Zootaxa 5051 (1): 151–170
https://www.mapress.com/j/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.5051.1.11
http://zoobank.org/urn:lsid:zoobank.org:pub:82B4BCC0-BE67-4BC2-BE3E-68D39F72CEEE

On some deep-sea Stenheliinae from the Gulf of California and the west coast of the Baja California Peninsula (Mexico): *Pseudostenhelia bathyalis* sp. nov., and *Beatricella calidafornax* sp. nov. (Copepoda: Harpacticoida: Miraciidae)

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Abstract

At present, only a handful of harpacticoid species of the families Ameiridae Boeck, Ancorabolidae Sars, Argestidae Por, and Rhizothrichidae Por have been described from the deep sea of the Gulf of California and west coast of the Baja California Peninsula. Recent efforts resulted in the description of a new genus, *Wellstenvalia* Gómez & Cruz-Barraza, 2021, closely related to *Muohuysia* Özdikmen, 2009 and *Wellstenhelia* Karanovic & Kim, 2014 and some new deep-sea species of *Delavalia* Brady, 1869. Other new stenheliin genera from the Gulf of California and the west coast of the Baja California Peninsula are the subjects of another contribution in this volume. The present contribution deals with the description of the first deep-sea representatives of *Pseudostenhelia* Wells, 1967 and *Beatricella* Scott, 1905, two typically shallow brackish water and marine genera. Some comments on their relationships are given.

Key words: Copepoda, new species, Mexico, taxonomy

Introduction

The subfamily Stenheliinae Brady currently accommodates 14 genera: *Anisostenhelia* Mu & Huys, 2002 (monotypic), *Beatricella* Scott, 1905 (monotypic), *Cladorostrata* Tai & Song, 1979 (two species), *Delavalia* Brady, 1869 (50 species), *Itostenhelia* Karanovic & Kim, 2014 (two species), *Lonchoeidestenhelia* Gómez, 2020 (monotypic), *Melima* Por, 1964 (five species), *Muohuysia* Özdikmen, 2009 (monotypic), *Onychostenhelia* Itô, 1979 (two species), *Pseudostenhelia* Wells, 1967 (three species), *Stenhelia* Boeck, 1865 (eight species), *Wellstenhelia* Karanovic & Kim, 2014 (nine species), *Wellstenvalia* Gómez & Cruz-Barraza (monotypic), and *Willenstenhelia* Karanovic & Kim, 2014 (six species) (Gómez 2021; Gómez & Cruz-Barraza 2021; Karanovic & Kim 2014; Wells 2007). Stenheliinae is a predominantly shallow-water taxon and only a few representatives (*Wellstenvalia wellsi* Gómez & Cruz-Barraza, 2021, and some species of *Delavalia*) are known from the deep sea (>200 m depth) (see Gómez & Cruz-Barraza 2021, Gómez 2021).

Pseudostenhelia is primarily a marine and brackish shallow-water genus with three species, *P. prima* Wells, 1967, *P. secunda* Wells, 1971 and *P. wellsi* Coull & Fleeger, 1977 and the so far monotypic *Beatricella* seems to be restricted to shallow marine habitats. Preliminary analyses of deep-sea sediment samples taken in the central and southern regions of the Gulf of California, and in the west coast of the Baja California Peninsula during four oceanographic cruises on board research vessel “El Puma” (Universidad Nacional Autónoma de México) (Fig. 1) revealed a high species richness and diversity of benthic harpacticoids of which the subfamily Stenheliinae is an important component. Previous studies (*e.g.* Mu & Huys 2002; Willen 2003) discussed on the shallow origin of some deep-sea stenheliins, *viz. Delavalia*, which seems to be confirmed in the present study. Here I describe the first species of *Pseudostenhelia* and *Beatricella* from the deep-sea of the Gulf of California and west coast of the Baja California Peninsula. This is the eighth contribution on deep-sea harpacticoids and the second of a series of papers on deep-sea stenheliins from the Gulf of California and adjacent waters dedicated to Prof. J. B. J. Wells.

Accepted by R. Huys: 20 Oct. 2020; published: 12 Oct. 2021

Materials and methods

For a full description of materials and methods see Gómez & Cruz-Barraza (2021).

Abbreviations used in the text: acro, acrothek; ae, aesthetasc; BENP, baseoendopod; ENP, endopod; EXP, exopod; EXP (ENP)1 (2,3), first (second, third) exopodal (endopodal) segment.

The type material was deposited in the Copepoda collection of the Instituto de Ciencias del Mar y Limnología, Unidad Académica Mazatlán (ICML-EMUCOP), and microphotographs are available in http://metadata.icmyl.unam.mx.

The map showing the sampling locations (Fig. 1) where the new taxa were found was prepared with SimpleMappr (Shorthouse 2010).

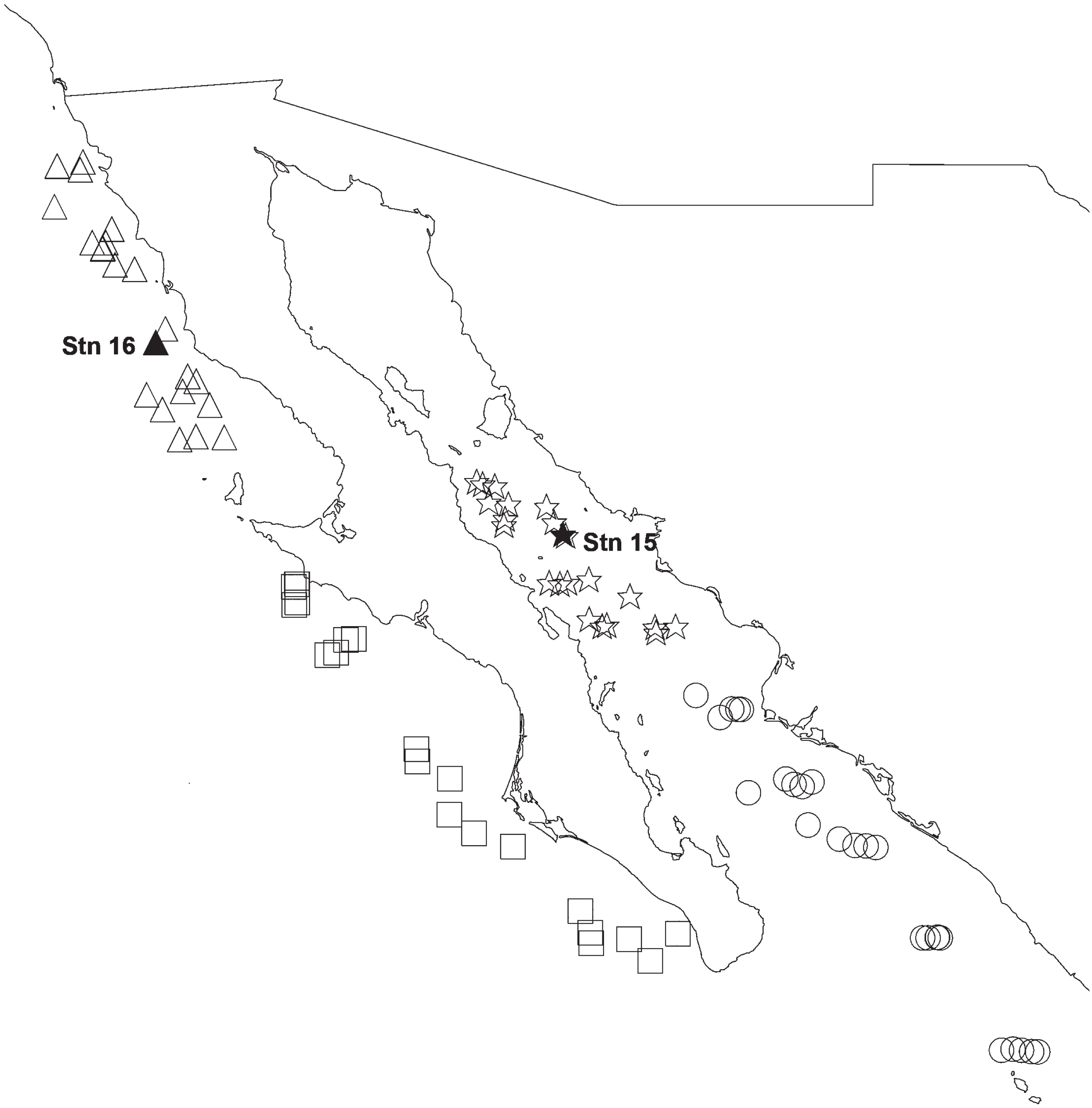

FIGURE 1. Sampling locations visited during oceanographic cruises Talud IV (circles), Talud X (stars), Talud XV (squares) and Talud XVIB (triangles). Solid figures represent positive collection of *Pseudostenhelia bathyalis* **sp. nov.** (triangle) and *Beatricella calidafornax* **sp. nov.** (star).

Systematics

Order Harpacticoida Sars, 1903

Family Miraciidae Dana, 1846

Subfamily Stenheliinae Brady, 1880

Genus *Pseudostenhelia* Wells, 1967

Type species. *Pseudostenhelia prima* Wells, 1967 (by original designation).

Other species. *Pseudostenhelia secunda* Wells, 1971; *P. wellsi* Coull & Fleeger, 1977.

***Pseudostenhelia bathyalis* sp. nov.**
(Figs. 2–6)
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Type locality. Southeastern San Quintin Basin, off Bahia del Rosario, Baja California, Mexico; Talud XVIB cruise, sampling station 16 (29.81333°N, 116.12166°W); depth, 1,752 m; organic carbon content, 4.08%; organic matter content, 7.01%; sand 5.45%; clay, 11.94%; silt, 82.61%.

Specimens examined. Female holotype (EMUCOP-290514-01) dissected and mounted onto seven slides; Talud XVIB cruise, sampling station 16 (29.81333°N, 116.12166°W); May 29, 2014; coll. S. Gómez.

Etymology. The specific epithet *bathyalis* from the Greek βαθύς (bathys), deep, refers the environment where the species was found.

Description of female. Total body length measured from tip of rostrum to posterior margin of caudal rami 620 µm. Habitus pyriform, widest at posterior end of cephalothorax, tapering posteriad (Fig. 2A); cephalothorax/body length ratio, 0.3.

Prosome consisting of cephalothorax with fused first pedigerous somite, and second to fourth free pedigerous somites. Cephalothorax (Fig. 2A) slightly wider than long, no surface sensilla detected, hyaline fringe smooth, surface covered by small depressions. Free pedigerous somites without expansions laterally nor dorsally, without spinular ornamentation, no surface sensilla detected, integument covered by small depressions, weakly sclerotized, hyaline fringe smooth, width of second to fourth pedigerous somites decreasing progressively (Fig. 2A).

Urosome consisting of fifth pedigerous somite (first urosomite), genital double-somite (genital—second urosomite—and third urosomites fused), two free urosomites, and anal somite; urosomites without expansions laterally nor dorsally, integument weakly sclerotized, surface covered by small depressions (Fig. 2A).

Fifth pedigerous somite without spinular ornamentation, seemingly without sensilla (Fig. 2A), hyaline fringe narrow.

Second and third urosomites completely fused forming genital double-somite, without any trace of division, slightly longer than wide, widest part measured in the middle, no surface sensilla nor spinular ornamentation detected, posterior hyaline fringe smooth (Fig. 2A).

Fourth and fifth urosomites seemingly without surface sensilla dorsally (Fig. 2A) nor ventrally (Fig. 2C), dorsally without (Fig. 2A), ventrally with medial row of spinules (Fig. 2C).

Anal somite 1.7 times as wide as long (Fig. 2A, C), with lateroventral spinules close to joint of caudal rami, seemingly without sensilla, with two lateral and two ventral pores (Fig. 2C); anal operculum inconspicuous.

Caudal rami elongate, about five times as long as wide (Fig. 2A–C) and about two times as long as anal somite, slightly divergent, each ramus with one subdistal pore ventrally, with dorsal spinules close to seta II, and on inner margin subdistally, with seven elements (Fig. 2B–C); seta I and II arising subdistally, the former ventral to and half the length of the latter; seta III subdistal, arising ventrally (Fig. 2B; lost in Fig. 2C); seta IV and V arising distally, both with fracture plane and rat-like, the former shorter; seta VI issuing at inner distal corner; dorsal seta VII triarticulate at base, situated subdistally close to inner margin.

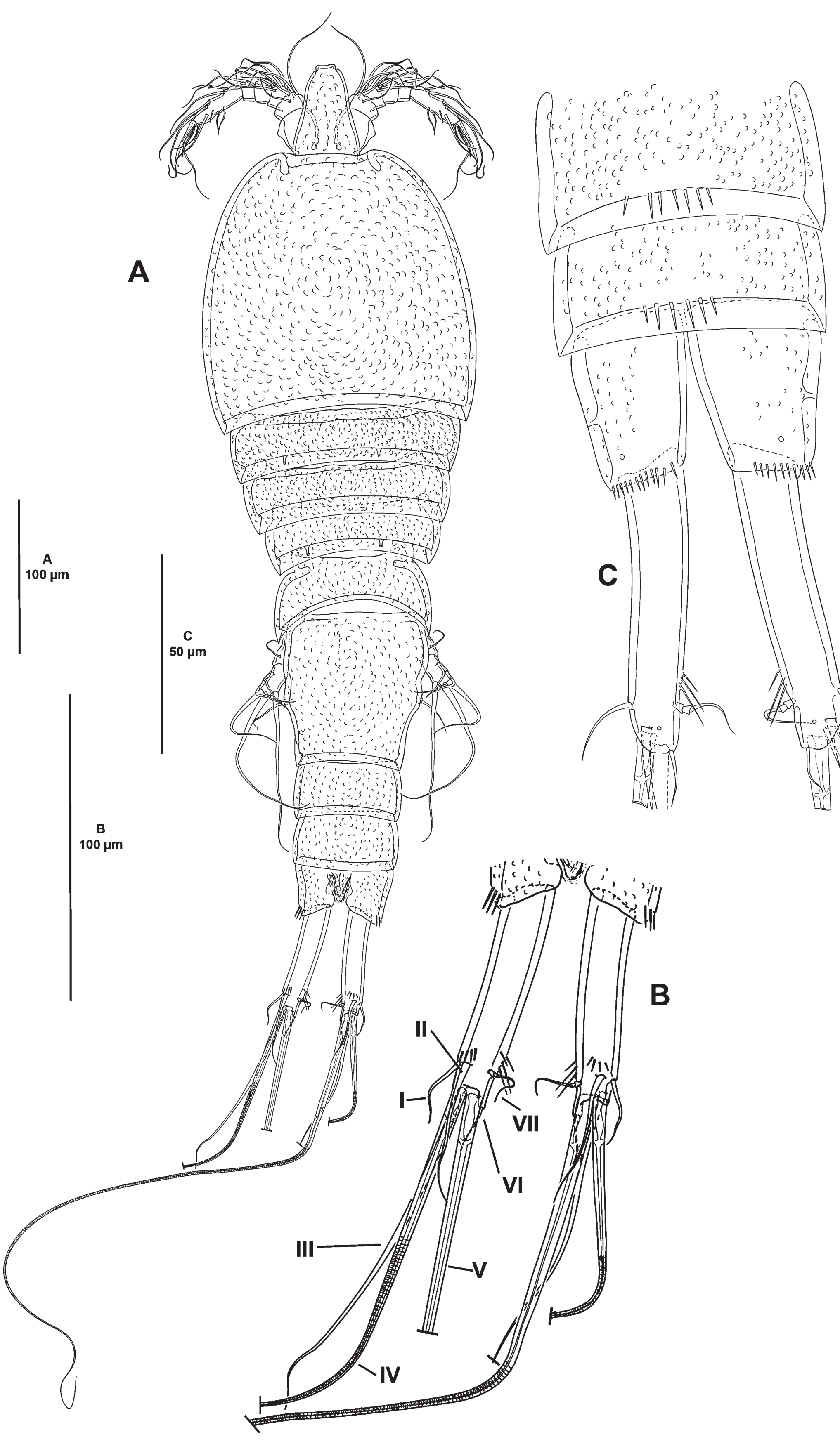

FIGURE 2. *Pseudostenhelia bathyalis* **sp. nov.**, female: A, habitus, dorsal (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10570); B, caudal rami, dorsal; C, fourth, fifth, and anal somite, and caudal rami, ventral.

Rostrum (Fig. 3A) trapezoidal, not fused to cephalothorax, slightly bifid, subdistal sensilla lost during dissection.

Antennule (Fig. 3A) six-segmented, all segments smooth except for spinular row on first segment; all setae smooth; second segment with two, third segment with one seta with fracture plane; sixth segment with two articulated setae. Armature formula: 1(1); 2(9); 3(7); 4(4 + (1 + ae)), 5(2); 6(11 + acro). Acrothek consisting of two setae and one slender aesthetasc fused basally.

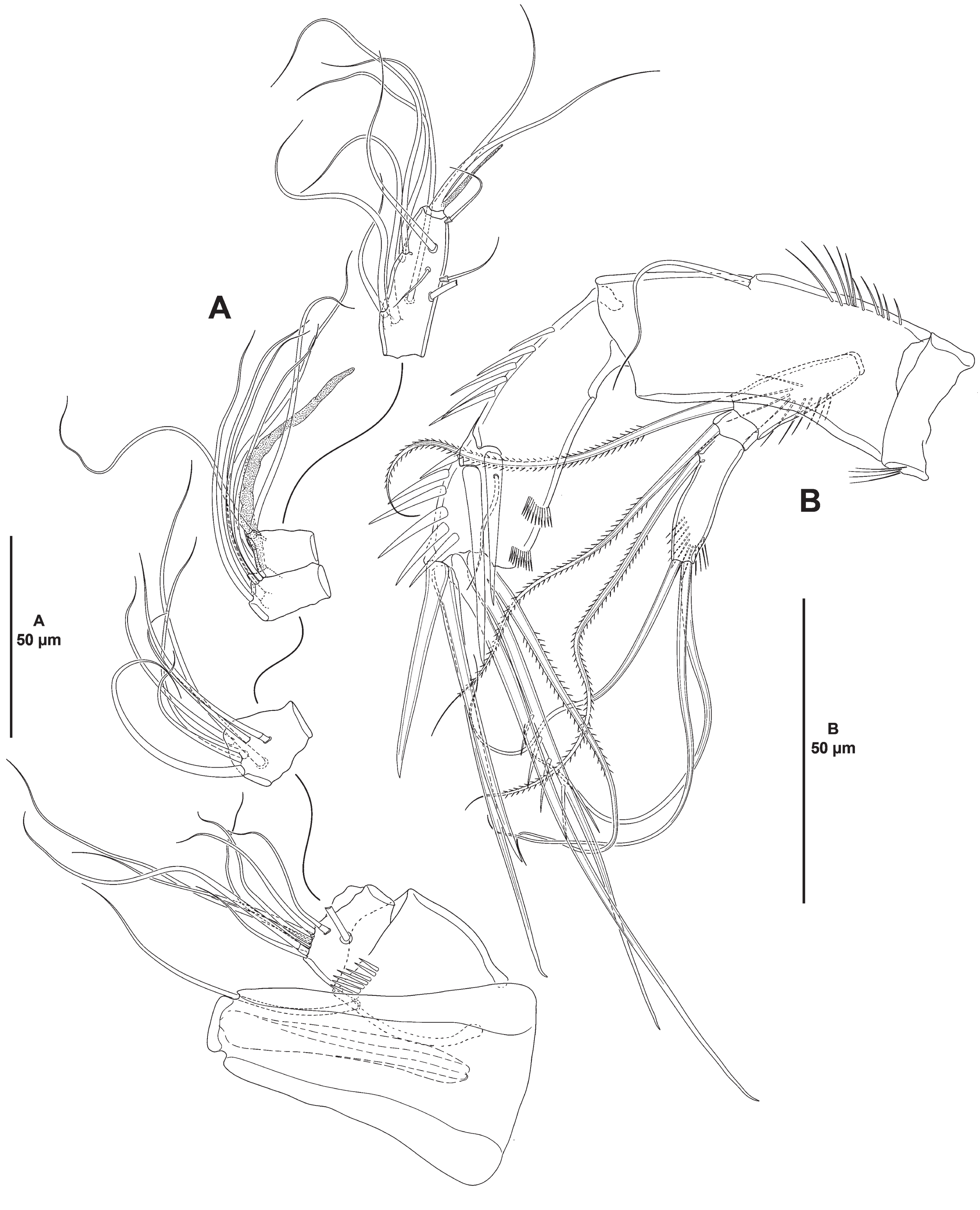

FIGURE 3. *Pseudostenhelia bathyalis* **sp. nov.**, female: A, rostrum and antennule (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10578); B, antenna (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10569).

Antenna (Fig. 3B). Coxa short, with some slender outer spinules. Allobasis as long as free endopodal segment, with inner spinules proximally, with one slender abexopodal seta arising midway inner margin. Exopod three-segmented; first and third segments longest, each about three times as long as wide, and with spinules as shown; first and second segment with one pinnate seta each, third segment with one pinnate proximal and three smooth apical setae. Endopod with strong inner spinules, laterally with two spines and one slender seta, distally with six elements (outermost pinnate seta fused basally to strongly spinulose adjacent element), outer margin with two subdistal frills.

Mandible (Fig. 4A) with relatively short coxa. Gnathobase wide, ventral distal corner produced into small sharp semi-hyaline process, with several acute teeth distally, and two smooth setae ventrally. Basis elongate, with narrow base, widest medially, with spinules as shown, with three subdistal setae. Exopod elongate, about four times as long as wide, tapering distally, with three lateral and three distal setae. Endopod recurved, twisted over exopod, with two lateral and six distal elements (two pairs of which fused basally).

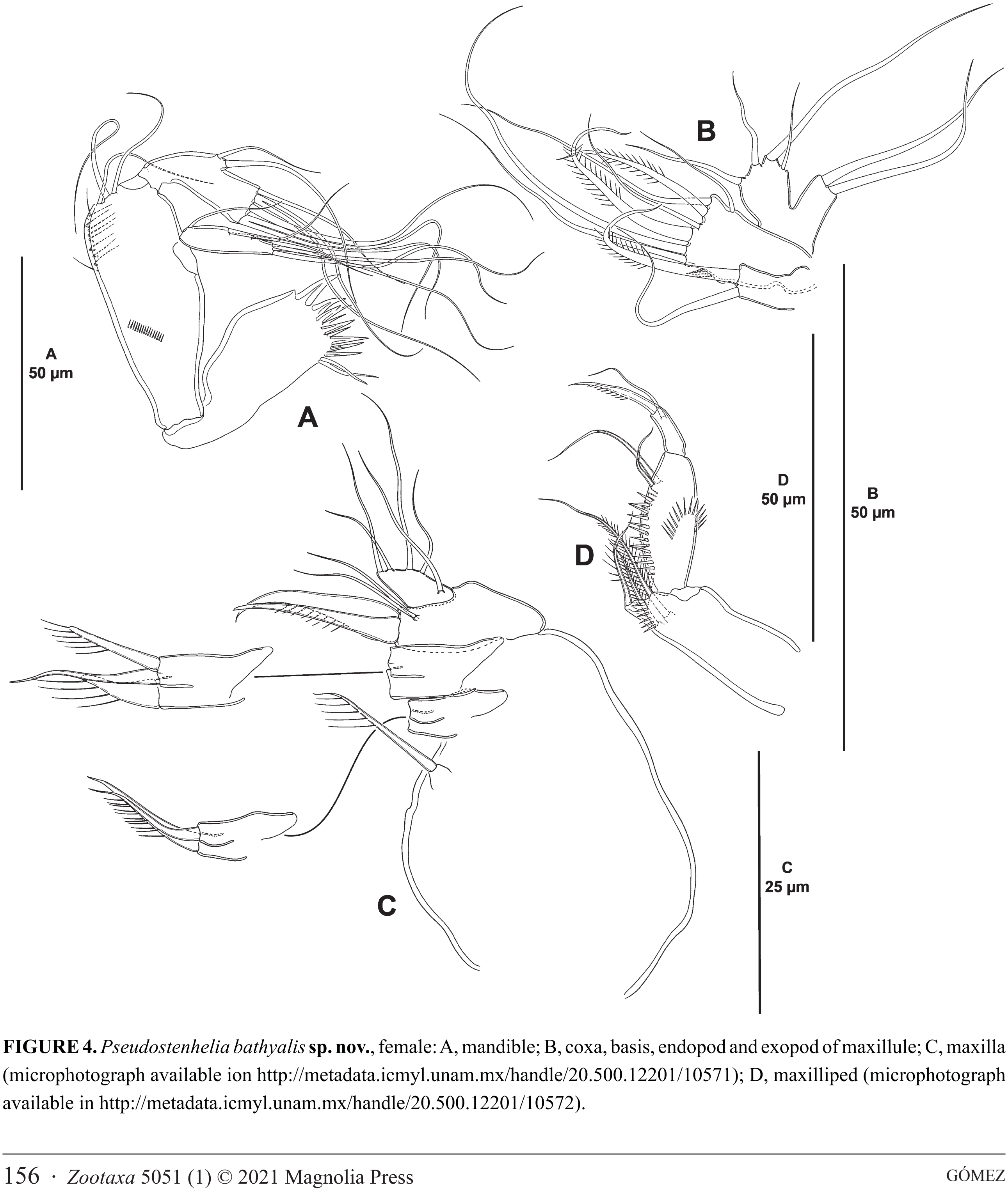

FIGURE 4. *Pseudostenhelia bathyalis* **sp. nov.**, female: A, mandible; B, coxa, basis, endopod and exopod of maxillule; C, maxilla (microphotograph available ion http://metadata.icmyl.unam.mx/handle/20.500.12201/10571); D, maxilliped (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10572).

Maxillule (Fig. 4B). Praecoxa and arthrite lost during dissection. Coxa with one pinnate and one smooth seta. Basis with small inner spinules, and with seven elements of which two pinnate. Exopod and endopod one-segmented, confluent, not fused to supporting basis; endopod larger than exopod, the former with four, the latter with two setae.

Maxilla (Fig. 4C). Large syncoxa seemingly without spinular ornamentation, with three endites; proximal endite smallest, with one seta; middle endite with one smooth and one spinulose seta; distal endite with one smooth and two spinulose elements. Basis drawn out into strong spinulose claw, additionally with strong naked spine and two slender setae. Endopod about 1.5 times as long as wide, with five slender setae (one arising basally, two medially, and two apically).

Maxilliped (Fig. 4D) subchelate. Syncoxa elongate, rectangular; about 2.5 times as long as wide, with inner spinules subdistally, with two pinnate setae issuing subdistally at the same level, and one distal pinnate element arising from pedestal. Basis slightly shorter than syncoxa, oval, with arched row of outer spinules, with one anterior and one posterior inner spinular row as depicted, with two slender subdistal setae, one of which visibly longer. Endopod one-segmented, with one claw-like spinulose element and one smooth seta.

P1 (Fig. 5A). Coxa massive, trapezoidal, with proximal and subdistal outer spinules. Basis with few inner slender spinules, and with stronger spinules medially, between rami, and at base of outer and inner spines, of which the former smooth, the latter pinnate. Exopod three-segmented, reaching middle of ENP2; first segment longest, second segment shortest, length ratio of EXP1–EXP3 1, 0.5, 0.8; all segments without outer nor inner acute distal processes; EXP1 with outer and distal spinules, with outer spine, without inner armature; EXP2 with distal spinules, with outer and inner rat-like setae; EXP3 with two outer, one apical and one inner rat-like element, with spinules at base of outer and distal element. Endopod two-segmented, segments without inner nor outer acute distal processes; ENP1 reaching middle of EXP2, 1.8 times as long as wide and slightly shorter than ENP2, with slender long inner spinules, with strong outer and with small distal spinules, with one long inner seta; ENP2 slenderer than ENP1, 4.5 times as long as wide, with strong outer spinules, with one inner and one distal rat-like seta, and one outer spine.

P2–P3 (Figs. 5B, 6A). Coxa shorter but wider than in P1, with one proximal and one subdistal row of spinules. Basis with acute inner process, with set of long inner spinules proximally, and with small spinules at base of outer seta. Exopod three-segmented, shorter than ENP; of P2 reaching middle, of P3 reaching distal third of ENP2; EXP1 longest, length ratio of P2/P3 EXP1–EXP3 1, 0.6, 0.7/1, 0.6, 0.8; EXP1 and EXP2 with outer and subdistal outer spinules, with outer acute process, EXP1 with, EXP2 seemingly without inner hyaline frill, EXP3 without spinular ornamentation; EXP1 and EXP2 without inner armature; EXP3 with two inner and two apical setae, and two outer spines. ENP arising from pedestal, at a higher level than EXP, two-segmented; ENP1 0.7 times as long as ENP2; ENP1 and ENP2 with longitudinal row of strong outer spinules; P2 and P3 ENP1 with one inner element, of P2 visibly shorter; P2 ENP2 with five, P3 ENP2 with seven setae/spines. No pores detected on EXP nor on ENP.

P4 (Fig. 6B). Coxa largely as in P2 and P3. Basis largely as in P2 and P3, but without inner acute process, and with both rami arising at the same level. Exopod three-segmented, two times as long as ENP; EXP1 longest, length ratio of EXP1–EXP3 1, 0.9, 0.9; EXP1 and EXP2 with outer and subdistal outer spinules, without acute outer process; EXP1 with, EXP2 seemingly without inner hyaline frill; EXP3 without spinular ornamentation; EXP1 and EXP2 without inner armature; EXP3 with three inner and two apical setae, and two outer spines. ENP two-segmented; ENP1 slightly shorter than ENP2; ENP1 and ENP2 with longitudinal row of strong outer spinules; ENP1 with one strong and stiff inner element; ENP2 with five setae/spines. No pores detected on EXP nor on ENP.

Setal formula of swimming legs as follows:

	P1	P2	P3	P4
EXP	0,1,112	0,0,222	0,0,222	0,0,322
ENP	1,111	1,221	1,421	1,221

P5 (Fig. 6C). BENP pentagonal, poorly developed, without spinular ornamentation; endopodal lobe with four setae as shown; first and second outermost setae close to each other. Exopod oval, nearly as long as wide, without spinular ornamentation, with five setae. No pores detected on BENP nor on EXP.

P6 lost during dissection.

Male. Unknown.

Remarks and discussion. The genus *Pseudostenhelia* accommodates three species, *P. prima*, *P. secunda*, and

P. wellsi. Members of the genus have a preference for shallow brackish conditions with detritus-rich fine sediments (mud and fine sand). The discovery of the female of *P. secunda* in plankton samples from Lake Kolleru (India) (Ranga Reddy 1984) is, to the best of my knowledge, the only report of a species of this genus from freshwater habitats. *Pseudostenhelia prima*, the first species assigned to this genus, was found in fine sediments (mud or muddy sand) from Saco da Inhaca, a shallow inlet south of Inhaca Island (Mozambique) (Wells 1967). The male of *P. secunda*, the second species included in this genus, was found in muddy sediments from the estuary of the Vellar river near Parangipettai (formerly Porto Novo) in the Tamil Nadu State (India) (McIntyre 1968; Wells 1971), and the female was found in a freshwater lake (see above; Ranga Reddy 1984). Finally, *P. wellsi* was found in muddy intertidal sediments from South Carolina (USA) (Coull & Fleeger 1977).

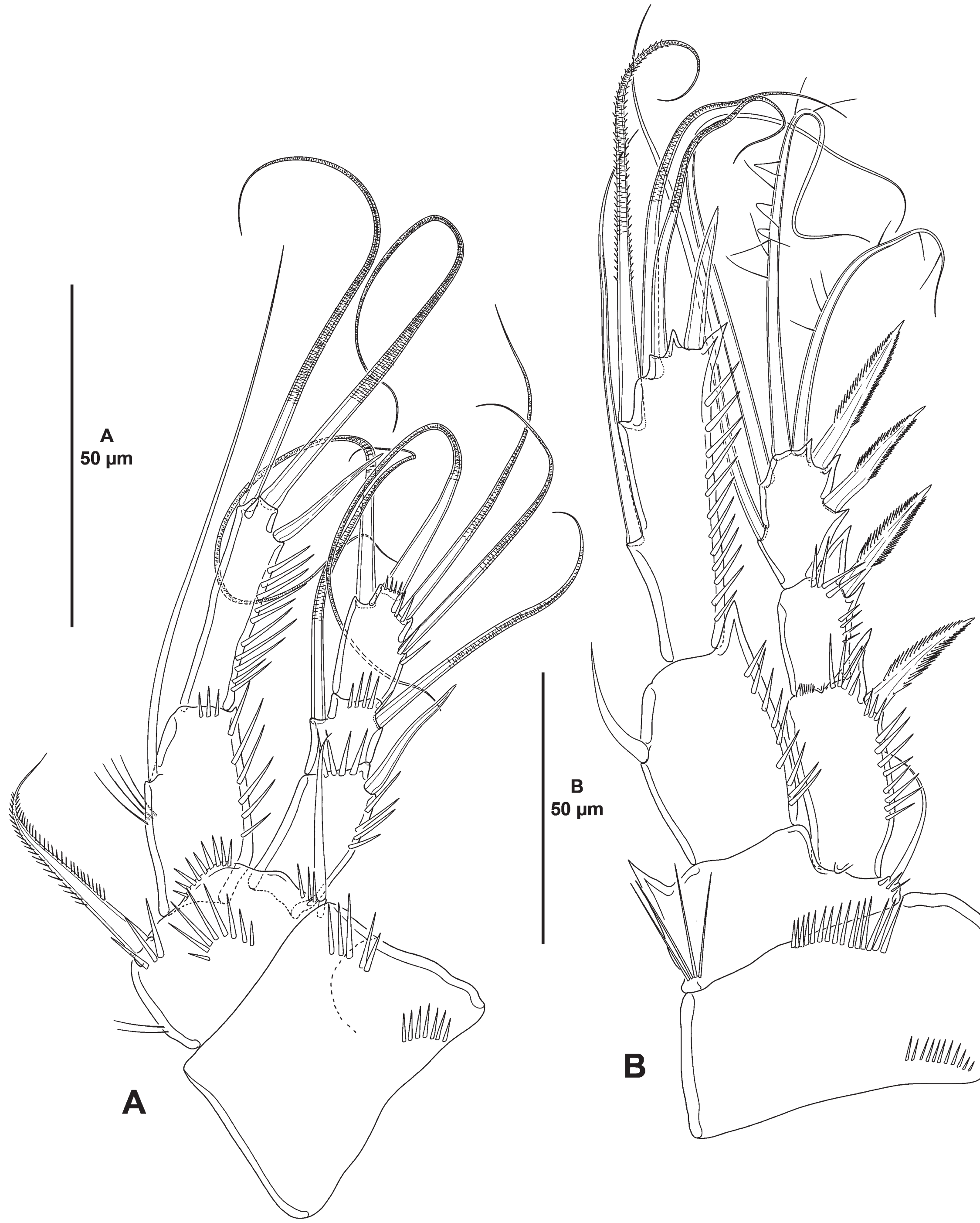

FIGURE 5. *Pseudostenhelia bathyalis* **sp. nov.**, female: A, P1, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10573); B, P2, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10574).

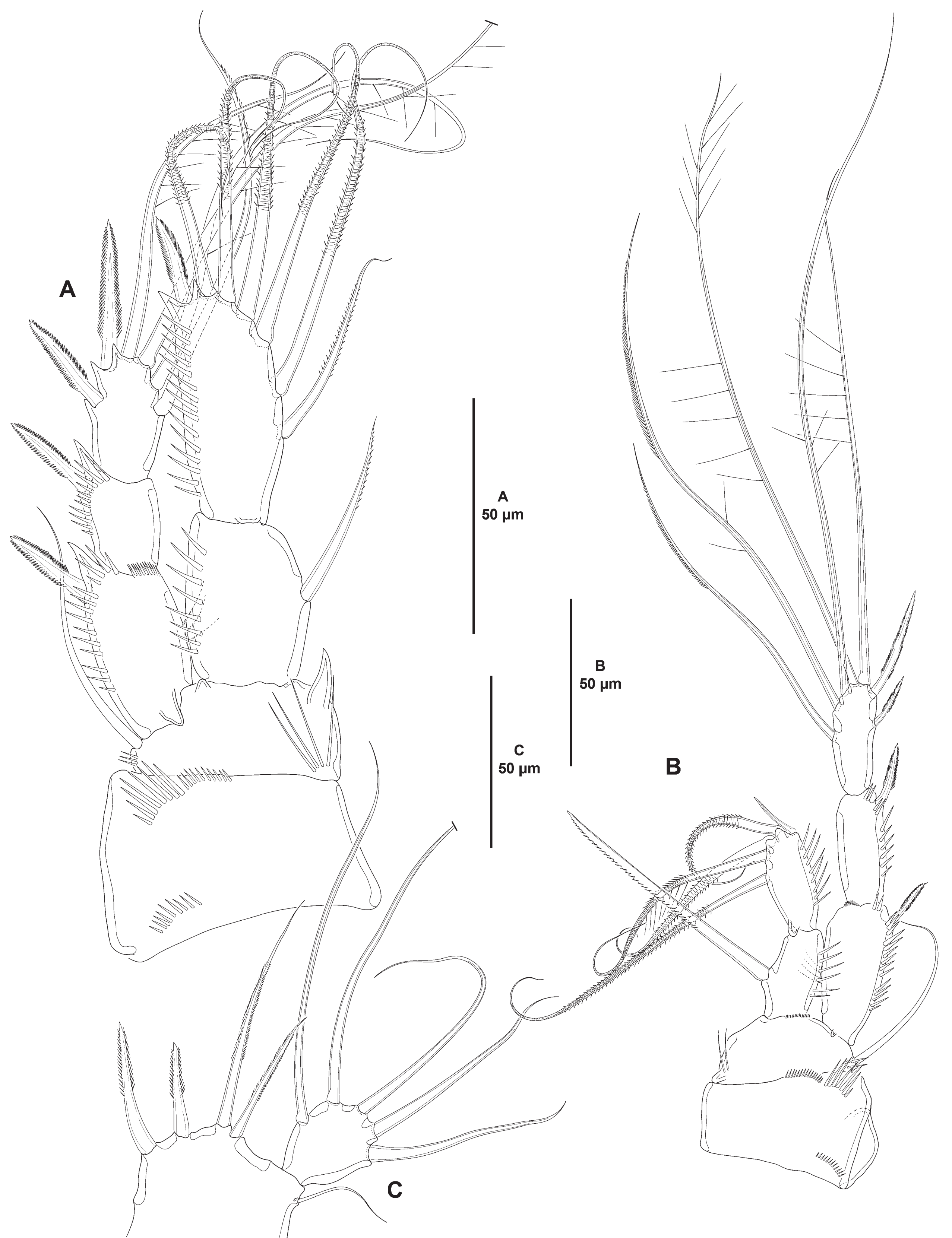

FIGURE 6. *Pseudostenhelia bathyalis* **sp. nov.**, female: A, P3, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10575); B, P4, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10576); C, P5, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10577).

The relationships between *Pseudostenhelia* and some other stenheliins are not clear. Dahms *et al.* (2005) proposed some apomorphies for *Pseudostenhelia* (Dahms *et al.* 2005: 12, table 2) based on naupliar morphology. They also gave a list of characters shared by *Stenhelia*, *Delavalia*, and *Pseudostenhelia*, *viz.* the extremely foreshortened cephalic shield, the presence of a spinous process on the distal third (middle?; Huys & Mu 2008) of the second antennulary segment and a notched inner seta on the third antennulary segment, and a lobate outer protuberance of the first segment of the exopod of the antenna. Huys & Mu (2008) questioned the phylogenetic significance of these characters, but admitted that they appear to be unique within Harpacticoida.

Huys & Mu (2008) drew attention to a core group of Stenheliinae (*Onychostenhelia*, *Cladorostrata*, and *Delavalia*) sharing a synapomorphic confluent maxillulary exopod and endopod not fused to the supporting basis. This condition is present also in *Wellstenhelia* (Karanovic & Kim 2014; Gómez & Cruz-Barraza 2021) and *Lonchoeidestenhelia* (Gómez, 2020) and is confirmed here for *Pseudostenhelia*. Note that Ranga Reddy (1984) described the maxillulary rami as discrete and separated from basis, but this is most probably erroneous. The significance of this condition in the maxillulary rami is not clear but Huys & Mu (2008) suggested that the confluent maxillulary rami separated from the basis could be a strong synapomorphy for *Onychostenhelia*, *Cladorostrata* and *Delavalia*, but also for *Lonchoeidestenhelia*. However, its presence in some other stenheliin lineages (*e.g. Pseudostenhelia*, and *Wellstenhelia*) seems to indicate convergent evolution (see also Gómez & Cruz-Barraza 2021).

Pseudostenhelia shares a plesiomorphic anal operculum (semicircular, relatively small, weakly chitinized and flanked by a sensilla on each side) with *Melima* and *Delavalia* (Willen 2003), but also with *Wellstenhelia* (see also Gómez & Cruz-Barraza 2021), and it is completely absent in *Stenhelia* and *Anisostenhelia* (Mu & Huys 2002), and *Onychostenhelia* (Huys & Mu 2008).

Although its significance is not clear, the caudal seta I is either a spine-like element or a reduced seta in most stenheliins, but it is a well-developed seta (most probably plesiomorphic) in *Pseudostenhelia* and *Onychostenhelia*, and some species of *Delavalia* (Gómez & Cruz-Barraza 2021).

In addition to the synapomorphic nature of the structure of the maxillulary rami in *Onychostenhelia*, *Cladorostrata*, and *Delavalia* (see above), Huys & Mu (2008) suggested that the resemblance in leg segmentation and armature between *Onychostenhelia* and *Pseudostenhelia* observed by Itô (1979) had little phylogenetic significance. However, as noted above (see also Gómez & Barraza 2020), the phylogenetic importance of the confluent maxillulary rami separated from the supporting basis, the shape of caudal seta I, and anal operculum is questionable. On the other hand, the shape of P1 EXP (EXP3 smaller than EXP2 and EXP3), giving the entire ramus a characteristic appearance (except for the somewhat longer P1 EXP3 in *P. bathyalis* **sp. nov.)**, the exceedingly long outer elements of P1 EXP2 and EXP3, and the two-segmented endopod of P2–P4, seem to be strong synapomorphies for these two genera.

Both sexes are known for all *Pseudostenhelia* species except for *P. bathyalis* **sp. nov.** The female of the new deep-sea species can be readily separated from the females of its congeners by the segmentation of the antennule (with six segments in the new species, but with five segments in other species), and by its armature complement of P2 ENP2 and P3 ENP2, with five and seven setae instead of four and five setae respectively. The minute proximal endite of the maxillary syncoxa with one seta only, and the reduction of the armature complement on the P5 EXP from six to five setae seem to be the only potential apomorphies for the species.

Genus *Beatricella* T. Scott, 1905

Type species. *Beatricella aemula* (Scott, 1893) (by subsequent designation).

Species inquirenda. *Stenhelia aemula* (Scott, 1893) *sensu* Marinov (1977) (Mu & Huys 2002).

Other species. *Beatricella calidafornax* **sp. nov.**

Diagnosis (amended). As in Mu & Huys (2002: 203–204), but caudal rami about as long as anal somite or as long as three last urosomites combined, caudal seta I spine-like, female antennule eight- or seven-segmented, P1 EXP2 with or without inner seta, outermost seta of female P5 endopodal lobe small or well developed.

***Beatricella calidafornax* sp. nov.**
(Figs. 7–12)
urn:lsid:zoobank.org:act:D94080DF-76FE-4D05-AF12-7251716F325A

Type locality. Guaymas Basin, between San Pedro Nolasco Island and Tortuga Island, Gulf of California, Mexico; Talud X cruise, sampling station 15 (27.7°N, 111.6333°W); depth, 1,570 m; organic carbon content, 4.48%; organic matter content, 8.37%; sand, 4.49%; clay, 11.96%; silt, 84%.

Specimens examined. One female holotype dissected and mounted onto eight slides (EMUCOP-110207.04); February 11, 2007; coll. S. Gómez.

Etymology. According to one of several theories, the name California comes from the Old Spanish Calit Fornay, an alteration of the Latin *calida fornax*, hot furnace. The specific epithet makes reference to the region where the species was found. It is to be treated as a noun in apposition.

Differential diagnosis (based on the female only). Stenheliinae: *Beatricella*. Caudal rami elongate, cylindrical, 5.7 times as long as wide, and as long as three last urosomites combined. Antennule seven-segmented, with aesthetasc on fourth and last segments. P1 EXP2 with inner seta. P2 EXP1 without inner seta. Outermost seta of P5 BENP well developed.

Description of female. Total body length measured from tip of rostrum to posterior margin of caudal rami, 540 µm; habitus pyriform, widest at posterior end of cephalothorax, tapering posteriad.

Prosome consisting of cephalothorax with fused first pedigerous somite, and second to fourth free pedigerous somites. Free pedigerous somites without expansions or spinular ornamentation; integument smooth, weakly sclerotized.

Urosome consisting of fifth pedigerous somite (first urosomite), genital double-somite (genital—second urosomite—and third urosomites fused), two free urosomites, and anal somite. Urosomites without expansions laterally nor dorsally; integument weakly sclerotized.

Genital double-somite with laterodorsal internal rib marking original division between second (genital) and third urosomite (Fig. 7A, C), completely fused ventrally (Fig. 7B); proximal half (genital somite) with dorsolateral spinules close to posterior margin, and with posterior sensilla as depicted; distal half (third urosomite) with two sets of dorsolateral spinules (Fig. 7A, C), without surface ornamentation ventrally except for two sensilla (Fig. 7B).

Fourth urosomite as in posterior half of genital double-somite.

Fifth urosomite without sensilla; with one set of dorsolateral spinules (Fig. 7A, C); ventrally with two sets of spinules (Fig. 7B).

Anal somite (Fig. 7A–C) three times as broad as long from dorsal view, two times as broad as long from ventral view; dorsally with row of spinules close to joint with caudal rami, and one pore on each side; anal operculum nearly straight, flanked by one sensilla on each side; ventrally with two pores on each side, medially cleft, with spinules close to insertion with caudal rami.

Caudal rami elongate, cylindrical, 5.7 times as long as wide, and as long as three last urosomites combined; each ramus with one subdistal pore ventrally; with small spinules close to insertion site of caudal seta II (Fig. 7A–C); with seven elements; seta I spine-like, ventral to seta II, the former visibly smaller, both arising subdistally on lateral margin; seta III ventral, subdistal, slightly longer than seta II; seta IV and V situated distally; seta VI issuing at inner distal corner; dorsal seta VII triarticulate at base, situated subdistally close to inner margin.

Rostrum (Fig. 8A) trapezoidal, not fused to cephalothorax, slightly longer than two first antennulary segments combined, slightly bifid, with two subdistal sensilla.

Antennule (Fig. 8A) seven-segmented; all segments smooth, except for spinular row on first segment. All setae smooth except for pinnate seta on first, second, third, and sixth segments; second and third segments each with one seta with fracture plane; sixth and seventh segments each with one articulated seta. Armature formula: 1(1); 2(11); 3(8); 4(5 + (1 + ae)), 5(3); 6(8); 7(4 + acro). Acrothek consisting of two setae and one slender aesthetasc fused at their bases.

Antenna (Fig. 8B). Coxa short, with some spinules at inner and outer margins. Allobasis as long as free endopodal segment, inner margin with small proximal spinules and long spinules on proximal third, with one pinnate abexopodal seta arising midway inner margin. Exopod three-segmented, issuing proximally; first and third segments longest, each about 4.3 times as long as wide, with lateral and apical spinules as shown; first segment with one subdistal pinnate seta; third segment with one lateral pinnate element and three distal setae, of which two fused basally; second segment shortest, about 1.5 times as long as broad, and about one fourth the length of last segment, without surface ornamentation, with one distal pinnate seta. Free endopodal segment elongate, inner margin with proximal row of small spinules, subdistally with curved row of strong spinules, with medial and subdistal fringe; armature consisting of two lateral spines and two accompanying setae, one inner distal geniculate spine, three distal geniculate spines (of which innermost shorter) and one slender seta, and one outer distal geniculate seta fused basally to shorter element.

Mandible (Fig. 9A–B) with relatively short coxa. Gnathobase wide; ventral distal corner produced into small sharp semi-hyaline process; with two strong bicuspidate teeth, several smaller bicuspidate teeth, some spinules, and one slender smooth element accompanied by pinnate seta. Basis elongate, with proximal constriction, tapering distally; with some minute spinules at proximal third; with three subdistal setae. Exopod arising from short pedestal, elongate, about three times as long as wide, and 0.4 times as long as basis, tapering distally; with two outer, two inner, and two apical slender setae, the latter fused basally. Endopod recurved, twisted over exopod (Fig. 9B); with three lateral setae, and five distal elements (two slender setae and two strong elements, and longest element fused to endopod and with hyaline flange in middle part).

Maxillule (Fig. 9C–D). Arthrite of praecoxa with two surface setae and eight bare distal elements (one of which a slender seta arising next to ventralmost spine), one spinulose dorsal spine, and one lateral spinulose recurved seta (Fig. 9D). Coxa with spinular row and three setae, one of which pinnate. Basis with two endites; proximal endite with four, distal endite with three slender setae. Exopod and endopod fused basally, not fused to basis, one-segmented; endopod larger than exopod, with four setae; exopod small, with two setae.

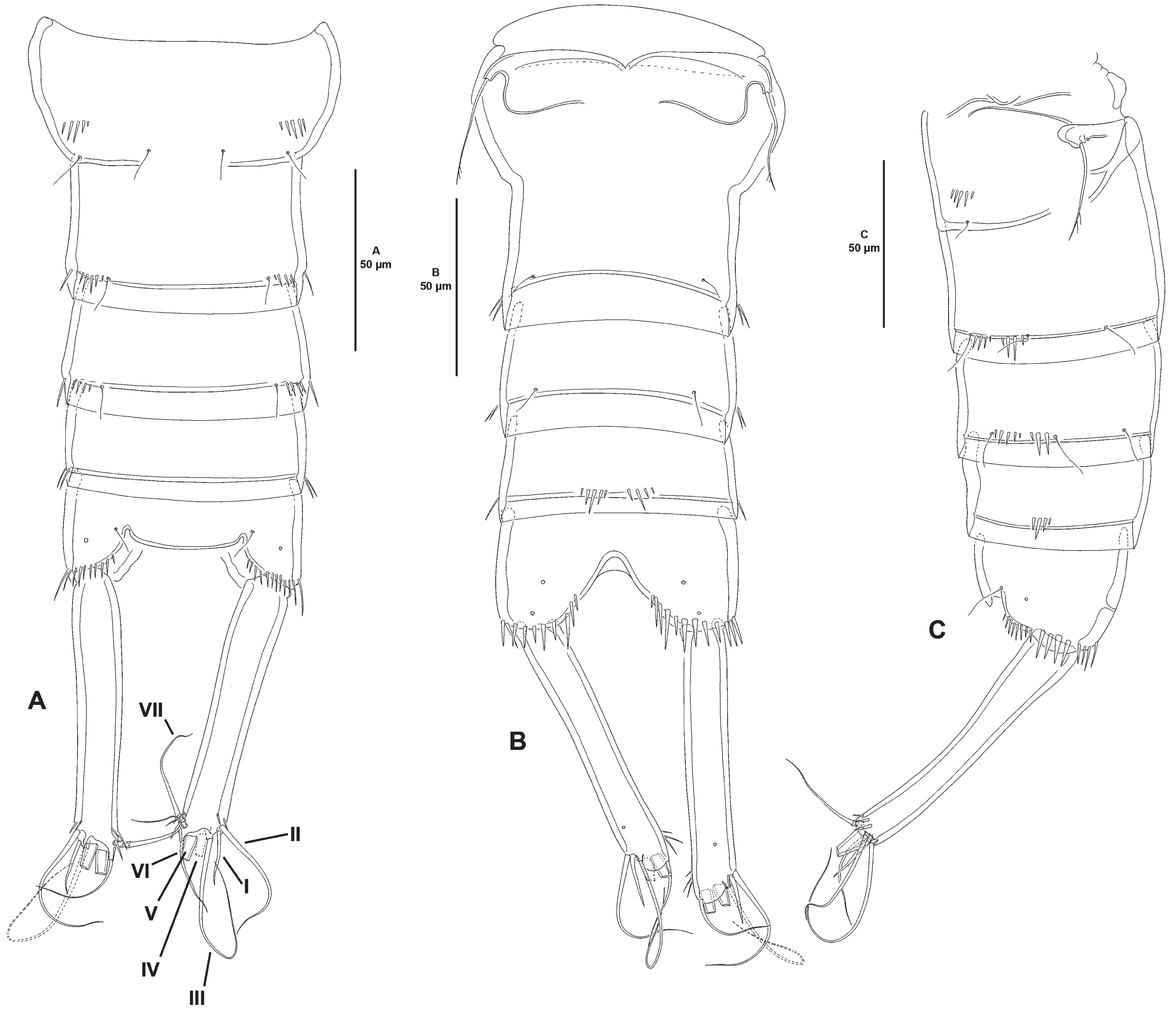

FIGURE 7. *Beatricella calidafornax* **sp. nov.**, female: A, urosome, dorsal (P5-bearing somite omitted); B, urosome, ventral (P5-bearing somite omitted) (microphotograph of the anal somite and caudal rami in ventral view available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10568); C, urosome, lateral (P5-bearing somite omitted).

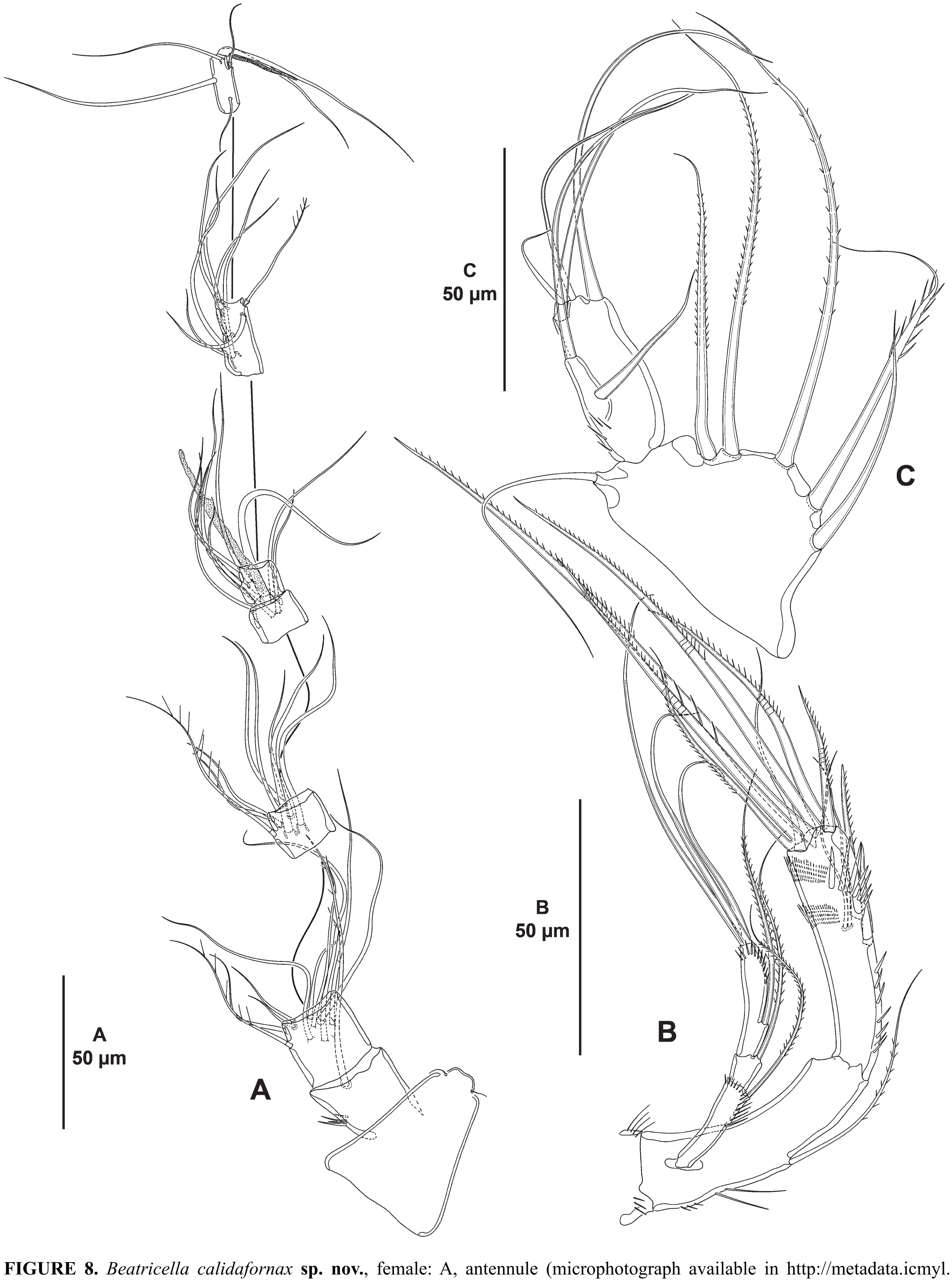

FIGURE 8. *Beatricella calidafornax* **sp. nov.**, female: A, antennule (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10560) and rostrum (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10567); B, antenna; C, P5, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10566).

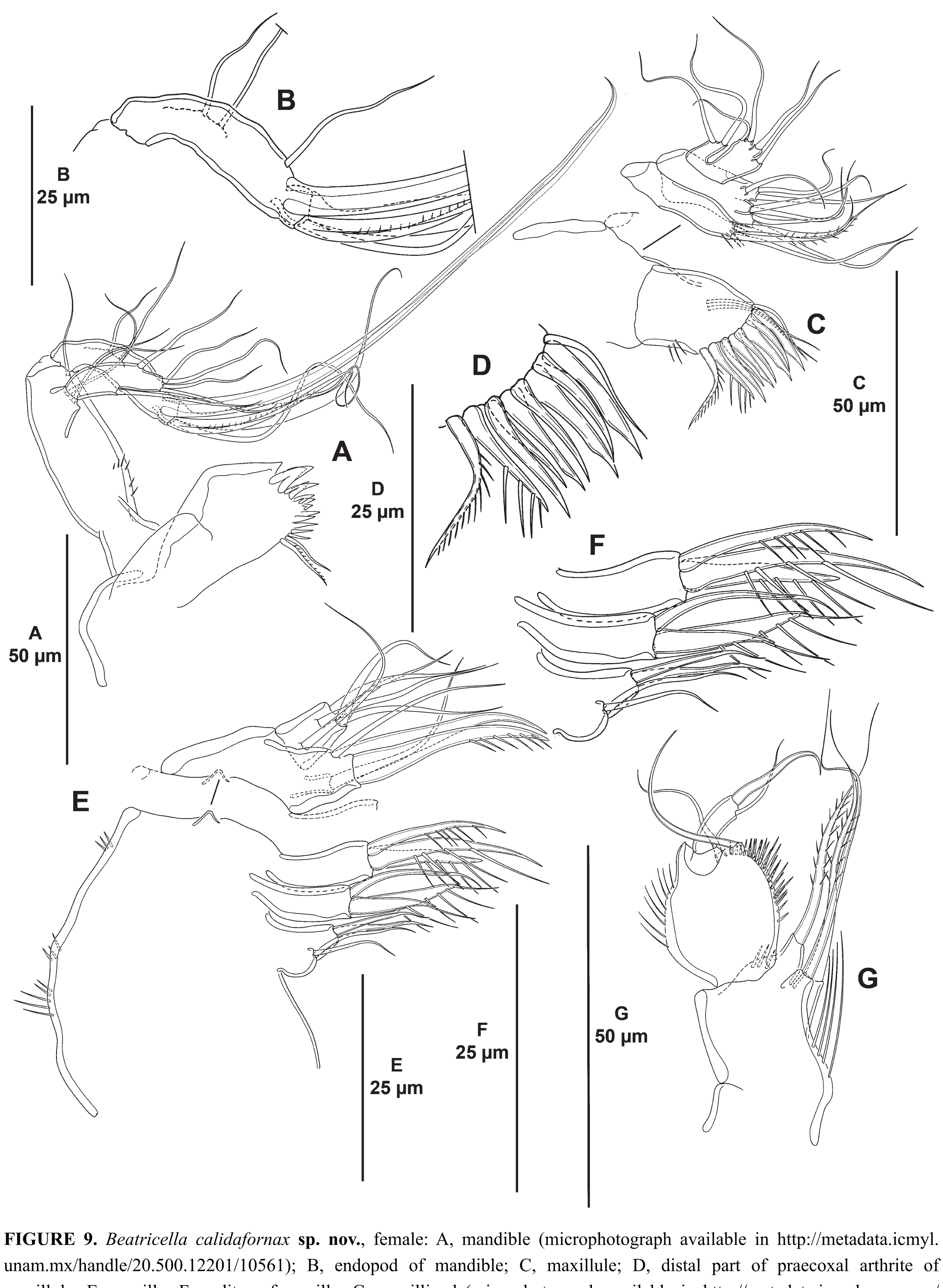

FIGURE 9. *Beatricella calidafornax* **sp. nov.**, female: A, mandible (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10561); B, endopod of mandible; C, maxillule; D, distal part of praecoxal arthrite of maxillule; E, maxilla; F, endites of maxilla; G, maxilliped (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10562).

Maxilla (Fig. 9E–F). Large syncoxa with outer spinules as shown; with three endites (Fig. 9F); proximal endite smallest, bilobate, each lobe with two setae; middle and distal endites elongate, the latter slightly longer, with three elements each. Basis drawn out into strong claw, additionally with strong spinulose spine and two slender setae. Endopod small, 1.5 times as long as wide, with six slender setae (one arising basally, one medially, and four apically).

Maxilliped (Fig. 9G) subchelate. Syncoxa rectangular, about 1.5 times as long as wide; with long inner spinules; with one bare and two spinulose strong elements, of which bare seta and one spinulose element more proximal and both at the same level, the other arising distally from long pedestal. Basis shorter than syncoxa, oval; with slender outer spinules, with one anterior and one posterior inner spinular row as depicted, and two slender distal setae. Endopod one-segmented, slender, with one claw-like element and one seta.

P1 (Fig. 10A). Basis with inner and outer spine, with small strong spinules between rami, and with comparatively slender spinules at bases of outer and inner spine, with long slender inner spinules. Exopod three-segmented, slightly shorter than endopod; first segment longest, third segment shortest, length ratio of EXP1–EXP3 1, 0.8, 0.7; with spinular ornamentation as shown; first segment without, second segment with inner seta, third segment with four elements in all. Endopod three-segmented, ENP1 reaching middle of EXP2, about 0.7 times as long as ENP2 and ENP3 combined; with outer and distal spinular ornamentation as shown; with one strong pinnate inner seta arising at distal third; ENP2 and ENP3 visibly slenderer, the former with one inner seta and outer spinules, the latter with few subdistal outer spinules and three apical elements.

P2 (Figs. 10B, 12A). Intercoxal sclerite not transversely elongate; trapezoidal; with strong pointed process on distal outer corners; without surface ornamentation (Fig. 12A). Coxa massive, square, with some outer spinules proximally and subdistally, with pore close to inner distal corner. Basis with outer setiform element and strong acute inner process, the latter reaching proximal fourth of ENP1 and with slender spinules at its base. Exopod three-segmented, reaching slightly beyond ENP2; EXP1 longest, EXP2 shortest, length ratio of EXP1–EXP3 1, 0.8, 0.9; EXP1 and EXP2 with outer acute distal process, with outer distal pore, with longitudinal row of outer spinules and with inner distal frill, EXP1 without, EXP2 with inner seta; EXP3 with small outer spinules proximally, with two inner and two apical setae, and three outer spines. Endopod three-segmented, noticeably longer than EXP; ENP1–ENP3 length/width ratio 1.6, 2.5, 4.1; ENP1 with strong outer spinules and with subdistal outer pore, with inner and outer acute processes, the former larger and with inner minute spinules, with one slender short inner seta issuing midway inner margin of segment; ENP2 with comparatively smaller outer spinules, with inner distal frill and two inner setae of which proximalmost visibly shorter; ENP3 with small outer spinules and with proximal inner pore, with one inner seta, two inner apical elements and one outer distal spine, with outer distal process and two additional smaller processes flanking two innermost apical elements.

P3 (Figs. 11A, 12B). Intercoxal sclerite not transversely elongate; trapezoidal; wider than in P2; with strong pointed process on distal outer corners; without surface ornamentation (Fig. 12B). Coxa squared; with spinules close to proximal and distal outer corners; with distal outer pore. Basis with outer seta, with pointed inner process smaller than in P2 and with slender spinules at its base, with minute spinules at the base of ENP. Exopod three-segmented, reaching proximal third of ENP3; EXP2 shortest, EXP1 and EXP3 longest, length ratio of EXP1–EXP3 1, 0.7, 1; EXP1 and EXP2 with outer acute distal process, with longitudinal rows of outer spinules and with inner distal frill, each with subdistal outer pore, with one inner seta each; EXP3 with minute outer spinules proximally, without pore, with three inner setae, two apical elements, and three outer spines. Endopod three-segmented, slightly longer than EXP; ENP1 shortest, ENP3 longest, length ratio of ENP1–ENP3 1, 1.1, 1.5; ENP1 with short outer distal process, with minute inner distal spinules, and with inner slender seta; ENP2 with spinular ornamentation as in previous segment, with inner pinnate stiff seta; ENP3 with small outer spinules, with one proximal inner slender seta, one medial inner pinnate stiff element, and one subdistal long inner seta, of which the latter thickest, two distal setae and one outer distal spine; acute processes flanking outer spine and two distal innermost setae.

P4 (Figs. 11B, 12C). Intercoxal sclerite not transversely elongate; trapezoidal; smaller than in P3; with strong pointed process on distal outer corners; without surface ornamentation (Fig. 12C). Coxa squared; ornamented as in P3. Basis as in P3, but inner process smaller. Exopod three-segmented, slightly longer than ENP; length ratio of EXP1–EXP3 1, 0.9, 1.1; EXP1 and EXP2 with outer distal process less developed than in P3, with longitudinal row of small outer spinules, with subdistal outer pore, with inner distal frill, and with inner seta; EXP3 with subdistal outer pore, with three inner setae, two apical elements, and three outer spines. Endopod three-segmented, shorter than EXP; ENP1 shortest, ENP3 longest, length ratio of ENP1–ENP3 1, 1.1, 1.3; ENP1 with strong outer spinules, without pore, with short outer distal process, with inner long stiff pinnate element; ENP2 as in previous segment except for slender inner seta and noticeably larger outer distal process; ENP3 with subdistal pore and some outer spinules, with two inner setae, two inner apical elements, and one outer apical spine, with short acute processes flanking outermost distal spine and two innermost distal elements.

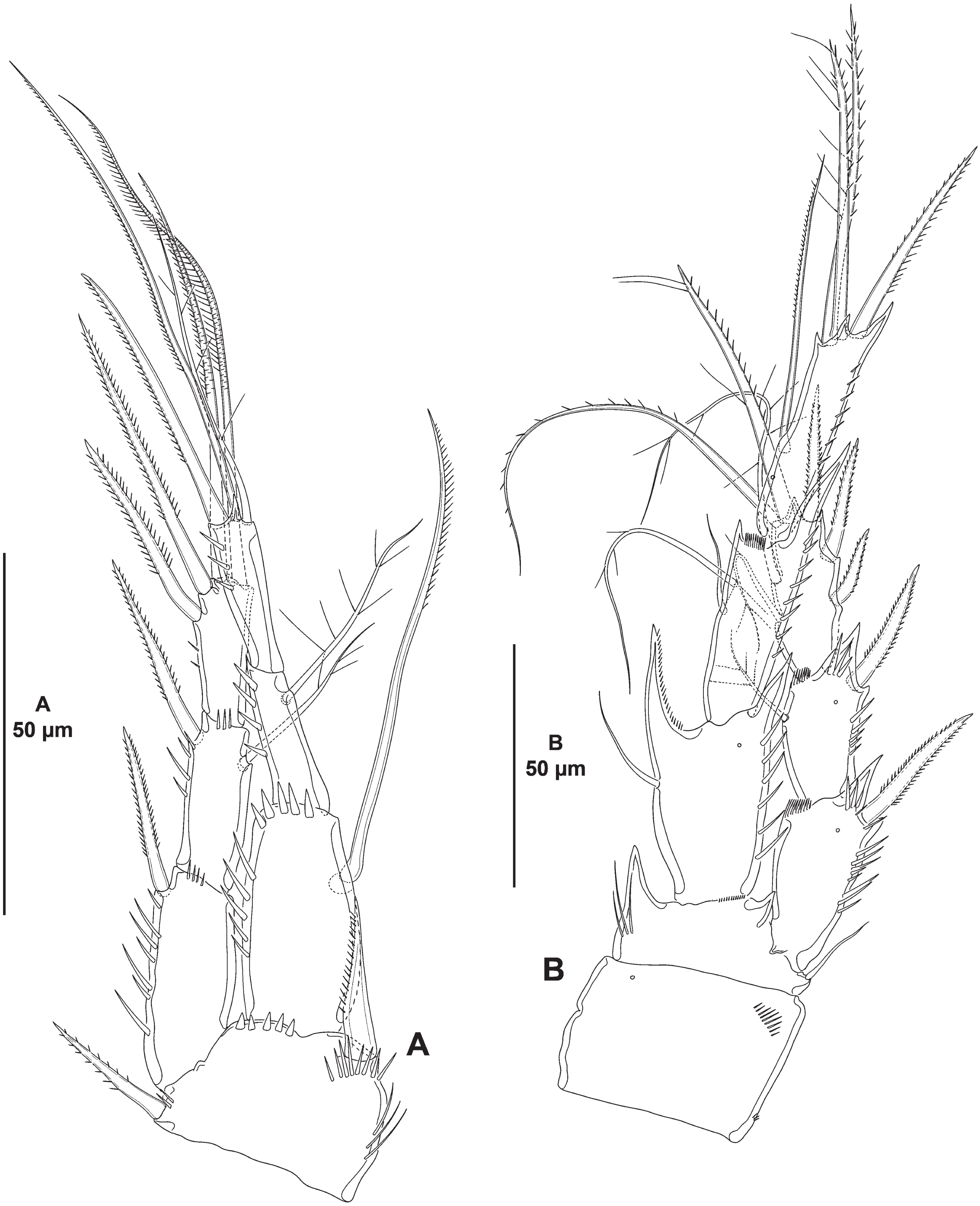

FIGURE 10. *Beatricella calidafornax* **sp. nov.**, female: A, P1, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10563); B, P2, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10564).

Setal formula of swimming legs as follows:

	P1	P2	P3	P4
EXP	0,1,022	0,1,223	1,1,323	1,1,323
ENP	1,1,111	1,2,121	1,1,321	1,1,221

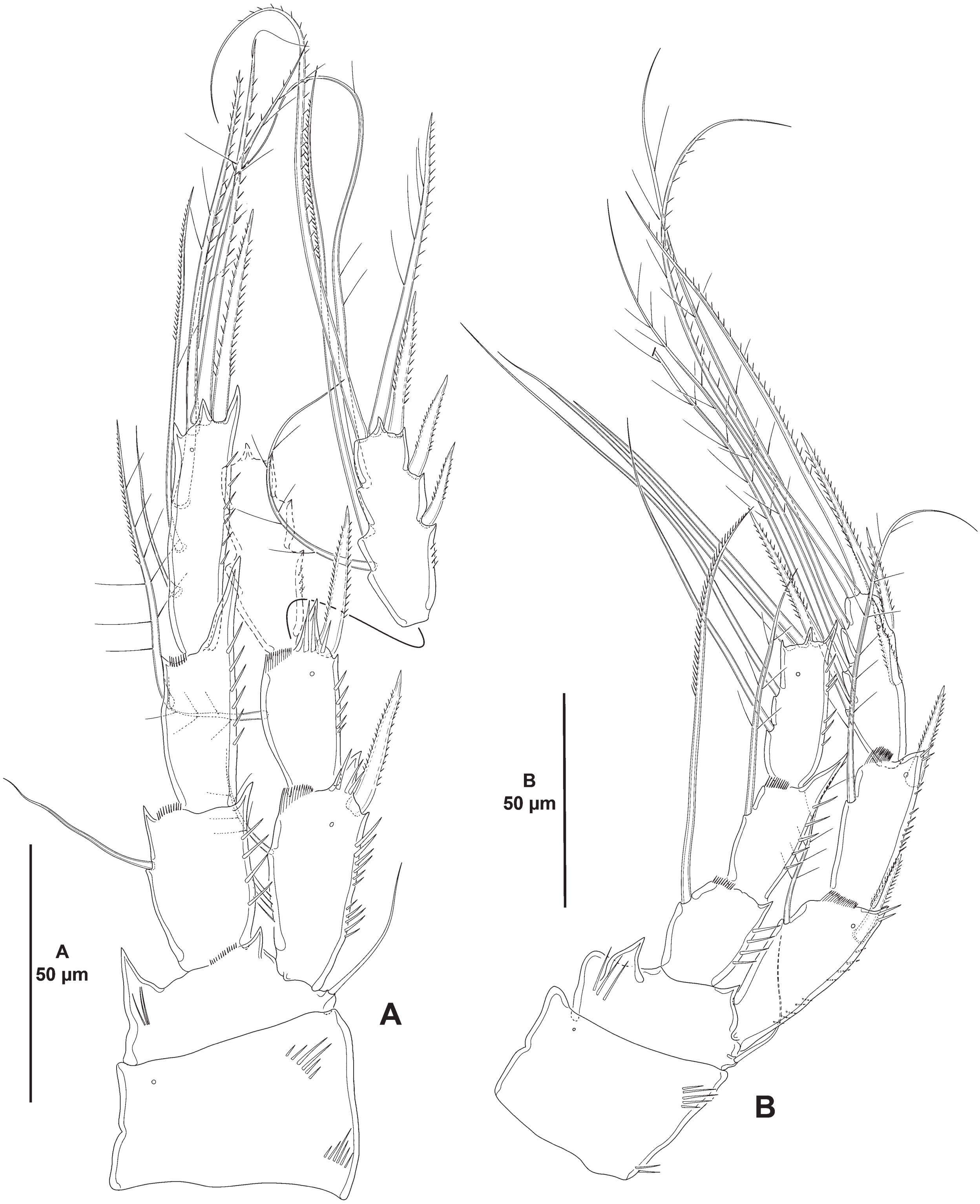

FIGURE 11. *Beatricella calidafornax* **sp. nov.**, female: A, P3, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10559); B, P4, anterior (microphotograph available in http://metadata.icmyl.unam.mx/handle/20.500.12201/10565).

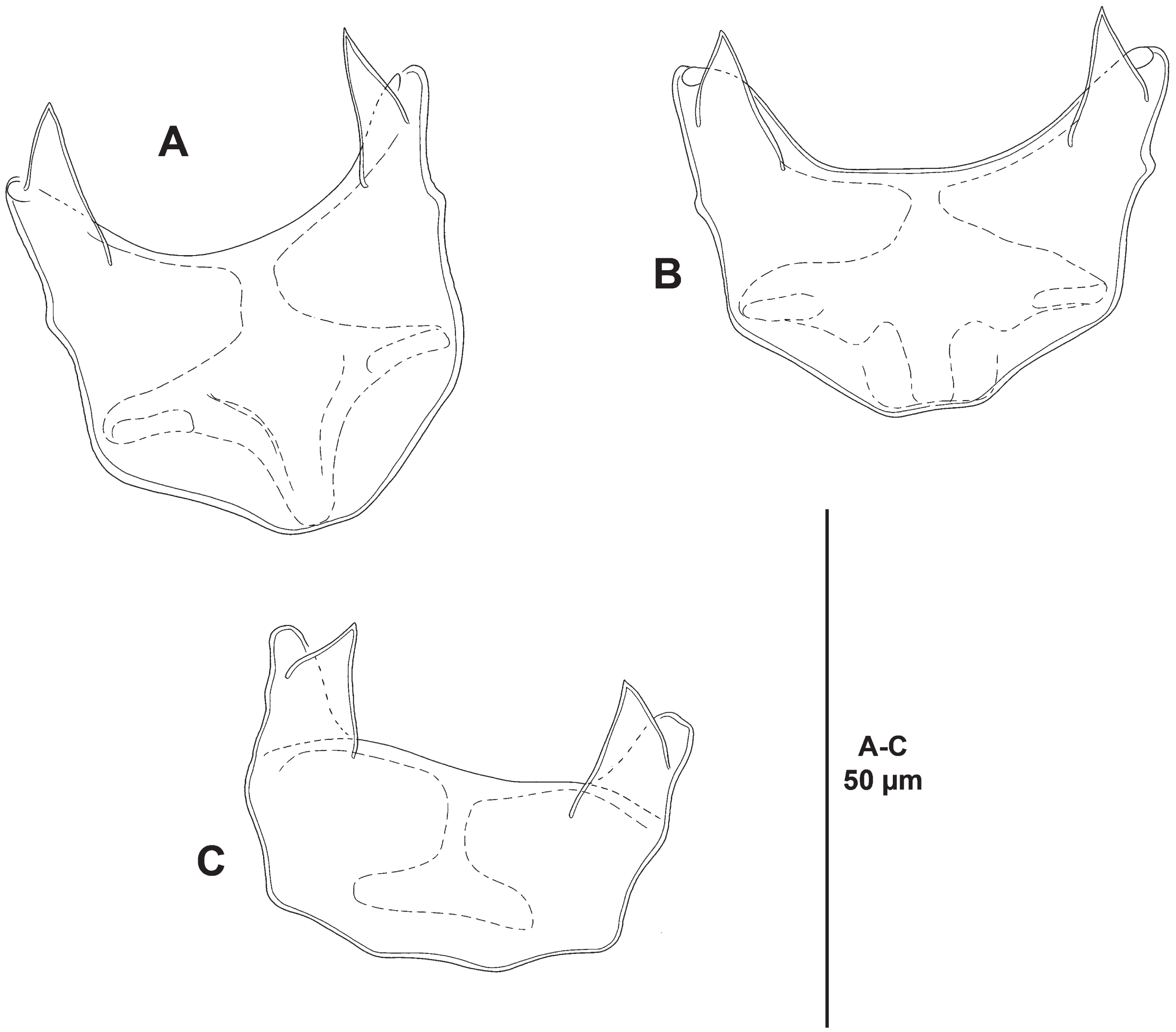

FIGURE 12. *Beatricella calidafornax* **sp. nov.**, female: A, intercoxal sclerite of P2, anterior; B, intercoxal sclerite of P3, anterior; C, intercoxal sclerite of P4, anterior.

P5 (Fig. 8C). Baseoendopod pentagonal, with five setae, innermost and outermost setae shortest, all setae normal. Exopod oval, with some outer proximal spinules, with six setae, of which apical medial seta shortest.

P6 (Fig. 7B–C) minute flap covering ventrolateral genital aperture, fused to somite, without surface ornamentation, with one slender seta.

Male. Unknown.

Remarks and discussion. The genus *Beatricella* was reinstated by Mu & Huys (2002) to reallocate *Delavalia aemula* Scott, 1893 and one *species inquirenda*, *Stenhelia aemula sensu* Marinov (1977). According to Mu & Huys (2002: 203), *Beatricella* does not display any of the seven synapomorphies for *Stenhelia* and *Anisostenhelia*, but can be defined upon three apomorphies: 1) male P2 ENP2 drawn out into sigmoid finely pinnate process and outer margin with row of long spinules, 2) P4 ENP1 with very long stout seta, and 3) the male P5 EXP incorporated in baseoendopod and outermost seta modified into strong spine. According to Mu & Huys (2002), the sigmoid process on the male P2 ENP2 of *Beatricella* is an apomorphy for the genus. However, the apomorphic status of the long stout inner seta on P4 ENP1 and the fused male P5 EXP and BENP with outermost element modified into a strong spine is uncertain as it is shared by some other stenheliins (see Gómez & Cruz-Barraza 2021).

The new species proposed here was attributed to the genus *Beatricella* by the combination of its three-segmented P1 ENP, primitive armature formula of P2 EXP3 (with two inner setae; armature formula 223) and P3 EXP3 (with three inner setae; armature formula 323), and presence of normal setae only on the endopodal lobe of P5. Mu & Huys (2002) suggested that the lack of an inner seta on P1 EXP2 could be a potential synapomorphy for *Beatricella*, *Stenhelia* and *Anisostenhelia,* but also *Lonchoeidestenhelia*. However, the presence of an inner seta on P1 EXP2 in *B. calidafornax* **sp. nov.** seems to confirm that the lack of an inner seta on P1 EXP2 in *B. aemula* is likely the result of a secondary loss and cannot be regarded as synapomorphic for *Beatricella, Lonchoeidestenhelia,* and *Stenhelia-Anisostenhelia*. On the other hand, *B. calidafornax* **sp. nov.** is similar to *Itostenhelia*, *Willenstenhelia*, *Wellstenhelia*, and *Wellstenvalia* in the retention of one inner seta on P1 EXP2. It is similar also to *A. asetosa* in the loss of the inner seta on P2 EXP1. Interestingly, *A. asetosa* shares the armature formula of P2 EXP (0,1,123) with *Willenstenhelia*.

The description of the new species proposed herein confirms that the caudal seta I of *Beatricella* is spine-like and this condition is shared, at least, with *Anisostenhelia*, *Cladorostrata*, *Itostenhelia*, *Lonchoeidestenhelia*, most species of *Wellstenhelia* and *Me. papuaensis*, and some species of *Delavalia* (see Gómez & Cruz-Barraza 2021).

The male of *B. calidafornax* **sp. nov.** remains unknown, but this species can be readily separated from *B. aemula* by the relative length of caudal rami (as long as anal somite in *B. aemula*, but as long as three last urosomites combined in the new species), number of segments of the female antennule (eight segments in *B. aemula*, but seven segments in the new species), armature complement of P1 EXP2 (without inner seta in *B. aemula*, but with inner seta in *B. calidafornax* **sp. nov.**), P2 EXP1 (with inner seta in *B. aemula*, but without inner armature in the new species), and relative length of outermost seta on female P5 endopodal lobe (very small in *B. aemula*, but well developed in the Mexican species).

Acknowledgements

This study was financed by the Programa de Apoyo a Proyectos de Investigación e Innovación Tecnológica (PAPIIT) of the Dirección General de Asuntos del Personal Académico of the Universidad Nacional Autónoma de México (UNAM-DGAPA-PAPIIT), project IN202116 "Distribución y riqueza de comunidades de microinvertebrados poco conocidos del Golfo de California". Talud IV cruise was financed by CONACyT, project 31805-N "Biocenosis y composición química de invertebrados bentónicos y pelágicos en aguas profundas del sur del golfo de California, en relación con las condiciones ambientales". Talud X cruise was financed by the Programa de Apoyo a Proyectos de Investigación e Innovación Tecnológica (PAPIIT) of the Dirección General de Asuntos del Personal Académico of the Universidad Nacional Autónoma de México (UNAM-DGAPA-PAPIIT), project IN217306-3 "Biocenosis de invertebrados bentónicos y pelágicos en aguas profundas del Pacífico Mexicano en relación con las condiciones ambientales". Talud XV and XVIB cruises were financed by the Consejo Nacional de Ciencia y Tecnología (CONACyT), project CONACyT 000000000179467 "Biodiversidad y recursos pesqueros en las aguas profundas de la costa oeste de la Península de Baja California".

Ship time was provided by the Coordinación de la Investigación Científica, UNAM. The authors thank all scientists, students and crew members for their help and support during Talud IV, X, XV and XVIB cruises.

References

Boeck, A. (1865) Oversigt over de ved Norges Kyster jagttagne Copepoder henhörende til Calanidernes, Cyclopidernes og Harpactidernes Familier. *Forhandlinger i Videnskabsselskabet i Kristiania*, 1864, 226–282.

Brady, G.S. (1869) On the crustacean fauna of the salt-marshes of Northumberland and Durham. *Natural History Transactions of Northumberland, Durham and Newcastle-upon-Tyne*, 3, 120–136.

Brady, G.S. (1880) *A Monograph of the free and semi-parasitic Copepoda of the British Islands*, 2. The Ray Society, London, 182 pp.

Coull, B.C. & Fleeger, J.W. (1977) A new species of *Pseudostenhelia*, and morphological variations in *Nannopus palustris* (Copepoda, Harpacticoida). *Transactions of the American Microscopical Society*, 96, 332–340. https://doi.org/10.2307/3225863

Dahms, H.-U., Schizas, N.V. & Shirley, T.C. (2005) Naupliar evolutionary novelties of *Stenhelia peniculata* (Copepoda, Harpacticoida) from Alaska affirming taxa belonging to different categorial rank. *Invertebrate Zoology*, 2, 1–14. https://doi.org/10.15298/invertzool.02.1.01

Dana, J.D. (1846) Notice of some genera of Cyclopacea. *American Journal of Science and Arts*, Series 2, 1, 225–230.

Gómez, S. (2020) On some new species of Stenheliinae Brady, 1880 (Copepoda, Harpacticoida, Miraciidae) from north-western Mexico, with the proposal of *Lonchoeidestenhelia* gen. nov. *Zookeys*, 987, 41–79.

https://doi.org/10.3897/zookeys.987.52906
Gómez, S. (2021) On some deep-sea Stenheliinae from the Gulf of California and the west coast of the Baja California Peninsula (Mexico): the genus *Delavalia* and proposal of *Archaeohuysia* gen. nov. and *Diarthropodella* gen. nov. (Copepoda: Harpacticoida: Miraciidae). *Zootaxa*, 5051 (1), 171–135.
https://doi.org/10.11646/zootaxa.5051.1.12
Gómez, S. & Cruz-Barraza, J.A. (2021) On some deep-sea Stenheliinae from the Gulf of California and the west coast of the Baja California Peninsula (Mexico): *Wellstenhelia euterpoides* sp. nov., and *Wellstenvalia wellsi* gen. et sp. nov. (Copepoda: Harpacticoida: Miraciidae). *Zootaxa*, 5051 (1), 117–150.
https://doi.org/10.11646/zootaxa.5051.1.10
Huys, R. & Mu, F.H. (2008) Description of a new species of *Onychostenhelia* Itô (Copepoda, Harpacticoida, Miraciidae) from the Bohai Sea, China. *Zootaxa*, 1706 (1), 51–68.
https://doi.org/10.11646/zootaxa.1706.1.2
Itô, T. (1979) Descriptions and records of marine harpacticoid copepods from Hokkaido, VII. *Journal of the Faculty of Sciences, Hokkaido University*, *Zoology*, 22, 42–68.
Karanovic, T. & Kim, K. (2014) New insights into polyphyly of the harpacticoid genus *Delavalia* (Crustacea, Copepoda) through morphological and molecular study of an unprecedented diversity of sympatric species in a small South Korean bay. *Zootaxa*, 3783 (1), 1–96.
https://doi.org/10.11646/zootaxa.3783.1.1
Marinov, T. (1977) Harpacticoida from the Eastern Central Atlantic Coast. *Izvestiya na Instituta Okeanografiya I Ribno Stopanstvo, Varna*, 15, 83–98.
McIntyre, A.D. (1968) The meiofauna and macrofauna of some tropical beaches. *Journal of Zoology*, 156, 377–392.
https://doi.org/10.1111/j.1469-7998.1968.tb04360.x
Mu, F. & Huys, R. (2002) New species of *Stenhelia* (Copepoda, Harpacticoida, Diosaccidae) from the Bohai Sea (China) with notes on subgeneric division and phylogenetic relationships. *Cahiers de Biologie marine*, 43, 179–206.
https://doi.org/10.21411/CBM.A.C482EC6A
Özdikmen, H. (2009) Substitute names for two genera of Harpacticoida (Crustacea: Copepoda). *Munis Entomology & Zoology*, 4, 297–298.
Por, F.D. (1964) A study of Levantine and Pontic Harpacticoida (Crustacea, Copepoda). *Zoologische Verhandelingen, Leiden*, 64, 1–128.
Ranga Reddy, Y. (1984) The undescribed female of *Pseudostenhelia secunda* Wells, 1971 (Copepoda Harpacticoida) and keys to the genus. *Hydrobiologia*, 114, 149–156.
https://doi.org/10.1007/BF00018111
Sars, G.O. (1903) Copepoda Harpacticoida. Parts I & II, Misophriidæ, Longipediidæ, Cerviniidæ, Ectinosomidæ (part). *An account of the Crustacea of Norway, with short Descriptions and Figures of all the Species*, 5, 1–28, pls. I–XVI.
Scott, T. (1893) Additions to the fauna of the Firth of Forth. Part V. *Reports of the Fishery Board for Scotland, Edinburgh*, 11 (3), 197–219.
Scott, T. (1905) Notes on British Copepoda: change of names. *Annals and Magazine of natural History*, Series 7, 16, 567–571.
https://doi.org/10.1080/03745480509443084
Shorthouse, D.P. (2010) SimpleMappr, an online tool to produce publication-quality point maps. Available from: https://www.simplemappr.net (accessed 12 April 2019)
Tai, A.-Y. & Song, Y.-Z. (1979) Freshwater Copepoda. Harpacticoida. *In*: Shen, C.-J. (Ed.), *Fauna Sinica, Crustacea.* Science Press, Beijing, pp. 164–300. [in Chinese]
Wells, J.B.J. (1967) The littoral Copepoda (Crustacea) of Inhaca Island, Mozambique. *Transactions of the Royal Society of Edinburgh*, 67, 189–358.
https://doi.org/10.1017/S0080456800024017
Wells, J.B.J. (1971) The Harpacticoida (Crustacea: Copepoda) of two beaches in south-east India. *Journal of natural History*, 5, 507–520.
https://doi.org/10.1080/00222937100770381
Wells, J.B.J. (2007) An annotated checklist and keys to the species of Copepoda Harpacticoida (Crustacea). *Zootaxa*, 1568 (1), 1–872.
https://doi.org/10.11646/zootaxa.1568.1.1
Willen, E. (2003) A new species of *Stenhelia* (Copepoda, Harpacticoida) from a hydrothermal, active, submarine volcano in the New Ireland Fore-Arc system (Papua New Guinea) with notes on deep sea colonization within the Stenheliinae. *Journal of natural History*, 37, 1691–1711.
https://doi.org/10.1080/00222930110114437