 13A–C) of *Cletocamptus sinaloensis* from Jansen Lagoon are illustrated in detail. The written description has been given elsewhere (Gómez et al. 2004) and it is not presented here.

#### Variability

*Male.* Two males (USNM 242172) possess a minute seta on each P6 (see Figure 11D).

*Female.* USNM 242172 possesses two inner setae on the second exopodal segment of left P2; the setae of P6 of another paratype are somewhat longer (not shown).

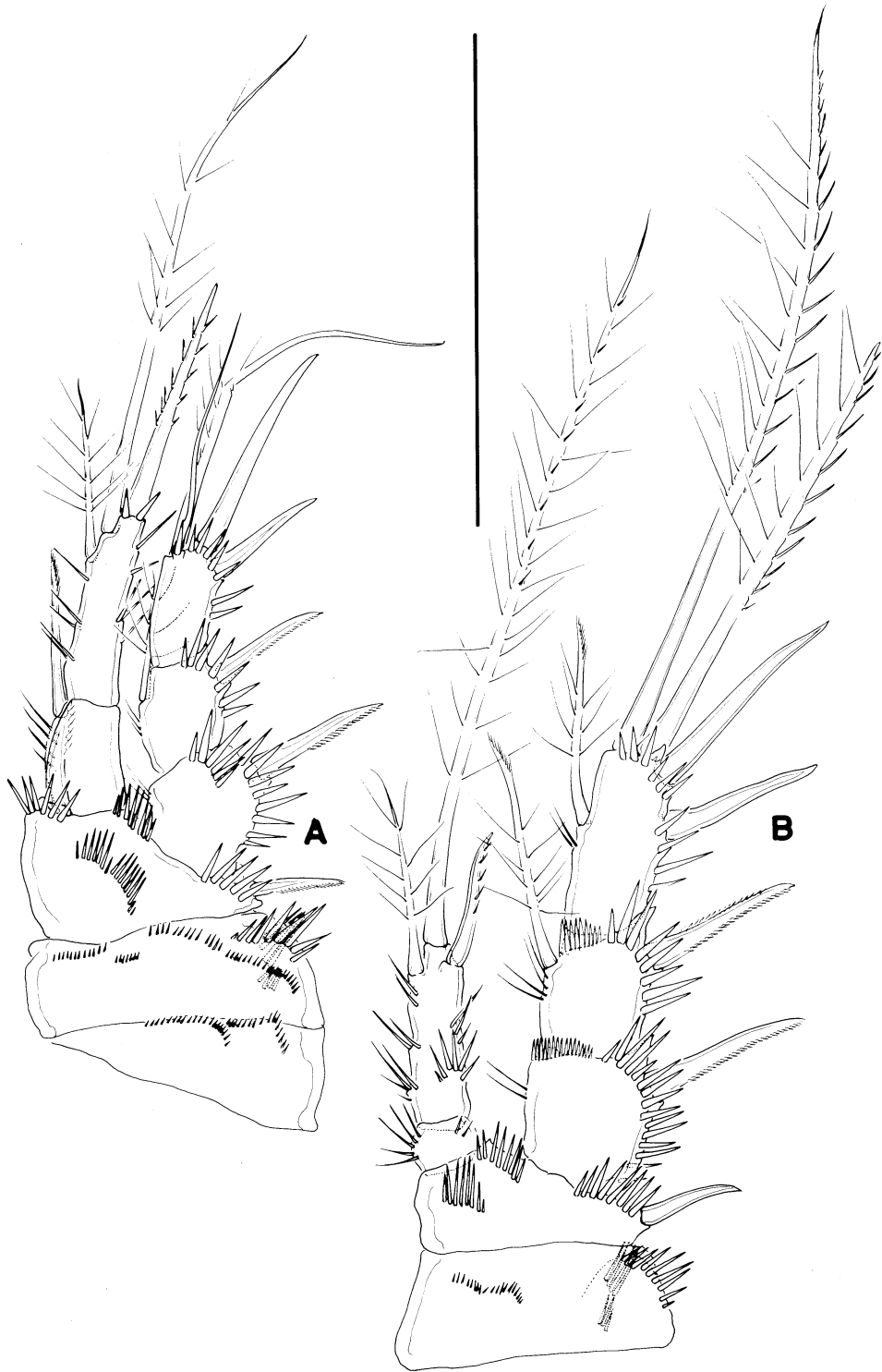


Figure 9. *Cletocamptus sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, female. (A) P1; (B) P2. Scale bar: 100  $\mu$ m.



Figure 10. *Cletocamptus sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, female. (A) P3; (B) P4. Scale bar: 100  $\mu$ m.

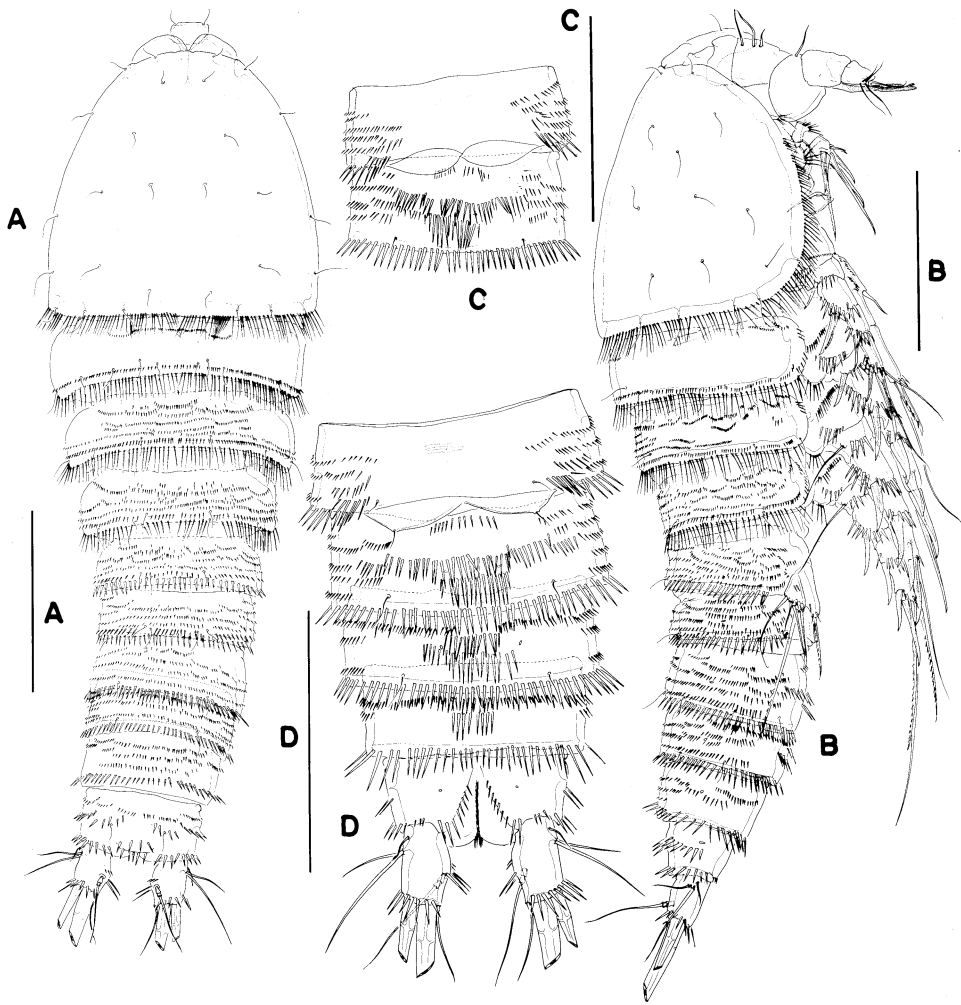


Figure 11. *Cletocamptus sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, male. (A) Habitus, dorsal; (B) habitus, lateral; (C) P6 and third urosomite, ventral; (D) urosome (P5-bearing somite omitted) showing P6 with small seta. Scale bars: 100  $\mu$ m.

***Cletocamptus levis* sp. nov.**  
(Figures 14–25)

*Type material*

One female holotype (MZUSP 16669) preserved in alcohol, one male allotype dissected and mounted on to four slides (MZUSP 16670), four female dissected paratypes (MZUSP 16671, MZUSP 16675, MZUSP 16673, MZUSP 16674), and seven female paratypes preserved in alcohol (MZUSP 16672), 3 October, 1998, coll. Guilherme Lotufo.

*Type locality*

Cananéia, São Paulo, Brazil (25°01'S, 47°57'W).



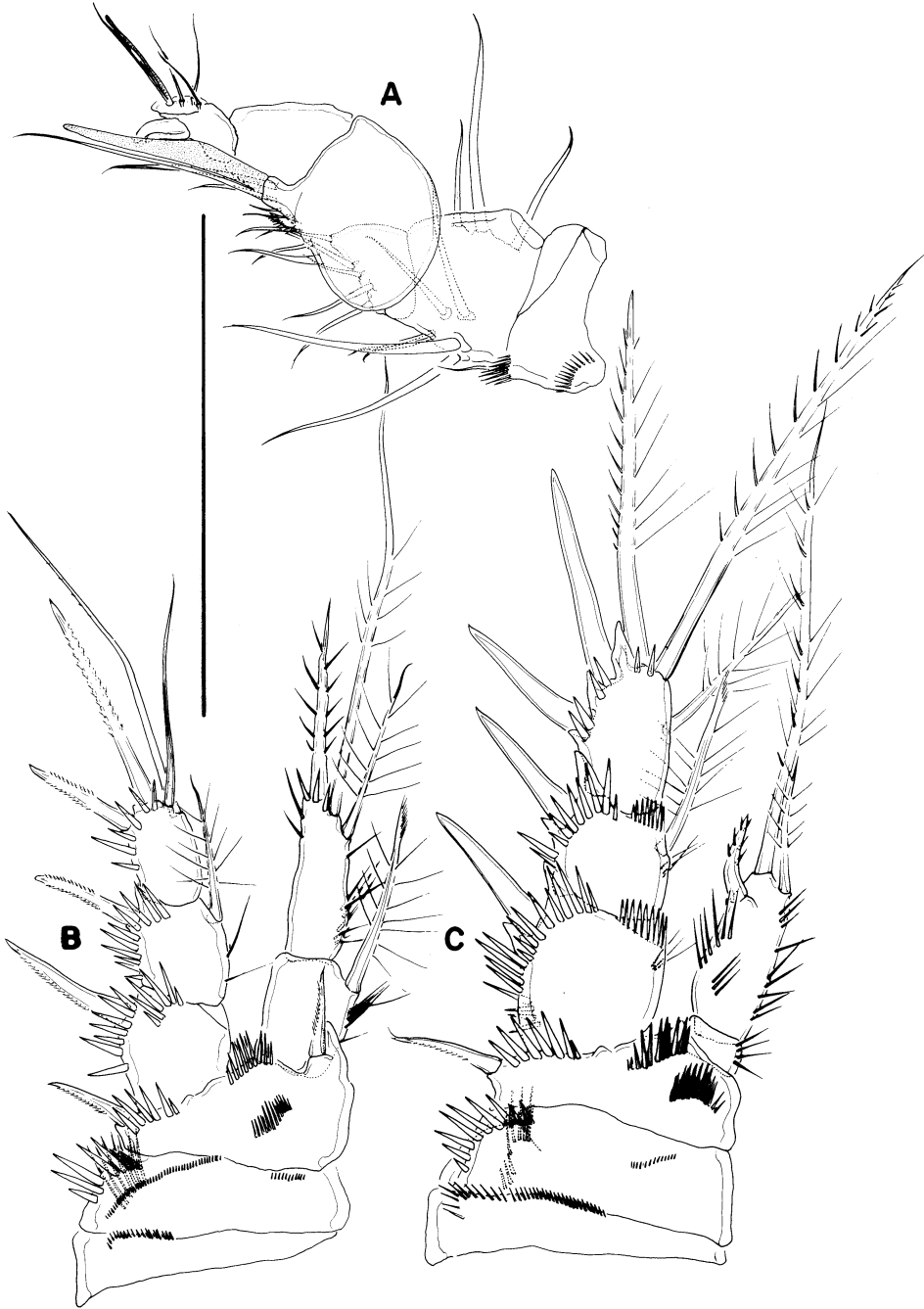


Figure 12. *Cletocampus sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, male. (A) Antennule; (B) P1; (C) P2. Scale bar: 100  $\mu\text{m}$ .

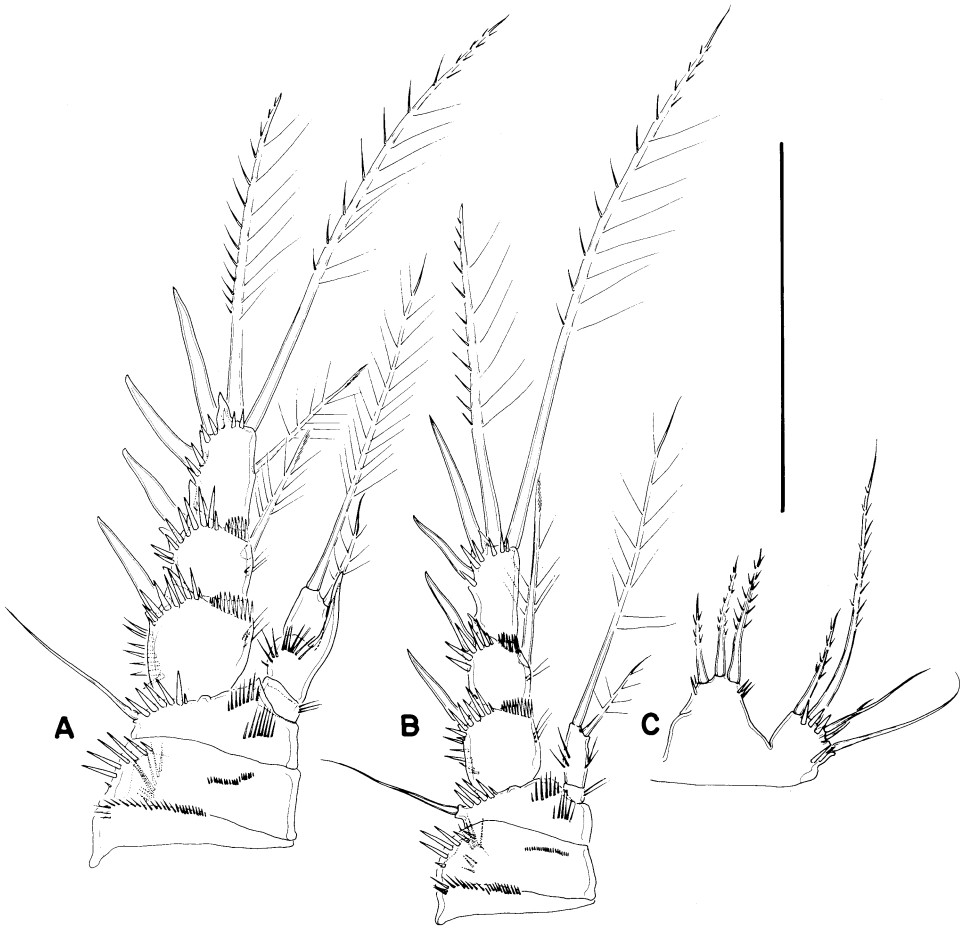


Figure 13. *Cletocamptus sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, female. (A) P3; (B) P4; (C) P5. Scale bar: 100  $\mu$ m.

#### *Etymology*

The specific epithet refers to the variation in spinular ornamentation of the body somites and anal operculum.

#### *Description*

*Female.* Habitus (Figures 14A, B, 15A, 16A) tapering posteriorly; total body length measured from tip of rostrum to posterior margin of caudal rami ranging from 500 to 680  $\mu$ m (mean 588  $\mu$ m,  $n=10$ ; holotype 585  $\mu$ m). Rostrum (Figure 18G) defined at base, triangular, with pair of setules subapically and with small spinules distally. Cephalic shield with long, fine spinules along lateral margin (Figures 14B, 16A), and without (Figure 14A) or with smaller spinules along posterior dorsal and dorsolateral margin (Figures 15A, 16A). Dorsal and lateral spinular ornamentation of free thoracic somites (P2–P4-bearing somites) as in Figures 14A, B, 15A or 16A, B. Dorsal and lateral surface of first urosomite (P5-bearing somite) ornamented as in Figures 14A, B, 15A, B, 16A, B. Genital somite with

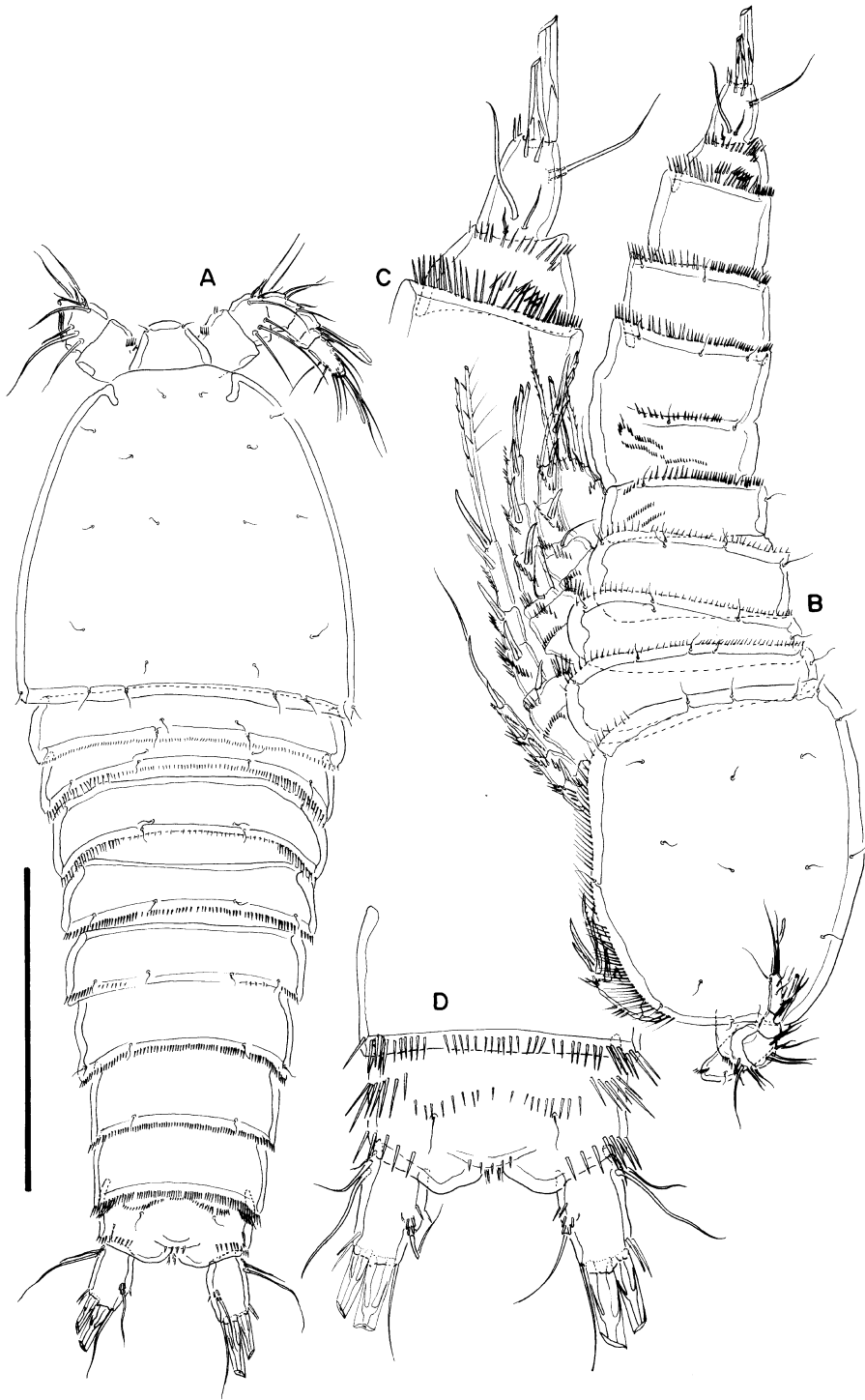


Figure 14. *Cletocampus levis* sp. nov., female. (A) Habitus, dorsal; (B) habitus, lateral; (C) anal somite and right caudal ramus, lateral; (D) anal somite and caudal rami, dorsal. Scale bar: 167  $\mu\text{m}$  (A, B); 100  $\mu\text{m}$  (C, D).

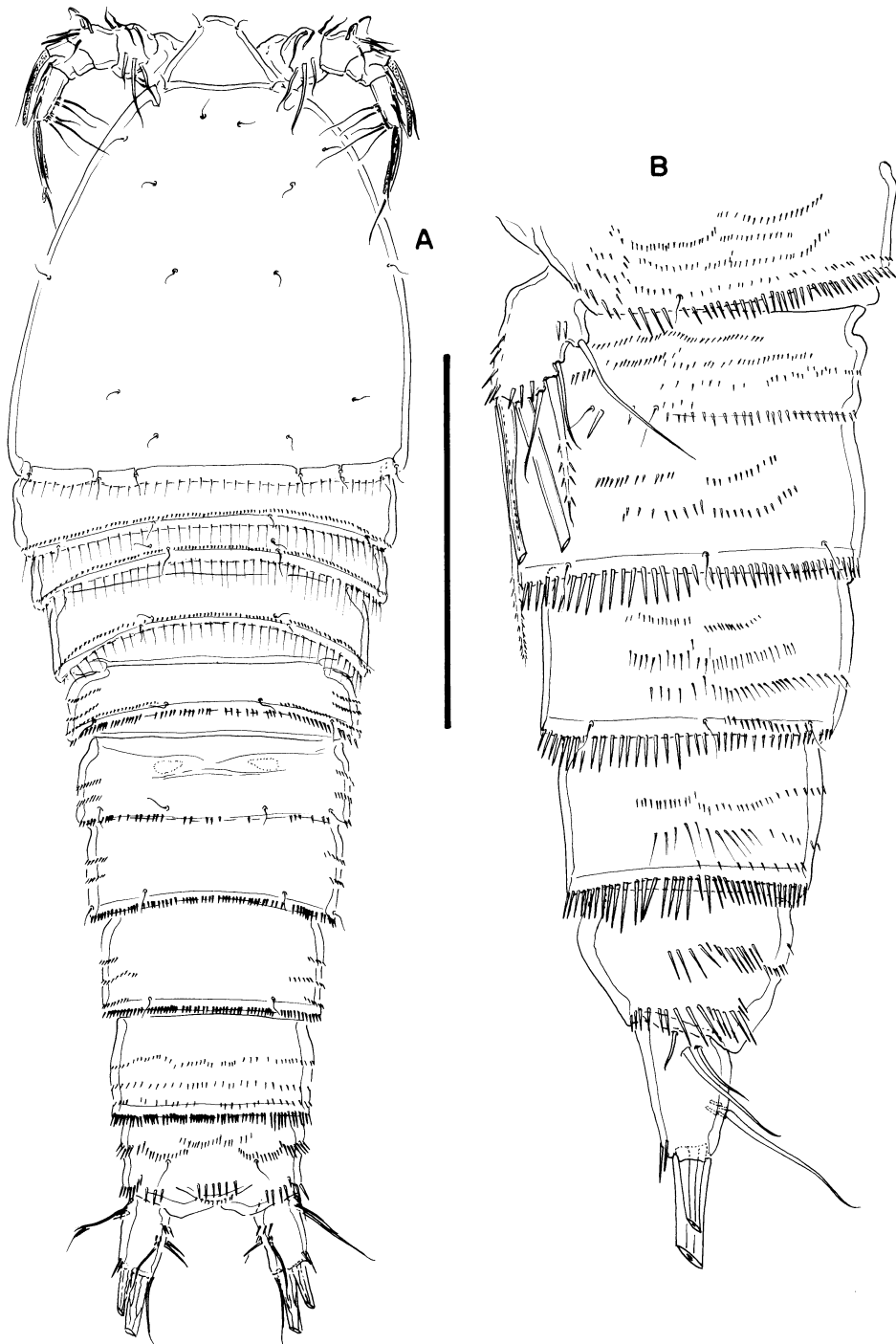


Figure 15. *Cletocamptus levis* sp. nov., female. (A) Habitus, dorsal; (B) urosome, lateral. Scale bar: 167  $\mu\text{m}$  (A); 100  $\mu\text{m}$  (B).

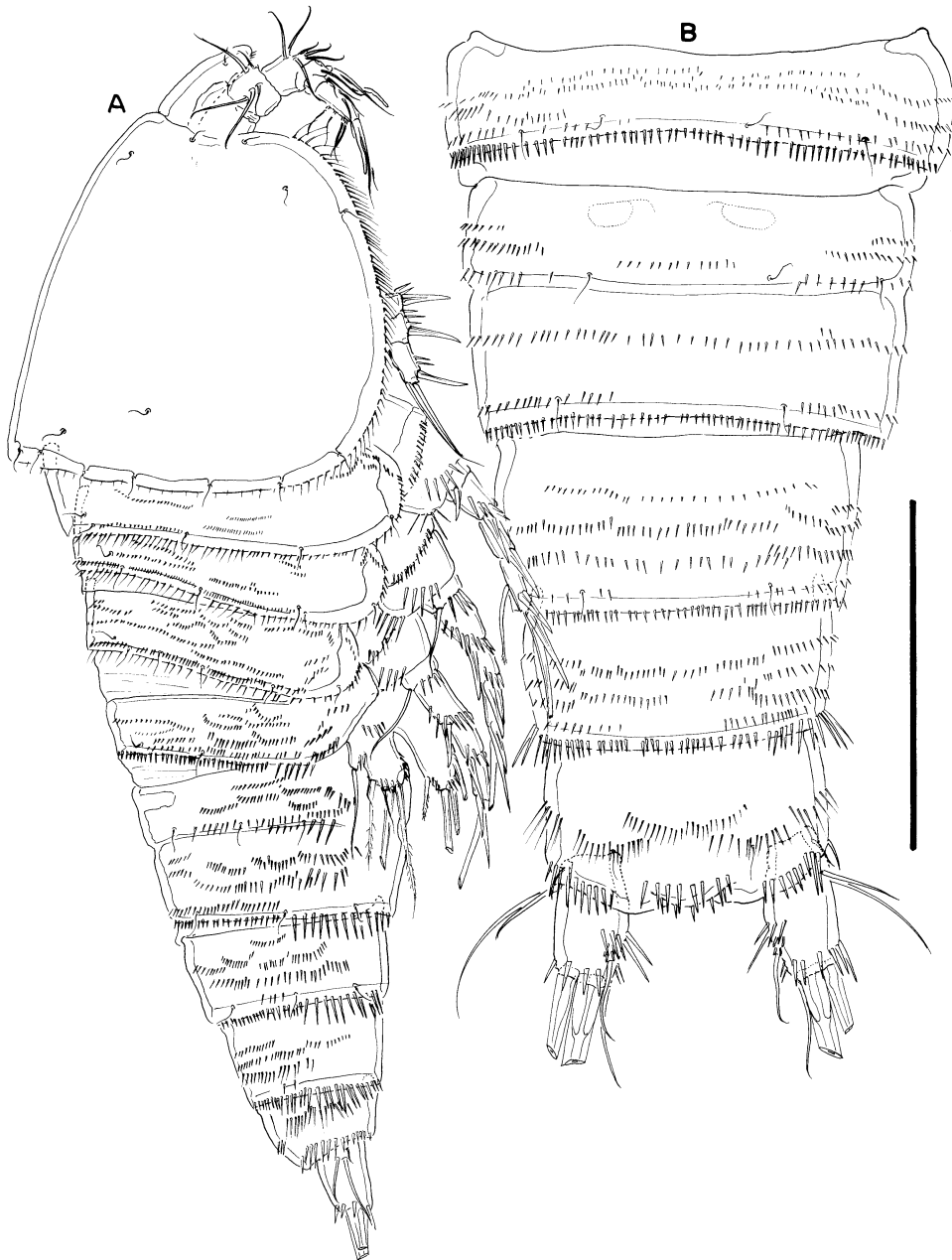


Figure 16. *Cletocamptus levis* sp. nov., female. (A) Habitus, lateral; (B) urosome, dorsal. Scale bar: 167  $\mu\text{m}$  (A); 100  $\mu\text{m}$  (B).

subcuticular rib dorsally and laterally indicating former division between first and second genital somites (Figures 14A, B, 15A, B, 16A, B), but completely fused ventrally (Figure 17A). Dorsal and lateral surface ornamentation of first and second genital somites, and fourth and fifth urosomites variable (Figures 14A, B, 15A, B, 16A, B). Dorsal surface of anal somite with transverse spinule rows (Figures 14A, D, 15A, 16B);

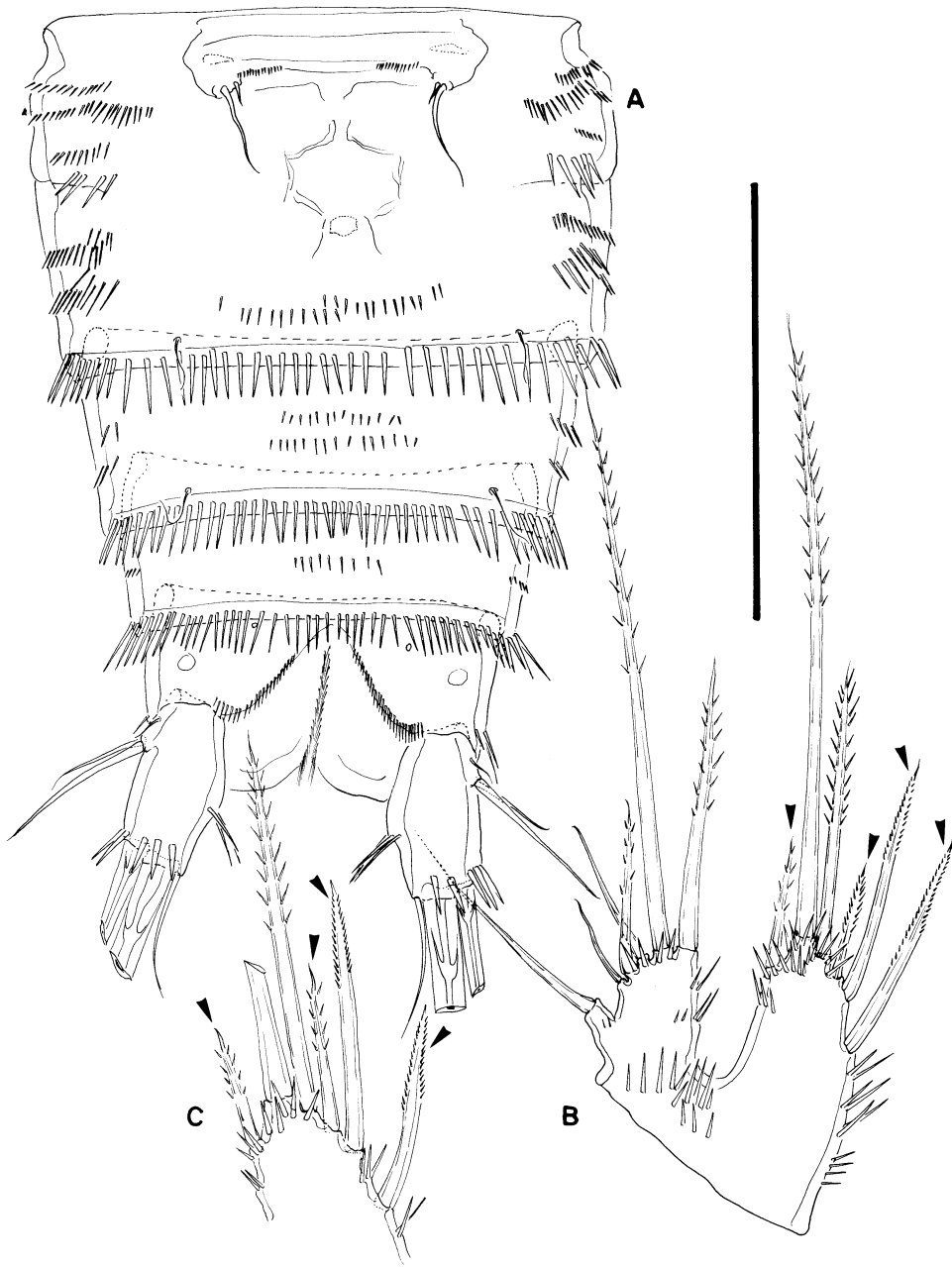


Figure 17. *Cletocamptus levis* sp. nov., female. (A) Urosome, ventral; (B) P5; (C) baseendopodal lobe of P5, another specimen. Scale bar: 100  $\mu\text{m}$  (A, B); 85  $\mu\text{m}$  (C).

rounded anal operculum with variable number of spinules (see Figures 14A, D, 15A, 16A). Caudal rami (Figures 14A–D, 15A, B, 16A, B, 17A) about 1.5 times longer than wide; dorsal surface smooth, except for some small spinules close to insertion of seta VII (Figures 14A, D, 15A, 16B); with (Figure 16B) or without (Figures 14A, B, 15A) spinules close to posterior margin dorsally; with spinules close to posterior margin ventrally; without

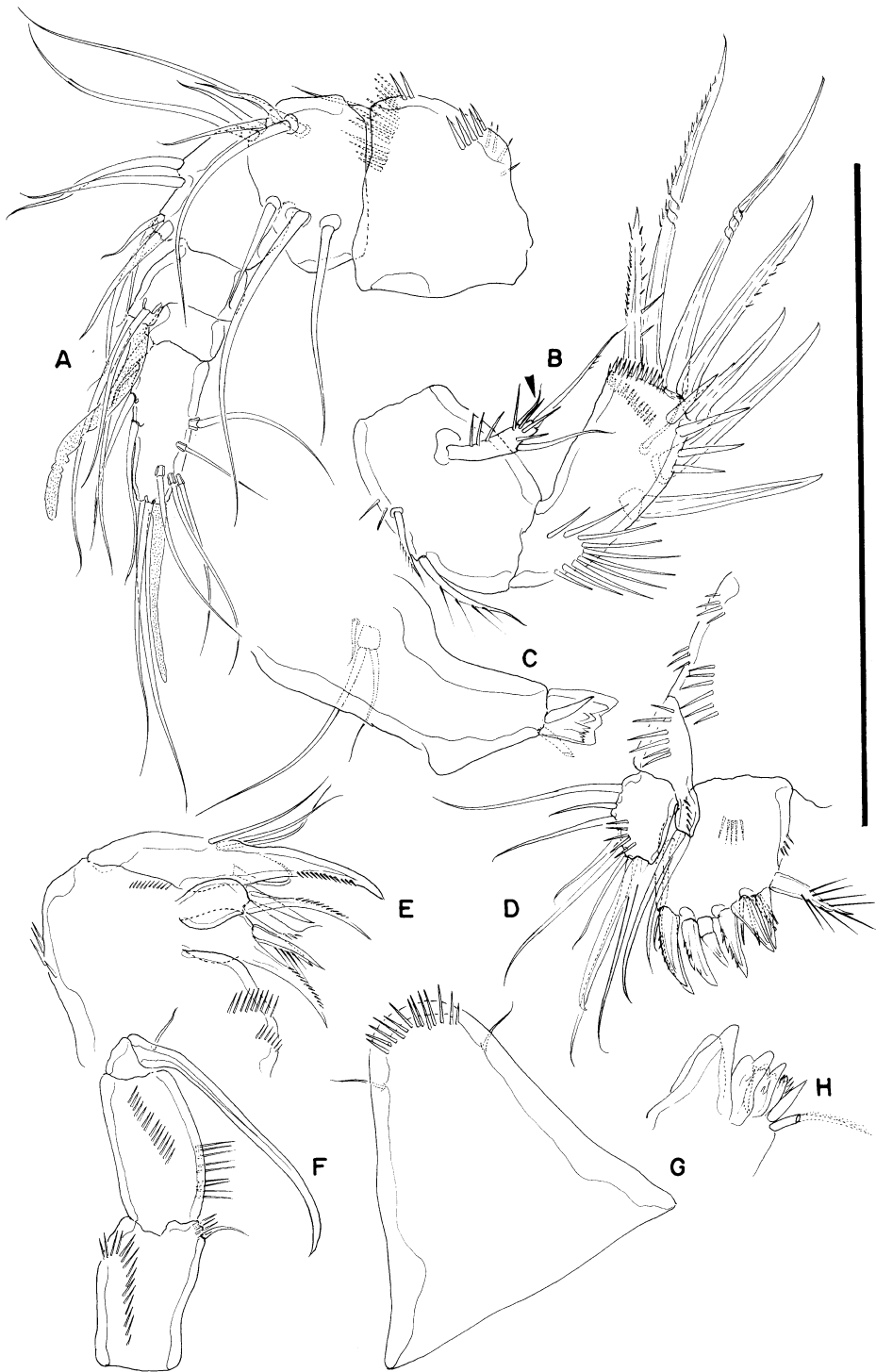


Figure 18. *Cletocampus levis* sp. nov., female. (A) Antennule; (B) antenna; (C) mandible; (D) maxillule; (E) maxilla; (F) maxilliped; (G) rostrum; (H) chewing edge of mandible, another view. Scale bar: 100  $\mu$ m.



Figure 19. *Cletocamptus levis* sp. nov., female. (A) P1; (B) P2. Scale bar: 100  $\mu$ m.



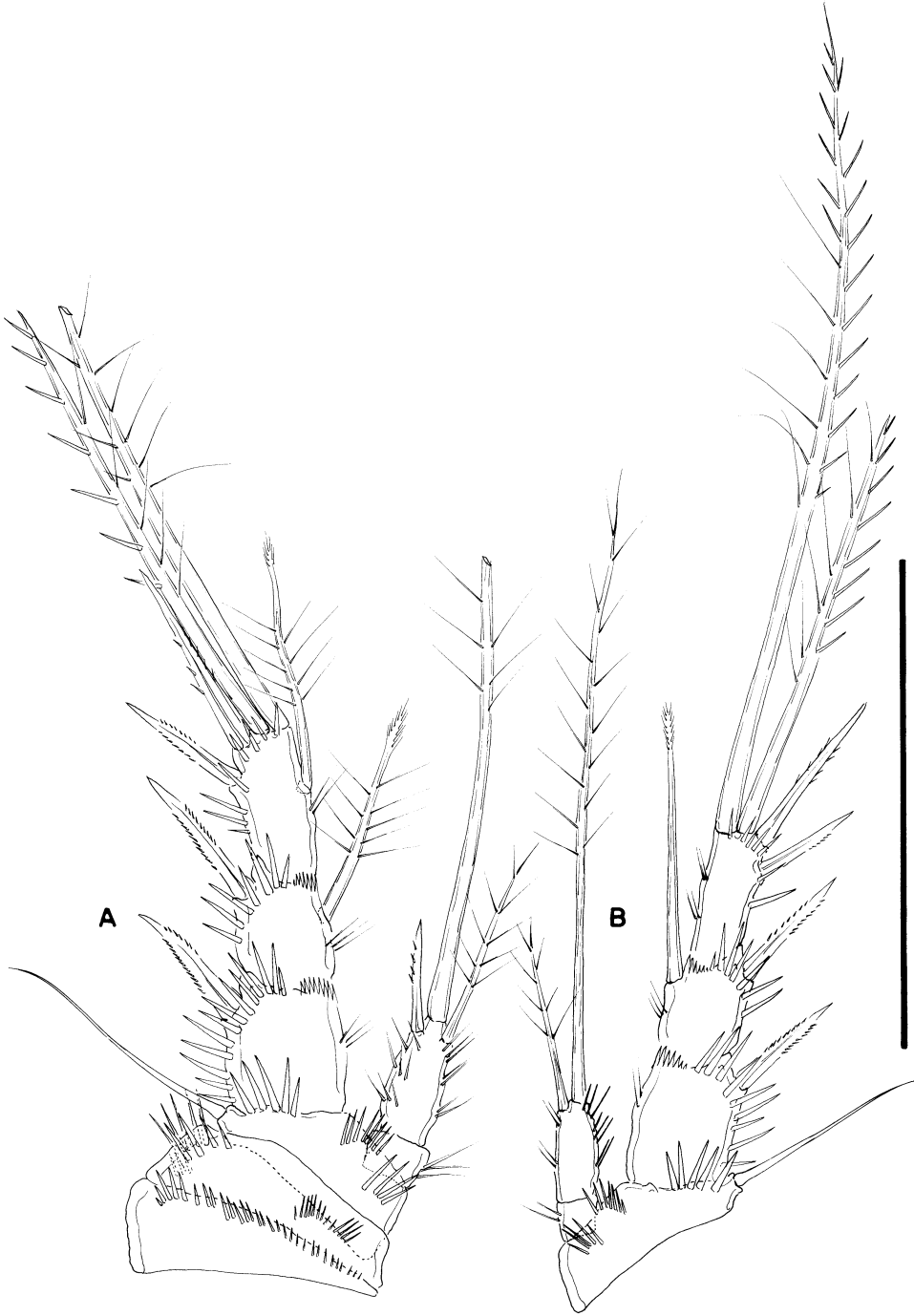


Figure 20. *Cletocamptus levis* sp. nov., female. (A) P3; (B) P4. Scale bar: 100  $\mu$ m.

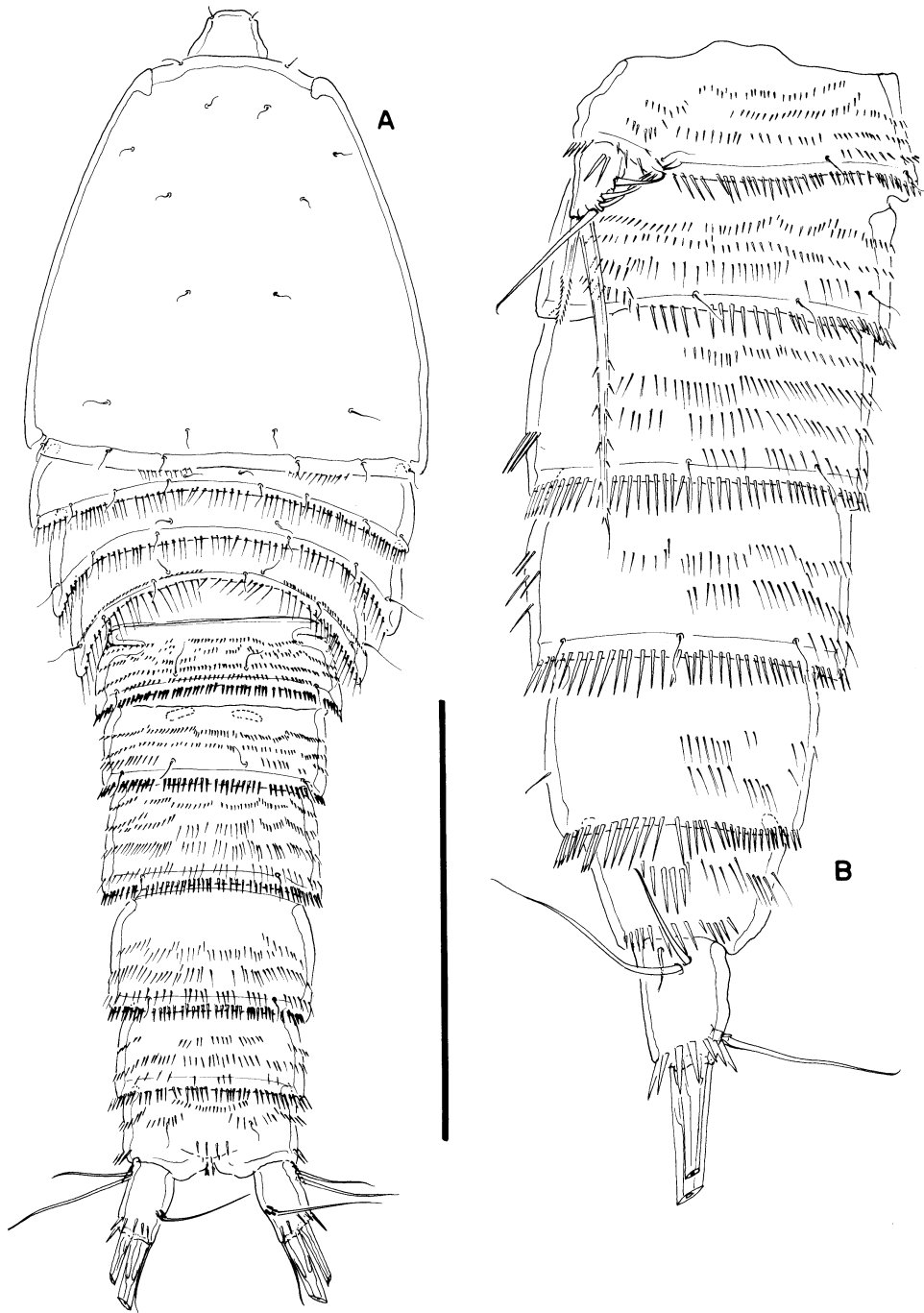


Figure 21. *Cletocamptus levis* sp. nov., male. (A) Habitus, dorsal; (B) urosome, lateral. Scale bar: 200  $\mu\text{m}$  (A); 86  $\mu\text{m}$  (B).

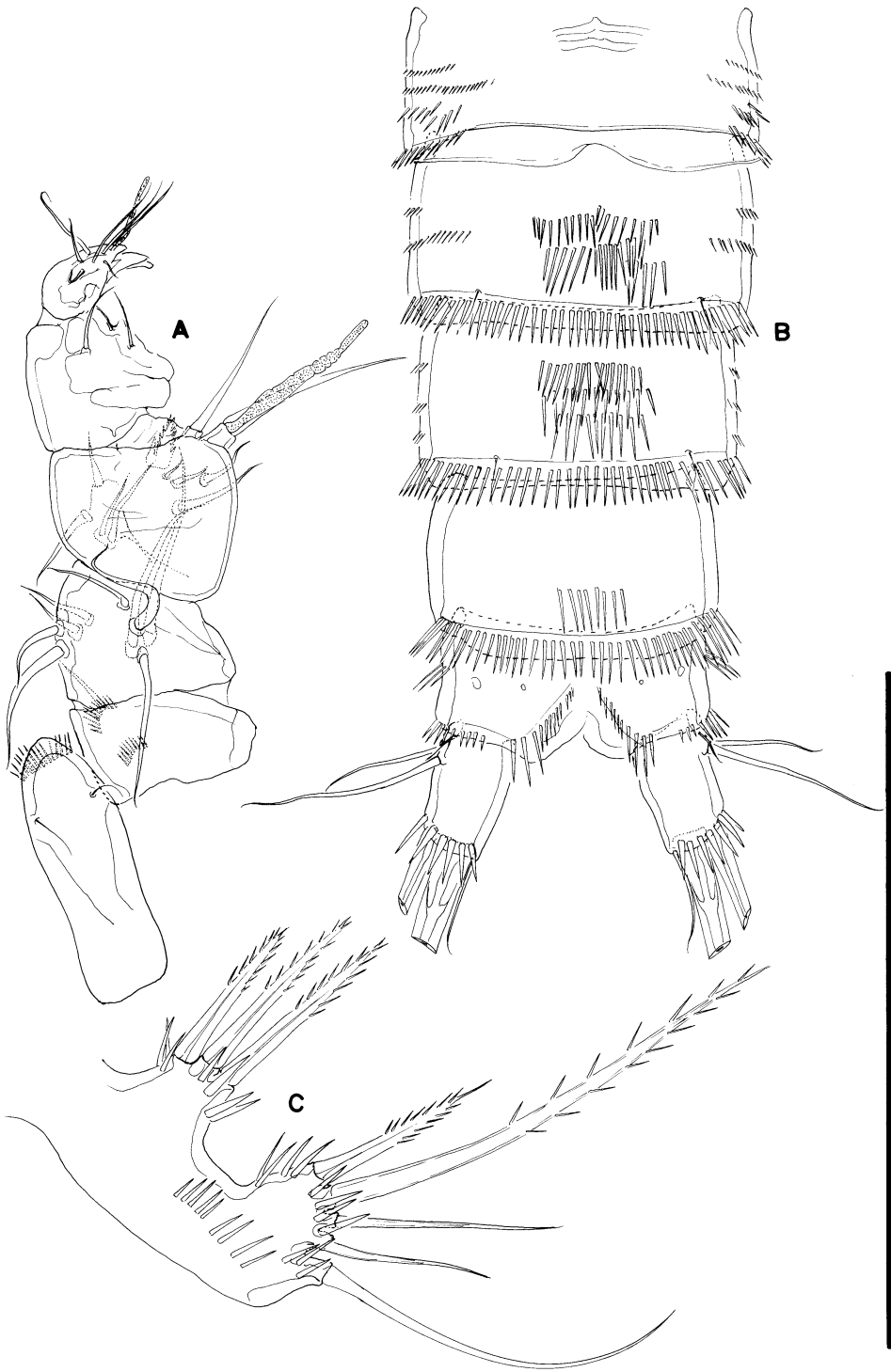


Figure 22. *Cletocamptus levis* sp. nov., male. (A) Antennule; (B) urosome, ventral (P5-bearing somite omitted); (C) P5. Scale bar: 143  $\mu$ m (A); 167  $\mu$ m (B); 100  $\mu$ m (C).

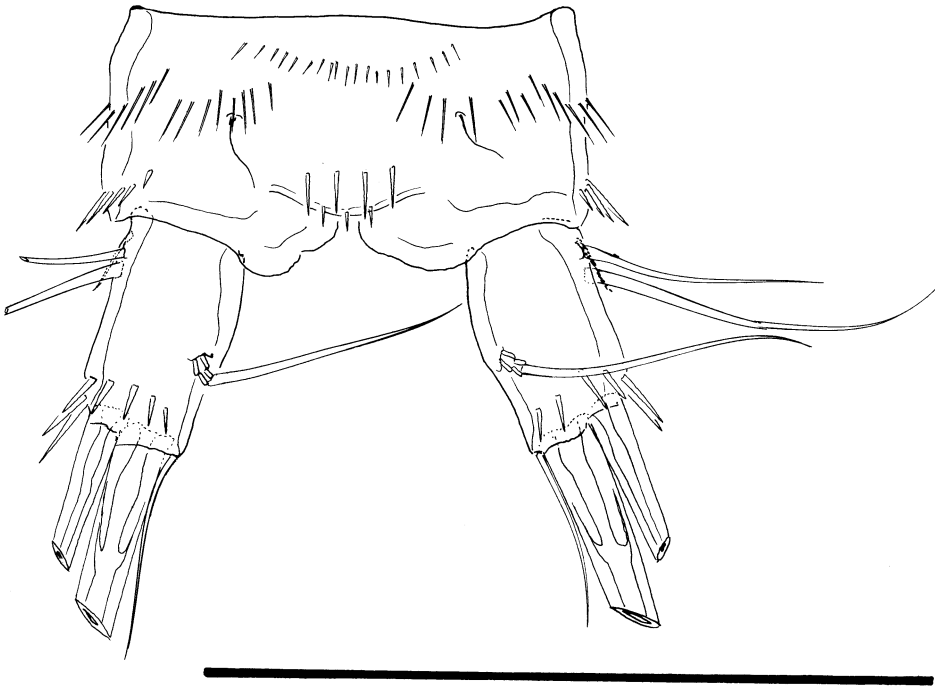


Figure 23. *Cletocamptus levis* sp. nov., male. Anal somite and caudal rami, dorsal. Scale bar: 100  $\mu$ m.

(Figure 14A, D) or with (Figures 15A, 16B, 17A) long spinules medially on inner margin of caudal rami; with seven setae.

Antennule (Figure 18A) six-segmented; surface of segments smooth except for two rows of spinules on first segment. Armature formula, 1-(1), 2-(9), 3-(6), 4-(1 + [1 + ae]), 5-(1), 6-(9 + [1 + ae]).

Antenna (Figure 18B): allobasis with two abexopodal setae. Free endopodal segment with inner strong spinules proximally and subdistally; with two lateral inner spines and a slender seta (the latter indicated in Figure 18B), and five distal elements. Exopod one-segmented; about seven times longer than wide; with few spinules, and with one inner, one outer (arrowed in Figure 18B) and one apical seta.

Mandible (Figure 18C, H) robust; chewing edge with bicuspidate teeth, four (or five?) multicuspidate teeth, one pyriform element and one lateral seta. Palp (Figure 18C) one-segmented, with two long setae unequal in length and one small seta arising nearby.

Maxillule (Figure 18D) robust; arthrite of praecoxa with few spinules, one surface seta, seven distal spines and one lateral strong seta, the latter spinulose. Coxa with some spinules and with two slender setae. Basis with some median spinules and three apical setae; exopod and endopod represented by three setae each.

Maxilla (Figure 18E): syncoxa with minute spinules along inner and outer margin and close to joint with allobasis; with two endites, each bearing three setae. Allobasis drawn into strong claw bearing one accompanying seta. Endopod represented by three setae.

Maxilliped (Figure 18F) subchelate. Syncoxa with row of spinules and a small seta on inner distal corner. Basis without armature and with one anterior and one posterior longitudinal spinule row. Endopod drawn into long and slender claw with one accompanying small seta.



Figure 24. *Cletocampus levis* sp. nov., male. (A) P1; (B) P2. Scale bar: 100  $\mu$ m.

P1 (Figure 19A): praecoxa with spinules close to joint with coxa. The latter with anterior transverse spinule rows and with spinules in outer distal corner posteriorly. Basis with median spinule row and with stronger spinules at base of exopod, between rami and at base of inner basal spine. Exopod three-segmented. Endopod two-segmented, ENP 2 reaching the middle of EXP 3.

P2 (Figure 19B): praecoxa as in P1. Coxa with median row of small spinules and with strong spinules close to outer distal corner anteriorly, and with some spinules close to outer



Figure 25. *Cletocamptus levis* sp. nov., male. (A) P3; (B) P4. Scale bar: 100  $\mu$ m.

distal corner posteriorly. Basis with spinules between rami and at base of endopod and with stronger spinules at base of exopod; outer element spine-like. Exopod three-segmented and ornamented as figured. Endopod two-segmented, reaching tip of EXP 1; ENP 1 small, slightly wider than long; ENP 2 with long spinules as figured and with one outer spine, one apical and one inner seta.

P3 (Figure 20A): praecoxa and coxa as in P2. Basis as in P2 except for seta-like outer element. Exopod as in P2. Endopod as in P2 except for comparatively shorter ENP 2.

P4 (Figure 20B): basis as in P2. Exopod as in P2, except for lack of inner seta on EXP 3. Endopod two-segmented, barely reaching the middle of EXP 1; ENP 1 small, slightly wider than long; ENP 2 with inner and outer slender spinules and two apical setae.

P5 (Figure 17B, C): exopod and baseopod fused. Exopodal lobe reaching insertion site of outermost baseopodal seta; baseopodal lobe with spinule patches along inner and outer margin, with spinules at base of apical and subapical setae; with one outer, one apical, and four inner setae; relative length of setae variable (compare relative length of arrowed setae on Figure 17B, C). Exopod with spinules as figured and with five setae plus outer seta of basis.

Armature formula of female P1–P5 as in Table II.

P6 (Figure 17A) represented by median plate in anterior half of first genital somite, each vestigial leg represented by a long and slender outer seta and a minute inner element. Copulatory pore in the middle of genital double somite.

*Male.* General body shape (Figure 21A) as in female except for genital-double somite. Lateral margin of cephalic shield with long, slender spinules; with few small spinules along posterior margin dorsally. Rostrum (see Figure 22A) sexually dimorphic, more slender than in female. Prosomites (P2–P4-bearing somites) smooth dorsally (as in the female shown in Figure 15A), except for long, slender spinules along posterior margin and for transverse row of minute spinules close to posterior margin of P4-bearing somite. First to fifth urosomites (Figure 21A, B) with transverse spinule rows as in the female (see Figure 16A, B). Third and fourth urosomites with strong spinules ventrally; fifth urosomite with one transverse row of strong spinules ventrally (Figure 22B). Anal somite (Figures 21A, B, 22B, 23) as in female; anal operculum with some dorsal spinules and comparatively smaller spinules along posterior margin (as in the female shown in Figure 15A). Caudal rami (Figures 21A, B, 22B, 23) as in female.

Antennule (Figure 22A) six-segmented; subchirocer. Last segment with two acute teeth.

Antenna, mandible, maxillule, maxilla and maxilliped (not shown) as in female.

P1 (Figure 24A) as in female, except for dimorphic inner projection and slender inner spine of basis, ornamentation of the outer seta of ENP 2 (with spinules in the female, but with setules in the male) and relative length of apical seta of ENP 2 (nearly three times as long as supporting ramus in the female, but less than two times as long as supporting ramus in the male).

P2 (Figure 24B) as in female except for dimorphic (slightly stronger) inner spine on ENP 2 and comparatively stronger outer spines of exopod.

P3 (Figure 25A): exopod as in female except for comparatively stronger outer spines. Endopod three-segmented; ENP 1 as in female; ENP 2 with strong spinules, with inner apophysis reaching far beyond ENP 3, the latter with two setae.

P4 (Figure 25B) as in female except for comparatively stronger outer exopodal spines.

Table II. Armature formula of female P1–P5 of *Cletocamptus levis* sp. nov.

	P1	P2	P3	P4	P5
EXP	I-0; I-1; I,I,1	I-0; I-1; II,I,1	I-0; I-1; II,I,1	I-0; I-1; II,I,0	5
ENP	0-1; 0,I,1	0-0; I,1,1	0-0; I,1,1	0-0; 0,2,0	6

P5 (Figure 22C): both P5 fused; exopodal and baseopodal lobes fused; the former with transverse row of strong spinules at its base and along inner and outer margin, with four setae plus outer seta of basis. Baseopodal lobe with strong spinules subdistally and apically and with three elements.

P6 (Figure 22B) represented by a plate, without armature.

## Discussion

At present the valid species within *Cletocamptus* are *C. retrogressus* Schmankeiwitsch, 1875, *C. confluens* (Schmeil, 1894), *C. albuquerqueensis* (Herrick, 1894), *C. trichotus* Kiefer, 1929, *C. feei* (Shen, 1956), *C. affinis* Kiefer, 1957, *C. gravihatus* (Shen and Sung, 1963), *C. helobius* Fleeger, 1980, *C. merbokensis* Gee, 1999, *C. axi* Mielke, 2000, *C. schmidtii* Mielke, 2000, *C. deborahdexterae* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, *C. stimpsoni* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, *C. sinaloensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004, and *C. fourchensis* Gómez, Fleeger, Rocha-Olivares and Foltz, 2004. Gómez et al. (2004) considered as *species inquirendae* some species within the genus and they also considered as doubtful some records of *C. deitersi*. Additional doubtful records of *C. deitersi* are those of Brehm (1936, 1965), Chappuis (1936), Ringuet (1958a, 1958b, 1960, 1962), Ringuet et al. (1965), Oliveira and Miranda (1971), Apostolov (1984), Ruber et al. (1994), and Loftus and Reid (2000).

To the best of my knowledge, only *C. trichotus*, *C. feei*, *C. affinis*, *C. gravihatus*, *C. helobius*, *C. axi*, *C. schmidtii*, *C. merbokensis*, *C. deborahdexterae*, *C. stimpsoni*, *C. sinaloensis*, and *C. fourchensis* have been reported only from or near their type localities. *Cletocamptus confluens*, *C. retrogressus*, and *C. albuquerqueensis* have been reported repeatedly from distant localities (for a list of references see Mielke 2000b, p 138–139 for *C. confluens*, Mielke 2001, p 6–8 for *C. retrogressus*, and Herrick 1894, Pallares 1962, Chappuis 1933, Lang 1948, p 1278, and Brehm 1954 for *C. albuquerqueensis*). *Cletocamptus affinis* was described from Turkey in 1957, and later a new subspecies, *C. affinis mongolicus* Stěrba, 1968, was described from Mongolia. Stěrba (1968, p 67) noticed a number of differences between his *C. affinis mongolicus* and Kiefer's *C. affinis*: ventral spinular ornamentation of female urosome, number of setae on the caudal rami, and number and relative size of the setae on P1 ENP 1 (similar to *C. feei*, *C. gravihatus*, and *C. helobius* in that P1 ENP 1 lacks the inner seta) and P3 ENP 2 (similar to *C. stimpsoni* in the number of setae). On the basis of current research it is suggested to elevate *C. affinis mongolicus* Stěrba, 1968 to full species rank as *Cletocamptus mongolicus* Stěrba, 1968.

Based on erroneous identifications of *Cletocamptus* species worldwide, *C. deitersi* was supposed to be a cosmopolitan species distributed in North, Central, and South America as well as in India, China, Ethiopia, Hawaii, Australia, Iran, and Malaysia (see Gómez et al. 2004 for a list of references). However, recent studies (Rocha-Olivares et al. 2001; Castro-Longoria et al. 2003; Gómez et al. 2004) have partially proved that its alleged cosmopolitan distribution is the result of incompleteness of Richard's (1897) description of the species (all specimens attributed to this species around the globe are morphologically similar and cannot be differentiated on the basis of Richard's 1897 original description), and the high intraspecific variability of the genus (Gómez et al. 2004; see also Dexter 1995; Suárez-Morales et al. 1996; Gee 1999; Mielke 2000a, 2001). Similarly, *C. confluens* seems to be distributed in Eastern and Western Europe, in Northern and Southern Africa, close to the Persian Gulf, India and Australia (Mielke 2000b, p. 139, Figure 7). It is possible that this species "may in reality represent an assemblage of barely discernible species" (Mielke



2000b). The same could be the case for *C. albuquerqueensis* and *C. retrogressus* and a thorough revision of these species is still pending.

Upon preliminary examination of the Brazilian material of *C. sinaloensis*, only two differences were observed when compared to the Mexican material of the species: the armature formula of the antennal exopod and the presence of spinules on the male fifth urosomite ventrally. The antennal exopod was described as having two setae only and the male fifth urosomite was described as lacking ventral spinules. Upon re-examination of the material of *C. sinaloensis* deposited in the Copepoda collection of the Institute of Marine Sciences and Limnology (Mazatlan Marine Station), three setae were observed on the antennal exopod (one lateral, and one apical, small seta masked by a bigger apical element) (Figure 8B), and the presence of spinular ornamentation on the male fifth urosomite (Figure 11D) was confirmed. The mouth parts, female and male P1–P6 are identical. The occurrence of the same species in the Atlantic coast of Brazil and in the Mexican Tropical Pacific seems to be a rather common phenomenon among benthic copepods as evidenced by the presence of *Cyclopina caissara* Lotufo, 1994 as reported recently by Gómez and Martínez-Arbizu (2004).

*Cletocamptus nudus* sp. nov. is similar to *C. fourchensis* in the bare anal operculum. Nevertheless, *C. nudus* sp. nov. differs from *C. fourchensis* in the relative size of the ventral spinules of the second genital segment, and fourth and fifth urosomites. The most obvious difference between these two species is the armature formula of the antennal exopod (with two setae in *C. nudus* sp. nov., and three setae in *C. fourchensis*) and armature formula of P3–P4 EXP 3 (P3 and P4 with two and one inner seta in *C. nudus* sp. nov., and with one and without inner seta in *C. fourchensis*). The female P5 of these two species differ in the relative length of the baseoendopodal setae, the distalmost inner apical seta being about three-quarters and half length of the apical element in *C. nudus* sp. nov. and *C. fourchensis*, respectively. *Cletocamptus nudus* sp. nov. seems to possess a very small element close to the single seta representing P6. The same was observed in some specimens of the Brazilian material of *C. sinaloensis* sp. nov. (not shown) but this character still has to be verified. *Cletocamptus nudus* sp. nov. seems to be related to *C. schmidti*, *C. stimpsoni*, and *C. retrogressus* in the armature formula of P3 EXP 3 and P4 EXP 3 (with two and one inner seta) but differs from the two latter species in the armature formula of P3 ENP 2 (with three setae in *C. nudus* sp. nov. and five elements in *C. retrogressus* and *C. stimpsoni*). In this regard, *C. nudus* sp. nov. seems to be more closely related to *C. schmidti* by the combination of the armature formula of the antennal exopod, mandible, P3 and P4, as well as in the shape of the lateral element on the maxillary arthrite. *Cletocamptus schmidti* and *C. nudus* sp. nov. can be separated based on the ornamentation of the anal operculum (without spinules in *C. nudus*, but with small spinules in *C. schmidti*), relative length of exopodal and baseoendopodal setae of the female P5, and above all on the length ratio of the female P1 EXP:ENP (P1 ENP of *C. nudus* sp. nov. being slightly longer than the exopod, but barely reaching beyond the tip of P1 EXP 2 in *C. schmidti*). Unfortunately, the male of *C. nudus* sp. nov. remains unknown and cannot be compared with the male of *C. schmidti*.

Mielke (2000a) described *C. axi* and *C. schmidti* from three sampling stations in the Galapagos Archipelago (Mielke 2000a, p. 282, Figure 7). In one sampling station (locality IX.4 of Santa Cruz; Mielke 2000a, Figure 7) he found these two species living together. Despite the fact that *C. axi* and *C. schmidti* revealed some intraspecific variability, Mielke (2000a) was able to define and separate these two species since “no intermediate animal was found” (Mielke 2000a). Even though the specimens of *C. levis* sp. nov. did not show any variability in the armature formula of mouth parts and swimming legs (except for some

slight variability in the relative length of the setae of P5 of one female paratype, see Figure 17B, C), three different types of dorsal spinular ornamentation of body somites and caudal rami were observed (compare Figures 14A, B, 15A, B, 16A, B), with the specimen shown in Figure 15 being intermediate. It is noteworthy that the ventral spinular ornamentation of the female urosome was found to be constant (i.e. no variability was observed in the female ventral spinular ornamentation of urosome). On the other hand, more or less the same number of specimens of each type was observed, therefore making it difficult to decide which type of somitic spinular ornamentation should define this species. However, because the dorsal surface spinular ornamentation of body somites of the only male observed (see Figure 21A, B) is similar to that of the female shown in Figure 16A, B, it is suggested that this type could define *C. levis* sp. nov. in terms of dorsal spinular ornamentation of body somites. Nevertheless, it has to be noted that the male lacks the inner long spinules on the caudal rami, which are well developed in the females shown in Figures 15A and 16B, but very small in the female shown in Figure 14A, D.

Previous to this paper, eight *Cletocamptus* species have been described from America (*C. helobius*, *C. sinaloensis*, *C. fourchensis*, *C. deborahdexterae*, *C. stimpsoni*, *C. axi*, *C. schmidti*, and *C. albuquerqueensis*). *Cletocamptus levis* sp. nov. is similar to *C. sinaloensis*, *C. fourchensis*, *C. deborahdexterae*, and *C. axi* in the armature formula of the mandibular palp (with two setae arising from the one-segmented palp, plus a small seta arising nearby), shape of the lateral spinulose element of the maxillary arthrite, and armature formula of P1–P4. However, *C. levis* sp. nov. can be separated from *C. sinaloensis*, *C. fourchensis*, and *C. deborahdexterae* by the P1 EXP:ENP length ratio (P1 ENP longer or as long as exopod in *C. sinaloensis*, *C. fourchensis*, and *C. deborahdexterae*, but P1 ENP 2 hardly reaching the middle of P1 EXP 3 in *C. levis* sp. nov.) and by the P5 BENP:EXP length ratio (exopod reaching the middle of the baseoendopodal lobe, far below the insertion site of the outermost seta in *C. sinaloensis*, *C. fourchensis*, and *C. deborahdexterae*, but reaching the insertion site of the outermost baseoendopodal seta, far above the middle of the baseoendopodal lobe in *C. levis* sp. nov.). *Cletocamptus levis* sp. nov., *C. helobius*, *C. axi*, *C. schmidti*, and *C. albuquerqueensis* are the only American representatives of the genus in which the P1 ENP is shorter than the P1 EXP (P1 ENP 2 barely reaching the middle of P1 EXP 3 in *Cletocamptus levis* sp. nov., *C. helobius*, *C. axi*, and *C. albuquerqueensis*, and P1 ENP barely reaching beyond the tip of P1 EXP2 in *C. schmidti*). *Cletocamptus levis* sp. nov. seems to be more closely related to *C. axi* than to *C. albuquerqueensis sensu* Pallares (1962) and *C. helobius* by the armature formula of the mandibular palp, length:width ratio of caudal rami, and relative length of female P3 ENP 2, P2–P4 EXP 1, and number of segments of the male P3 ENP. *Cletocamptus axi* and *C. levis* sp. nov. can be separated by the spinule ornamentation of the anal operculum (larger in *C. axi*), shape of female rostrum (oval-shaped in *C. axi*, triangular in *C. levis* sp. nov.), relative length of outer spinules of female P2–P4 EXP (longer in *C. axi*), and relative length of the setae on the male P5 EXP. *Cletocamptus levis* sp. nov. showed the typical sexual dimorphism for the genus in A1, basis of P1, outer spines of P2–P4, P2 ENP, P3 ENP, P5 and P6. It is noteworthy that *C. levis* showed sexual dimorphism in the rostrum, being more slender in the male than in the female (compare Figures 18G and 23A). The same has been observed only for *C. retrogressus* (Mielke 2001, p 4, Figure 2B) and *C. albuquerqueensis* (Pallares 1962, p. 242, Lám. I, Figure 8).

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