

Ryocalanus brasiliensis sp. nov. (Crustacea: Copepoda, Calanoida), a new ryocalanoid from the South Atlantic and the segregation of *Yrocalanus* gen. nov.

J. Renz^{*,1}, E. L. Markhaseva² and K. Schulz¹

¹ German Center for Marine Biodiversity Research (DZMB) – Senckenberg am Meer, c/o Biozentrum Grindel & Zoologisches Museum, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany

² Zoological Institute of the Russian Academy of Sciences, Universitetskaya Emb. 1, 190034 Saint Petersburg, Russia

Abstract

Received 13 December 2012
Accepted 5 April 2013
Published 18 September 2013

Key Words

hyperbenthic copepods
Brazilian Basin
geniculation antennule
deep sea

A new hyperbenthic calanoid copepod species, *Ryocalanus brasiliensis*, collected from abyssal depth in the Brazilian Basin, is described from female and male specimens. The new species is placed in the genus *Ryocalanus*, family Ryocalanidae, on account of the complex characteristics of the male antennule and segmentation and setation of swimming legs. *Ryocalanus brasiliensis* is distinguished from other species of this genus by its larger size, the shape of rostrum and urosomite segments, the number of robust spines on the coxa of leg 4 in females, and the male P5 and antennule morphology. A new genus, *Yrocalanus* gen. nov. is established to accommodate four species previously integrated into *Ryocalanus* that are distinctive in their smaller body size, shape of the rostrum and details of antennule and fifth legs of the male.

Introduction

Calanoid copepods belonging to the family Ryocalanidae are distributed in both, northern and southern hemispheres (Tanaka 1956; Andronov 1992; Markhaseva & Ferrari 1996; Shimode et al. 2000; Kosobokova et al. 2011; Renz et al. 2012) and species have been described from the Southern Ocean and South Atlantic, the central tropical Atlantic, the Arctic, the eastern tropical Pacific, the Izu region and Sagami Bay, Japan (Fig. 1). Several authors (Markhaseva & Ferrari 1996; Boxshall & Halsey 2004) suggested ryocalanoid copepods to be primarily members of the deep sea hyperbenthic community since all species, from which the sampling depth is known, were collected in depth exceeding 1200 m where temperatures are usually below 4 °C.

The monotypic superfamily Ryocalanoidea and family Ryocalanidae (Copepoda, Calanoida) was established by Andronov (1974) on the basis of a single male, *Ryocalanus infelix* Tanaka, 1956. The superfamily is characterised by the unique geniculated structure

of the male right antennule (Andronov 1974). Generally, in calanoid copepods the geniculated antennule serves as a grasping tool to capture the female during copulation prior to the transfer of the spermatophore to the genital double-somite by the modified fifth leg of the male (Ohtsuka & Huys 2001). Whereas in phylogenetically more basic families the main antennular geniculation is found exclusively between ancestral segments XX and XXI, this geniculation site in ryocalanoids is manifested distal to ancestral segment XXII enabling the distal antennular hind part to fold backwards. Additional supplemental geniculations located both proximal and distal to this segments can be found in some species (Huys & Boxshall 1991; Ohtsuka & Huys 2001).

Up to now, the superfamily Ryocalanoidea contains only a single family, Ryocalanidae Andronov, 1974, with 7 species attributed to the only genus *Ryocalanus* Tanaka, 1956. However, Renz et al. (2012) recognized two separate groups within this genus, differing in body size, the structure of the rostrum, modification of the male antennule and characteristics of the male fifth leg.

* Corresponding author, e-mail: Jasmin.Renz@senckenberg.de

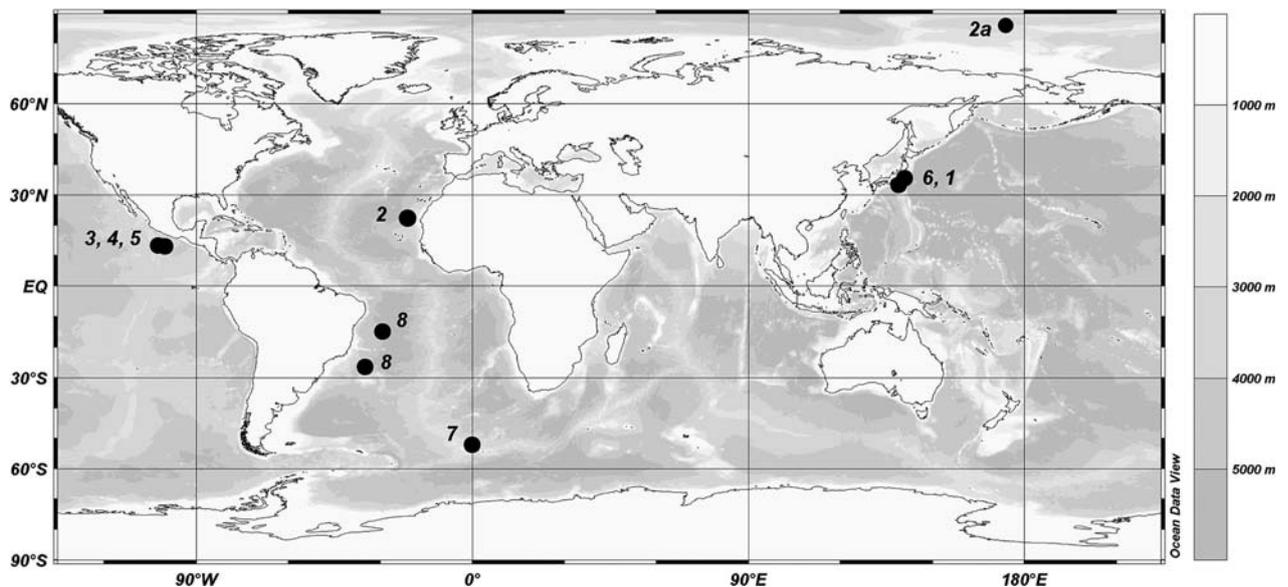


Figure 1. Distribution of *Ryocalanus* species in the world oceans; 1 *R. infelix*; 2 and 2a – *R. admirabilis*; 3, 4, 5 – *R. asymmetricus*, *R. bicornis*, *R. bowmani*; 6 – *R. spinifrons*; 7, 8 – *R. brasilianus* sp. nov.

Group I so far contains *Ryocalanus infelix* Tanaka, 1956, *R. bowmani* Markhaseva & Ferrari, 1996, and *R. spinifrons* Shimode, Toda & Kikuchi, 2000. Group II encompasses *R. asymmetricus* Markhaseva & Ferrari, 1996, *R. bicornis* Markhaseva & Ferrari, 1996, *R. admirabilis* Andronov, 1992 and *R. antarcticus* Renz, Markhaseva & Schulz, 2012.

A new species of *Ryocalanus* is described below after female and male specimens of a species that belongs to group I. In this paper a new genus is established for group II species, constituting the second genus within Ryocalanidae.

Materials and methods

Copepods were collected by RV *Meteor* in the South Atlantic (Brazilian Basin) during the DIVA III expedition (Latitudinal Gradients in Biodiversity in the deep Atlantic) within the CeDAMar project (Census of the Diversity of Abyssal Marine Life) in 2009. Sampling was carried out above the sea bed at depths of 4484 m using a closing epibenthic sledge (Brandt & Barthel 1995; Brenke 2005) with a mesh size of 300 µm. Samples were fixed in 96 % pure ethanol.

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.

Free segments of the antennule are designated by Arabic numerals, ancestral segments by Roman numerals; one seta and one aesthetasc attached to a segment of the antennule are designated as: 1s + 1ae.

The descriptive terminology of the maxillary segmentation follows Ferrari & Ivanenko 2008, with earlier terms given in parenthesis for easier understanding. The syncoxa of the maxilliped is here considered to have three praecoaxal endites and one coxal endite (Ferrari & Markhaseva 2000a, b; Ferrari & Ivanenko 2001). Type specimens are deposited at the Zoological Museum Hamburg, University of Hamburg (ZMH).

Systematics

Order **Calanoida** Sars, 1903

Superfamily **Ryocalanoidea** Andronov, 1974

Family **Ryocalanidae** Andronov, 1974

Genus ***Ryocalanus*** Tanaka, 1956

Ryocalanus brasilianus sp. nov.

Figures 2–7

Type material. Holotype. Adult female, dissected, body length 2.92 mm (ZMH K–43930); Brazilian Basin, 35°13.90'S, 26°34.78'W, station 554, project DIVA III, 22 July 2009, above the sea bed at a depth of 4484 m. Paratypes: 2 adult females, body length 2.88–3.04 mm (ZMH K–43931 and 43932), 1 adult male, body length 2.76 mm (ZMH K–43934), same data as for holotype; 1 adult male, dissected, body length 2.76 mm (ZMH K–43933); Brazilian Basin, 29°57.37'S, 14°58.41'W, station 561, project DIVA III, 23 July 2009, above the sea bed at a depth of 4484 m.

Etymology. The specific name is derived from the location of collection, the Brazilian Basin.

Description. Based on female holotype unless otherwise stated. Adult female, total length 2.92 mm; prosome 6.3 times as long as urosome. Rostrum (Figs 2b–d) one-pointed. Cephalosome and pediger 1 separate (Figs 2a–b), pedigers 4–5 separate; in lateral view posterolateral corners of prosome extended posteriorly into points, reaching to distal margin of the genital double-somite (Figs 2e–g). Ventral inner side of fifth somite with short spinules.

Urosome composed of genital double-somite and three articulated somites (Figs 2e–g). Genital double-somite asymmetrical, with lateral swelling on right side and faint line of incomplete fusion on dorsal and ven-

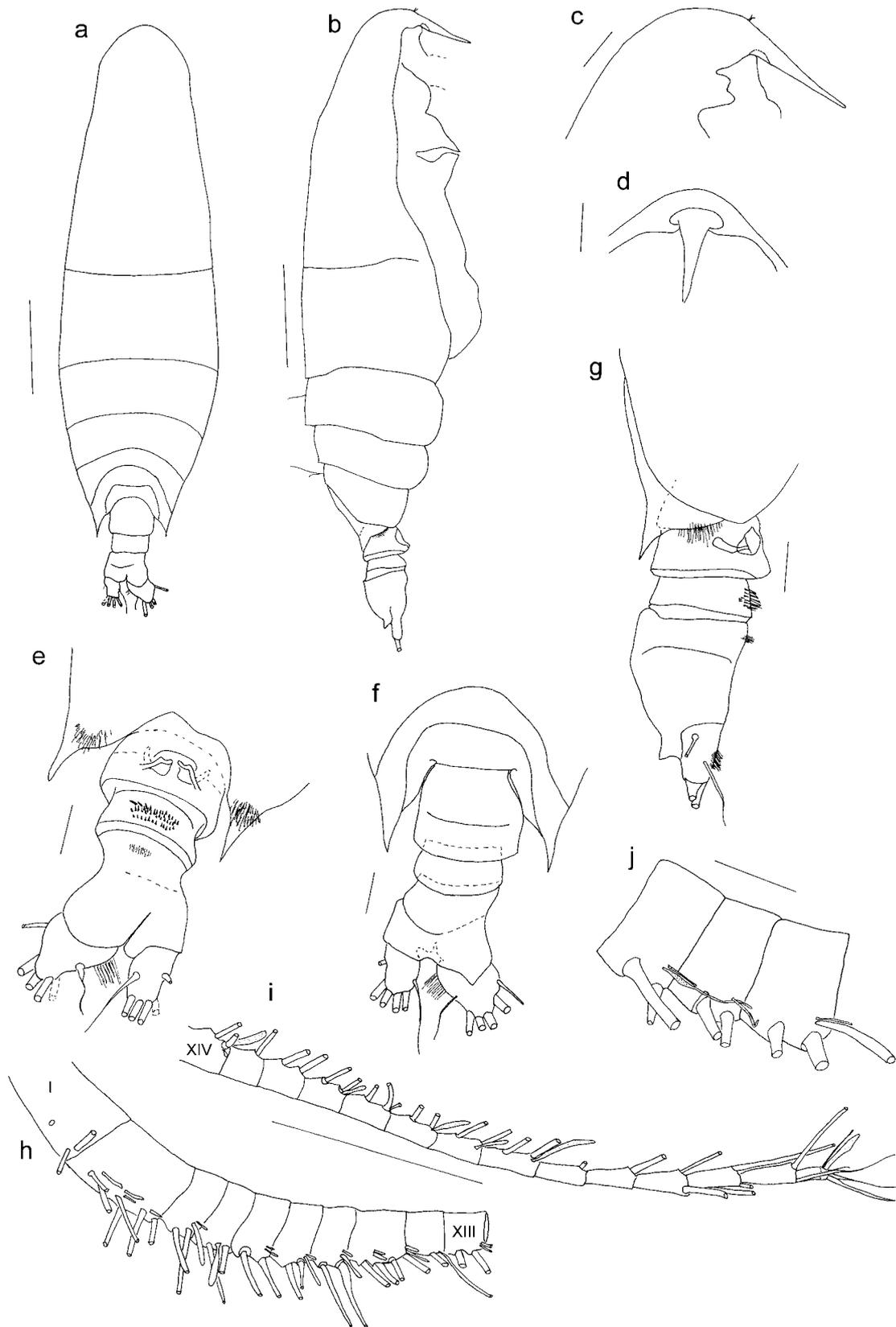
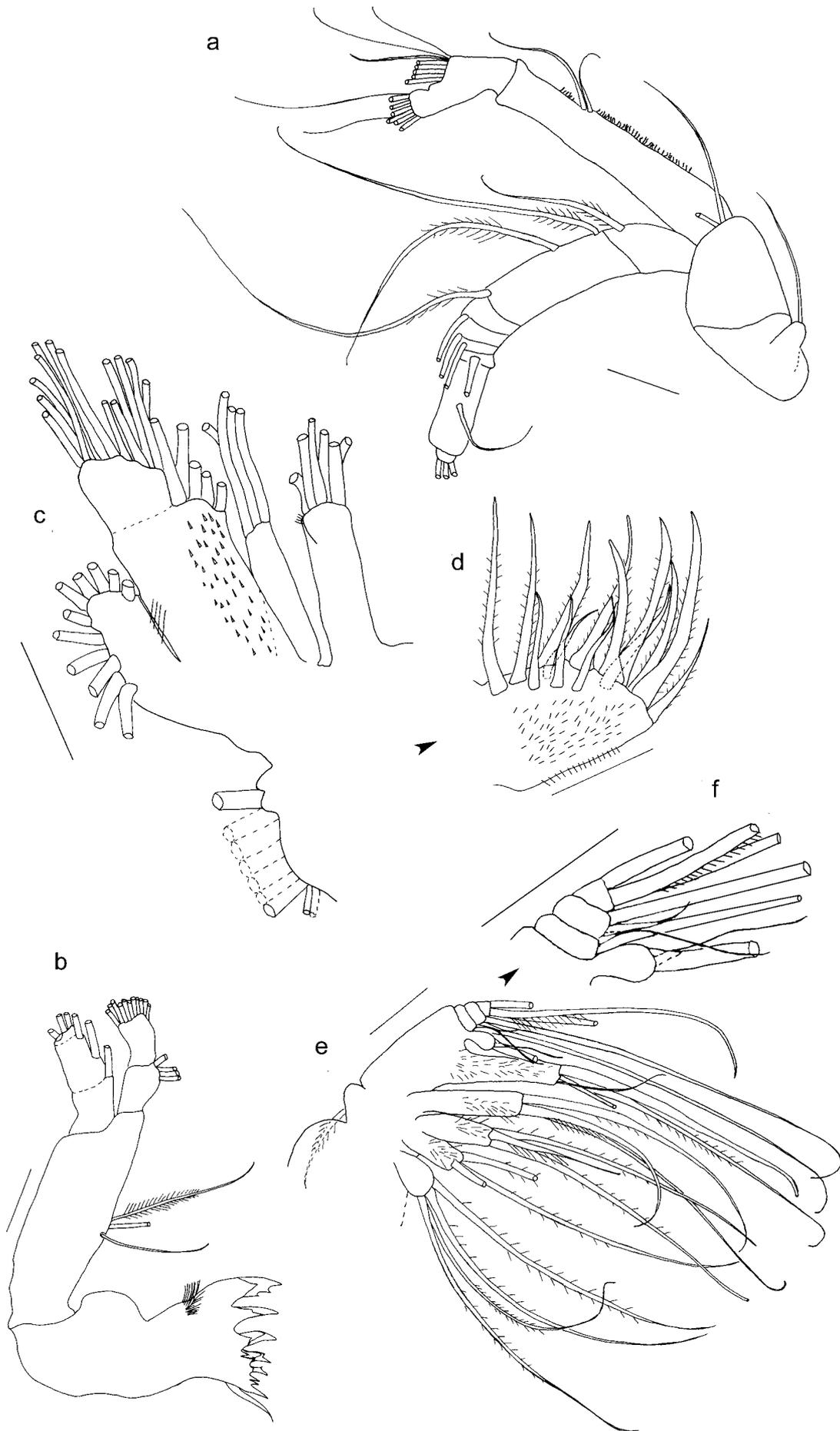


Figure 2. *Ryocalanus brasiliensis* sp. nov., female, holotype. **a.** habitus, dorsal; **b.** habitus, lateral; **c.** rostrum, lateral; **d.** rostrum, ventral; **e.** pedigers 4–5 and urosome, ventral, dotted setae additions after paratype, broken in holotype; **f.** pediger 5 and urosome; **g.** pediger 5 and urosome, lateral; **h.** antennule, segments I–XIII; **i.** antennule, segments XIV–XXVIII; **j.** antennule, segments V–VII as in paratype. Scale bars: a–b, h–i: 0.5 mm; c–g, j: 0.1 mm.



tral side. Urosomites 2 and 3 with transversal rows of spinules on ventral side (Figs 2 e). Urosomites 3 and 4 slightly asymmetrical and partly fused. Urosomite 3 wider on the left and urosomite 4 wider on right side. Caudal rami asymmetrical with right ramus wider than left and row of spinules on inner margin and with four terminal plus one ventral and dorsal setae each.

Antennule (Figs 2 h–i) of 24 free segments and extending to pediger 2. In holotype armature as follows: I – 2s + 1ae, II–IV – 6s + 4 ae, V – 2s + 2 ae, VI – 2s + 1 ae, VII – 2s + 2 ae, VIII – 2s + 2 ae, IX – 2s + 2 ae; X–XI – 4s + 4 ae, XII – 1s + 2ae, XIII – 2s (2s + 2ae in paratype), XIV – 2s + 1ae, XV – 1s (1s + 1ae in paratype), XVI – 2s (2s + 1ae in paratype), XVII – 2s + 1ae, XVIII – 2s + 1 ae, XIX – 2s (in paratype 2s + 1ae), XX – 2s, XXI – 2s + 1ae, XXII – 1s, XXIII – 1s, XXIV – 2s, XXV – 2s, XXVI – 2s, XXVII–XXVIII – 4s + 1ae.

Antenna (Fig. 3a), coxa with 1, basis with 2 setae; endopod segment 1 with two setae, segment 2 with 16 setae; exopod 8-segmented, with 1, 3, 1, 1, 1, 1, 1, 3 setae.

Mandible (Fig. 3b), gnathobase cutting edge with 8 unequal teeth plus ventral seta; exopodal segments incompletely fused, with 6 setae; first endopod segment with 4 setae, second with 11 setae; basis with 3 setae.

Maxillule (Figs 3c–d), praecoxal arthrite with 9 terminal spines, 3 posterior and 2 anterior setae; posterior surface of praecoxal arthrite with small spinules; coxal endite with 6 setae, coxal epipodite setae broken in holotype, with 9 setae (in paratype); proximal basal endite with 4 setae, distal basal endite with 5 setae and small surface spinules; endopod with 13 setae and patch of small surface spinules; exopod with 11 setae.

Maxilla (Figs 3e–f), basis (formerly considered coxa) with 1 outer seta; praecoxal endite bearing 4 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 4 setae; all endites with surface spinules. Endopod with 7 + 2 setae.

Maxilliped (Fig. 4a), 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 on partly incorporated endopod segment 1; endopod of 5 free segments with 4, 4, 3, 3 + 1, and 4 setae.

Swimming legs P1 to P4 biramous (Figs 4b–e). P1 (Fig. 4b), coxa with inner spinules, basis with medial inner seta and minute lateral seta distally; endopod 1-

segmented with 3 medial and 2 terminal setae; lateral lobe poorly developed with spinules and two inner wedge-shaped projections; exopod 3-segmented, segment 1 with lateral spine and inner spinules, segment 2 with long lateral spines nearly as long as whole exopod and medial seta, segment 3 with 2 lateral spines, 4 medial setae and terminal spine, distal-lateral and terminal spine each ca. 1.5 times as long as exopod.

Legs P2 to P4 with 3-segmented exopods, endopod 2-segmented in leg 2 and 3-segmented in legs 3 to 4. All endopod and exopod segments with rows of spinules on posterior surface. P2 to P4 with finely serrate terminal spine on exopod segment 3.

P2 (Fig. 4c), coxa with medial seta and surface spinules on inner margin; basis with rows of spinules on posterior surface; endopod segment 1 with one medial seta and inner wedge-shaped projection; segment 2 with two medial, two terminal and one lateral setae and inner and outer surface spinules. Exopod segment 1 with lateral spine and medial seta, segment 2 with lateral spine and medial seta, segment 3 with three lateral spines, five medial setae and terminal spine.

P3 (Fig. 4d), coxa with medial seta and inner surface spinules; basis with rows of spinules on posterior surface; endopod segments 1 and 2 with one medial seta each, segment 3 with two medial, two terminal and two lateral setae; exopod segments 1 and 2 with lateral spine and medial seta, segment 3 with three lateral spines, five medial setae and terminal spine.

P4 (Figs 4e–g), coxa with medial seta and inner surface spinules, 1 strong distolateral spine on right leg and patches of spinules on posterior surface; basis with spinules on posterior surface and row of spinules on distal margin; endopod segment 1 and 2 with one medial seta each, segment 3 with two medial, two terminal and two lateral setae; exopod segment 1 and 2 with lateral spine and one medial seta each, segment 3 with three lateral spines, five medial setae and terminal spine.

Adult male. Total length 2.76 mm, prosome 5.3 times as long as urosome. Rostrum (Figs 5a, c) one-pointed. Cephalosome and pediger 1 separate (Figs 5a, b), pedigers 4 and 5 separate. In lateral view posterolateral corners of prosome extended posteriorly into points slightly extending urosomite 1. Caudal rami (Fig. 5d–e) almost symmetrical, with four terminal plus one small dorsal and one ventral setae each.

Left antennule (Figs 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 – 2s + 2ae, IX – 2s + 2ae, X–XI – 4s + 4ae, XII – 1s + 2ae; 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 – 1s + 1ae, XXIII – 1s + 1ae, XXIV – 2s + 1ae, XXV – 2s + 1ae, XXVI – 2s, XXVII–XXVIII – 3s + 1ae.

◀ **Figure 3.** *Ryocalanus brasiliensis* sp. nov., female, holotype. **a.** antenna; **b.** mandible; **c.** maxillule, praecoxal arthrite not figured; **d.** praecoxal arthrite of maxillule; **e.** maxilla, dotted setae – additions after paratype, broken in holotype; **f.** maxilla, endopod. Scale bars: 0.1 mm.

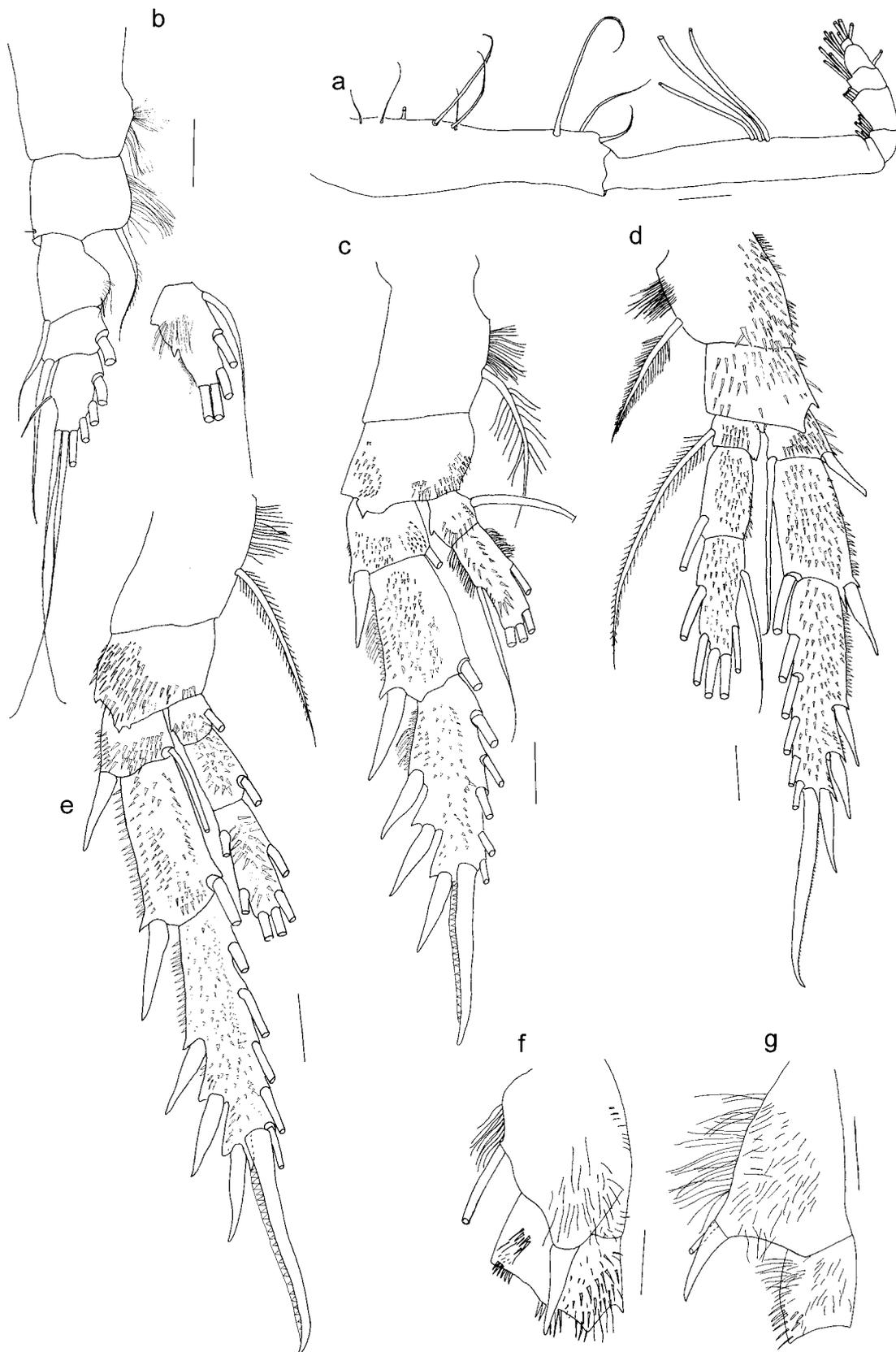


Figure 4. *Ryocalanus brasiliensis* sp. nov., female, holotype. **a.** maxilliped; **b.** P1 with endopodite figured separately, **c.** P2; **d.** P3; **e.** P4, left; **f–g.** coxa of right P4, different views. Scale bars: 0.1 mm.

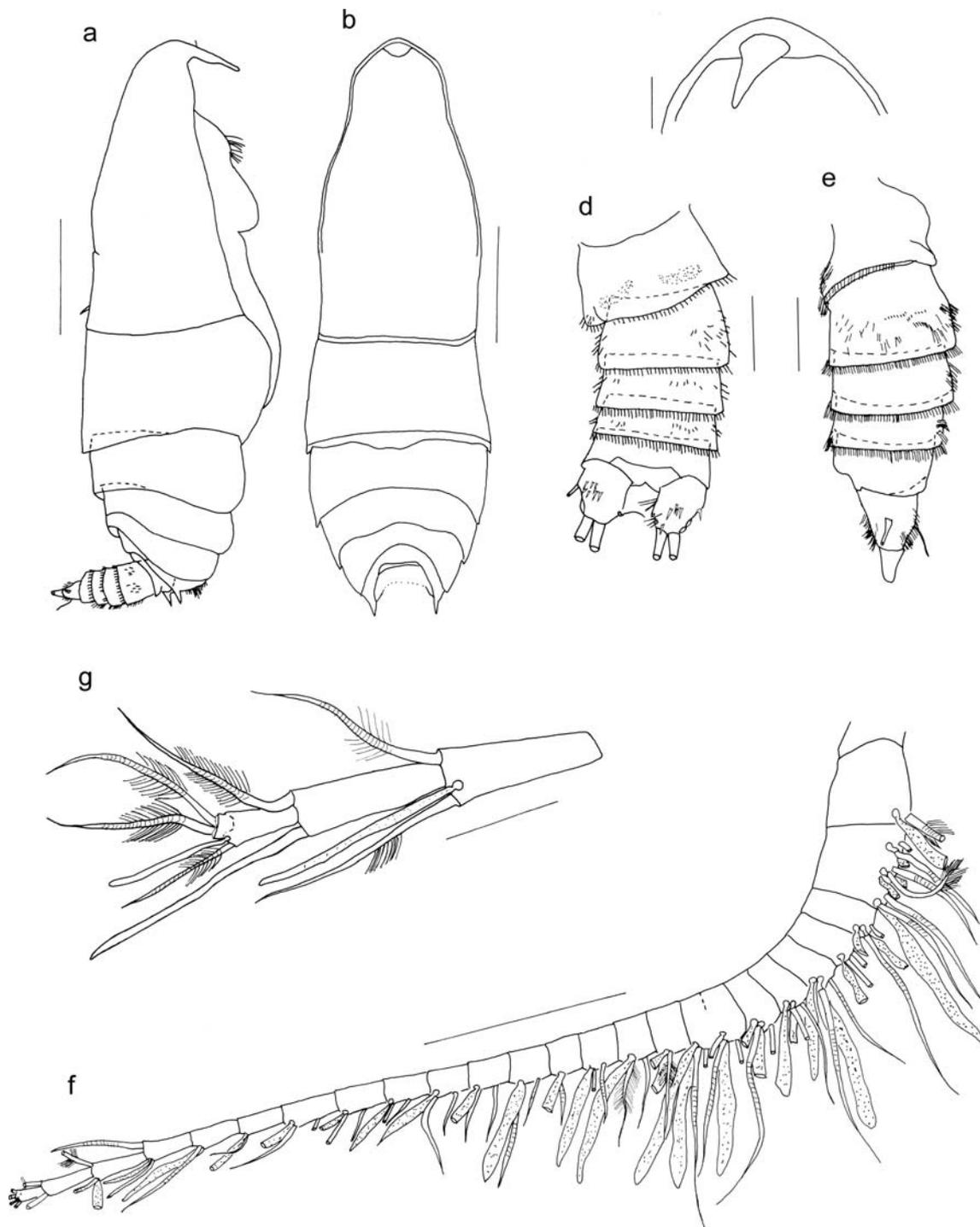


Figure 5. *Ryocalanus brasilianus* sp. nov., male, paratype. **a.** habitus, lateral; **b.** habitus, dorsal, urosome not figured; **c.** rostrum, ventral; **d.** urosome, dorsal; **e.** urosome, lateral; **f.** left antennule; **g.** left antennule, segments XXV–XXVIII. Scale bars: **a–b,** **f:** 0.5 mm; **c–d, g:** 0.1 mm.

Right antennule (Figs 6a, b) geniculated and strongly modified, of 23 free segments; segments XIV to XIX with lateral surface spinules; segments XX to XXVI strongly enlarged; segments XX and XXI with 1 proximal strong spine each, segment XXII with one strong lateral spine distally, segment XXIII with 14 short lateral teeth, segments XXIV–XXV fused, with thin and low lateral crest, segment XXVI with 17 short, stout, lateral teeth; joints XX–XXV inflated; geniculations oc-

curing between segments XIX and XX, XX and XXI, and XXII and XXIII. Armature as follows: Segment I – 1s + 1ae, II to XIX armature as in left antennule; XX–XXI – 1s + 1ae each, XXII–XXIII – 2s + 1ae each, XXIV – 2s + 1ae, XXV – 0, XXVI – 1s + 1ae, fused XXVII–XXVIII – 3s + 1ae.

Antenna and mandible similar to those of female.

Maxillule (Fig. 6c), praecoxal arthrite with 9 terminal spines and 4 posterior setae; posterior surface of

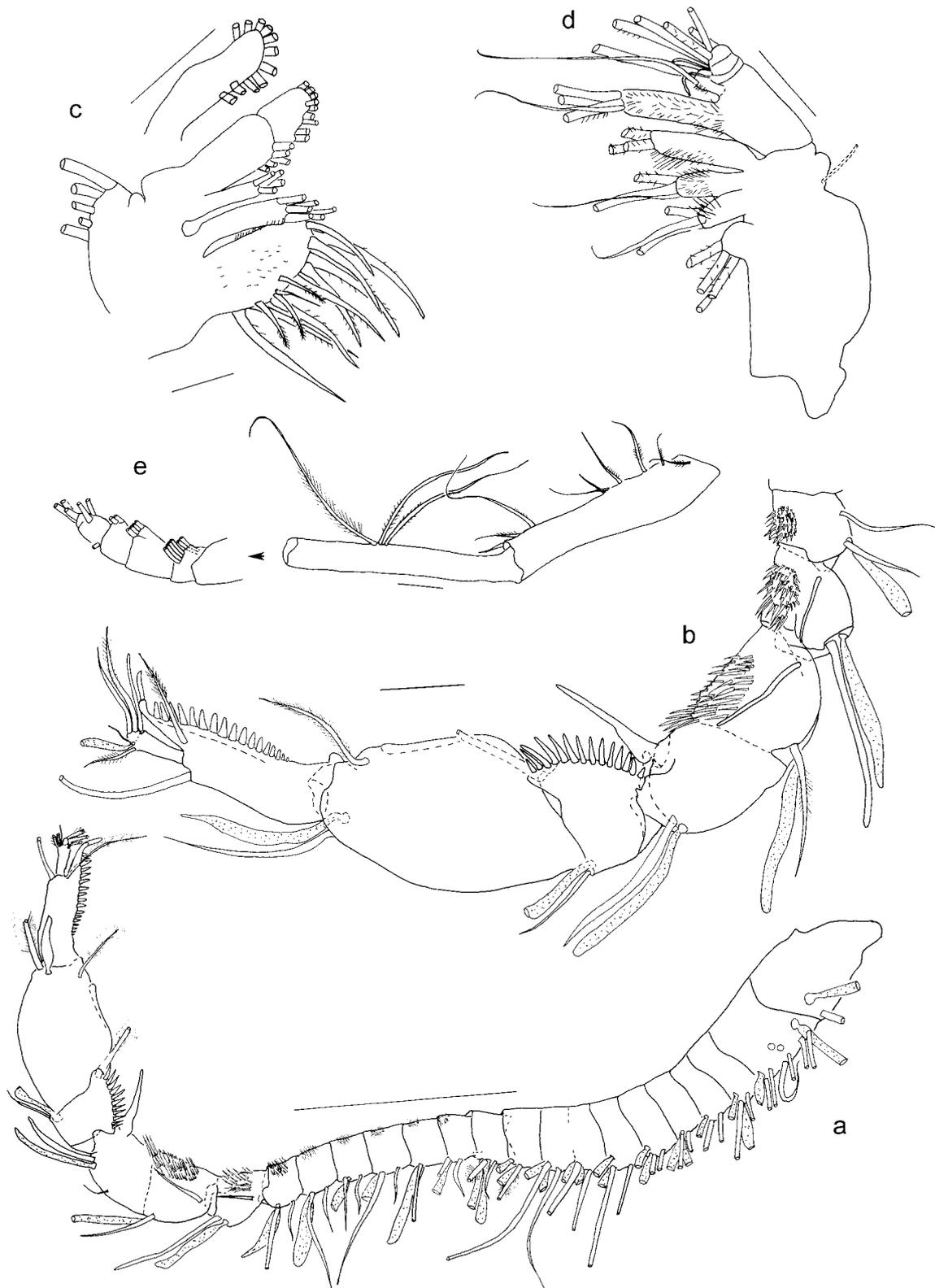


Figure 6. *Ryocalanus brasilianus* sp. nov., male, paratype. **a.** right antennule; **b.** right antennule, segments XIX–XXVIII; **c.** maxillule; **d.** maxilla; **e.** maxilliped with endopod separate. Scale bars: **a–c, e:** 0.1 mm; **d:** 0.5 mm.

praecoaxal arthrite with small spinules; coxal endite with 6 setae, coxal epipodite with 5 setae partly broken; proximal basal endite with 4 setae, distal basal endite with 5 setae; endopod with 9 setae, exopod with 11 setae.

Maxilla (Fig. 6d), basis with 1 outer seta; praecoaxal endite bearing 4 setae, coxal endite with 3 setae; basal endites with 3 setae each; lobe of proximal endopodal segment with 4 setae; all endites with surface spinules. Endopod with 7 + 2 setae.

Maxilliped (Fig. 6e), 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; endopod of 5 free segments with 4, 4, 3, 2, and 3 setae.

Segmentation of swimming legs P1 to P4 as in female. P1 (Fig. 7a), coxa with inner spinules, basis with medial inner seta and minute lateral seta; endopod with 3 medial and 2 terminal setae; lateral lobe poorly developed with spinules and two inner wedge-shaped projections; exopod segment 1 with lateral spine and inner spinules, segment 2 with lateral spine and medial seta, segment 3 with 2 lateral spines, 4 medial setae and terminal spine.

P2 to P4 all endopod and exopod segments with rows of spinules on posterior surface and finely serrate terminal spine on exopod segment 3.

P2 (Fig. 7b), coxa with medial seta and surface spinules on inner margin; basis with rows of spinules on posterior surface; endopod segment 1 with one medial seta and inner inner wedge-shaped projection; segment 2 with two medial, two terminal and one lateral setae. Exopod segment 1 with lateral spine and medial seta, segment 2 with lateral spine and medial seta and 2 lateral, scale like spines, segment 3 with three lateral spines, five medial setae and terminal spine as well as 2 lateral spine like attenuations.

P3 (Fig. 7c), coxa with medial seta and inner surface spinules; basis with rows of spinules on posterior surface; endopod segments 1 and 2 with medial setae, segment 3 with two medial, two terminal and two lateral setae; exopod segments 1 and 2 with lateral spine and medial seta each and three, scale-like spinules, segment 3 with three lateral spines, five medial setae plus terminal spine and 3 small lateral scale-like spinules on proximal lateral face.

P4 (Fig. 7d), coxa with medial seta and inner surface spinules and patches of spinules on posterior surface; basis with spinules on posterior surface and row of spinules on distal margin; endopod segment 1 and 2 with one medial seta each, segment 3 with two medial, two terminal and two lateral setae; exopod segment 1 with lateral spine and medial seta; segments 2 and 3 missing in paratype.

P5 (Fig. 7e) uniramous on both sides, covered with rows of spinules on posterior surface. Right leg with two segmented exopod, shorter than left leg. Right leg basis with medial spine, exopod segment 1 with disto-lateral spine, segment 2 with two terminal spines. Left leg with three segmented exopod. Left exopod basis with medial spine, exopod segment 1 with disto-lateral spine, terminal segment with two spines.

Remarks. The new species shares the main morphological characters with the species of *Ryocalanus* attributed to species group I (Renz et al. 2012). For this group females are only known for *Ryocalanus spinifrons*, while for *R. bowmani* and *R. infelix* only males were discovered so far.

Females of *R. brasiliensis* are well distinguished from the remaining species of this group by their larger size, the shape of the rostrum, the strongly asymmetrical, partly fused urosomites 3 and 4 and the caudal rami, the genital double-somite and in the number of robust spines on the coxa of P4 (1 large and robust spine in *R. brasiliensis* vs. 9 smaller spines in different location in *R. spinifrons*). These spines on the coxa of P4 are a modification typical for female members of the family Ryocalanidae in general. Since ryocalanid females lack a P5, which is usually used to remove discharged spermatophores from the female urosome (Ohtsuka & Huys 2001) these structures on the P4 possibly serve as a specialized element substituting the function of the lacking P5. Similar compensating structures can be observed in some aetideid copepods (e.g. Vaupel Klein 1982; Vaupel Klein 1998).

Males of *R. brasiliensis* differ from the remaining species (males only known for *R. bowmani* and *R. infelix*) in the shape and fusion of ancestral segments of the right antennule, the occurrence of scale-like spinules on P2 and P3 and the number and morphology of spines and segments of P5 (right leg exopod two segmented in *R. brasiliensis* vs. right leg exopod three segmented in *R. infelix*).

The present interpretation of the segmentation of the male geniculated antennule for *R. brasiliensis* sp. nov. is based on the interpretations proposed by both, Tanaka (1956), who was the first to discover a member of this genus, and Ohtsuka and Huys (2001). However, the present pattern of segmentation described herein does not completely fit in either of their descriptions, since a fusion of two ancestral segments proximal to the fused ancestral segments XXVII and XXVIII, in *R. infelix* indicated by a small terminal seta on segment XXV (Tanaka, 1956), is not observed in *R. brasiliensis* sp. nov. The interpretation of its segmentation therefore remains tentative and has to await new morphological data on more species of this genus.

Renz et al. (2012) recognized two different groups within Ryocalanidae. While so far species of group I were only described on the basis of either females (*R. spinifrons*) or males (*R. infelix*, *R. bowmani*), this is the first time when both sexes of a new species within group I are described. With the confirmation of important differences in several morphological characteristics between the two groups, we therefore give species of group II a separate generic status. Group I retains the name *Ryocalanus*, as it contains the type species of *Ryocalanus*.

***Ryocalanus* Tanaka, 1956**

Type species. *Ryocalanus infelix* Tanaka, 1956

Diagnosis. Medium to large sized copepods (> 1.6 mm) with a very short urosome. Rostrum 1-pointed. P1 endopod with proximal inner wedge-shaped projection. Male right antennule moderately modified. Male P5

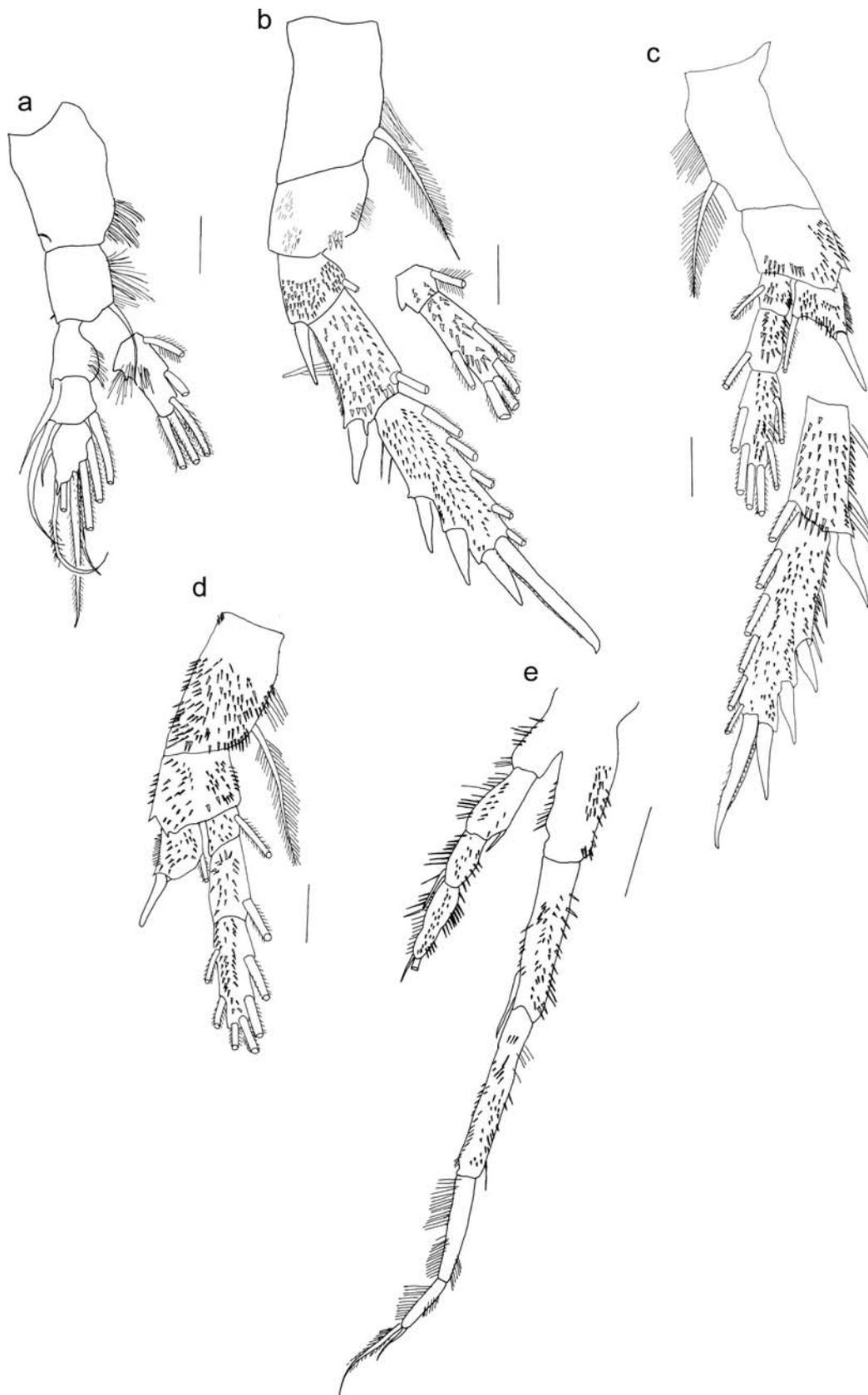


Figure 7. *Ryocalanus brasilianus* sp. nov., male, paratype. **a.** P1 with endopodite separate, **b.** P2 with endopodite separate; **c.** P3 with exopodite segments 2–3 separate; **d.** P4, exopodite segments 2–3 missing; **e.** P5. Scale bars: 0.1 mm.

uniramous, containing terminal spines on the distal exopod segments.

Description. Female. Body elongate; cephalosome and pediger 1, pedigers 4 and 5 separate. Rostrum 1-pointed. Posterior prosomal somite extending into one spine. Urosome of 4 somites; genital double-somite symmetrical or asymmetrical.

Antennule of 24–25 articulated segments, segments 8–9 (ancestral X–XI) fused.

Antenna, coxa with one seta, basis with two setae, exopod segments with 1, 3, 1, 1, 1, 1, 1, 3 setae, endopod segment 1 with 2–3 setae, segment 2 with two lobes with the proximal lobe bearing 8 and the distal lobe bearing 6 or 8 setae.

Mandibular gnathobase with nine teeth, mandibular palp with basis bearing 3 seta, endopod 2-segmented, first segment with 4 setae, second with 10–11 setae terminally; exopod unclear 4-segmented with 6 setae.

Maxillule praecoxal arthrite with 14 setae; coxal epipodite with 9 setae, coxal endite with 4 or 6 setae, proximal basal endite with 4 setae, distal basal endite with 4–5 setae, distal endite covered with surface spinules; endopodal segments separate or fused with 11 or 13 setae, exopod with 11 setae.

Maxilla, basis with or without 1 outer seta; praecoxal endite bearing 4–5 setae, coxal endite with 3 setae; basal endites with 3 setae each; lobe of proximal endopodal segment with 3–4 setae; endopod with 8 or 7 + 2 setae.

Maxilliped syncoxa with 1, 2, and 3 setae on proximal praecoxal, middle and distal praecoxal endites respectively; coxal endite with 3 setae; basis with 3 medial setae; endopod 6-segmented with segments bearing 2, 4, 4, 3, 2 or 3 + 1 and 4 setae.

Segmentation and setation of P1–P4 as described for *R. brasiliensis* sp. nov. P1 endopodite inner margin of first endopod segment with inner wedge-shaped projection; surface of P2–P4 segments strongly spinulose.

Male. Body elongate; cephalosome and pediger 1, pedigers 4 and 5 separate. Rostrum 1-pointed. Posterior prosomal somite extending into one spine or rounded. Urosome of 5 somites.

Antennule. Left antennule of 24–25 articulated segments, segments 8–9 (ancestral X–XI) partly fused; right antennule moderately modified, of 23–24 articulated segments. In right antennule segments XIX–XXVI of reasonably complex structure, subdistal ancestral segments XXIII and XXVI supplied with rows of lateral teeth (*R. infelix*, *R. brasiliensis*), or ancestral segments XXIII–XXIV and XXV bearing comb-like setae (*R. bowmani*).

Oral parts, in general, similar to those in female. Maxillule coxal epipodite with 5–6 setae (*R. brasiliensis* and *R. bowmani*) compared to 9 setae in female and endopod with 9–16 setae. Exopod might have less number of setae (10) compared to females.

P5 uniramous on both sides. Left leg exopod 3-segmented, longer than right; right leg, with two-three seg-

mented exopod. Left P5 exopod segment one with or without lateral spine, terminal segment with two spines, all exopod segments with spinules on posterior surface. Right leg basis with or without disto-lateral spine, exopod segment one with- or without disto-lateral spine on outer boarder, terminal exopod segment with two terminal spines, all segments with or without hairs.

P1–P4 as in female.

Following species are included in *Ryocalanus*: *R. infelix* Tanaka, 1956 (only male known), *R. bowmani* Markhaseva & Ferrari, 1996 (only male known), *R. spinifrons* Shimode, Toda & Kikuchi, 2000 (only female known), *R. brasiliensis* sp. nov. (both sexes known).

***Ryocalanus* gen. nov.**

Type species. *Ryocalanus admirabilis* Andronov, 1992

Etymology. The generic name is an anagram of *Ryocalanus* Tanaka, 1956, which is the type genus for this family.

Diagnosis. Small copepods (< 1.6 mm) with a comparatively long urosome. Rostrum bifid. P1 endopod proximal inner part smooth. Male right geniculated antennule is of highly complex structure. Males P5 is indistinctly biramous with small endopodal buds and with distal exopod segments lacking spines.

Description. Female. Body stout; cephalosome and pediger 1, pedigers 4 and 5 separate. Rostrum 2-pointed, symmetrical or asymmetrical. Posterior prosomal somite extending into one spine or bifurcate. Urosome of 4 somites; genital double-somite asymmetrical to varying degrees.

Antennule of 24–25 articulated segments, segments 8–9 (ancestral X–XI) fused.

Mandibular palp with basis bearing 2–3 setae, endopod two-segmented, first segment with 2–4 setae, exopod 4–5 segmented with 6 setae.

Maxillule coxal epipodite with 8–9 setae, coxal endite with 6 setae, proximal and distal basal endites with 4 and 5 setae; endopod with 13 or 16 setae.

Maxilla first praecoxal endite bearing 5 setae, basis with 0–1 outer seta; endopod bearing total of 7–9 setae.

Maxilliped syncoxa with 1, 2, and 3 setae on proximal praecoxal, middle and distal praecoxal endites, respectively. Its indication as 1,1,3 for *R. asymmetricus* in the original description is most probably due to the mechanical loss of one seta.

P1–P4 only weakly spinulose. Segmentation and setation of P1–P4 as in *Ryocalanus*, except for P1 endopod inner margin smooth and P1 exopod 3 in *R. asymmetricus* and *R. bicornis* according existing description with a single lateral spine.

Remaining characters as in *Ryocalanus* female.

Male. Body stout; cephalosome pediger 1, pedigers 4 and 5 separate. Rostrum 2-pointed, symmetrical or

asymmetrical. Posterior prosome, in lateral view, extending into one spine or bifurcate. Urosome of 5 somites.

Antennule. Left antennule of 24–25 articulated segment, segments 8–9 (ancestral X–XI) partly fused; right antennule strongly modified, of 23–24 articulated segments. In right antennule ancestral segments X–XVII moderately and XVIII–XXVI strongly enlarged and modified. Segments XVIII–XXIV of highly complex structure: segment XXI with 2 long and curved spine-like attenuations, segments XXIII–XXIV fused and comprise the largest segment. No lateral teeth or comb-like setae present on subdistal segments.

Maxillule, coxal epipodite with 5–9 setae, endopod segments with 13 setae, exopod with 10–11 setae.

P5 biramous on both sides, exopods 1–3-segmented, endopods bud-like, rudimentary, can be fused to basis; left leg longer than right, segments naked except for left segments 2 and 3, which can carry long spinules.

Remaining characters as in male *Ryocalanus*.

Following species are included in *Yrocalanus* gen. nov.: *Y. asymmetricus* (Markhaseva & Ferrari, 1996), *Y. bicornis* (Markhaseva & Ferrari, 1996), *Y. admirabilis* (Andronov, 1992) and *Y. antarcticus* (Renz, Markhaseva & Schulz, 2012).

Acknowledgements

The authors thank Prof. Pedro Martinez and Dr. Saskia Brix for providing the unsorted copepod fraction of DIVA III, which yielded the specimens described in this paper. Research of E. L. Markhaseva at Deutsches Zentrum für Marine Biodiversitätsforschung (DZMB-Senckenberg, Biozentrum Grindel & Zoologisches Museum Hamburg) was funded by DFG grant RE2808/2-1.

References

- Andronov, V. N. 1974. Phylogenetic relations of large taxa within the suborder Calanoida (Crustacea, Calanoida). – *Zoologicheskii Zhurnal* [Zoological Journal] 53: 1002–1012. [In Russian, English summary].
- Andronov, V. N. 1992. *Ryocalanus admirabilis* sp. n. (Copepoda, Calanoida, Ryocalanidae) from the central-eastern Atlantic. – *Zoologicheskii Zhurnal* [Zoological Journal] 71 (7): 140–144 [in Russian].
- Boxshall, G. A. & Halsey, S. H. 2004. An introduction to copepod diversity. – The Ray Society, (Part 1), London, 421 p.
- Brandt, A. & Barthel, D. 1995. An improved supra- and epibenthic sledge for catching Peracarida (Crustacea, Malacostraca). – *Ophebia* 43: 15–23.
- Brenke, N. 2005. An epibenthic sledge for operations on marine soft bottom and bedrock. – *Marine Technology Society Journal* 39: 10–19.
- Ferrari, F. D. & Ivanenko, K. 2001. Interpreting segment homologies of the maxilliped of cyclopoid copepods by comparing stage-specific changes during development. – *Organisms, Diversity and Evolution* 1: 113–131.
- Ferrari, F. D. & Ivanenko, K. 2008. The identity of protopodal segments and the ramus of maxilla 2 of copepods (Copepoda). – *Crustaceana* 81(7): 823–835.
- Ferrari, F. D. & Markhaseva, E. L. 2000a. *Brachycalanus flemingeri* and *B. brodskyi*, two new copepods (Crustacea: Calanoida: Phaenidae) from benthopelagic waters of the tropical Pacific. – *Proceedings of the Biological Society of Washington* 113: 1064–1078.
- Ferrari, F. D. & Markhaseva, E. L. 2000b. *Grievella shanki*, a new genus and species of scolecitrichid calanoid copepod (Crustacea) from a hydrothermal vent along the southern East Pacific Rise. – *Proceedings of the Biological Society of Washington* 113: 1079–1088.
- Huys, R. & Boxshall, G. A. 1991. Copepod evolution. – The Ray Society, London, 468 pp.
- Kosobokova, K. N., Hopcroft R. R. & Hirche H.-J. 2011. Patterns of zooplankton diversity through the depths of the Arctic's central basins. – *Marine Biodiversity* 41: 29–50.
- Markhaseva, E. L. & Ferrari F. D. (1996). Three new species of *Ryocalanus* from the eastern tropical Pacific (Crustacea, Copepoda: Ryocalanidae). – *Zoosystematica Rossica* 4 (1): 63–70.
- Ohtsuka, S. & Huys, R. 2001. Sexual dimorphism in calanoid copepods: morphology and function. – *Hydrobiologia* 453/454: 441–466.
- Renz, J., Markhaseva, E. L. & Schulz, K. 2012. *Ryocalanus antarcticus* sp. nov. (Crustacea: Copepoda) – first ryocalanoid from the southern Ocean. – *Proceedings of the Zoological Institute RAS* 316: 148–158.
- Shimode, S., Toda T. & Kikuchi T. 2000. *Ryocalanus spinifrons*, a new species of Ryocalanidae (Copepoda: Calanoida), from the southwestern part of Sagami Bay, Japan. – *Hydrobiologia* 432: 127–133.
- Tanaka, O. 1956. Rare species of Copepoda Calanoidea taken from the Izu region. – *Breviora*, Museum of Comparative Zoology, Cambridge Massachusetts 64: 1–8.
- Vaupel Klein, J. C. von, 1982. A taxonomic review of the genus *Euchirella* Giesbrecht, 1888 (Copepoda, Calanoida). II. The type species, *Euchirella messinensis* (Claus, 1863). A. The female of f. *typica*. – *Zoologische Verhandlungen* 198: 1–131.
- Vaupel Klein, J. C. von, 1998. Interpretation of character phylogenies in calanoid copepods by implementing Dollo's law. – *Journal of Crustacean Biology* 18: 153–160