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RYOCALANUS ANTARCTICUS SP. NOV. (CRUSTACEA: COPEPODA) – FIRST RYOCALANOID FROM THE SOUTHERN OCEAN

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ABSTRACT

A new ryocalanoid copepod, *Ryocalanus antarcticus* sp. nov., is described from both genders collected during the German expeditions EASIZ-II in 1998 and ANDEEP SYSTCO in 2008 above the seabed in deep waters of the Southern Ocean. The new species is well distinguished from congeners in the shape of the genital double-somite and the posterior corners of prosome, the structure of distal segments of geniculated antennule in male and details of leg 1 and limb armament. Species of *Ryocalanus* are separated into two groups. Group I contains medium to large sized copepods with a single rostrum, a geniculated moderately modified right antennule in the male, and the distal segments of the male uniramous leg 5 armed with terminal spines. Group II of Ryocalanidae share the small size (<1.6 mm), a bifid rostrum, the male highly complex geniculated right antennule, with strongly modified distal segments, and an indistinctly biramous male leg 5 with distal exopod segments lacking terminal spines. *R. antarcticus* sp. nov. is the first ryocalanoid copepod recorded from the Southern Ocean.

Key words: benthopelagic, Copepoda, *Ryocalanus antarcticus* sp. nov., Southern Ocean

RYOCALANUS ANTARCTICUS SP. NOV. (CRUSTACEA: COPEPODA) – ПЕРВЫЙ ПРЕДСТАВИТЕЛЬ РИОКАЛАНОИД ИЗ ЮЖНОГО ОКЕАНА

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РЕЗЮМЕ

Новый вид веслоногих ракообразных риокаланоид *Ryocalanus antarcticus* sp. nov. описан по самке и самцу из коллекций немецких экспедиций EASIZ-II, 1998г. и ANDEEP SYSTCO, 2008г., собранных с больших глубин из придонных вод в Южном океане. Новый вид хорошо отличается от других видов рода формой генитального сомита и задних углов просомы, строением дистальных сегментов геникулирующей антеннулы самцов и деталями вооружения конечностей. Виды рода *Ryocalanus* разбиты на две группы. В состав группы I входят копеподы среднего и большого размеров с нераздвоенным рострумом; умеренно модифицированной геникулирующей антеннулой самцов и одноветвистой пятой парой ног у которой дистальные сегменты снабжены терминальными шипами. Виды Ryocalanidae в группе II характеризуются малыми размерами (<1.6 мм); раздвоенным рострумом; сложно устроенной геникулирующей антеннулой самца с сильно модифицированными сегментами и пятой парой ног без терминальных шипов на дистальных сегментах экзоподитов, но с рудиментарными эндоподитами. *R. antarcticus* sp. nov. – первая находка представителей надсемейства риокаланоид в Южном океане.

Ключевые слова: бентопелагический, Copepoda, *Ryocalanus antarcticus* sp. nov., Южный океан

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INTRODUCTION

Andronov (1974) established the superfamily Ryocalanoidea for the monotypic family Ryocalanidae based on *Ryocalanus infelix* Tanaka, 1956 introduced by Tanaka (1956) after a single male specimen. To date six species of the single ryocalanoid genus have been recognized mostly from deep sea benthopelagic habitats. However, at present only *R. admirabilis* Andronov, 1992 is known from both sexes. The genus has been considered remarkable by Tanaka (1956) and Andronov (1974, 1992) in that the right antennule of the male shows a geniculation pattern atypical of any other calanoid family. In ancestral calanoid copepods the main antennulary geniculation is supposed to be located between the ancestral segments XX and XXI (Bradford-Grieve et al. 2010), whereas in Ryocalanidae the main geniculation is probably placed between segments XXII and XXIII – XXIV, enabling the distal antennulary part to fold backwards – with several additional supplemental geniculations located both proximal and distal to this site (Ohtsuka and Huys 2001, Boxshall and Halsey 2004).

In view of the present finding of a new ryocalanid species it now becomes evident that species formerly attributed to *Ryocalanus* may be separated into two morphological groups, with group I containing the type species *R. infelix* Tanaka, 1956, *R. bowmani* Markhaseva et Ferrari, 1996 and *R. spinifrons* Shimode, Toda et Kikuchi, 2000; and group II including *R. admirabilis*, *R. asymmetricus* Markhaseva et Ferrari, 1996, *R. bicornis* Markhaseva et Ferrari, 1996, and the new species from deep Antarctic waters.

The species of group I are of greater size (>1.9 mm) and have a very short urosome, a single rostrum, a male right antennule with subdistal segments of moderately complex structure and not strongly swollen; a uniramous male leg 5 without endopodal remnants, a 3-segmented left exopod ornamented with surface setules and terminal spines; the right exopod shorter than the left, 1 to 3-segmented and occupied with distal spines.

The species of group II are small (<1.6 mm) and bear a comparatively longer urosome; a bifid rostrum; a male right antennule of complex structure, with subdistal and distal segments strongly modified, several subdistal segments swollen and some additional supplemental geniculations; an indistinctly biramous male leg 5 with small endopodal buds, the left exopod ornamented with setules and lacking terminal spines and the right exopod shorter than the left, with one to three exopodal segments and without terminal spines on the distal exopodal segment.

Ryocalanoideans have been reported from the north Atlantic (Andronov 1992), eastern and western north Pacific (Tanaka 1956, Markhaseva and Ferrari 1996, Shimode et al. 2000) and the Arctic Ocean (Kosobokova et al. 2011). In the Southern Ocean a single ryocalanoidean species has only once been reported from near-bottom Antarctic waters in the eastern Weddell Sea; however, this species has not been described yet (Schulz and Markhaseva 2000). Recently, a sample from 52°02´S, 00°00´E in the Southern Ocean yielded another female of this particular species, which is now described below.

MATERIAL AND METHODS

Ryocalanid specimens were sorted from two samples collected by RV Polarstern in the Southern Ocean. The species was collected during EASIZ II Programme (Ecology of the Antarctic Sea Ice Zone) in 1998 and additional specimens in 2008 during expedition ANDEEP-SYSTCO (ANtarctic benthic DEEP-sea biodiversity: colonisation history and recent community patterns – SYSTem COupling). Sampling was carried out close to the sea bed at depths of 1983 and 2987 m using a closing epibenthic sledge (Brandt and Barthel 1995, Brenke 2005). Prior to dissection specimens were cleared in lactic acid and some were stained by adding a solution of chlorazol black E dissolved in 70% ethanol/30% water. All figures have been prepared using a *camera lucida* on a Zeiss Axioskop compound microscope fitted with interference contrast optics.

The following abbreviations are used in the descriptions: P1–P5, swimming legs 1 to 5. Free segments of the antennule are designated by Arabic numerals, ancestral segments by Roman numerals; one seta and one aesthetask attached to a segment of the antennule are designated as: 1s + 1ae, "?" indicates that a setal element was broken so that its identity on the antennule could not be determined and only the scar at its former position was counted. Further, descriptive terminology of the maxillary segmentation follows Ferrari and Ivanenko (2008) (earlier terms are given in parenthesis for easier understanding), and the syncoxa of the maxilliped is here considered to have three praecoxal endites and one coxal endite (Ferrari and Markhaseva 2000a, b; Ferrari and Ivanenko 2001).

Institutional abbreviations. ZIN, Zoological Institute of the Russian Academy of Sciences, Saint Petersburg, Russia; ZMH, Zoological Museum Hamburg, University of Hamburg, Hamburg, Germany.

SYSTEMATICS

Order Calanoida G.O. Sars, 1903

Superfamily Ryocalanoidea Andronov, 1974

Family Ryocalanidae Andronov, 1974

Genus *Ryocalanus* Tanaka, 1956

***Ryocalanus antarcticus* sp. nov.**
(Figs 1–6)

Holotype. Adult female, dissected, body length 1.04 mm (ZMH K–43077); eastern Weddell Sea, off Vestkapp, 73°24´S, 22°08´W, station 48–130, project EASIZ-II, 08 February 1998, above the sea bed at depth of 1983 m.

Paratypes. 3 adult females, body length 1.00 mm; 5 adult males, body length 0.75–0.80 mm (ZMH K–43078), same data as for holotype. 1 adult female, body length 1.05 mm and 2 adult males, body length 0.80 mm (ZIN 91105), same data as for holotype, and 1 adult female, body length 1.05 mm (ZIN 91106); Southern Ocean, 52°02'S, 00°00'E, station 85-8, project ANDEEP-SYSTCO, 27 January 2008, above the sea bed at depth of 2987 m.

Type deposition. Holotype and part of paratypes are deposited at ZMH, other paratypes – at ZIN.

Description. Adult female, total length 1.00–1.05 mm; prosome 4.7–5.2 times as long as urosome. Rostrum (Fig. 1A, C–D) as a plate with 2 distal rami. Cephalosome (Fig. 1A–B, E–F) and pediger 1 not quite complete separate, pedigers 4 and 5 separate; posterior corners prolonged into asymmetrical triangular lobes extending to end of genital double-somite (left) and urosomite 3 (right) respectively (Fig. 1E–G, L). Urosome 4-segmented, genital double-somite asymmetrical, in dorsal view more prominent on left (Fig. 1E, G–H). Genital double-somite and urosomites 2 and 3 each with fringe of spinules along posterior borders. Caudal rami (Fig. 1H, L) slightly asymmetrical with left ramus slightly wider than right, with four terminal setae, ventral seta and scar of dorsal seta.

Antennule (Fig. 2A–D) of 24 free segments and extending to pediger 2. In holotype armature as follows: I – 2s + ?, II–IV – 6s, V – 2s, VI – 2s, VII – 2s + ?, VIII – 2s, IX – 2s + 1?; X–XI – 4s, XII – 1s + 1ae, XIII – 2s; XIV – 2s + 1ae, XV – 1s, XVI – 2s, XVII – 1s + 1?, XVIII – 2s, XIX – 2s + 1ae, XX – 2s, XXI – 2s + 1ae, XXII – 0, XXIII – 1s, XXIV – 2s, XXV – 2s, XXVI – 2s, XXVII–XXVIII – 4s + 1ae. Armature of paratypes demonstrates more aesthetasks broken or saved compared to holotype.

Antenna (Fig. 2E–F), coxa with 1 seta; basis with 2 setae; endopodal segment 1 with 2 setae, segment 2 with 16 setae; exopod 8-segmented, with 1, 3, 1, 1, 1, 1, 1, 3 setae.

Mandible (Fig. 3A), gnathobase cutting edge with 8 teeth; exopod of 5 segments with 1,1,1,1 and 2 setae; endopod segment 1 with 4 setae, endopod segment 2 with 11 setae; basis with 3 setae.

Maxillule (Fig. 2G–I), praecoxal arthrite with 9 terminal spines, 4 posterior and 1 anterior setae; small teeth located at base of middle terminal spine (marked by asterisk in Fig. 2H); posteroanterior surface of praecoxal arthrite with small spinules; coxal endite with 6 setae, coxal epipodite with 9 setae; proximal basal endite with 4 setae, distal basal endite with 5 setae; endopod with 13 setae and small surface spinules, exopod with 11 setae.

Maxilla (Fig. 3B), basis (formerly considered coxa) with outer seta; praecoxal endite bearing 5 setae, coxal endite (formerly considered distal praecoxal endite) with 3 setae; basal endites (formerly considered coxal endites) with 3 setae each; lobe of proximal endopodal segment (formerly considered proximal basal endite) with 3 setae; endopod with 7 plus 2 setae.

Maxilliped (Fig. 3C), syncoxa with 1 seta on proximal praecoxal endite, 2 setae on middle endite, and 3 setae on distal praecoxal endite; coxal endite with 3 setae. Basis with 3 medial setae plus 2 setae distally of partly incorporated endopod segment 1; free endopodal segments with 4, 4, 3, 3+1, and 4 setae.

P1 (Figure 3D), basis with medial distal seta curved outwards, very short distolateral seta and patches of surface spinules on anterior and posterior surface; endopod 1-segmented with 3 medial and 2 terminal setae; lateral lobe poorly developed with short transverse row of ca. 6–7 spinules; exopod 3-segmented, segment 1 with lateral spine extending to one-third of lateral spine of segment 2, spine of segment 2 slightly longer than distal lateral spine of segment 3, proximal lateral spine of segment 3 about one-half length of distal lateral spine.

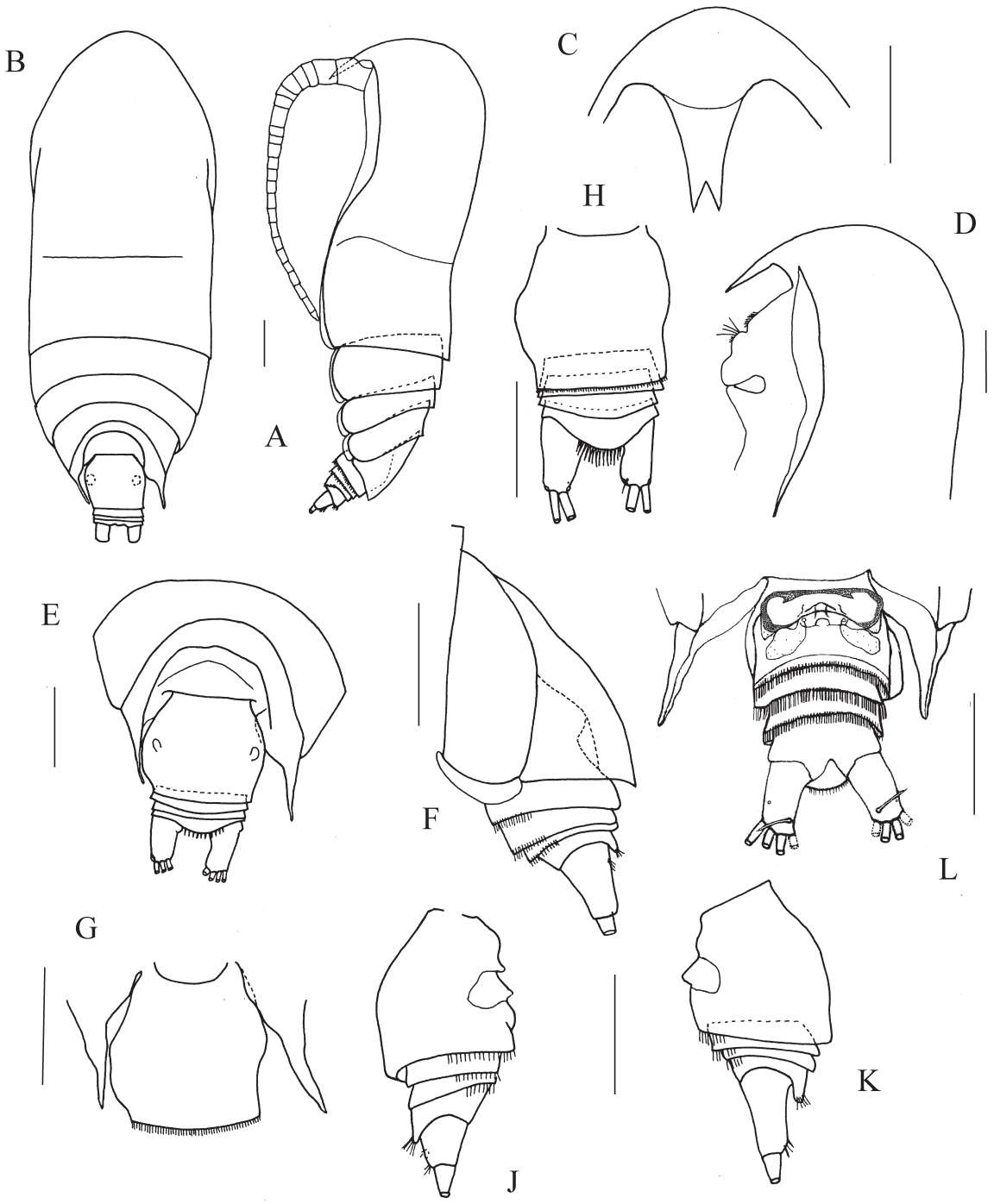

Fig. 1. *Ryocalanus antarcticus* sp. nov., female: A – habitus, lateral; B – habitus, dorsal; C – rostrum, ventral; D – rostrum, lateral; E – pedigers 4–5 and urosome, dorsal; F – pedigers 4–5 and urosome, lateral; G – posterior prosome and genital double-somite, dorsal; H – urosome, dorsal; J – urosome, right lateral; K – urosome, left lateral; L – posterior prosome and urosome, ventral; A, C–D, F, H–K – holotype; B, E, L – paratypes from EASIZ-II; G – paratype from ANDEEP-SYSTCO. Scale bars = 0.1 mm.

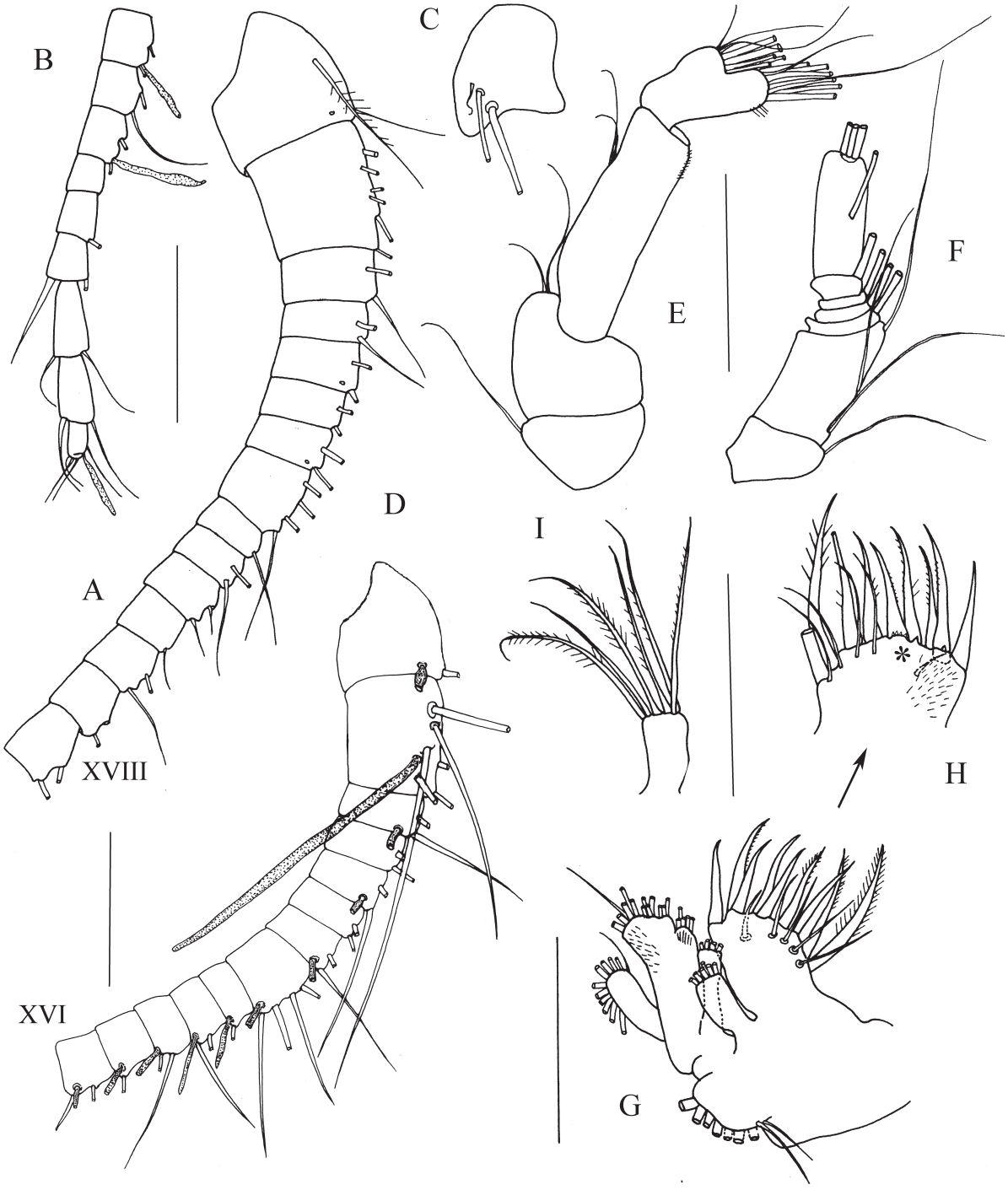

Fig. 2. *Ryocalanus antarcticus* sp. nov., female: A – antennule, segments I–XVIII, round dots are scars of broken aethetasks; B – antennule, segments XIX–XXVIII; C – antennule, segment I; D – antennule, segments I–XVI; E– antenna, coxa, basis and endopod; F – antenna, exopod; G – maxillule; H – praecoxal arthrite, asterisk marks teeth near bases of middle terminal spines; I – maxillule, coxal endite; A, B – paratype from ANDEEP-SYSTCO; C–F – paratypes from EASIZ-II; H – holotype. Scale bars = 0.1 mm.

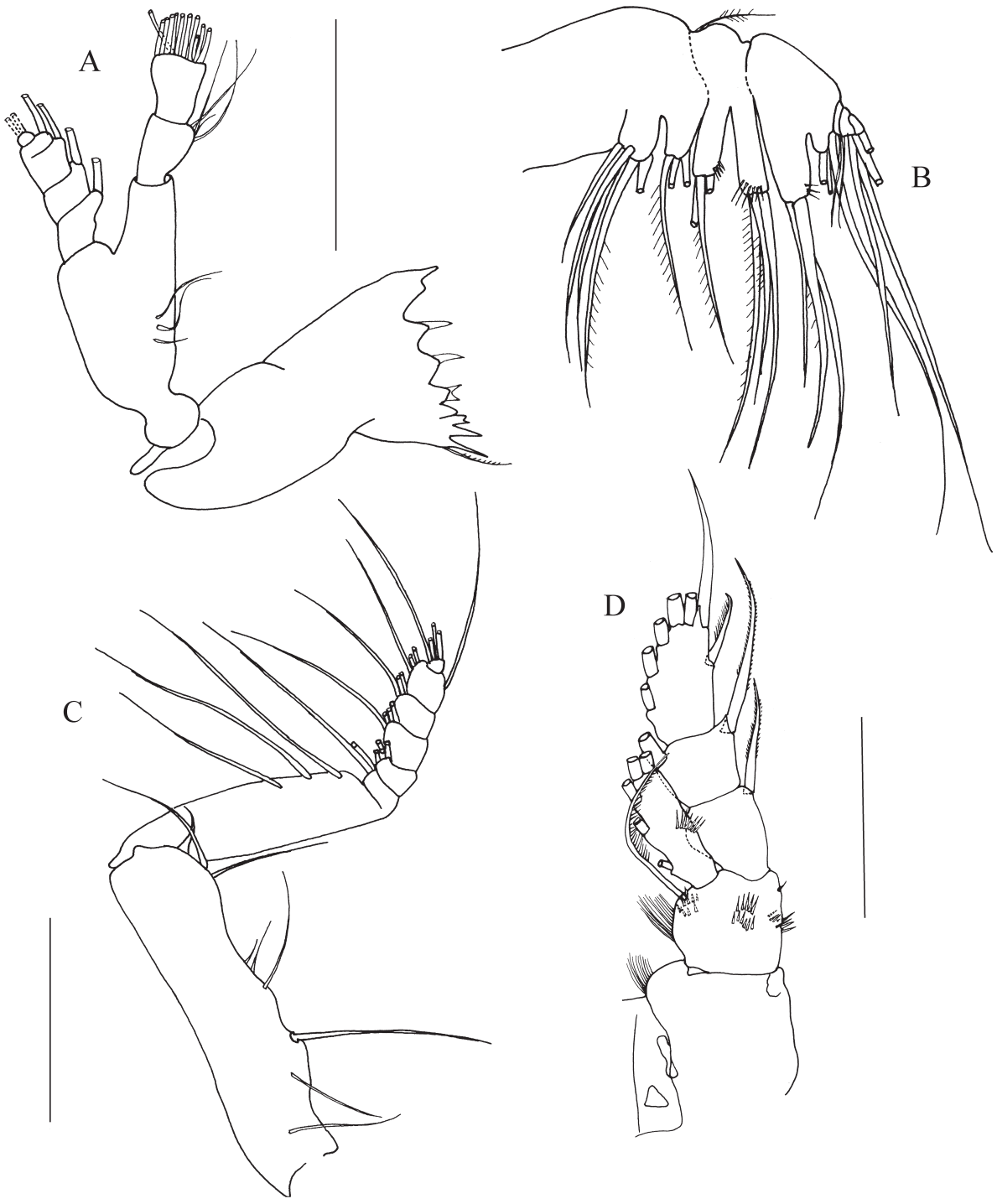

Fig. 3. *Ryocalanus antarcticus* sp. nov., female: A – mandible, B – maxilla; C – maxilliped; D – P1; A – paratype from ANDEEP-SYSTCO; B–D – paratypes from EASIZ-II. Scale bars = 0.1 mm.

P2 to P4 (Fig. 4A–C) biramous with 3-segmented exopods, endopod 2-segmented in leg 2 and 3-segmented in legs 3 to 4. P2 to P4 with finely serrate terminal spine on exopod segment 3.

P2 (Fig. 4A), coxa with medial seta and lateral surface spinules; basis with rows of spinules on posterior surface near base of endopod and distolaterally; endopod segment 1 with 1 medial seta; segment 2 with 2 medial, 2 terminal and 1 lateral setae. Exopod segment 1 with lateral spine, medial seta and posterior spinules distolaterally, segment 2 with lateral spine and medial seta, segment 3 with 3 lateral spines, 5 medial setae and terminal spine.

P3 (Fig. 4B), coxa with medial seta and lateral surface spinules; basis with rows of spinules on posterior surface near the base of endopod and distolaterally; endopod segment 1 with medial seta, segment 2 with 1 medial seta, segment 3 with 2 medial, 2 terminal and 2 lateral setae; exopod segment 1 with lateral spine, medial seta and posterior spinules, segment 2 with lateral spine and medial seta, segment 3 with 3 lateral spines, 5 medial setae and terminal spine.

P4 (Fig. 4C), coxa with medial seta, 2 strong and unequal laterodistal spines and patches of spinules on posterior face; basis with spinules on posterior surface and row of spinules on distal margin; endopod segment 1 with medial seta, segment 2 with 1 medial seta and tiny spinules along distal border, segment 3 with 2 medial, 2 terminal and 2 lateral setae; exopod segment 1 with lateral spine, medial seta and scattered spinules distolaterally on posterior face, segment 2 with lateral spine and medial seta, segment 3 with three lateral spines, 5 medial setae and terminal spine.

Adult male, total length 0.75–0.80 mm, prosome 4.1–5.0 times as long as urosome. Rostrum (Fig. 5A, C–D) as plate with 2 asymmetrical rami, right one longer than left. Cephalosome (Fig. 5A, B) and pediger 1 separate, pedigers 4 and 5 separate; posterior corners prolonged into short triangular lobes (Fig. 5A–B) slightly extending beyond urosomite 1. Caudal rami (Fig. 5E) symmetrical, with 4 terminal plus small dorsal and ventral setae each.

Left antennule (Fig. 5F–G) unmodified of 24 free segments, extending to urosome, armature as follows: I – 1s + 1ae, II–IV – 6s + 4ae, V – 2s + 2ae, VI – 2s + 1ae, VII – 2s + 2ae, VIII – 1s + 1ae, IX – 2s + 2ae, X–XI – 4s + 3ae, XII – 2s + 1ae; XIII – 2s + 1ae; XIV – 2s + 1ae, XV – 1s + 1ae, XVI – 2s + 1ae, XVII – 2s + 1ae, XVIII – 2s + 1ae, XIX – 2s + 1ae, XX – 2s + 1ae, XXI – 2s + 1ae, XXII – 0, XXIII – 1s + 1ae, XXIV – 2s + 1ae, XXV – 2s, XXVI – 2s, XXVII–XXVIII – 4s + 1ae.

Right antennule (Fig. 6A–D) geniculate, strongly modified, of 23 free segments; segments I to IX slightly enlarged compared to left limb, armature as in left antennule; segments X to XXV strongly enlarged; segment XVIII widened, segment XXI with 2 long and curved spine-like attenuations distally, fused segments XXIII– XXIV comprising largest segment, ovoid in outline and bearing lobe proximally; segments XXII, XXV, and XXVI elongate, latter with distal projection; segment XXVIII partly fused to penultimate segment. Armature as follows: X–XI – 4s + 1ae, XII – 1s, XIII – 2s, XIV – 2s + 1ae, XV – 1s, XVI – 2s + 1ae, XVII – 1s + 1ae, XVIII – 2s + 1ae, XIX – 1s, XX – 2s, XXI – 2 spine-like attenuations + 1ae, XXII – 1s + 1ae, XXIII–XXIV – 3s + 1ae, XXV – 2s, XXVI – 2s + 1ae, XXVII–XXVIII – 5s + 1ae.

Antenna, mandible, maxillule, and maxilla similar to those of female but with some setae slightly shorter.

P1 (Fig. 5H) generally as in female, but distal lateral spines of exopodal segments 1 to 3 of equal length and that of segment 2 not extending beyond distal end of segment 3.

P2–P3 similar to those of female. P4 as in female, but coxa without 2 strong spines mediodistally.

P5 (Fig. 5I) biramous, exopods 3-segmented on both sides, endopods bud-like, rudimentary; left leg longer than right; exopod segments naked, except for left segment 2 with long spinules medially and distally and exopod segment 3 with long spinules mediodistally.

Etymology. The specific name indicates the source of specimens from Antarctic waters.

Remarks. The new species shares main morphological characters with the three species of *Ryocalanus* attributed to species group II. Females of *R. antarcticus* are well distinguished from the remaining species of this group by the asymmetrical shape of the posterior corners of the prosome and the genital double-somite, and in details of P1 exopod 3 which bears 2 lateral spines (*vs* only one lateral spine reported for *R. asymmetricus* and *R. bicornis*). The female of the new species is more closely related to *R. admirabilis*, but differs from this species in the following characters: i) symmetrical rostrum (*vs* slightly asymmetrical rostrum in *R. admirabilis*); ii) asymmetrical posterior lobes of the prosome (*vs* sym-

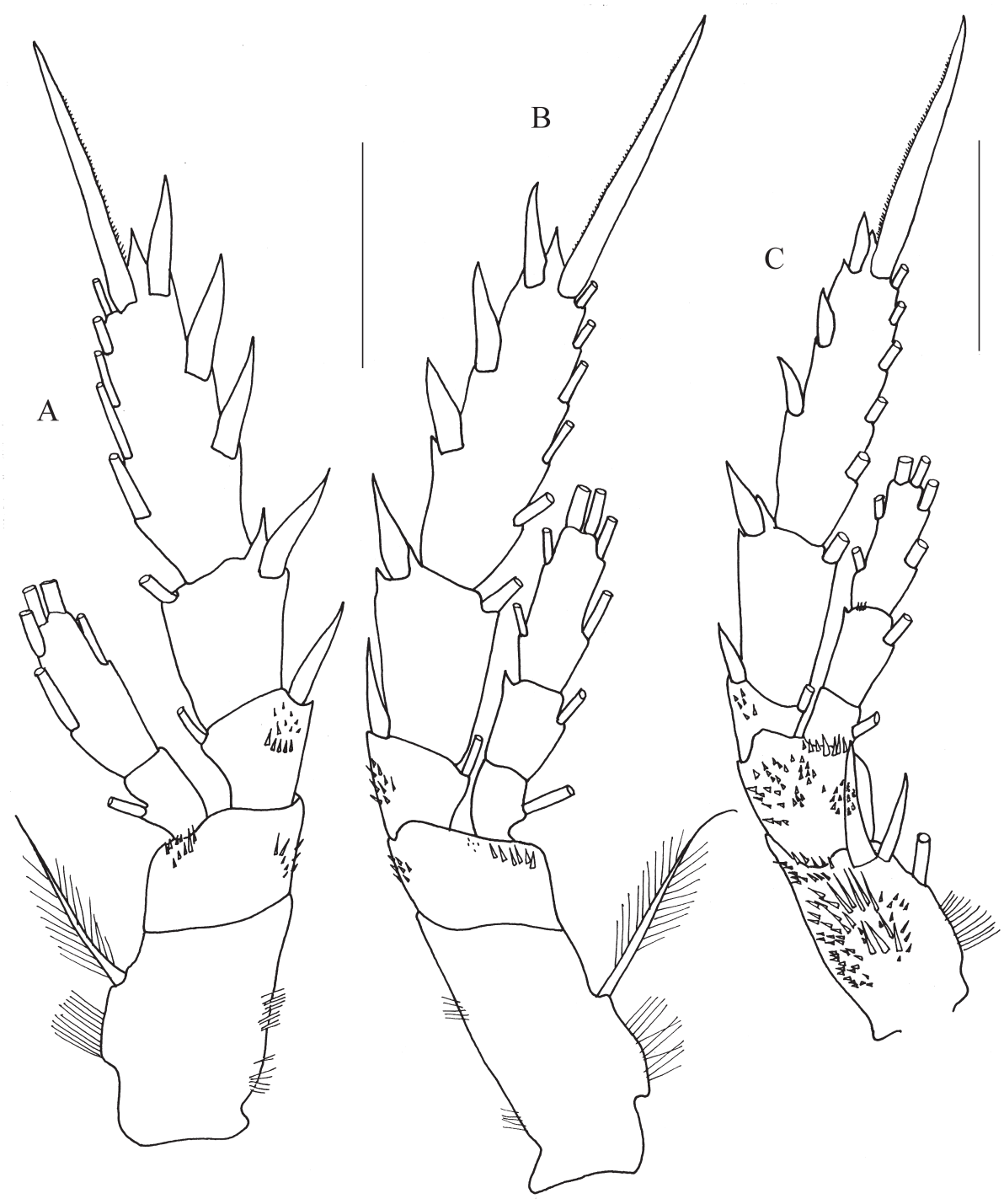

Fig. 4. *Ryocalanus antarcticus* sp. nov., female: A – P2; B – P3; C – P4; A, B – holotype. C – paratype from EASIZ-II. Scale bar = 0.1 mm.

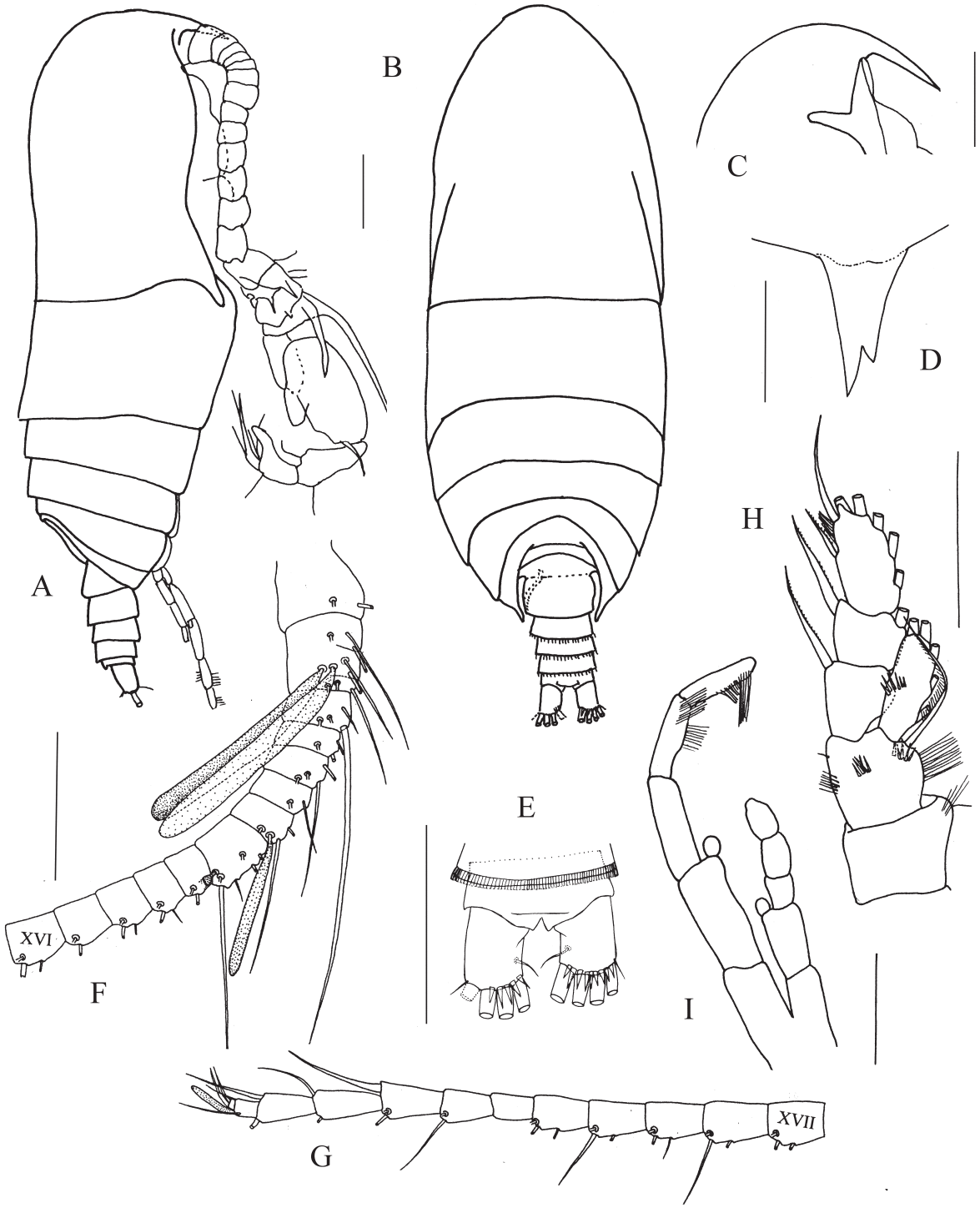

Fig. 5. *Ryocalanus antarcticus* sp. nov., male, paratype from EASIZ-II: A – habitus, lateral; B – habitus, dorsal; C – rostrum, lateral; D – rostrum, ventral; E – urosomal segment 5 and caudal rami; F – left antennule, segments I – XVI; G – left antennule, segments XVII–XXVIII; H – P1; I – P5. Scale bars = 0.1 mm.

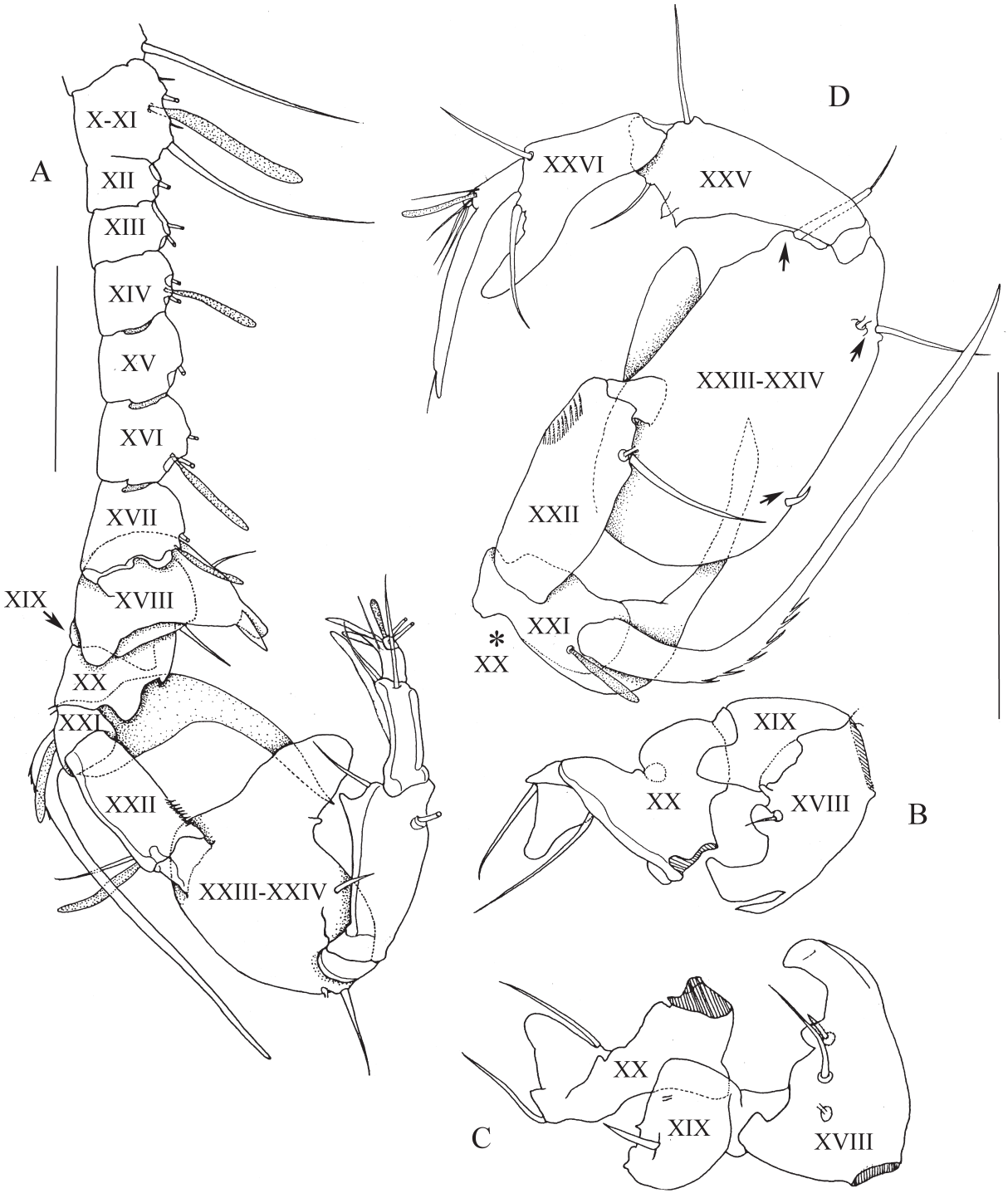

Fig. 6. *Ryocalanus antarcticus* sp. nov., male, paratype from EASIZ-II: A – right antennule, segments X–XXVIII, arrow shows small segment XIX; B, C – right antennule, segments XVIII–XX, other views; D – antennule, segments XXI–XXVIII (asterisk marks place of attachment of segment XX). Scale bars = 0.1 mm.

metrical lobes in *R. admirabilis*); iii) an asymmetrical, not barrel-like genital double-somite (in dorsal view) with swelling on the left (*vs* a genital double-somite barrel-like in dorsal view, nearly symmetrical and with small projection on the right in *R. admirabilis*). Males of *R. antarcticus* differ by: i) fused ancestral segments XXIII–XXIV of the right antennule with a large attenuation about 0.7 times as wide as its segment (*vs* small attenuation about 0.24 times as wide in *R. admirabilis*); and ii) a P5 with right 3-segmented exopod (*vs* one-segmented in *R. admirabilis*).

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