



Two new species of the deep-sea genus *Parameiropsis* (Copepoda: Harpacticoida) from the eastern central Pacific

DAE HYUN CHO¹, JIN HEE WI² & HAE-LIP SUH^{1,3}

¹Department of Oceanography, Chonnam National University, Gwangju 61186, Korea

²Research Institute for Coastal Environment and Fishery-policy, Industrial–Education Cooperation B/D, Chonnam National University, Gwangju 61186, Korea

³Corresponding author. E-mail: suhhl@chonnam.ac.kr

Abstract

Two new species of *Parameiropsis* are herein described that were identified from the Korean Deep Ocean Study (KODOS) in the Clarion–Clipperton Fracture Zone, located in the eastern central Pacific. *Parameiropsis kodosensis* n. sp. is similar to *P. magnus* Itô, 1983 in two key respects: the presence of a distal seta on the syncoxa of the maxilliped, and the general features of its swimming legs. However, *P. kodosensis* can be differentiated from *P. magnus* by a higher length-to-width ratio of the caudal ramus (2.5:1 and 1:1 respectively), the setal number on the exp-3 of P1, and the exp and benp of P5 are separated in *P. kodosensis*, while they are fused in *P. magnus*. *Parameiropsis tetraspinosa* n. sp. resembles *P. peruanus* Becker, 1974 in the absence of a fused seta in the outermost spine on the endopod of antenna and the general features of the swimming legs. However, *P. tetraspinosa* can be distinguished from *P. peruanus* by a higher length-to-width ratio of the caudal ramus (3.9:1 and 2.3:1 respectively), the presence of a distal seta on the syncoxa of the maxilliped, and by its medially fused P5. In this study full descriptions and a comparison with previously described species are provided. Additionally, a key to females of *Parameiropsis* species is given.

Key words: box corer, Clarion–Clipperton Fracture Zone, deep sea, Parameiropsidae, taxonomy

Introduction

The family Parameiropsidae Corgosinho & Martínez Arbizu, 2010 is a deep-sea taxon. It includes only one genus, *Parameiropsis* Becker, 1974. The genus *Parameiropsis* was established by Becker (1974) with descriptions of *P. peruanus* and *P. rapiens* Becker, 1974 from the Peru Trench in the Pacific and an Atlantic deep-sea site off the coast of northern Africa, respectively. Becker (1974) originally placed the genus *Parameiropsis* in the family Ameiridae and mentioned certain similarities between *Parameiropsis* and *Ameiropsis* Sars, 1907. However, Corgosinho & Gheerardyn (2009) raised the question of the familial position of the genus *Parameiropsis* based on several distinct morphological differences, including the much shorter antennule, the shape of the rostrum, and the swimming legs. Recently, this genus was relocated to the family Parameiropsidae (see Corgosinho & Martínez Arbizu 2010). To date, eight species have been classified in the genus *Parameiropsis*: two species (*P. peruanus* and *P. magnus*) from the Pacific (Becker 1974; Itô 1983), five species (*P. antennafortis* Corgosinho & Gheerardyn, 2009, *P. neptuni* Corgosinho & Martínez Arbizu, 2010, *P. poseidonicus* Corgosinho & Martínez Arbizu, 2010, *P. rapiens*, and *P. senckenbergi* Corgosinho & Martínez Arbizu, 2010) from the Atlantic (Becker 1974; Corgosinho & Gheerardyn 2009; Corgosinho & Martínez Arbizu 2010), and *P. amphitriteae* Corgosinho & Martínez Arbizu, 2010 from the Arctic.

The Clarion–Clipperton Fracture Zone (CCFZ), located in the eastern central Pacific, is an economically important site because of manganese nodule mining and the impetus to develop an environmental management plan (Rademaekers *et al.* 2015). In the course of an environmental survey of the Korean Deep Ocean Study (KODOS), meiobenthic samples were collected from the CCFZ. MOF (2014) reported that, of the major meiobenthic taxa found in this survey, harpacticoid copepods were the second highest in abundance (3.7 ~ 23.1%).

Although the CCFZ is one of the Pacific deep-sea regions that have been extensively surveyed, information on the systematics of Harpacticoida is still scarce (Menzel 2011; Menzel *et al.* 2011). No specimens of the genus *Parameiropsis* have been described from the CCFZ. *Parameiropsis* species are generally extremely rare. For the eight species described to date, there are no descriptions that include accounts of both sexes. Only females of five species have been described (*P. amphitriteae*, *P. antennafortis*, *P. magnus*, *P. peruanus*, and *P. rapiens*), and only the males of three species (*P. neptuni*, *P. poseidonicus*, and *P. senckenbergi*).

In this study, two new species belonging to the genus *Parameiropsis* are reported from new samples from the CCFZ. Only females of these species were present in these samples. The objectives of the present study were to describe the two new species and to confirm the presence and nature of the morphological differences found on the basis of comparisons with previously recorded species. Additionally, we provide a key for the known species including the two new species.

Material and methods

Sediment samples were collected in the eastern central Pacific KODOS area (10°30.98'N/131°18.993'W, depth 4988 m and 10°30.11'N/131°19.987'W, depth 5036 m) with a box corer (0.25 m²) from a shipboard platform, R/V Onnuri, in August 2014. After recovery of the box corer, the supernatant water was siphoned off with a sieve (250 µm mesh) to yield the organisms. Macrofaunal organisms found on the manganese nodules were manually removed from the nodules. The nodules were then removed from the surface of the sediment and washed with a 250 µm mesh sieve. The upper 10 cm of sediment was sliced into two layers: 0–5 and 5–10 cm. The sediment of each layer was transferred into an elutriator equipped with seawater filtration systems, and the sediments were washed using a flow of filtered seawater for one hour. The meiofauna from the overflow were sieved with a 250 µm mesh sieve, and the residue from each sieve was preserved in a 10% formalin-seawater solution. The collected animals were subsequently identified and counted in the laboratory. Harpacticoid copepods were dissected under a dissecting microscope (Nikon, SMZ645), placed in mounted CMC-10 aqueous mounting medium (Maters Company, Inc., Wood Dale, IL, USA), mounted on slides, and sealed with high-quality nail varnish. Drawings were made with a differential interference contrast microscope (Nikon Eclipse Ci) equipped with a drawing tube. The total length of each specimen was measured from the tip of the rostrum to the posterior end of the anal somite in the lateral view. The scale bars in the figures are marked in micrometers (µm). The terminology of body and appendage morphology follows that of Huys & Boxshall (1991). The type material has been deposited in the collections of the Marine Biodiversity Institute of Korea (MABIK) in Seocheon, Korea.

The following abbreviations are used in the text: benp = baseopod; enp = endopod; enp-1 (2, 3) = proximal (middle, distal) segment of endopod; exp = exopod; exp-1 (2, 3) = proximal (middle, distal) segment of exopod; P1–P6 = first to sixth thoracopod.

Systematics

Subclass Copepoda Milne-Edwards, 1840

Order Harpacticoida Sars, 1903

Family Parameiropsidae Corgosinho & Martínez Arbizu, 2010

Genus *Parameiropsis* Becker, 1974

Generic diagnosis (amended from Becker 1974). Females. Body cylindrical. Rostrum small, triangular, not fused to cephalothorax. Antennule 8-segmented in females, aesthetasc on third and eighth segments. Antenna with basis or allobasis; exp 1-segmented, small; enp 1-segmented with 7 strong spines (2 subdistal, 5 distal), outermost spine modified. Mandible with elongated coxa and very long gnathobasis; mandibular palp with unarmed basis, exp 1-segmented, enp 1-segmented. Maxillule with very long praecoxal arthrite, enp represented lobe, exp 1-segmented. Maxilla syncoxa fused to basis; basis with 3 endites, proximal basal endite reduced; enp-1 drawn into strong,

sclerotized claw with strong spine; enp-2 with 2 slender setae. Syncoxa of maxilliped with 2 distal setae; enp with strong claw armed with 1 seta. Intercoxal sclerite of P1 transversely elongated; intercoxal sclerite of P2–P4 longitudinally elongated. P1–P4 both rami tapering distally, 3-segmented. Basis of P1 with strong inner spine. P5 benp fused medially; benp with 1 outer seta on basis; endopodal lobe with 4 long spines; exp 1-segmented.

***Parameiropsis kodosensis* n. sp.**

(Figs. 1–4)

Type locality. Eastern central Pacific Ocean, 10°30.98'N 131°18.993'W, at a depth of 4988 m.

Material examined. Female holotype dissected and mounted on eight slides (MABIK CR00235259).

Etymology the specific name refers to the type locality in the Pacific Ocean (Clarion–Clipperton Fracture Zone; CCFZ): KODOS is the Korean license area for exploration of polymetallic nodules in the CCFZ.

Description of female. Body (Figs. 1A, B) length 1.85 mm, almost cylindrical, widest at posterior margin of cephalothorax, tapering posteriorly, with slight demarcation, without clear distinction between prosome and urosome. Cephalothorax and second to fifth urosomites with distal hyaline membrane. Prosome 0.8 times as long as urosome excluding caudal rami, 0.7 times length including caudal rami.

Prosome (Figs. 1A, B) comprising cephalothorax with completely fused first pedigerous somite and three free pedigerous somites. Second to fourth pedigerous somites with pointed posterolateral corners in dorsal view.

Urosome (Figs. 1A, B) 5-segmented, comprising fifth pedigerous somite, genital double–somite (fused genital and first abdominal somites) and three free abdominal somites. Genital double–somite (Fig. 1A) as long as wide in dorsal view, line of fusion marked only by a short lateral subcuticular rib (Fig. 1B).

Anal somite (Figs. 1A, B) elongated, tapering posteriorly, approximately 1.2 times as long as preceding somite; anal operculum not reaching distal margin of anal somite.

Caudal rami (Figs. 1A, C) with almost straight inner and outer margins, about half as long as anal somite, approximately 2.5 times as long as wide, inner margin unornamented, with 6 setae: setae II and VII of similar length, seta III distally to seta II, about as long as seta VI, longer than setae II and VII, seta IV (Fig. 1A') 3.8 times as long as caudal rami, seta V (Fig. 1A'') longest, approximately 2.3 times as long as seta IV.

Rostrum (Fig. 1A) not fused to cephalothorax, nearly rectangular.

Antennule (Figs. 1B, 2A) 8-segmented, approximately 0.7 times as long as cephalothorax, relative lengths (%) of segments measured from proximal end along caudal margin 20.2:19.3:25.4:7.9:8.8:4.4:3.5:10.5; first segment short, bearing 1 seta on outer distal margin and 4 spinules (1 anterior, 3 posterior); second segment with 5 simple setae on posterior margin and 1 naked seta on anterior margin, 1 seta on outer distal margin; third segment longest, with 1 seta each at proximal, middle and distal margin on outer margin and slender long apical aesthetasc fused basally with 2 apical setae; proximal 3 segments stronger than distal 5 segments; fifth segment with 1 long unipinnate seta on distal outer margin; sixth and seventh segments with 1 apical and 1 inner marginal seta, respectively; eighth segment with 3 inner simple setae, 3 long setae, and aesthetasc apically. Armature formula as follows: 1/7/3 + (1 + Ae)/0/1/2/2/6 + Ae.

Antenna (Figs. 2B, C) comprising coxa, allobasis, free second enp, and exp: coxa thick, short, and bare; allobasis thick, about twice as long as wide, with three longitudinal rows of spinules on proximal edge (arrowed in Fig. 2B), distal row of spinules longer than anterior; exp 1-segmented, with 1 setulose seta on inner medial margin, 3 subapical spinules, and 1 apical setulose seta; endopodal segment shorter than allobasis, with group of spinules on proximal inner margin, inner medial margin with 2 robust spines ornamented with crenulations along medial margin (arrowed in Fig. 2B), 6 short blunt spinules, and 1 long simple seta, row of setules on outer distal margin, distal margin with 4 crenulated spines (3 spines missing), 1 modified spine bearing 11 simple spinules and 1 bipinnate seta fused to spine (arrowed in Fig. 2C), 1 bipinnate seta and row of setules.

Labrum (Fig. 2D) represented by a triangular plate, with bifid tip and fringed by hyaline membrane around apex.

Mandible (Fig. 2E) with elongate coxa, with row of spinules subdistally; gnathobasis very long, with sharp cutting edge composed by 3 strong teeth apically, of which medial teeth multicuspidate, and 1 tooth and 1 long stout subdistal seta furnished with a row of spinules longitudinally; basis of mandibular palp unarmed; exp 1-segmented with 2 apical bipinnate setae; enp 1-segmented, stronger than exp, with 3 apical and 1 subapical seta.

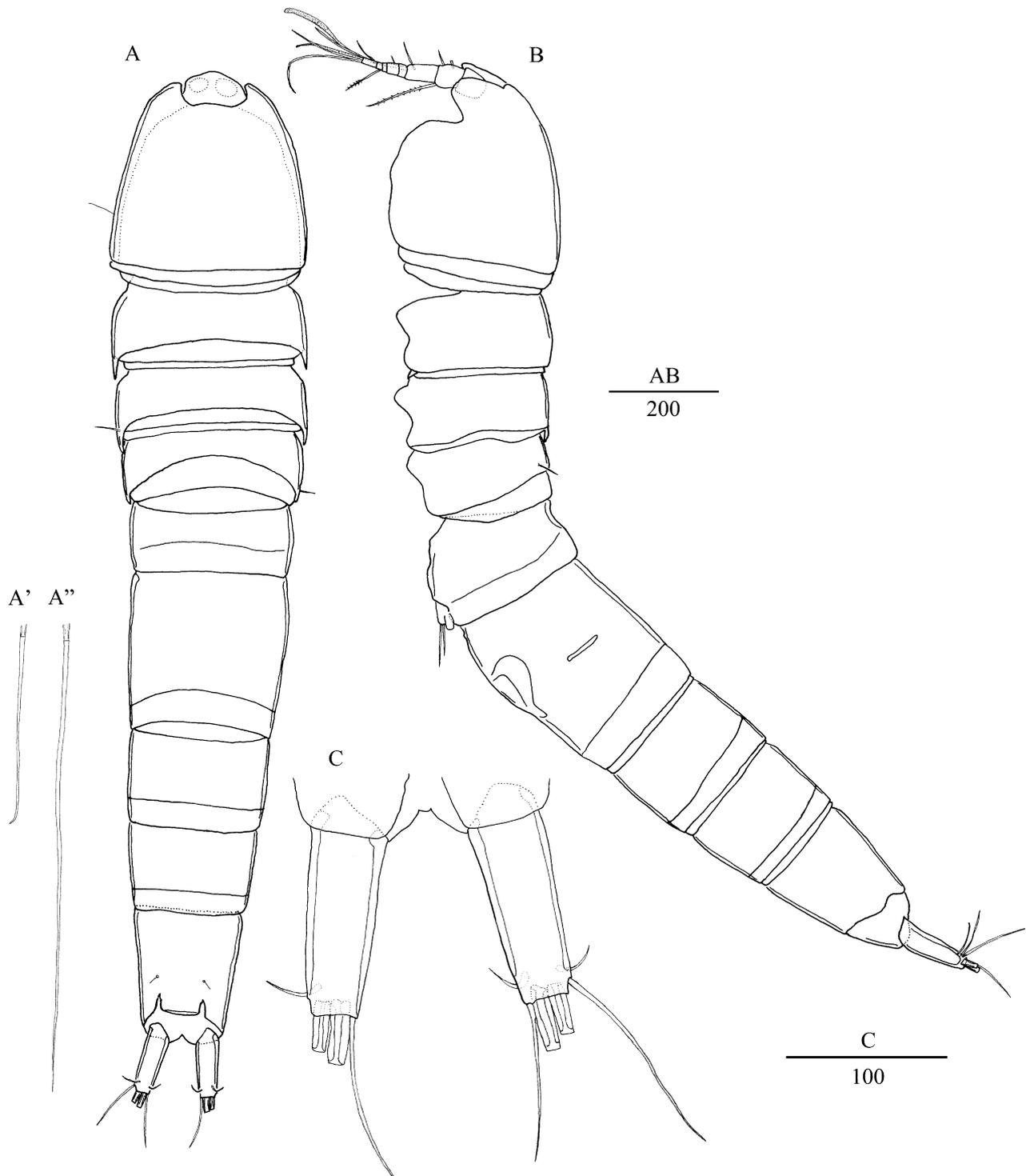


FIGURE 1. *Parameiopsis kodosensis* n. sp., holotype female. A, habitus, dorsal view; A', partial view of seta IV; A'', partial view of seta V; B, habitus, lateral view; C, caudal rami, ventral view. Scale bars are given in µm

Maxillule (Figs. 2F, G) with elongate praecoxal arthrite with 6 slender apical setae, 2 very long and 1 short setae subdistally, 4 spinules proximally on oral margin; coxal endite with 3 slender setae apically; basal endite with 4 apical setae (1 bipinnate seta, 3 simple setae) and 2 subapical setae on oral margin; enp fused to basis and represented by lobe armed with 2 setae; exp represented by distinct segment.

Maxilla (Fig. 2H) syncoxa with vertical row of prominent spinules on posterior surface, furnished with 2 endites; proximal endite armed with 2 bipinnate setae; distal endite with 1 short unipinnate seta, 1 long simple seta, and 1 long unipinnate seta; basis drawn into strong, sclerotized and serrated claw with strong accompanying spine.

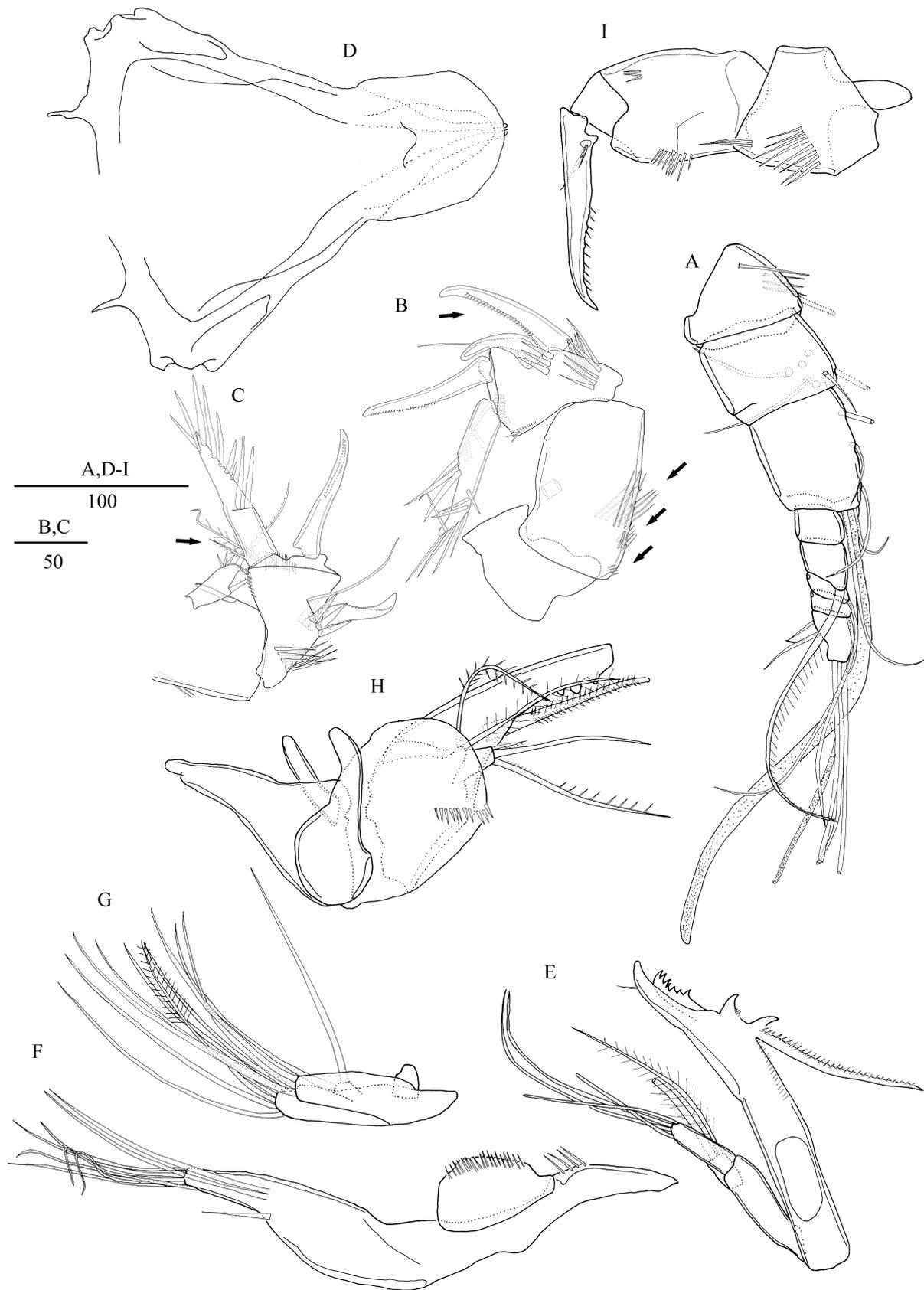


FIGURE 2. *Parameiopsis kodosensis* n. sp., holotype female. A, antennule; B, antenna; C, antenna; D, labrum; E, mandible; F, maxillule praecoxa; G, maxillule coxa, basis, exp and enp; H, maxilla; I, maxilliped. Arrows point to significant features. Scale bars are given in μm .

Maxilliped (Fig. 2I) syncoxa with transverse row of strong spinules, small spinule on distal inner side, and 2 setae on inner distal margin; basis longer than syncoxa, with longitudinal row of spinules along inner and outer margin; enp drawn into strong claw, with strong spinules along distal concave margin.

Armature formula of P1 to P4 as follows (Roman numerals indicate spines; Arabic numerals indicate setae):

	Exp	Enp
P1	I-0;I-1;II,II,0	0-1;0-1;I,2,0
P2	I-1;I-1;III,II,2	0-1;0-1;I,2,2
P3	I-0;I-1;III,II,3	0-1;0-1;I,2,3
P4	I-1;I-1;III,I,3	0-1;0-1;I,2,2

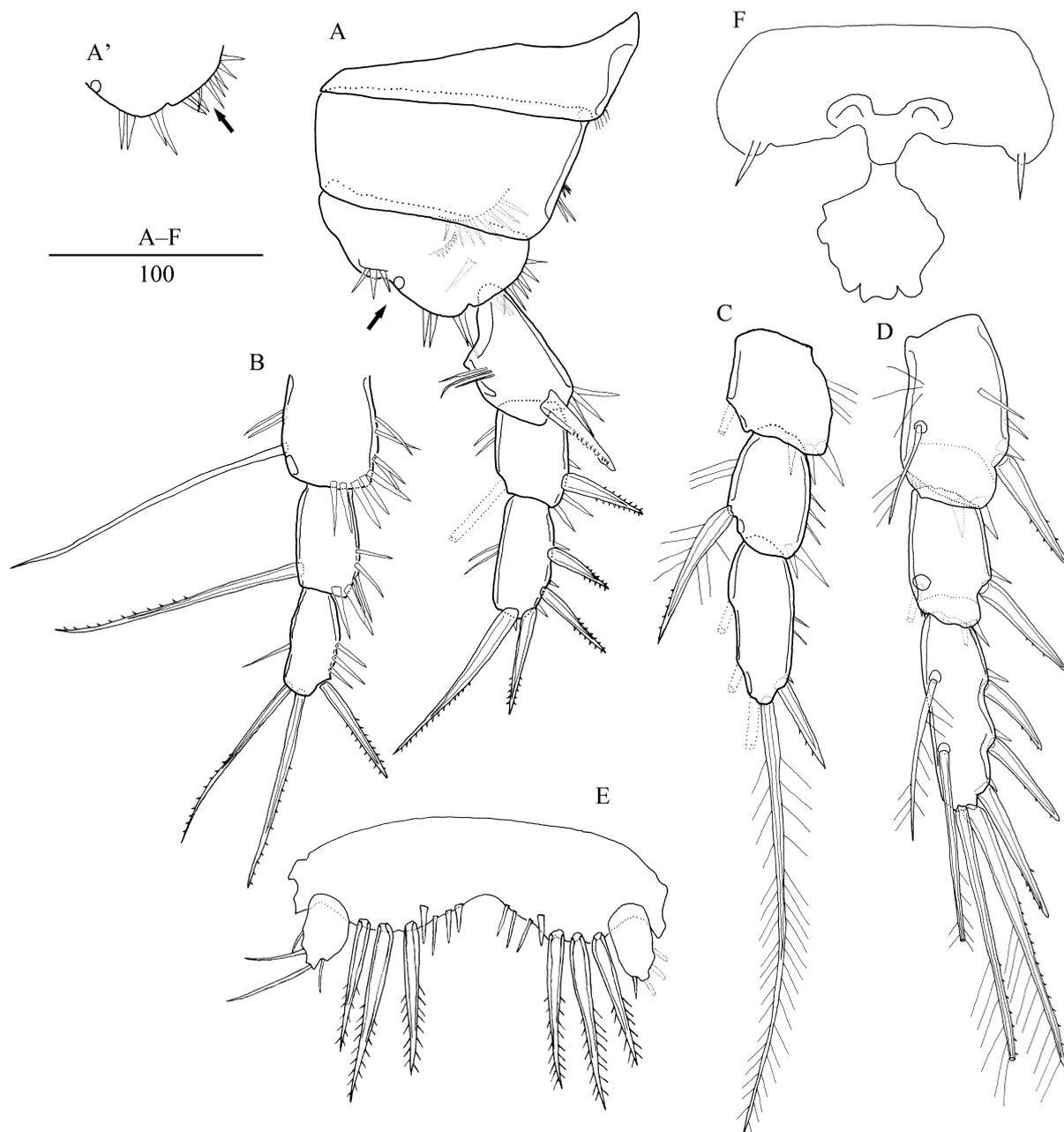


FIGURE 3. *Parameiopsis kodosensis* n. sp., holotype female. A, P1 without enp, inner spine indicated by arrow; A', detail of P1 basis close to enp-1, outer seta indicated by arrow; B, P1 enp; C, P2 enp; D, P2 exp; E, P5; F, P6. Scale bars are given in μm

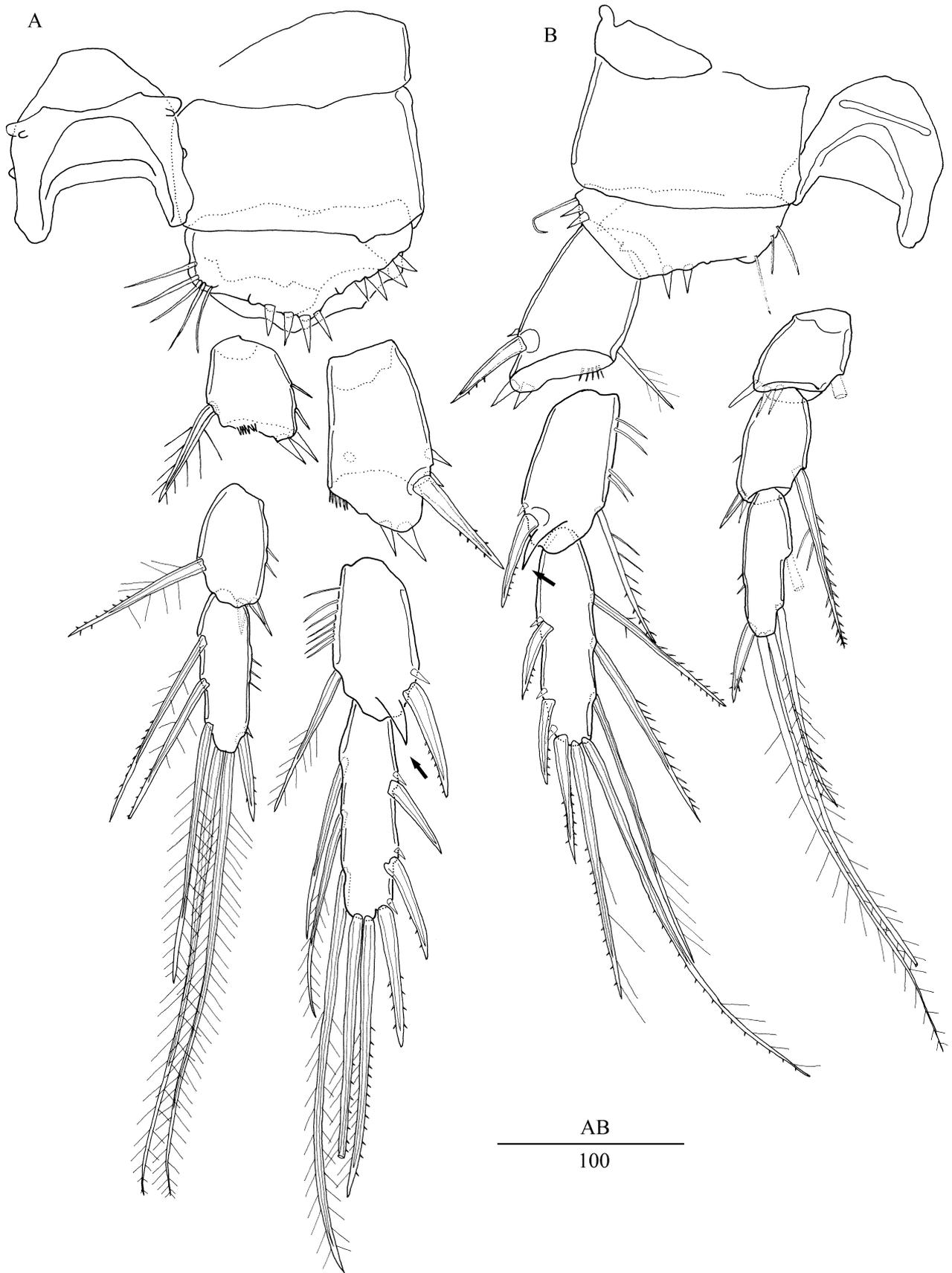


FIGURE 4. *Parameiopsis kodosensis* n. sp., holotype female. A, P3; B, P4. Arrows point to processes on the outer distal margin of exp-2. Scale bars are given in μm .

P1 (Figs. 3A, B) coxa wide with one transverse row of spinules on middle side and some spinules along outer margin. Basis short, narrower than coxa, with inner spine (arrowed in Fig. 3A), three transverse rows of spinules of which one along outer margin, one near base of enp, and one on distal middle side and 1 small outer seta (arrowed in Fig. 3A'). Both rami subequal in length, tapering gradually toward distal segment: exp-1 about twice as long as wide, with 3 spinules on distal corner, row of spinules on near inner margin and armed with 1 unipinnate spine apically; exp-2 shorter than exp-1, with 1 inner seta, some spinules along inner margin, 2 spinules on outer distal corner and armed with 1 bipinnate spine subapically; exp-3 slightly longer than exp-2, with some spinules along inner margin and armed with 2 outer spines and 2 apical spines. Enp with row of spinules along outer margin of each segment: enp-1 armed with 1 long, flexible and slender seta subapically on inner margin; enp-2 shorter than enp-1, with 1 long seta subapically on inner margin; enp-3 as long as enp-2, with 1 outer subapical bipinnate spine and 2 apical setae.

P2 (Figs. 3C, D) intercoxal sclerite, coxa, and basis not found. Exp-1 approximately 1.7 times as long as wide, with 1 long slender seta on inner lateral margin, 3 short strong spinules on outer lateral margin, 2 strong spinules and row of setules along anterodistal margin and armed with 1 subapical outer spine. Exp-2 approximately 1.8 times as long as wide, with 1 short strong spinule near base of outer spine, 3 strong spinules and row of setules along anterodistal margin and armed with subapical outer spine. Exp-3 approximately 3 times as long as wide, with 3 strong outer spines (distalmost one longest, proximal 2 spines shorter than those of exp-1 and exp-2), 1 long outer apical bipinnate spine armed with setules on outer margin and spinules on inner margin, 1 long inner apical bipinnate seta armed with spinules on outer margin and setules on inner margin, and with 2 bipinnate setae on inner margin. Enp-1 approximately 1.3 times as long as wide, with 1 inner seta, row of setules and 3 short strong spinules distally on outer margin. Enp-2 approximately 1.6 times as long as wide, narrower than preceding segment: inner margin with 1 subapical seta, biplumose on proximal half, unipinnate on distal half, and 1.2 times as long as segment; outer margin with row of spinules, with 2 short strong spinules distally. Enp-3 approximately 2.7 times as long as wide, with 2 inner and 2 apical setae, 1 outer spine accompanied by a small spinule, and some spinules along outer margin.

P3 (Fig. 4A) intercoxal sclerite smooth, rostrocaudally elongated, with deeply concave distal margin. Praecoxa approximately 0.4 times as long as wide, bare. Coxa bigger than praecoxa, approximately 0.6 times as long as wide, bare. Basis short, narrower than coxa, with row of long spinules along inner margin and two transverse rows of strong spinules near base of exp and distal middle margin, respectively. Both rami tapering distally, 3-segmented. Exp approximately 1.3 times as long as enp. Exp-1 approximately 1.8 times as long as wide, with 2 short strong spinules near base of outer spine, 2 strong spinules on outer distal margin, row of setules on inner distal margin, and armed with 1 subapical outer spine. Exp-2 approximately 1.9 times as long as wide, with 1 subapical seta and row of spinules on inner margin, process on outer distal margin (arrowed in Fig. 4A), 1 short strong spinule near base of outer spine, and armed with 1 subapical outer spine. Exp-3 approximately 3.7 times as long as wide, with 3 strong outer spines (distalmost one longest, 2 proximal spines shorter than those of exp-1 and exp-2), 1 long outer apical bipinnate spine armed with spinules on the outer margin and setules on the inner margin, 1 long inner apical bipinnate seta armed with spinules on the outer margin and setules on the inner margin and 3 bipinnate inner setae (distalmost one longest, almost twice longer than segment). Enp-1 approximately 1.2 times as long as wide, with 1 short strong bipinnate subapical seta and as long as segment on inner margin, row of setules on distomedial margin, and 2 spinules on outer margin and 2 strong spinules along outer distal margin. Enp-2 approximately 1.7 times as long as wide, inner margin with 1 subapical seta being biplumose at proximal half and bipinnate at distal half and as long as segment; outer margin with few spinules, with 2 short strong spinules apically. Enp-3 approximately 3.1 times as long as wide, with 3 inner setae: distalmost one longest, 1.6 times as long as segment, 2 proximal setae biplumose at proximal half, unipinnate at distal half; outer margin with 1 outer spine; medial margin with 2 apical setae.

P4 (Fig. 4B) intercoxal sclerite smooth, with deeply concave distal margin. Coxa approximately 0.6 times as long as wide, bare. Basis short, narrower than coxa, with long spinules on inner margin and two transverse rows of strong spinules near base of exp and distal middle margin, respectively. Both rami 3-segmented. Exp approximately 1.5 times as long as enp. Exp-1 approximately 1.7 times as long as wide: outer margin with 1 subapical outer spine, 1 short strong spinule near base of outer spine, and 2 strong spinules distally; inner margin with 1 slender seta; distal margin with row of setules. Exp-2 approximately 2.1 times as long as wide: outer margin with process at distal margin (arrowed in Fig. 4B), 1 subapical spine, 1 short spinule near base of spine; inner margin with 1 subapical seta and row of slender spinules. Exp-3 approximately 4 times as long as wide: outer margin with 3 strong outer spines (distalmost one longest, 2 proximal spines shorter than those of exp-1 and exp-2); apex with 1 long outer apical bipinnate spine armed with spinules on the outer margin and setules on the inner margin, 1 long inner apical bipinnate seta armed with spinules on the outer margin and setules on the inner margin;

inner margin with 3 setae. Enp-1 approximately 1.1 times as long as wide: outer margin with 3 short strong spinules on distal margin; inner margin with 1 subapical seta. Enp-2 approximately 1.8 times as long as wide, narrower than preceding segment: outer margin with 2 short strong spinules on distal margin; inner margin with 1 subapical seta, ornamented with spinules medially and pinnate distally, approximately 1.5 times as long as segment. Enp-3 approximately 3 times as long as wide: outer margin with spinules medially and 1 strong spine distally; apex with 2 long bipinnate setae; inner margin with 2 setae.

P5 (Fig. 3E) medially fused; benp with outer seta on basis and 3 long spines and 4 spinules on endopodal lobe; exp 1-segmented, longer than wide, with 1 short outer seta, 1 subapical seta, 1 apical seta and 1 inner short seta.

P6 (Fig. 3F) represented by opercula closing off genital aperture on either side; each armed with 1 seta.

Remarks. The presence of a distal seta on the syncoxa of the maxilliped and the general features of the swimming legs of *Parameiropsis kodosensis* n. sp. shows a close relationship with *P. magnus* from the waters southeast of Mindanao Island (Philippines). Nevertheless, *P. kodosensis* can be differentiated from *P. magnus* by the following morphological characteristics: 1) the length-to-width ratio of the caudal ramus is greater in *P. kodosensis* than in *P. magnus* (2.5:1 vs. 1:1), 2) the labrum has a bifid tip in *P. kodosensis*, 3) the maxilliped basis has a less developed claw on enp in *P. kodosensis* (vs. prominently developed in *P. magnus*), 4) exp-3 of P1 has a different setal count in *P. kodosensis* (III, II, 0 vs. II, II, 0), and 5) the exp and benp of P5 are separated in *P. kodosensis*, while they are fused in *P. magnus*. Of the other five previously described species for which the female is known, only *P. peruanus* has a separate P5 exp. It is similar to *P. kodosensis* in some ways, such as the relative length of the genital double-somite to the urosome excluding caudal rami, and the length-to-width ratio of the caudal rami. However, *P. kodosensis* and *P. peruanus* can be differentiated by the following morphological features: the proportional length of the sixth urosomal segment to the urosome including caudal rami is smaller in *P. kodosensis* (0.17 vs. 0.25); in the maxilliped, the syncoxa have 2 distal setae in *P. kodosensis* (vs. without seta), the claw on the enp with proximal seta (vs. without), and exp-3 of P1 has a short strong spine on the distal margin in *P. kodosensis* (vs. seta).

Parameiropsis tetraspinosa n. sp.

(Figs. 5–8)

Type locality. Eastern central Pacific Ocean, 10°30.11'N 131°19.987'W, at a depth of 5036 m.

Material examined. Female holotype dissected and mounted on nine slides (MABIK CR00235060).

Etymology. The specific name *tetraspinosa* is taken from the four spines of the endopodal lobe of P5.

Description of female. Body (Figs. 5A, B). Length 2 mm, almost cylindrical, maximum width at middle of second pedigerous somite, gradually tapered, with slight demarcation. Cephalothorax and second to fifth urosomites with distal hyaline membrane. Prosome 0.8 times as long as urosome excluding caudal rami, 0.7 times length including caudal rami.

Prosome (Figs. 5A, B) comprising cephalothorax completely fused to first pedigerous somite and three free pedigerous somites. Third and fourth pedigerous somites with pointed posterolateral corners in dorsal view. Second pedigerous somite with one pair of sensilla near mid- and posterolateral margins and mid region of posterodorsal margin. Third pedigerous somite with two pairs of sensilla near posterodorsal margin and one pair near posterolateral margin. Fourth pedigerous somite each with one pair of sensilla near posterodorsal and posterolateral margin.

Urosome (Figs. 5A, B) 5-segmented, comprising fifth pedigerous somite, genital double-somite (genital somite fused to first abdominal somite) and three free abdominal somites. Genital double-somite as long as wide; fusion line marked only by short lateral subcuticular rib.

Anal somite (Figs. 5A, B) elongate, tapered posteriorly, approximately 1.5 times as long as preceding somite, anal operculum not reaching distal margin of anal somite.

Caudal rami (Figs. 5A, C) with almost straight inner and outer margins, approximately half length of anal somite, almost 3.9 times longer than wide, inner margin unornamented, with 6 setae; setae II and VII of similar length, seta III lost in preparation, seta IV (Fig. 5C') longest, seta V (Fig. 5C'') approximately 3.7 times as long as caudal rami, seta VI longer than setae II and VII.

Rostrum (Fig. 5A) not fused to cephalothorax, sub-rectangular, with trifid tip and two sensilla apically inserted (Fig. 5D).

Antennule (Fig. 6A) 8-segmented, about half length of cephalothorax. Relative lengths (%) of segments measured from proximal end along caudal margin 18.6:20.5:23.6:9.1:8.4:4.6:3.8:11.4; first segment short, bearing 2 spinules on outer margin, 1 seta on outer distal margin, and 4 spinules on posterior surface; second segment with 3 naked setae (2 long and 1 short) on anterior surface, 3 setae (1 pinnate and 2 naked) on outer margin, and 4 naked setae on posterior surface; third segment longest, with 4 setae (1 proximal, 2 middle, and 1 distal) along outer margin, each 1 long naked seta on anterior and posterior surface, long slender distal aesthetasc basally fused to 1 distal seta; proximal 3 segments more robust and longer than distal 5 segments; fourth segment each with 1 naked seta medially and distally on outer margin; fifth segment each with 1 long naked seta on mid- and disto-outer margins and 1 long pinnate seta on distal margin; sixth segment with 1 distal seta and 1 inner seta; seventh segment with 1 long naked distal seta; eighth segment with 3 simple setae on inner margin, 1 long simple apical seta, and 1 narrow aesthetasc fused to 2 long setae apically. Armature formula as follows: 1/10/6 + (1 + Ae)/2/2/2/1/4 + (2 + Ae).

Antenna (Fig. 6B) comprising coxa, allobasis, free second enp, and exp: coxa thick, short, and bare; allobasis thick, about twice as long as wide, with three longitudinal rows of spinules on proximal edge (arrowed in Fig. 6B); exp 1-segmented, with 1 setulose seta on inner medial margin, 3 subapical spinules, and 1 apical setulose seta; free endopodal segment shorter than allobasis, with group of spinules on proximal inner margin, inner medial margin with 2 robust spines ornamented with crenulations along medial margin (arrowed in Fig. 6B), 5 short blunt spinules, and 1 long simple seta, row of setules on outer distal margin, distal margin with 4 crenulate spines, 1 modified spine bearing 8 simple spinules and 1 simple seta (arrowed in Fig. 6B), 1 bipinnate seta and row of setules.

Labrum (Fig. 6C) represented by a triangular plate, with single tip and fringed by hyaline around apex.

Mandible (Fig. 6D) comprising coxa, basis, enp, and exp: coxa elongated, with spinules on proximal margin; long gnathobasis with a sharp cutting edge, armed with 2 apical long teeth (outer teeth with 1 long spinule, inner teeth multicuspidate), 2 subapical short teeth (inner teeth with 1 short spinule), and 1 long and strong seta distally inserted on oral margin, with inner row of spinules; basis approximately 3 times as long as wide, with row of spinules along inner margin; exp 1-segmented, with 2 apical setae (inner unequally bifid setulose seta, outer seta broken); enp 1-segmented, with 4 apical setae fused to segment, 1 apical seta, and row of spinules along inner margin.

Maxillule (Fig. 6E) comprising praecoxa, coxa, basis, exp, and enp: praecoxa elongated, praecoxal arthrite with 6 slender setae apically, 2 subapical simple setae, 1 spinule on inner proximal margin, and 2 long simple setae on anterior surface; coxal endite with row of spinules along outer proximal margin and 3 slender setae and 1 geniculate seta apically; basal endite with 3 apical setae and 2 simple setae on posterior surface; exp 1-segmented represented by distinct segment armed with 1 bipinnate seta and 1 simple seta; enp 1-segmented fused to basis and represented by lobe armed with 2 long simple setae.

Maxilla (Fig. 6F) comprising syncoxa, basis, and enp: syncoxa with 2 endites, proximal endite armed with 1 long bipinnate seta, distal endite armed 1 long unipinnate seta and 1 long simple seta; basis drawn into strong, sclerotized and serrated claw, with strong accompanying spine inserted on inner proximal margin; enp fused to basis and armed with 2 distal simple slender setae.

Maxilliped (Fig. 6G) comprising syncoxa, basis, and enp: syncoxa thick, with group of spinules on inner proximal margin, 2 setae on inner distal margin; basis longer than syncoxa, with row of spinules along inner margin and longitudinal row of spinules on outer medial margin; enp 1-segmented, as long as basis, drawn into strong claw, concave margin ornamented with strong spinules along inner distal margin, 1 long slender seta on inner proximal margin, and 2 simple setae.

Armature formula of P1 to P4 as follows:

	Exp	Enp
P1	I-0;I-1;III,II,0	0-1;0-1;I,I,1,0
P2	I-1;I-1;III,II,2	0-1;0-1;I,2,2
P3	I-1;I-1;III,II,3	0-1;0-1;I,2,3
P4	I-1;I-1;III,II,3	0-1;0-1;I,2,2

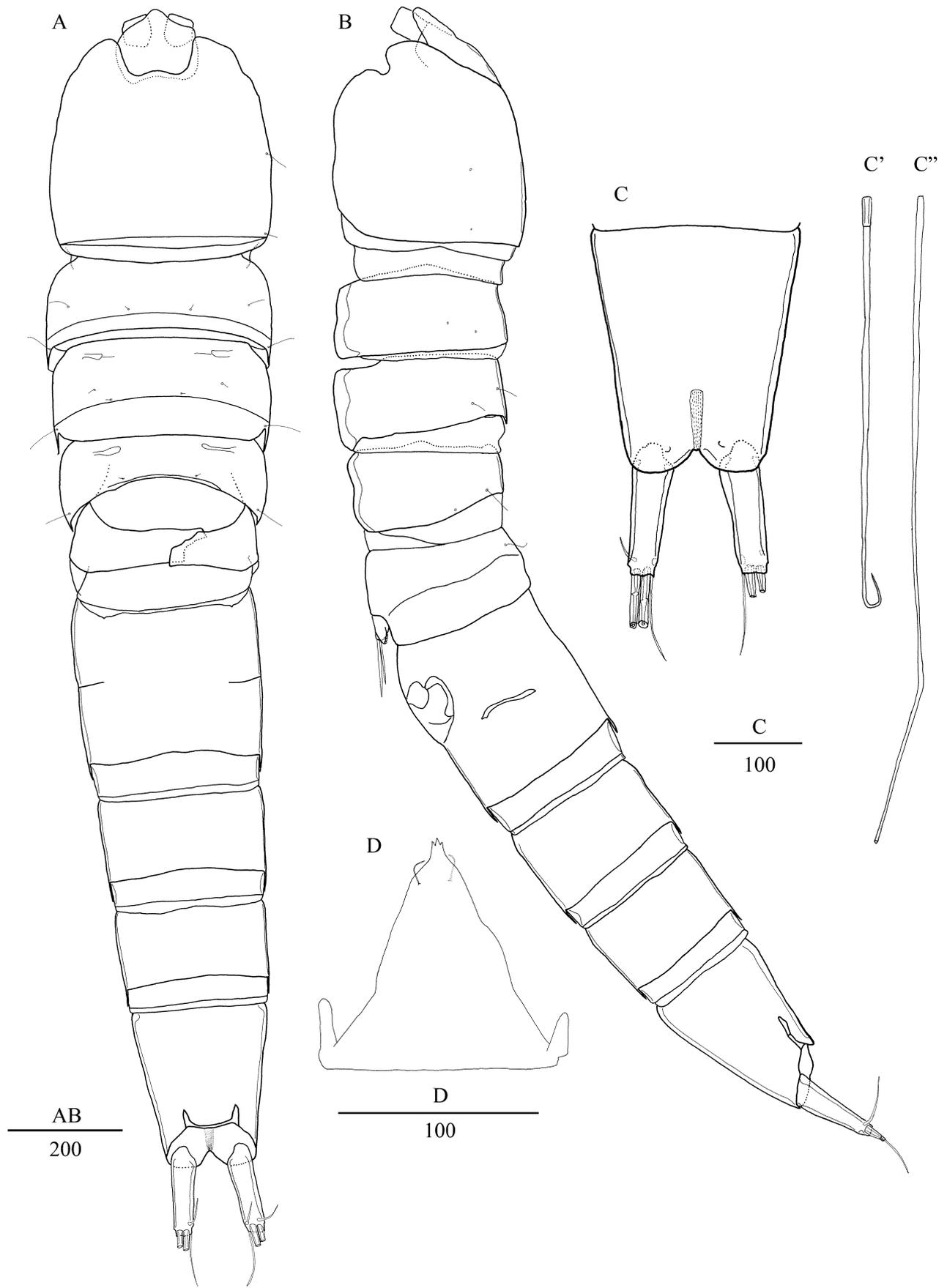


FIGURE 5. *Parameiopsis tetraspinosa* n. sp., holotype female. A, habitus, dorsal view; B, habitus, lateral view; C, caudal rami, ventral view; C', partial view of seta IV; C'', partial view of seta V; D, rostrum. Scale bars are given in μm .

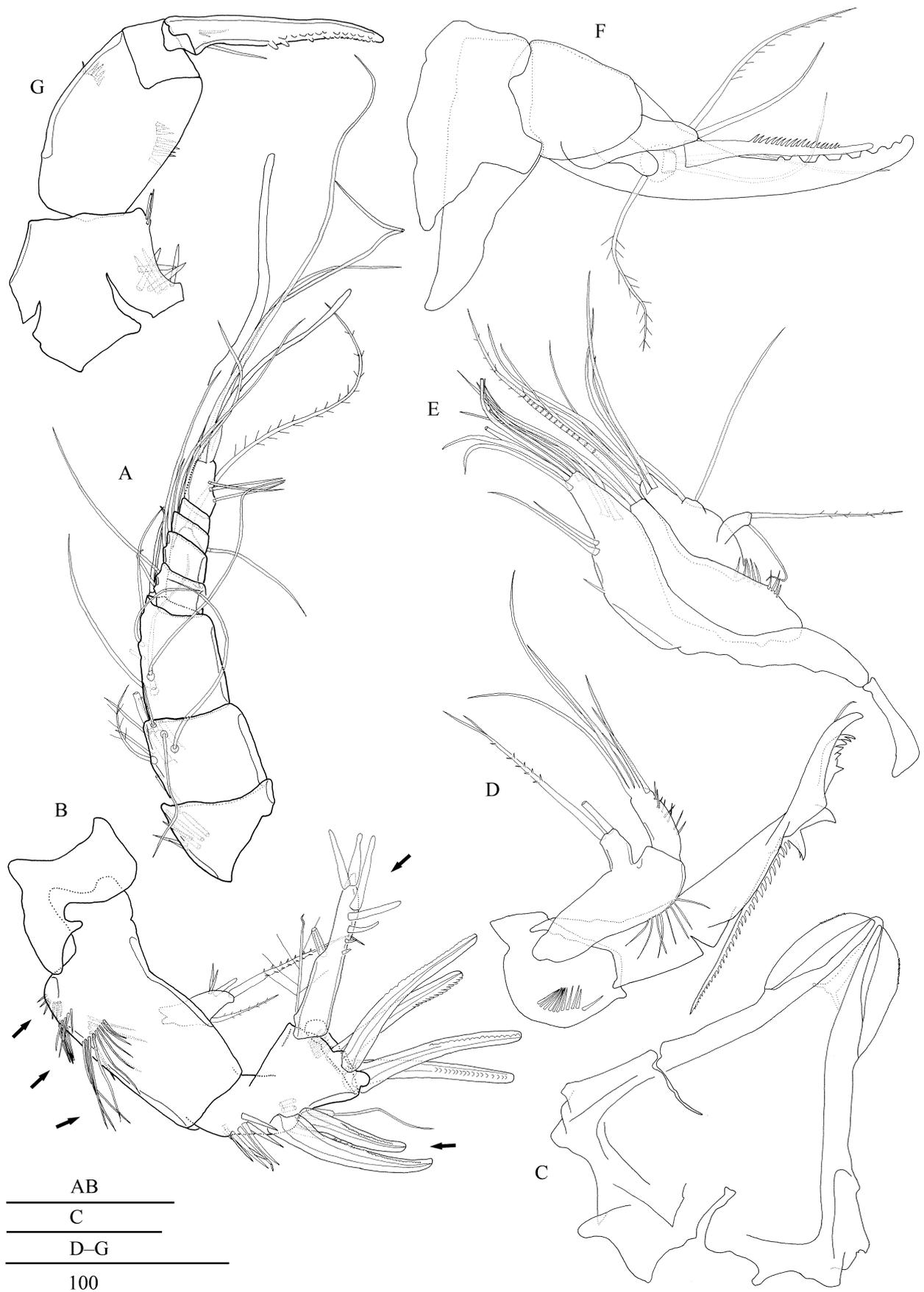


FIGURE 6. *Parameiopsis tetraspinosa* n. sp., holotype female. A, antennule; B, antenna; C, labrum; D, mandible; E, maxillule; F, maxilla; G, maxilliped. Arrows point to significant features. Scale bars are given in μm .

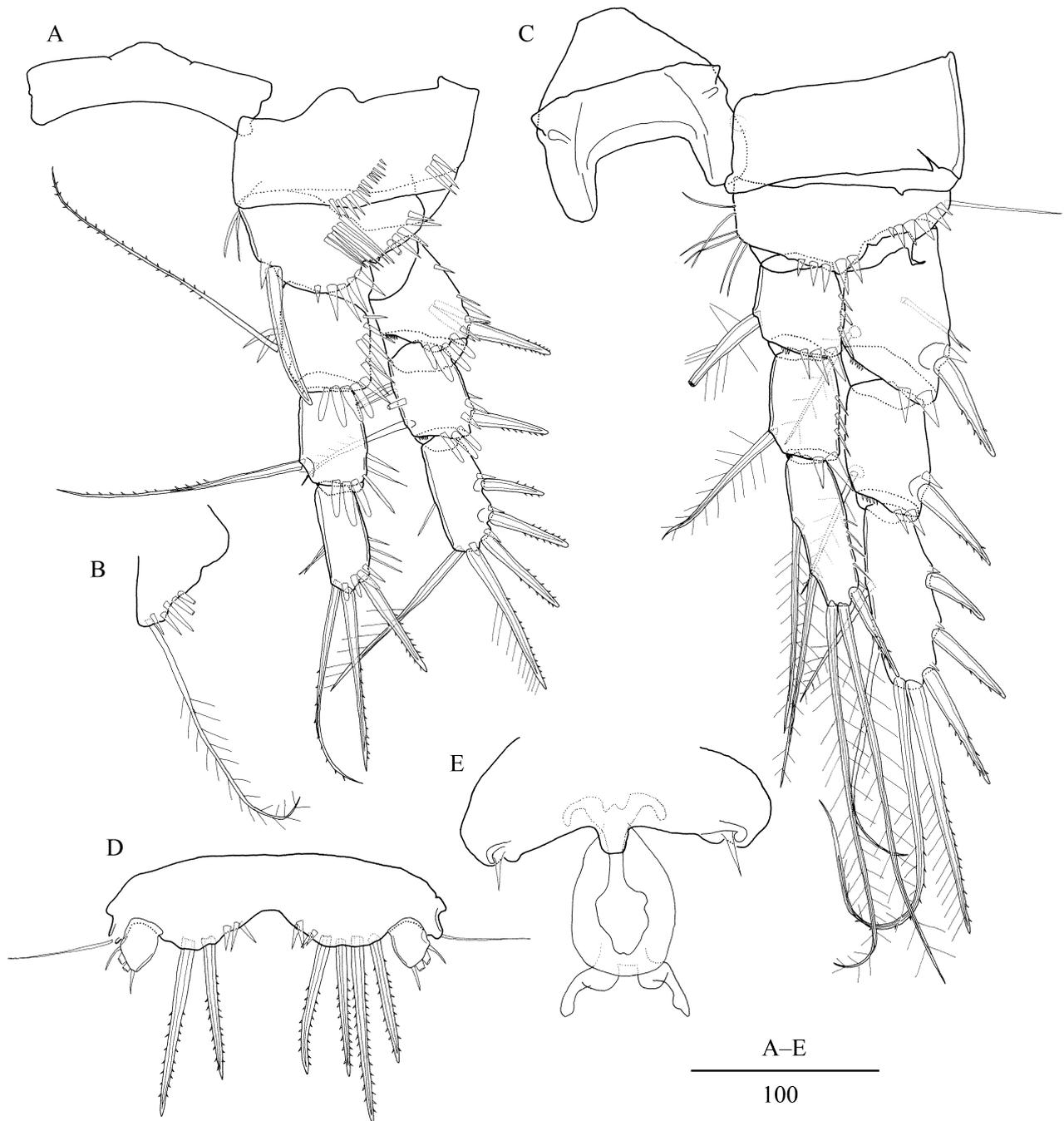


FIGURE 7. *Parameiopsis tetraspinosa* n. sp., holotype female. A, P1; B, detail of right P1 basis close to exp-1; C, P2; D, P5; E, P6. Scale bars are given in μm .

P1 (Figs. 7A, B) intercoxal sclerite transversely elongated, bare. Coxa approximately 0.4 times as long as wide, with two oblique rows of spinules near center and outer of distal margin on anterior surface. Basis short, narrower than coxa, with spinules and 1 long strong spine on inner margin, reaching beyond distal margin of exp-1, 1 long bipinnate outer seta, three transverse rows of spinules (one near base of exp, one on distal middle side, one on proximal middle side, the latter with longest spinules), and 1 strong spinule at base of inner spine. Both rami subequal in length, tapering gradually toward distal segment: exp-1 approximately 1.3 times as long as wide, with some spinules along outer margin, row of blunt spinules along outer distal margin, 2 short spinules near base of outer spine, 2 long spinules on posterior surface, setules on inner distal margin and armed with 1 bipinnate spine subapically; exp-2 shorter than exp-1, with 1 inner seta, 2 short spinules near base of outer spine, 2 spinules along

inner margin, blunt spinules along outer distal margin, setules on inner distal margin and armed with 1 unipinnate outer spine; exp-3 slightly longer than exp-2, with 1 spinule on inner margin, 3 outer bipinnate spines (distalmost one longest, proximal 2 outer spines shorter than spines of exp-1 and exp-2), 1 outer apical bipinnate spine (longer than other spines, armed with spinules on the outer margin and setules on the inner margin), 1 long inner apical unipinnate spine. Enp with row of spinules along outer margin on each segment; enp-1 approximately 1.3 times as long as wide, with 2 strong spinules and 1 long bipinnate subapical seta 2.6 times as long as segment on inner margin, row of blunt spinules along outer distal margin; enp-2 shorter than enp-1, with 1 long unipinnate subapical seta on inner margin, approximately 2.5 times as long as segment and shorter than inner seta of enp-1, row of blunt spinules along outer distal margin; enp-3 similar in length to enp-1, with some spinules on inner margin, 1 outer bipinnate spine, 1 outer apical unipinnate spine, 1 long inner apical unipinnate seta, armed with setules on the inner margin.

P2 (Fig. 7C) intercoxal sclerite smooth, rostrocaudally elongated, with deeply concave distal margin. Coxa approximately 0.4 times as long as wide, bare. Basis short, narrower than coxa, with 1 long simple outer seta, row of long spinules along inner margin and two transverse rows of strong spinules near base of exp and distal middle margin, respectively. Both rami tapering toward distal segment, 3-segmented. Exp approximately 1.3 times as long as enp: exp-1 approximately 1.7 times as long as wide, with 1 bipinnate subapical outer spine and 1 slender bipinnate subapical inner seta, 1 spinule subapically on outer margin, 1 long slender spinule on posterior surface, 1 short spinule near base of outer spine, 2 strong spinules along outer distal margin, and row of setules on inner distal margin; exp-2 shorter than exp-1, with 1 bipinnate subapical outer spine, 1 bipinnate subapical inner seta, 1 short spinule near base of outer spine, 2 short spinules along outer distal margin, and row of setules on the inner distal margin; exp-3 similar in length to exp-1, with 3 outer spines which distalmost longest, 1 long outer apical bipinnate spine (longer than other spines, armed with spinules on outer margin and setules on inner margin), 1 long inner apical bipinnate seta, armed with spinules on outer margin and setules on inner margin, 2 bipinnate inner setae. Enp with row of spinules along outer margin on each segment; enp-1 as long as wide, with 1 bipinnate subapical seta on inner margin, row of spinules along outer margin, 3 strong spinules along outer distal margin and row of setules on inner distal margin; enp-2 longer than enp-1, with 1 bipinnate subapical seta on inner margin, row of spinules along outer margin, 2 strong spinules along outer distal margin and row of setules on inner distal margin; enp-3 longest, with 2 inner and 2 apical setae, 1 outer spine accompanied by a small spinule, and some spinules along outer margin.

P3 (Figs. 8A, B) intercoxal sclerite smooth, rostrocaudally elongated, with deeply concave distal margin. Coxa approximately 0.4 times as long as wide, bare. Basis with 1 bipinnate outer seta, row of spinules along inner margin and two transverse rows of strong spinules near base of outer seta and distal middle margin. Both rami tapering toward distal segment, 3-segmented. Exp approximately 1.3 times as long as enp; exp-1 approximately 2.1 times as long as wide, with 1 subapical inner seta, row of setules on inner distal margin, 1 short strong spinule near base of outer spine, 2 strong spinules along outer distal margin, and armed with 1 subapical outer spine; exp-2 shorter than exp-1, with 1 subapical inner seta as long as segment, 1 short spinule near base of outer spine, 2 strong spinules along outer distal margin, row of setules on inner distal margin, and armed with 1 subapical outer spine; exp-3 similar in length to exp-1, with 4 strong outer spines (abnormal), 1 long outer apical bipinnate spine armed with spinules on outer margin and setules on inner margin, 1 long inner apical bipinnate seta armed with spinules on outer margin and setules on inner margin, and 3 bipinnate inner setae. Enp with row of spinules along outer margin of each segment; enp-1 as long as wide, with 1 subapical inner seta, 3 strong spinules along outer distal margin and row of setules along inner distal margin; enp-2 longer than enp-1, with 1 subapical inner seta, 2 strong spinules along outer distal margin, and row of setules on inner distal margin; enp-3 longest, with 1 strong outer bipinnate spine, 2 apical bipinnate setae, and 3 inner setae.

P4 (Fig. 8C) intercoxal sclerite smooth, rostrocaudally elongated, with deeply concave distal margin. Coxa approximately 0.6 times as long as wide, bare. Basis with 1 naked outer seta, row of spinules along inner margin and two transverse rows of strong spinules near base of outer seta and distal middle margin. Both rami tapering toward distal segment, 3-segmented. Exp approximately 1.4 times as long as enp; exp-1 approximately 1.9 times as long as wide, with 1 slender bipinnate inner seta, 1 spinule near base of outer spine, 2 strong spinules along outer distal margin, and armed with 1 subapical outer spine; exp-2 shorter than exp-1, with 1 bipinnate inner seta, 1 spinule near base of outer spine, and 1 strong spinule on outer distal margin, and armed with 1 subapical outer spine; exp-3 longer than exp-1, with 3 outer spines, 1 long outer apical bipinnate spine armed with spinules on the

outer margin and setules on the inner margin, 1 long inner apical bipinnate seta armed with spinules on the outer margin and setules on the inner margin, and 3 bipinnate inner setae. Enp with row of spinules along outer margin on each segment, except for enp-1; enp-1 approximately 1.5 times as long as wide, with 1 bipinnate subapical inner seta and 3 strong spinules along outer distal margin; enp-2 longer than exp-1, with 1 bipinnate subapical inner seta and 2 strong spinules along outer distal margin; enp-3 longest, with 1 strong outer bipinnate spine, 2 apical bipinnate setae, and 2 bipinnate inner setae.

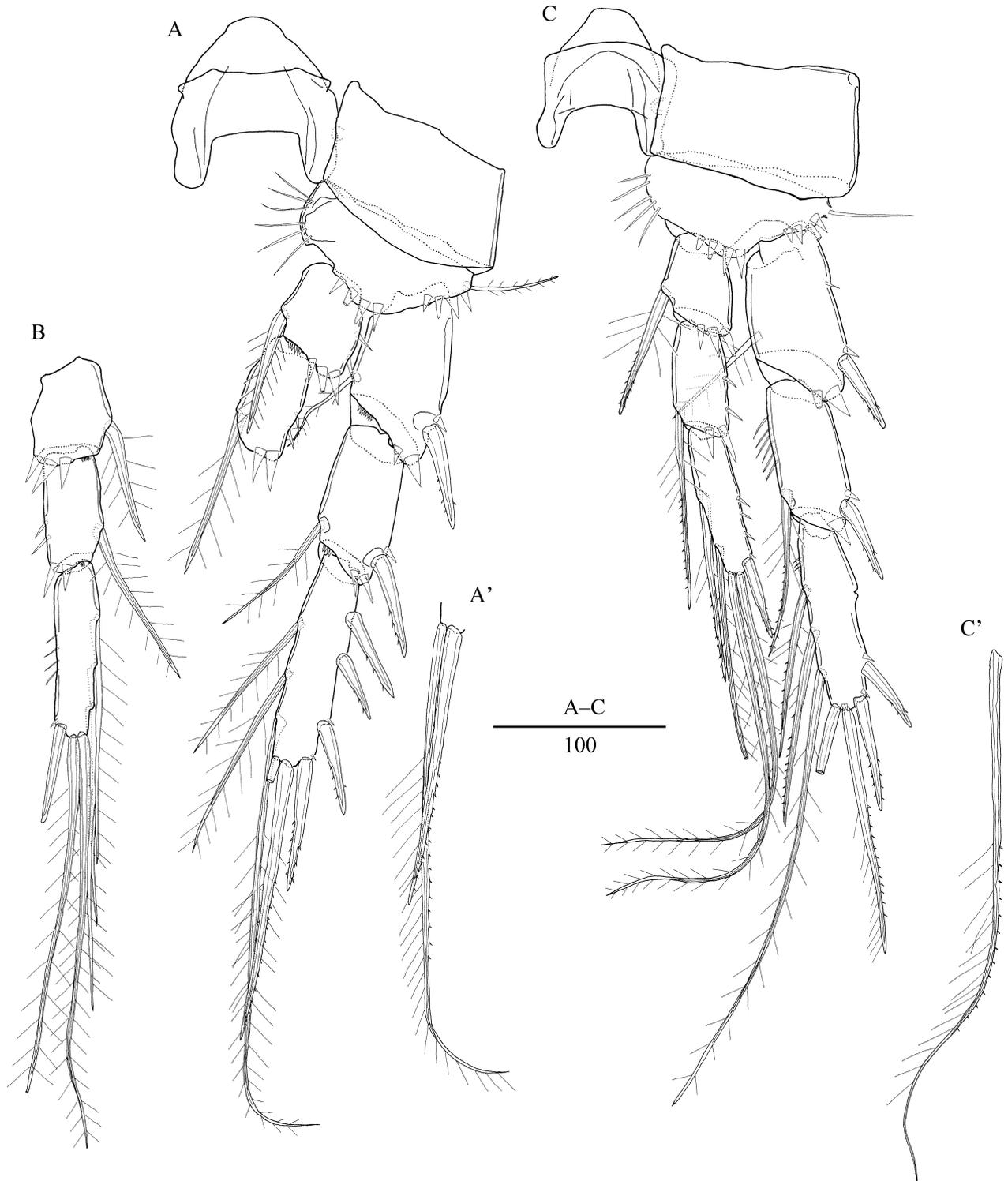


FIGURE 8. *Parameiopsis tetraspinosa* n. sp., holotype female. A, P3; A', inner distal seta and outer distal spine on P3 exp-3; B, enp of right P3; C, P4; C', partial view of inner distal seta. Scale bars are given in μm .

P5 (Fig. 7D) composed of benp fused medially, and separate exp. Benp with outer simple seta on basis. Endopodal lobe wide armed with 4 long bipinnate spines, with length ratio (from inner side) 1.1:1.1:1.4:1, and row of spinules. Exp 1-segmented, approximately 1.2 times as long as wide, armed with 4 setae.

P6 (Fig. 7E) formed by a fused plate with 1 simple seta on each side. Genital aperture fused; a single copulatory pore followed by a long copulatory tube; seminal receptacles paired.

Remarks. *Parameiopsis tetraspinosa* n. sp. is similar to *P. peruanus* in the absence of a seta fused to the outermost spine of the enp of the antenna and the general features of the swimming legs. However, the two species can be differentiated by a greater length-to-width ratio of the caudal ramus in *P. tetraspinosa* (3.9:1 vs. 2.3:1), the presence of a distal seta on the syncoxa of the maxilliped in *P. tetraspinosa*, and by the medially fused P5 in *P. tetraspinosa*. Additionally, *P. tetraspinosa* resembles *P. magnus* in terms of the morphological combination of the maxilliped syncoxa with 2 distal setae and the general features of the swimming legs. However, *P. tetraspinosa* can be distinguished from *P. magnus* by a greater length-to-width ratio of the caudal ramus in *P. tetraspinosa* (3.9:1 vs. 1:1), the presence of a proximal seta and a less developed claw on the enp of the maxilliped in *P. tetraspinosa* (vs. prominently developed), and the fact that P5 has separate exp and benp in *P. tetraspinosa*. The presence of a distal seta on the syncoxa of the maxilliped is also found in four previously described species (*P. rapiens*, *P. magnus*, *P. poseidonicus* and *P. amphitriteae*). Of these, *P. magnus* has 2 setae on the syncoxa of the maxilliped, whereas the other three species cited each have 1 seta. Additionally, *P. tetraspinosa* can be separated from the other species in terms of the morphological combination of the 4 outer spines on the endopodal lobe of P5, whereas the corresponding number is 3 in *P. peruanus*, *P. rapiens*, *P. magnus*, and *P. kodosensis* and 2 in *P. antennafortis*, *P. poseidonicus*, *P. neptuni*, *P. senckenbergi*, and *P. amphitriteae*.

Discussion

Harpacticoida contains approximately 4300 species in 589 genera and 56 families (Wells 2007). Of these, the family Ameiridae Boeck, 1865 includes more than 400 species belonging to 45 valid genera (Walter & Boxshall 2015) and characterized by a transformed inner basal spine on the male P1 (Lang 1948; Lee & Huys 2002; Boxshall & Halsey 2004). The systematic position and species composition of the family Ameiridae has been in dispute for several decades (Brady 1880; Scott 1909; Lang 1944). Historically, its taxonomic position has been in a state of flux (Lee & Huys 2002; Seifried 2003).

Becker (1974) established the genus *Parameiopsis* with descriptions of two new species based on a single female specimen from each: *P. rapiens* from an Atlantic deep-sea site off the northern African coast, and *P. peruanus* from the Peru Trench in the eastern Pacific. He placed the genus *Parameiopsis* in the family Ameiridae based on morphological similarities with *Parameiopsis* and *Ameiopsis* Sars, 1907 and on the diagnostic characteristics of the family Ameiridae proposed by Lang (1944). A third species (*P. magnus*) was recorded from a deep-sea site off Mindanao Island, Philippines, in the western Pacific. This species is characterized by a P5 with medial fusion, which is an important characteristic of this genus (separated in *P. peruanus* and *P. rapiens*, but fused in *P. kodosensis* n. sp. and *P. tetraspinosa* n. sp.). Corgosinho & Gheerardyn (2009) reported a fourth species based on females of *P. antennafortis* from the Porcupine Seabight in the northeastern Atlantic. These authors then questioned the position of this genus. This taxonomic scheme has been adopted in recent taxonomic studies (Boxshall & Halsey 2004; Wells 2007). According to the groundpattern of the Podogenonta, P1 is defined by the following autapomorphies: enp-1 as least as long as exp-1 and exp-2 together, enp-2 and enp-3 short, enp-3 with an outer claw-like seta superimposing a geniculate outer terminal seta and a miniaturized inner terminal seta (Willen 2000; Seifried 2003). However, the species of *Parameiopsis* showed the following differences from other Podogenonta: enp-1 approximately the same size as exp-1; enp-1, enp-2 and enp-3 subequal in length; enp and exp subequal in length; enp-3 with a normal outer terminal spine/seta and an inner terminal seta. Therefore, Corgosinho & Gheerardyn (2009) placed *Parameiopsis* as *incertae sedis* within Harpacticoida. Moreover, Gee (2009) expressed some doubts about the familial position of this genus (as Ameiridae), suggesting that morphological characteristics such as a short robust antennule and a large triangular rostrum differed from those of the family Ameiridae. Subsequently, Corgosinho & Martínez Arbizu (2010) found four new species of *Parameiopsis*. Of these, three species were each based on a single male specimen from the Atlantic (*P. poseidonicus* and *P. neptuni* from the Angola Basin and *P. senckenbergi* from the Guinea Basin), and the fourth was

TABLE 1. Comparison of female characters between different species of the genus *Parameiropsis*

	<i>P. peruvianus</i>	<i>P. rapiens</i>	<i>P. magnus</i>	<i>P. antennaeformis</i>	<i>P. amphitriteae</i>	<i>P. kodosensis</i>	<i>P. tetraspinosa</i>
Mean body length (µm)	1200	1380	3000	625	910	1851	2000
Proportional length of caudal rami (%)	13.1	7.7	6.7	12.9	12.5	9.7	11.5
Length/wide of caudal rami	2.3	1	1	2	2	2.5	3.9
Inner margin spinules of caudal rami	N	N	N	N	Y	N	N
Caudal rami with developed seta III	N	N	N	N	Y	N	N
Antennule segments	8	8	8	4	8	8	8
Antenna enp with fused seta in outermost spine	N	N	Y	Y	Y	Y	N
Corpus mandibularis	Long	Long	Long	Short	Long	Long	Long
Bulge on mandibular gnathobasis	N	N	Y	N	N	N	N
Maxilliped syncoxa with seta/spine on distal margin	N	Y	Y(2)	N	Y	Y(2)	Y(2)
Number of outer spine on exp-3 of P1–P4	3,3,3,3	3,3,3,3	3,3,3,3	2,2,2,2	2,2,2,2	2,3,3,3	3,3,3,3
Number of outer and inner distal spine on exp-3 of P1–P4	0,0,0,0	0,0,0,0	1,1,1,1	0,0,0,0	1,1,0,0	2,1,1,1	1,1,1,1
Number of seta/spine on exp-3 of P1–P3	2,2,3	2,2,3	2,2,3	2,1,2	1,2,2	2,2,3	2,2,3
Number of outer and inner distal spine on exp-3 of P1	0	0	1	1	1	0	1
Outer distal seta or spine of exp-3 of P1	Long	Long	Long	Long	Short	Short	Long
P5 fused medially	N	N	Y	N	Y	Y	Y
Exp and bemp of P5	Separated	Fused	Fused	Fused	Fused	Separated	Separated

based on a female of *P. amphitriteae* from the Laptev Sea in the Arctic. According to Corgosinho & Martínez Arbizu (2010), the absence of a seta on the outer margin of the antennary basis and the presence of a 1-segmented exp of the antenna with at most 2 setae, criteria supporting the inclusion of *Parameiopsis* within Ameiridae as proposed by Becker (1974), have been described in certain genera within the family Argestidae Por, 1986. Furthermore, the absence of these characteristics, as discussed regarding the Podogennonta P1, in *Parameiopsis*, precludes the inclusion of this genus in Podogennonta (see Corgosinho & Martínez Arbizu 2010). Corgosinho & Martínez Arbizu (2010) created the family Parameiopsidae to revise the family Ameiridae. This family presently comprises 1 genus: *Parameiopsis* Becker, 1974.

So far, females of seven *Parameiopsis* species have been described, including the two new species examined in the present study. The results of the morphological comparison presented in Table 1 show that the species can be distinguished from one another by the following features: the presence of spinules on the inner margin and the developed seta III of the caudal rami in *P. amphitriteae*, an antennule with 4 segments in *P. antennafortis* (vs. 8 segments in others), a bulge on the mandibular gnathobasis in *P. magnus*, and the presence of 2 distal setae on the syncoxa of the maxilliped in *P. magnus*, *P. kodosensis* and *P. tetraspinosa*. The setal numbers on enp-3 and exp-3 of P1–P4 vary greatly. The number of setae/spines on enp-3 of P1–P3 (2, 2 and 3, respectively) overlaps in *P. magnus*, *P. peruanus*, *P. rapiens*, *P. kodosensis* and *P. tetraspinosa* (vs. 2, 1, and 2 in *P. antennafortis* and 1, 2, and 2 in *P. amphitriteae*). However, the species can be differentiated from one another by the number of outer spines on exp-3 of P1–P4 differ: there are 2 in *P. antennafortis* and *P. amphitriteae*, 3 in *P. peruanus*, *P. rapiens*, *P. magnus*, and *P. tetraspinosa*, and 2, 3, 3, and 3 in *P. kodosensis*. Furthermore, the description of inner terminal setae/spines on exp-3 of P1 differ: a bipinnate seta (with inner and outer spinules) in *P. peruanus* and *P. rapiens*, a bipinnate seta (with inner and outer setules) in *P. amphitriteae*, a seta armed with outer setules and inner spinules in *P. magnus*, and a terminal spine armed with outer setules and inner spinules in *P. antennafortis*. In *P. kodosensis* and *P. tetraspinosa* exp-3 of P1 with 2 bipinnate terminal spines (with inner and outer setules) and 1 outer and 1 unipinnate terminal spine, respectively. Additionally, the number of spines on the endopodal lobe of P5 differ: there are 2 in *P. antennafortis* and *P. amphitriteae*, 3 in *P. peruanus*, *P. rapiens*, and *P. magnus*, and 4 in *P. tetraspinosa*. Overall, the combination of the presence or absence of a syncoxal seta of the maxilliped, the elements of exp-3 and enp-3 of P1–P4 and endopodal lobe of P5, and the presence or absence of exp and benp on P5 with or without medial fusion show that *P. kodosensis* and *P. tetraspinosa* are new species.

Key to females of the genus *Parameiopsis*

1. Exp-3 of P1 with 5 spines/setae (3 outer and 2 distal) 2
- Exp-3 of P1 with 4 spines/setae (2 outer and 2 distal) 5
2. Caudal rami as long as wide 3
- Caudal rami approximately 2.4 times longer than wide 4
- Caudal rami approximately 4 times longer than wide; endopodal lobe of P5 with 4 spines; P5 fused medially, benp not fused to the exp *Parameiopsis tetraspinosa* n. sp.
3. Enp-3 of P1 with outer spine; presence bulge on mandibular gnathobasis; exp-3 of P1–P4 with 1 outer spine; enp-3 of P1 with 1 outer spine; P5 represented by fused plate *Parameiopsis magnus*
- These characters not combined *Parameiopsis rapiens*
4. Maxilliped syncoxa with seta on distal; exp-3 of P1 with 2 outer spines and short distal spine; exp-3 of P1–P4 with distal spine *Parameiopsis kodosensis* n. sp.
- Maxilliped syncoxa without seta on distal; exp-3 of P1 with 3 outer spines and long distal spine; exp-3 of P1–P4 without distal spine *Parameiopsis peruanus*
5. Exp-3 of P1 with 2 outer spines, 1 distal spine and 1 inner distal seta; enp-3 of P1 with 1 outer spine, 1 outer distal spine and 1 long inner seta; P5 fused medially; caudal rami short, 2 times longer than wide, inner margin with longitudinal row of spinules and with developed seta III *Parameiopsis amphitriteae*
- Exp-3 of P1 with 2 outer spines and 2 setae distally inserted; enp-3 of P1 with outer spine, 1 outer distal seta and 1 small and slender inner distal seta; P5 not fused medially; antennule 4-segmented *Parameiopsis antennafortis*

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