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Two new species of Parastenocarididae (Copepoda, Harpacticoida) from India

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Abstract

To date, 20 species of Parastenocarididae are known from the Indian subcontinent. This paper gives the description of two more new species from the coastal deltaic belt of the Rivers Krishna and Godavari in the Andhra Pradesh state of the southeastern Indian peninsula. They are: *Parastenocaris enckelli* **n. sp.** from a hyporheic habitat, and *Dussartstenocaris bisetosa* **n. sp.** from a farm bore. *Parastenocaris enckelli* belongs to the *brevipes*-group of the genus *Parastenocaris* Kessler, 1913 *sensu* Lang 1948 and Reid 1995, and is characterized by the following features: the male leg 4 basal complex consists of a large chitinized plate, with two digitiform hyaline structures at its proximal outer corner of the anterior surface, and one smooth, moderately strong, claw-like spine at the inner distal corner of basis; the endopod of the same leg is membranous, with bulbous proximal part having a diagonal row of three spinules, and its distal part is drawn out into smooth pointed structure; and the male leg 3 ancestral proximal segment is subproximally dilated, elongate, with ladle-shaped apophysis, which is slightly longer than the spiniform thumb. *Parastenocaris enckelli* is closely related to the Indian *P. edakkal* Totakura, Ranga Reddy & Shaik, 2014, and the Sri Lankan *P. brincki* Enckell, 1970. To accommodate *Dussartstenocaris bisetosa* in the monotypic Western Australian genus *Dussartstenocaris* Karanovic & Cooper, 2011, three of the original generic criteria are amended. *D. bisetosa* is chiefly characterized by the complex exopodal thumb on the male leg 3, the caudal ramus having only two lateral setae located slightly anterior to its midlength together with the distally inserted dorsal seta, and also the presence of a short spiniform process at the inner distal corner of leg 5 in both sexes. *Dussartstenocaris bisetosa* differs from *D. idioxenos* Karanovic & Cooper, 2011, by its shorter caudal rami, distinctly ornamented anal somite, two long modified spinules on the male leg 4 coxa, and rather small fifth legs with only two setae each in both sexes and smooth inner margins. This is the first report of the genus *Dussartstenocaris* from the Indian subcontinent. Brief biogeographic notes are also given for the two new species.

Key words: *brevipes*-group, *Dussartstenocaris bisetosa* **n. sp.**, *Parastenocaris enckelli* **n. sp.**, stygofauna, taxonomy

Introduction

Presently, about 300 nominal species and subspecies of Parastenocarididae grouped in 31 genera are known in the world (Gaviria-Melo & Chad 2015), with nine of Jakobi's (1972) 24 genera yet to be redefined or synonymised (Schminke 2013). The recent advancements in the systematics of the highly diversified family Parastenocarididae Chappuis, 1940, including the establishment of new genera, revalidation/revision and synonymisation of certain existing genera, have been summarised by Galassi & De Laurentiis (2004), Corgosinho & Martínez Arbizu (2005), Schminke (2008, 2009, 2010), Corgosinho *et al.* (2010), Cottarelli *et al.* (2010), Karanovic & Cooper (2011a, b), Corgosinho *et al.* (2012), and Karanovic *et al.* (2012), and others. As for the vast tectonic plate of the Indian subcontinent, encompassing the whole of India (surface area 3,287,590 km²), Bangladesh, Bhutan, Pakistan and Sri Lanka, studies on the parastenocaridid taxonomy were initiated by Enckell (1970), who described six new species under the nominotypical genus *Parastenocaris* Kessler, 1913, from Ceylon (now Sri Lanka): *Parastenocaris irenae* Enckell, 1970, *P. noodti* Enckell, 1970, *P. brincki* Enckell, 1970, *P. singhalensis* Enckell, 1970, *P. lanceolata* Enckell, 1970, and *P. curvispinus* Enckell, 1970. Three decades later, regular taxonomic and stygofaunistic surveys of crustaceans have begun in India, especially in the coastal deltaic belt of the Rivers Krishna and Godavari in the Andhra Pradesh state of the southeastern peninsular zone (see Karanovic & Pesce 2001; Karanovic & Ranga Reddy 2004; Ranga Reddy 2001, 2004a, b, 2014; Ranga Reddy & Totakura 2010; Totakura & Ranga Reddy 2014;

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Totakura *et al.* 2014; and others). Of about 80 new stygobiotic crustacean species so far collected, 54 species have been described formally (see Totakura & Ranga Reddy 2014; Ranga Reddy *et al.* 2014; Wilson *et al.* 2015). The Parastenocarididae in India is as yet known by 14 endemic species barring the most wide-spread Sri Lankan *P. curvispinus* (Ranga Reddy & Defaye 2007; Totakura *et al.* 2014). Together with the two new species described herein, the total number of the described parastenocaridid species on the Indian subcontinent is 22. Of these, all but *Kinnecaris godavari* Ranga Reddy & Schminke, 2009, *Siolicaris sandhya* (Ranga Reddy, 2001), *Proserpinicaris corgosinhoi* Totakura & Ranga Reddy & Shaik, 2014, *Proserpinicaris karanovici* Totakura, Ranga Reddy & Shaik, 2014, and *Himalayacaris alaknanda* Ranga Reddy, Totakura & Corgosinho, 2014, continue to be under the genus *Parastenocaris*—a "taxonomic repository" *sensu* Galassi & De Laurentiis 2004. Yet, except for the Indo-Sri Lankan *P. curvispinus* and the Indian *P. mahanadi* Ranga Reddy & Defaye, 2007, which are placed under *incertae sedis* by Schminke (2010: 351), the remaining five Sri Lankan species and seven Indian species belong to the *brevipes*-group, as revised by Reid (1995) or *Parastenocaris s. str.* of Galassi & De Laurentiis (2004) (see also Karanovic 2005; Ranga Reddy 2011; Totakura *et al.* 2014): *Parastenocaris gayatri* Ranga Reddy, 2001*, P. savita* Ranga Reddy, 2001, *P. muvattupuzha* Ranga Reddy & Defaye, 2009, *P. kotumsarensis* Ranga Reddy & Defaye, 2009 *P. sutlej* Ranga Reddy, 2011, *P. gundlakamma* Ranga Reddy, 2011, and *P. edakkal* Totakura, Ranga Reddy & Shaik, 2014. According to Reid (1995), the *brevipes*-group has possibly originated "in tropical Asia", but this hypothesis is at variance with the outcome of the recent cladistic analysis done on this "highly disjunct" group by Karanovic &Lee (2012) (see Discussion).

This paper gives an illustrated description of two parastenocaridid species: one from a porous, alluvial aquifer of the River Krishna, and another from a farm bore, both habitats located in the coastal deltaic belt of the Rivers Krishna and Godavari in the Andhra Pradesh state of the southeastern Indian peninsula.

Material and methods

The specimens of *Parastenocaris enckelli* **n. sp.** were collected from the sandy sediments of the River Krishna, Andhra Pradesh, southwestern India (see Type locality and Fig. 1). A rigid PVC tube (70 cm length, 4 cm diameter) was used to extract cores from the sediment surface to a depth of 10–20 cm. The samples were pooled in a bucket, filled with the habitat water at the sampling spot and stirred vigorously. The supernatant was filtered through a bolting-silk plankton net (70 µm mesh size) and the filtrate fixed in 5% formaldehyde. Back in the laboratory, the specimens were sorted out and preserved in 70% alcohol and later transferred into glycerol.

The specimens of *Dussartstenocaris bisetosa* **n. sp.** were collected by directly filtering the groundwater pumped from a farm bore (depth c. 10 m) with a plankton net for 20–30 minutes (see Fig. 1b in Totakura, Ranga Reddy & Shaik 2014). The filtrate was fixed and preserved as mentioned above.

Specimens were dissected in glycerol under a binocular stereo zoom microscope at a magnification of 90×. Drawings were made with the aid of a drawing tube mounted on a Leica DM 2500 Trinocular Research Microscope equipped with UCA condenser, IC objective prism and 1–2× magnification changer. Permanent preparations were mounted in glycerol and sealed with wax and Araldite. All the type material was deposited in the Muséum national d'Histoire naturelle, Paris (prefix MNHN).

Systematics

Subphylum Crustacea Brünnich, 1772

Class Maxillopoda Dahl, 1956

Subclass Copepoda H. Milne Edwards, 1840

Order Harpacticoida G. O. Sars, 1903

Family Parastenocarididae Chappuis, 1940

Subfamily Parastenocaridinae Chappuis, 1940

Genus *Parastenocaris* Kessler, 1913

***Parastenocaris enckelli* n. sp.**
(Figs. 2–7)

Type locality. River Krishna (water temperature 31°C, pH 7.0) near Kanaka Durga Varadhi at Vijayawada city (16°29′13.0″N, 80°37′ 38.6″E; elevation ca 10 m) in Krishna District, Andhra Pradesh state, southeastern India (Fig. 1).

Type material examined. Holotype male (MNHN-IU-2013-11923), dissected on 3 slides; allotype female (MNHN-IU-2013-11924), dissected on 4 slides; 1 male paratype (MNHN-IU-2013-11925) and 1 female paratype (MNHN-IU-2013-11926) whole-mounted on 1 slide each; 2 juveniles (1 male and 1 female, both of copepodid V stage) whole-mounted on 1 slide each in TVR's personal collections. 31 August 1998, Coll. Y. Ranga Reddy.

Description of adult male. Total body length, measured from tip of rostrum to posterior margin of caudal rami (excluding caudal setae) 362–378 μm. Preserved specimens colourless. Nauplius eye absent. Habitus (Fig. 2a, b) cylindrical and very slender, with inconspicuous podoplean boundary between prosome and urosome; prosome/urosome ratio about 0.6 in dorsal view; greatest width in dorsal view at fifth pedigerous somite. Free pedigerous prosomites narrower than distal half of cephalothorax. Body length/width ratio about 8.3; cephalothorax 1.4 times as wide as genital somite in lateral view. Free pedigerous somites without any lateral or dorsal expansions, all connected by well developed arthrodial membranes. Hyaline fringes of all somites smooth, very narrow and hard to distinguish from arthrodial membranes. Integument smooth, ornamented only with sensilla and pores. Cephalothorax with obovate, dorsal, cuticular double-window at about midlength. Pleural areas of cephalothorax and free pedigerous somites moderately developed; cephalic appendages and coxa of leg 1 clearly exposed in lateral view (Fig. 2b). Rostrum (Fig. 2a) small, subtriangular, membranous, not demarcated at base, barely reaching midlength of first antennular segment and ornamented with 2 small, dorsal sensilla. Cephalothorax (Fig. 2a, b) somewhat dilated behind, about 1.4 times as long as wide in dorsal view, representing 16.4% of total body length. Surface of cephalic shield ornamented with 8 pairs of large sensilla besides dorsal double-window. Second pedigerous somite 0.9 times as wide as posterior half of cephalothorax in dorsal view, with 2 pairs of large sensilla (1 dorsal, 1 lateral). Third pedigerous somite slightly wider and longer than second pediger, with 3 pairs of large sensilla (2 dorsal, 1 lateral). Fourth pedigerous somite slightly wider and longer than third prosomite and with 3 pairs of large posterior sensilla.

Urosome: first urosomite widest of all urosomites but slightly shorter than fourth prosomite, and with 2 pairs of large posterior sensilla. Second urosomite about as wide as first urosomite but slightly shorter, with 2 pairs of posterior sensilla and with small elliptical dorsal cuticular window in anterior half. Third urosomite about as long as first urosomite but slightly narrower, with wider dorsal cuticular window, and with 2 pairs of large posterior sensilla. Fourth urosomite slightly narrower than third one, with 2 pairs of large posterior sensilla, and with dorsal cuticular window. Preanal somite slightly narrower and longer than fourth urosomite, and without any surface ornamentation except for dorsal cuticular window. Anal somite (Fig. 3a, b) about as long as, but slightly narrower than, preanal somite, 1.2 times as long as wide and ornamented with 2 large dorsal sensilla, 1 lateral cuticular pore (Fig. 2b) in anterior half. A single large, longitudinally placed spermatophore (Figs. 2a, 3b) visible through fifth pediger and genital somite, about 2.7 times as long as wide, bean-shaped, with narrow and curved neck. Anal operculum moderately developed, ornamented with 1 transverse row of ventro-distal spinules, with slightly concave distal margin, not reaching posterior end of anal somite and representing 68% of somite's width. Anal sinus wide open.

Caudal rami (Figs. 2a, b, 3a, b): slightly divergent, distal third narrow, about 3 times as long as greatest width at subproximal level in dorsal view, 2.6 times as long in lateral view, and about 0.7 times as long as anal somite; full complement of setae (3 lateral, 1 dorsal, 2 apical, and 1 outer) and ornamented with large lateral cuticular pore anteriorly (Fig. 2b). Dorsal seta (VII) slender and smooth, inserted close to inner margin at about ¾ of ramus length at the level of setae I–III, about 0.8 times as long as caudal ramus, biarticulate basally. Inner apical seta (VI) smooth, inserted close to ventral margin, about 0.7 times as long as ramus. Middle apical seta (V) strongest, without breaking plane, unipinnate, about 4 times as long as ramus, directed distally. Outer apical seta (IV) also

without breaking plane and unipinnate, about 1.2 times as long as ramus, inserted subapically close to dorsal surface and directed laterally.

Antennule (Fig. 4b): slightly longer than cephalothorax, 8-segmented, prehensile, 'pocket-knife type' *sensu* Schminke 2010, and digeniculate; geniculation between segments 3 and 4, and 6 and 7; antepenultimate segment sharply bent inwards, forming sickle-shaped structure with its preceding segment; segment 8 directed medially. First segment short, ornamented with 1 row of spinules. Segments 5 and 6 moderately dilated, segment 5 without any proximal spinous process on anterior surface, with slender, elongate aesthetasc having blunt tip, overreaching ultimate segment, and fused basally to simple seta; shorter, slender, staff-like apical aesthetasc on segment 8, fused basally to 2 setae (acrotheck). Setal formula: 0.5.4.1.3+aes.0.0.9+aes. All setae slender, smooth except proximalmost seta on second segment unipinnate with long setules along outer margin. Length ratio of antennular segments from proximal to distal end and along caudal margin 1.0:2.7:1.4:0.2:1.3:0.9:0.8:1.5.

Antenna (Fig. 4c): relatively stout and composed of coxa, allobasis, 1-segmented endopod, and 1-segmented exopod. Coxa very short, unornamented. Allobasis about 2.6 times as long as maximum width, unarmed but ornamented with 1 crescentic row of spinules on anterior surface. Exopod small, cylindrical, about 3.2 times as long as wide, unornamented and armed with 1 apical unipinnate seta, which is 2.7 times as long as segment. Endopod 0.6 times as long as allobasis and 2.3 times as long as wide, with surface frill subdistally, ornamented with 2 spinular rows on inner margin, and armed with 2 short bipinnate similar spines laterally and 5 strong elements (2 spines, 2 geniculate and 1 unipinnate transformed setae) subapically.

Mandible (Fig. 4d, e): cutting edge narrow on elongate coxa and with 2 complex teeth ventrally, 1 unipinnate seta dorsally and several smaller teeth. Palp 1-segmented, subcylindrical, about 3.7 times as long as wide, unornamented and armed with 2 smooth, apical setae.

Maxillule (Fig. 4f): praecoxal arthrite trapezoidal, about 1.4 times as long as wide in lateral view; armed with 1 strong, smooth lateral seta and 3 strong, apical spinous processes. Coxal endite armed with 2 smooth apical setae. Basis slightly longer than coxal endite and armed with 2 smooth apical setae.

Maxilla (Fig. 4g): composed of syncoxa, basis, and 1-segmented endopod. Syncoxa unornamented and with 2 endites; proximal endite short, armed with 1 smooth apical seta; distal endite armed with 1 smooth seta and 1 strong pinnate seta apically. Allobasis prolonged into strong claw with serrulate inner margin and without seta at base. Endopod represented by small segment, armed with 2 smooth, subequal apical setae.

Maxilliped (Fig. 4h): with short and slender syncoxa, unarmed and unornamented. Basis slender, 2.6 times as long as wide and 2.1 times as long as syncoxa, unarmed and unornamented; endopod small, with unipinnate claw, slightly shorter than basis.

Leg 1 (Fig. 5a): coxa ornamented with 1 row of spinules near outer margin on dorsal surface. Basis shorter than coxa, trapezoidal; armed with 1 slender seta on outer margin and 1 spiniform seta on inner margin; ornamented with 1 row of large spinules at base of exopod, 1 ventral row of spinules at base of endopod, 1 row near inner margin and 1 cuticular pore on anterior surface. Exopod 3-segmented; first segment 0.8 times as long as next 2 segments combined, armed with 1 outer bipinnate spine on first segment; second segment unarmed and third segment with 4 elements (1 outer spine, 1 apical seta and 2 apical geniculate setae); ornamented with spinular rows along outer margin of all exopodal segments, as illustrated. Endopod 2-segmented, about as long as exopod; first segment reaching distal margin of second exopodal segment, 3 times as long as wide, unarmed and ornamented with 1 row of spinules on outer margin and 2 rows of spinules on inner margin; second segment ornamented with 1 transverse row of spinules on outer margin and armed apically with 1 long geniculate seta and 1 short spine; endopodal geniculate seta 1.5 times as long as entire endopod, 1.2 times as long as larger geniculate exopodal seta and almost 2.4 times as long as outer spine on endopod. All exopodal and endopodal armature elements unipinnate along outer margin except bipinnate spine on first exopodal segment.

Leg 2 (Fig. 5b): coxa large, unarmed and ornamented with 1 row of small spinules on outer margin. Basis much smaller than coxa, unarmed, ornamented with 1 row of spinules at base of exopod and 1 pore on anterior surface. Exopod 3-segmented; first segment 0.7 times as long as next 2 segments combined and slightly curved inwards; all segments ornamented with rows of spinules along outer margin, as illustrated, and segments 1 and 3 with hyaline frill each at inner distal corner; inner corner of second segment with 1 row of spinules; segment 1 armed with outer bipinnate spine; segment 2 unarmed. Segment 3 longer than segment 2, armed with 3 long elements: 1 subapical unipinnate spine and 2 apical bipinnate setae. Endopod 1-segmented, subcylindrical and distally dilated, almost 2.6 times as long as wide, about half as long as first exopodal segment; apical margin armed

with 1 smooth seta, which is 0.8 times as long as segment and pointing inwards, and ornamented with 2 spinules.

Leg 3 (Fig. 5c): coxa trapezoidal, ornamented with arched row of spinules near mid-distal margin ventrally. Basis robust, ornamented with 1 ventral row of minute spinules near outer margin and 1 pore on anterior surface; armed with moderately long, slender seta on outer margin. Endopod represented by smooth, slender seta, inserted at 3/4 of inner margin of basis. Both exopodal segments fused; ancestral proximal segment moderately stout, 3.5 times as long as wide, swollen at subproximal outer margin, only slightly curved inwards; small prominence on inner distal margin; 1 spinular row on posterior surface of outer distal corner; ancestral distal segment (apophysis) ladle-shaped with hyaline membrane, somewhat bent inwards, longer than thumb, unornamented and unarmed; thumb slender, spiniform, inwardly curved and reaching 3/4 of apophysis.

Leg 4 (Fig. 5d): coxa rectangular, ornamented with short oblique spinular row near outer distal corner. Basis shorter, trapezoidal in anterior view and armed with moderately long outer seta; ornamented with 1 pore on anterior surface. Exopod 3-segmented, ornamented with spinules along outer margins of all segments; segments 1 and 3 with hyaline frill each at inner distal corner; segment 2 with 1 row of spinules at inner distal corner; segment 1 stout, about as long as next 2 segments combined and armed with strong bipinnate outer spine; segment 2 unarmed; segment 3 armed with 1 outer spine and 1 inner bipinnate seta; inner apical seta 1.8 times as long as outer seta, 2.4 times as long as third exopodal segment, 0.8 times as long as entire exopod. Inner distal margin of basis with large chitinized plate, below which lie 2 hyaline, outwardly directed, blunt structures at outer corner (arrowed in Fig. 5d); also, with 1 smooth, moderately strong, somewhat claw-like spine at distal inner corner. Endopod proper as acutely pointed conical hyaline membrane, ornamented with 3 spinules at mid-outer margin.

Leg 5 (Figs. 2b, 3a): simple, elongated, rhomboidal plate; both legs fused at base, pointing caudally and slightly overreaching end of the somite, inner distal corner produced into long, acute spiniform process, ornamented with cuticular pore on anterior surface and armed with basal seta and 2 inner smooth setae on oblique distal margin; basal seta longer than entire leg; outer seta about 0.3 times as long as leg 5, and 1.2 times as long as inner seta.

Leg 6 (Fig. 3a): smooth, unarmed, forming simple operculum covering gonopore and elliptical in ventral view.

Description of adult female. Body length, measured as in male, 385–400 μm. Habitus (Fig. 4a): slightly less slender than in male, prosomites, colour and nauplius eye similar to male, except genital and first abdominal somites fused into double-somite.

Genital double-somite (Figs. 4a, 6a, b): shorter than maximum width (ventral view), without any trace of subdivision, with oval dorsal cuticular window in anterior half. Genital complex occupying anteroventral half of genital double-somite; genital apertures paired, each covered by vestigial sixth legs; copulatory pore medial; seminal receptacles small, hard to distinguish from internal tissue and gut content; copulatory duct very short and weakly sclerotized (Fig. 6c). Sensilla similar to those on male third urosomite, while 2 sensilla of male second urosomite missing. Third urosomite, preanal somite, and anal somite very similar to male.

Caudal rami (Figs. 4a, 6a, b): 0.7 times as long as anal somite, about 2.8 times as long as wide in ventral view, with armature and ornamentation as in male.

Antennule (Fig. 4i): 7-segmented, segment 1 ornamented with 4 minute spinules disto-ventrally, aesthetasc on segment 4 slender, overreaching tip of appendage, and that on segment 7 more slender, staff-like and fused basally to 2 apical setae; setal formula: 0.4.4.2+aes.0.2.8+aes. All setae except proximalmost one on segment 2 smooth. Length ratios of antennular segments from proximal to distal end and along caudal margin 1.0: 2.5: 2.2: 2.2: 0.5: 0.5: 1.3.

Antenna, labrum, mandible, maxillule, maxilla, maxilliped, and leg 5 similar to male.

Leg 1 (Fig. 7a): coxa rectangular, ornamented with 1 row of spinules near distal margin; basis trapezoidal, ornamented with 1 row of spinules near base of exopod, 1 row at base of endopod, 1 pore on proximal surface; armed with 1 small seta each on outer margin; exopod and endopod almost as in male.

Leg 2 (Fig. 7b): coxa trapezoidal, ornamented with 1 arched row of minute spinules near inner margin and another row at outer distal corner ventrally. Basis larger than coxa, unarmed, and ornamented with arched spinular row near outer distal corner and 1 pore proximally; exopodal segments as in male. Endopod cylindrical, 4.5 times as long as wide; apical margin armed with 1 seta and ornamented with 2 spinules.

Leg 3 (Fig. 7c): coxa with arched row of ventral spinules on outer distal margin. Basis ornamented with 1 arched spinular row near outer margin and armed with long and smooth outer seta, which is about 0.6 times as long as entire exopod. Exopod 2-segmented, ornamented with large spinules along outer margin, each segment with

hyaline frill distally on inner distal corner; segment 1 armed with single outer spine; segment 2 with outer spine and strong apical seta; seta 1.8 times as long as spine; all elements bipinnate. Endopod 1-segmented, slender, 0.6 times as long as first exopodal segment, tapering to pointed tip and with spinulose disto-lateral margins.

Leg 4 (Fig. 7d): exopod similar to male. Endopod lanceolate, slightly shorter than first exopodal segment; distal third bent inwards, gradually tapering to acuminate point and with serrulate lateral margins.

Leg 6 (Fig. 6c) vestigial, fused into simple cuticular flap, covering gonopores; unarmed and unornamented.

Etymology. The new species is named in honour of Dr. P. H. Enckell, who was the first to describe parastenocaridids from the Indian subcontinent. The specific epithet, *enckelli*, is a noun in the genitive singular.

Distribution and ecology. This species is so far known from the type locality, co-occurring with the following taxa: a species each of Harpacticoida, Cyclopoida and Cladocera, some rotifers, oligochaetes and chironomid larvae.

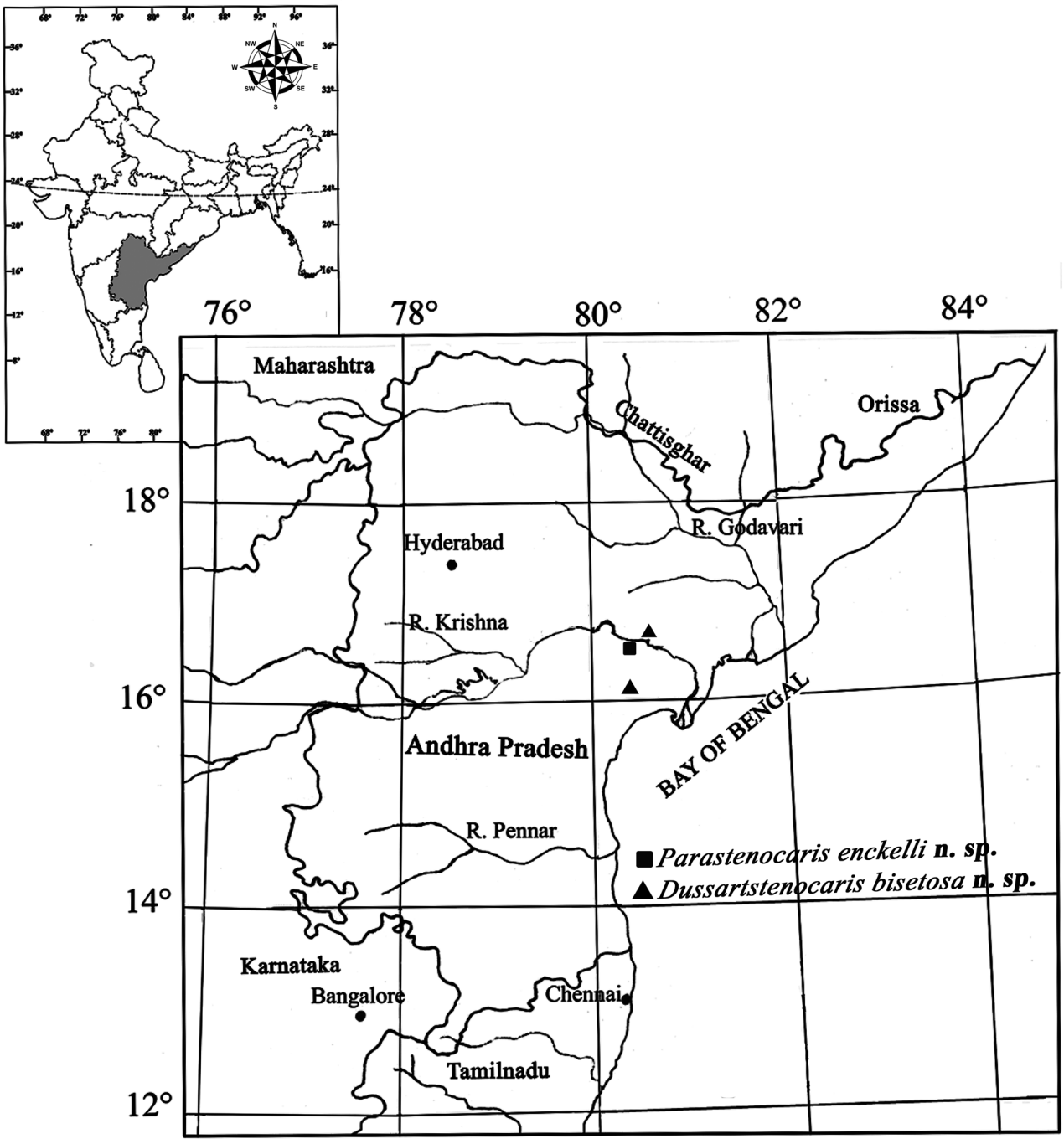

FIGURE 1. Map showing the distribution of *Parastenocaris enckelli* **n. sp.** (■) and *Dussartstenocaris bisetosa* **n. sp.** (▲).

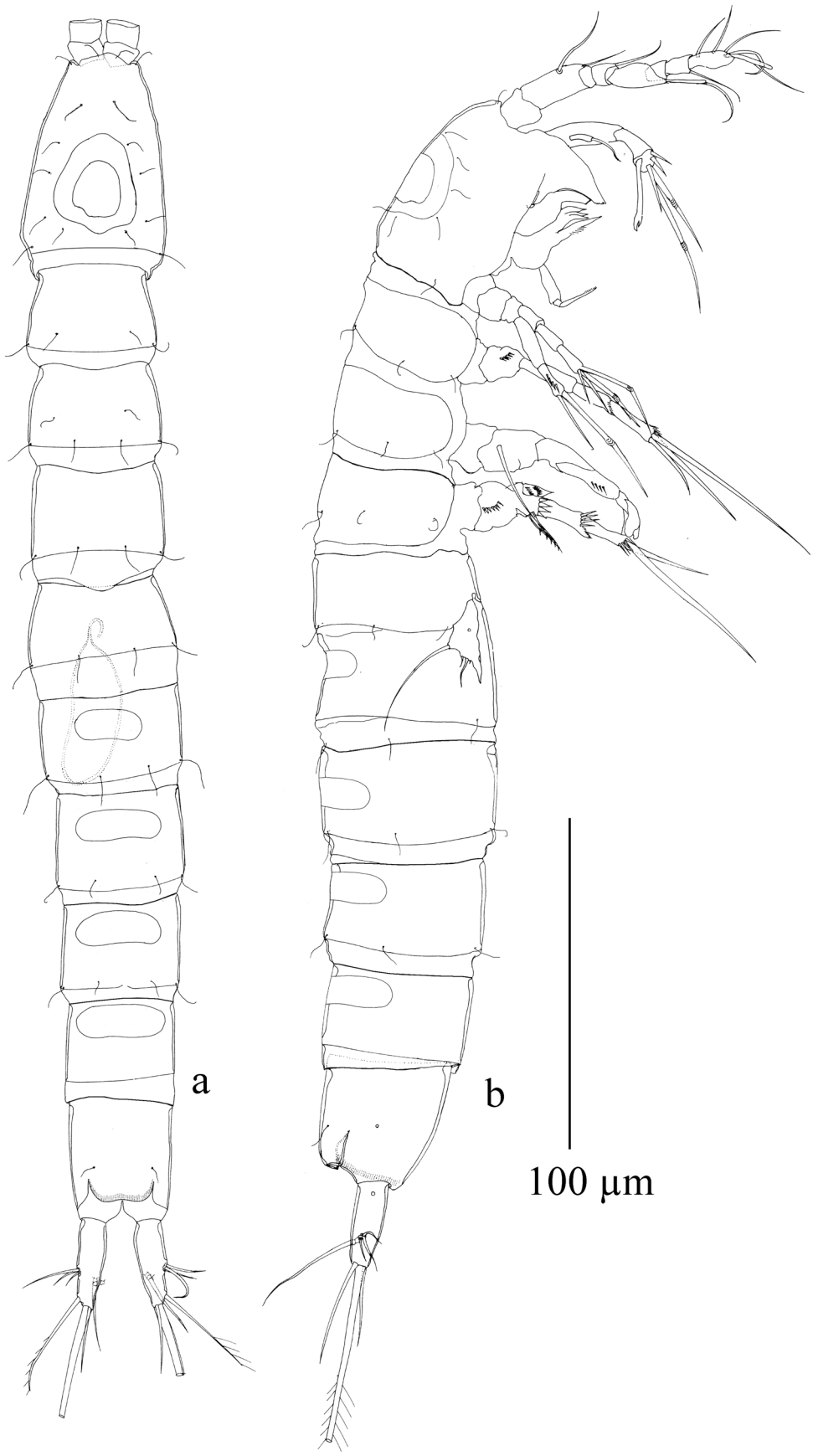

FIGURE 2. *Parastenocaris enckelli* **n. sp.**, holotype male: (a) habitus, dorsal view; (b) same, lateral view.

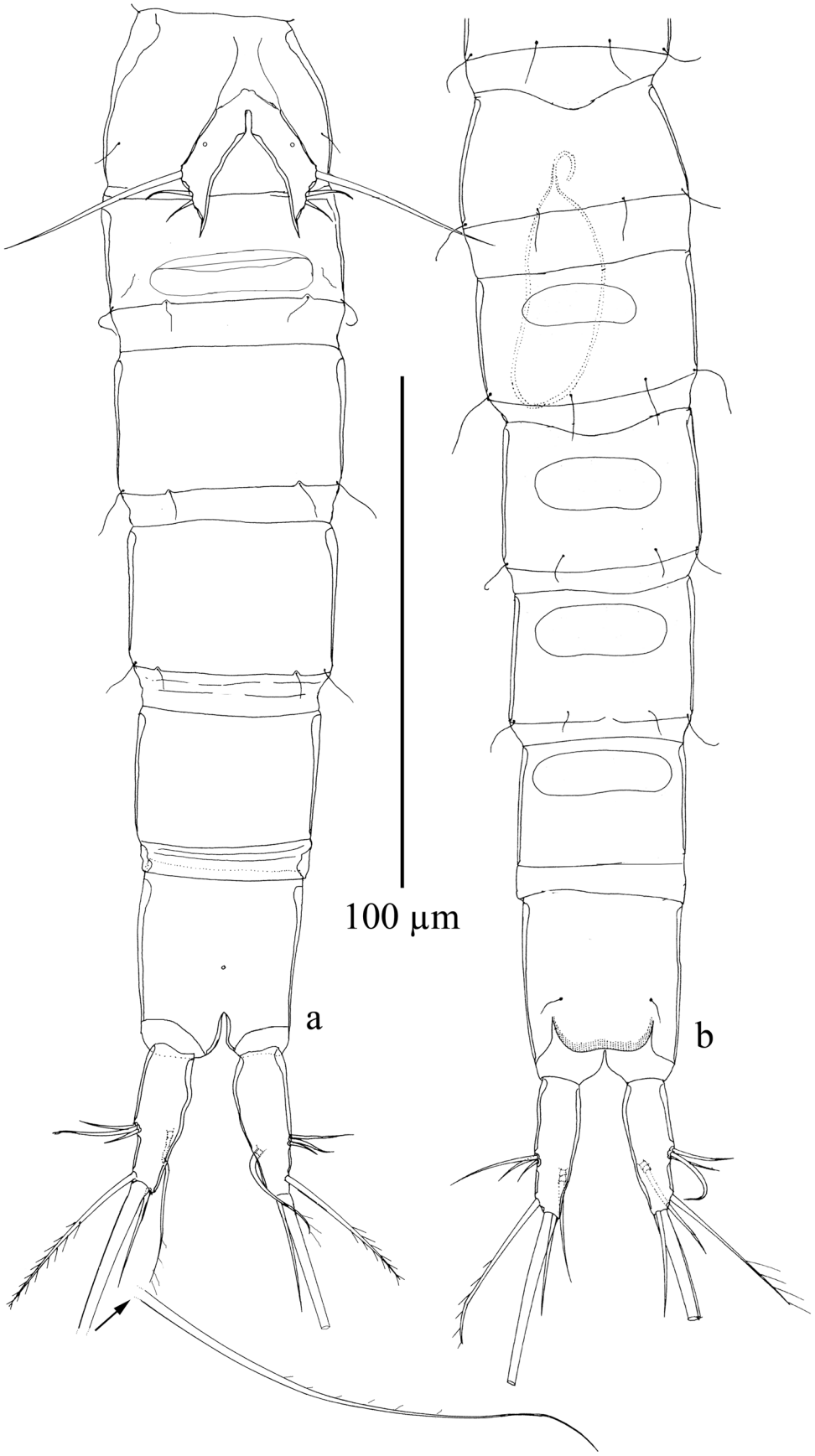

FIGURE 3. *Parastenocaris enckelli* **n. sp.**, holotype male: (a) urosome, ventral view; (b) same, dorsal view.

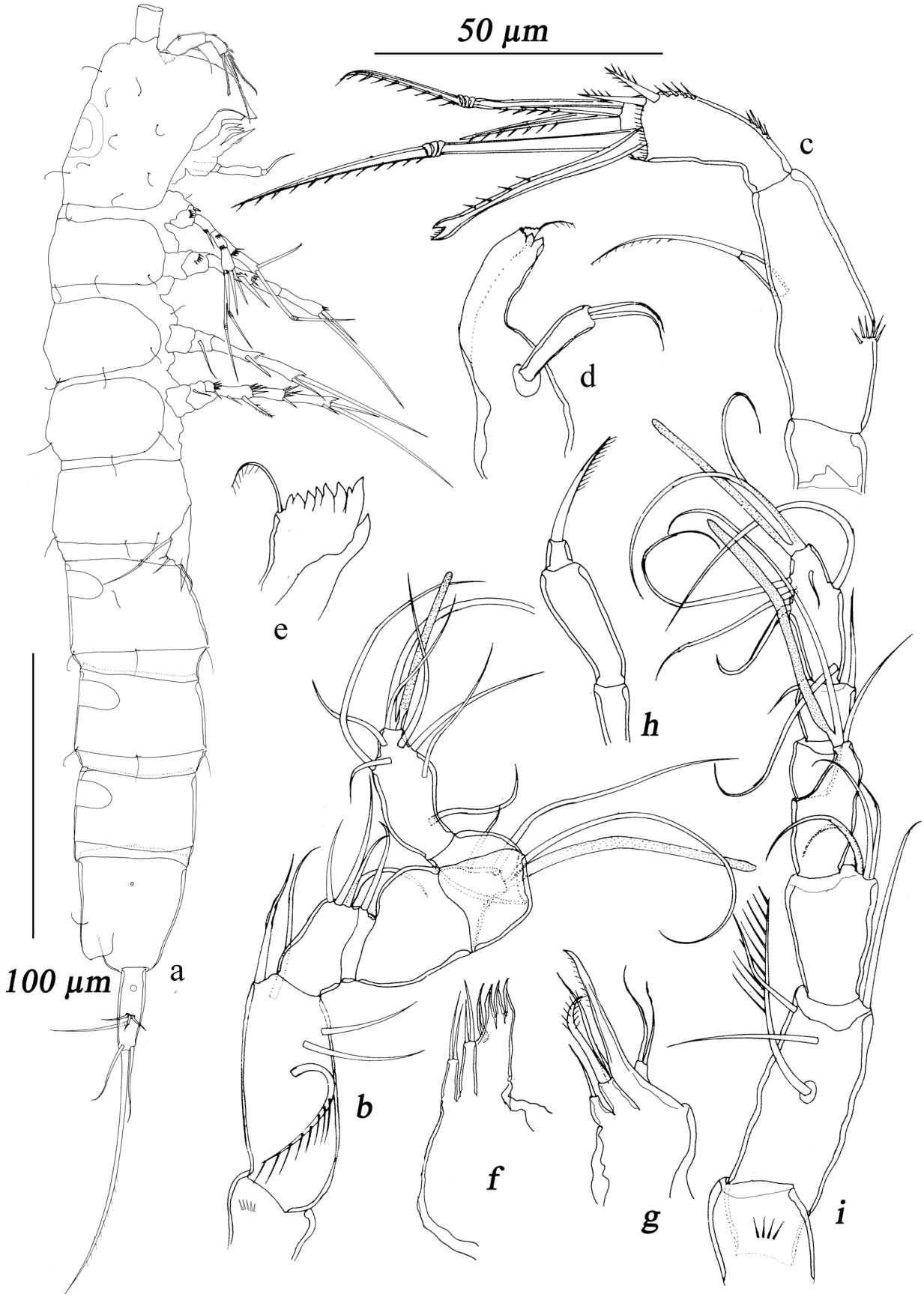

FIGURE 4. *Parastenocaris enckelli* **n. sp.**, paratype female (a, i); holotype male (b–h): (a) habitus, lateral view; (b) antennule, ventral view; (c) antenna, lateral view; (d) mandible, anterior view; (e) same, posterior view; (f) maxillule, lateral view; (g) maxilla, lateral view; (h) maxilliped, lateral view; (i) antennule, ventral view.

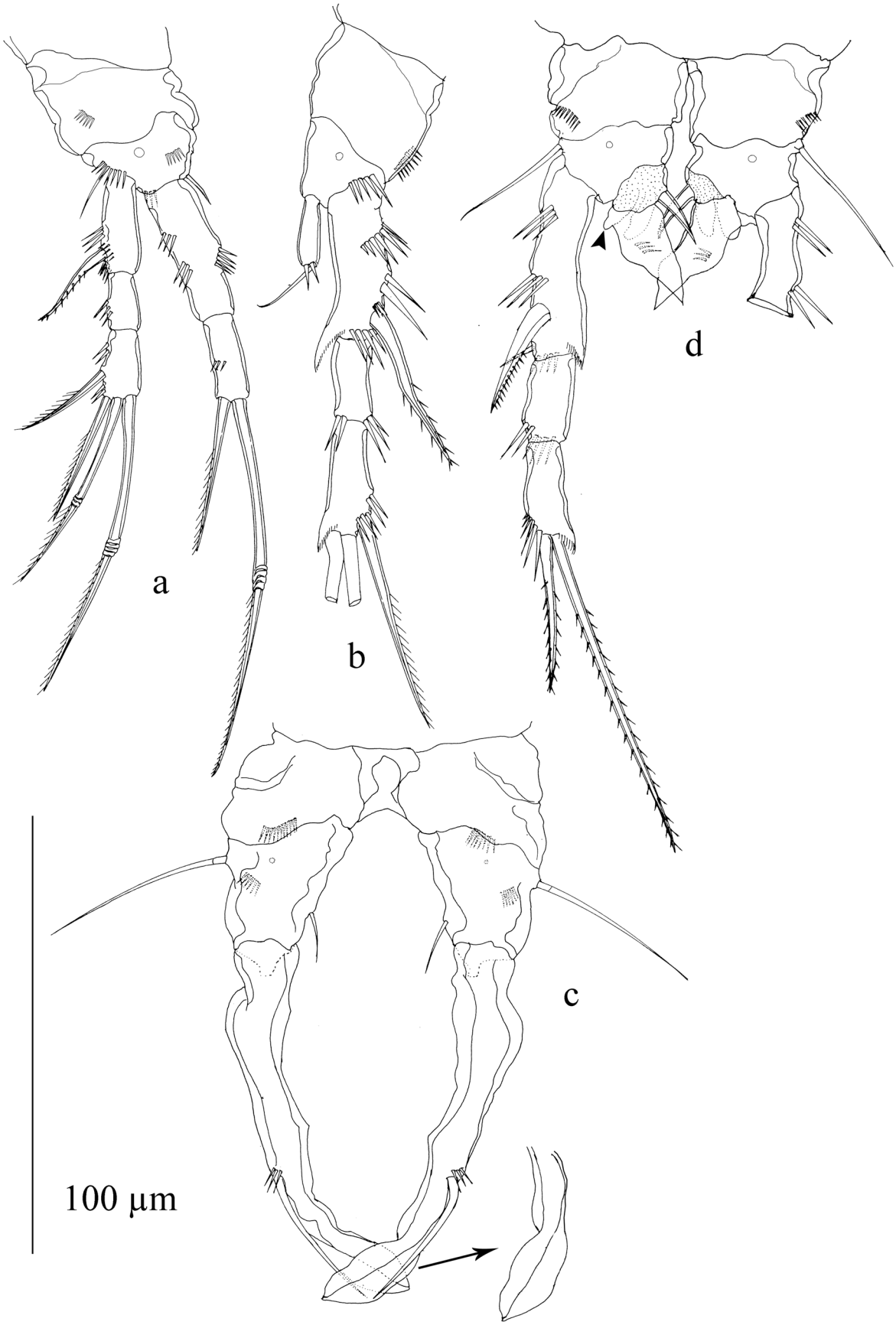

FIGURE 5. *Parastenocaris enckelli* **n. sp.**, holotype male: (a) leg 1, anterior view; (b) leg 2, anterior view; (c) leg 3, anterior view; (d) leg 4, posterior view.

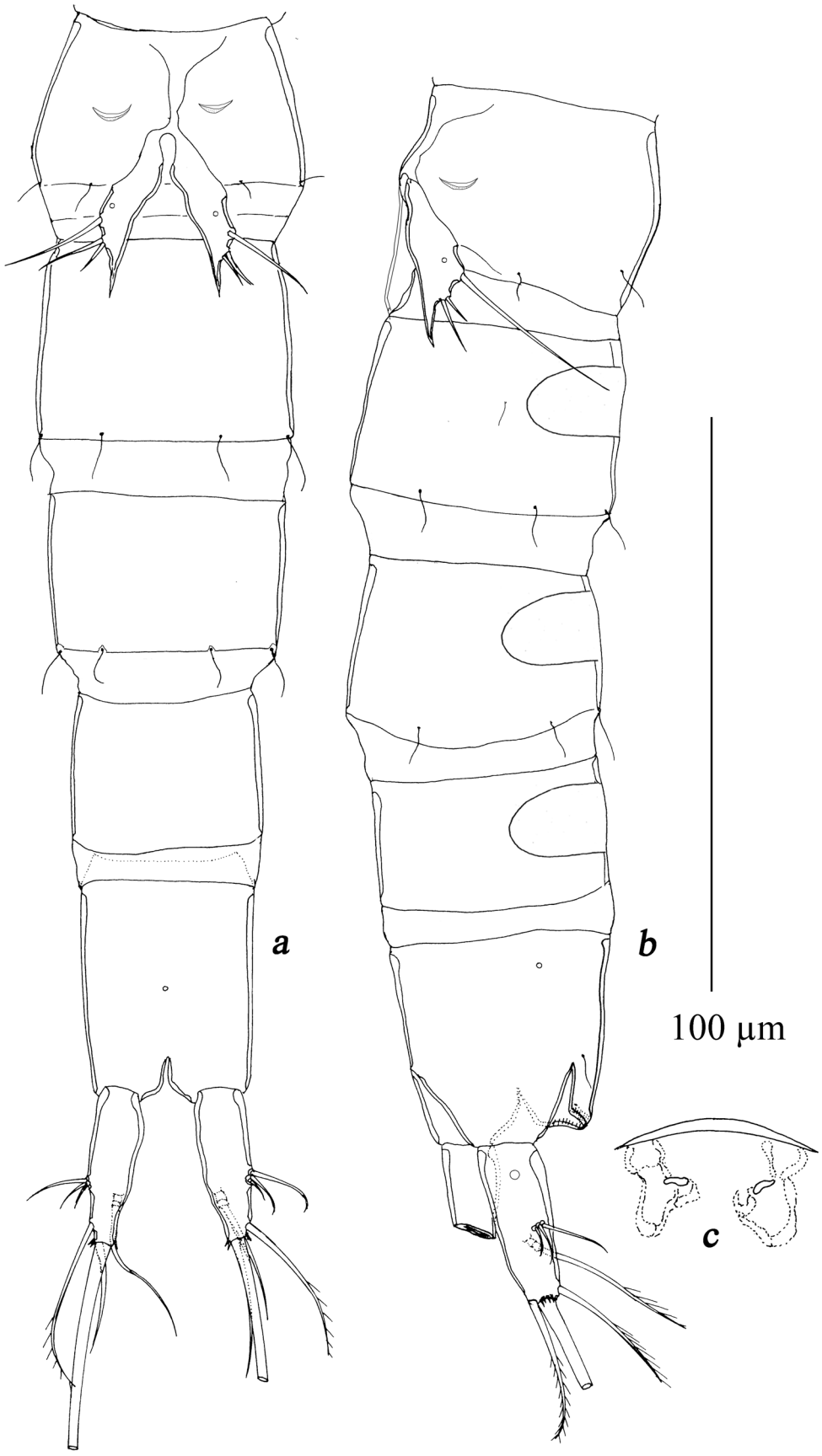

FIGURE 6. *Parastenocaris enckelli* **n. sp.**, allotype female: (a) urosome, ventral view; (b) same, lateral view; (c) genital field.

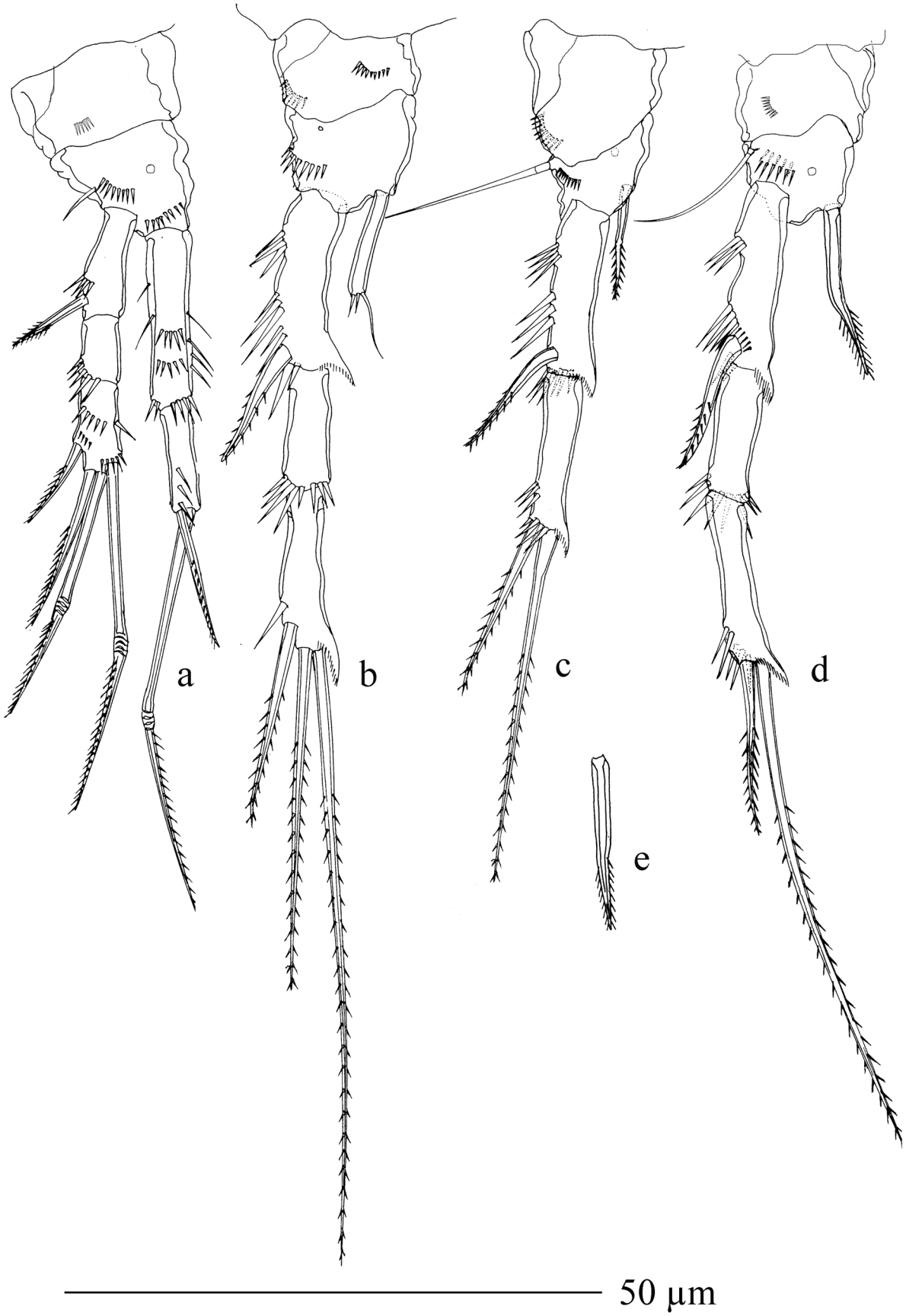

FIGURE 7. *Parastenocaris enckelli* **n. sp.**, allotype female: (a) leg 1, anterior view; (b) leg 2, posterior view; (c) leg 3, anterior view; (d) leg 4, anterior view; (e) endopod of leg 4.

Subfamily Fontinalicaridinae Schminke, 2010

Genus *Dussartstenocaris* Karanovic and Cooper, 2011

***Dussartstenocaris bisetosa* n. sp.**
(Figs. 8–13)

Type locality. Farm bore (water temperature 32ºC, pH 7.0) at Chintalapudi village, ~5 km from Nidubrolu town (16°02′23.8″N, 80°32′35.4″E; elevation ca 36.5 m) in Guntur District, Andhra Pradesh state, southeastern India (Fig. 1).

Type material examined. Holotype male (MNHN-IU-2013-11956) and allotype female (MNHN-IU-2013-11957), dissected on 4 slides each; 2 paratypes: 1 male (MNHN-IU-2013-11958), dissected on 4 slides; 1 male (MNHN-IU-2013-11959), whole-mounted on 1 slide; 04 January 2010, Coll. V. R. Totakura.

Other material examined. 1 male, dissected on 3 slides in TVR's personal collections. Farm bore at Kunchanapalli village (16º23′42.1″N, 80º32′28.2″E, elevation 26 m; water temperature 28ºC, pH 7.0) in Guntur District, Andhra Pradesh, South India, 21 December 2010, Coll. V. R. Totakura.

Description of adult male. Total body length, measured from tip of rostrum to posterior margin of caudal rami, 296–352 μm. Preserved specimens colourless. Nauplius eye absent. Habitus (Fig. 8A) cylindrical and slender, without any demarcation between prosome and urosome; prosome/urosome ratio about 0.8 in dorsal view; greatest width in dorsal view at genital somite. Body with thin, imperforated cuticle, length/width ratio about 7.4. Free pedigerous somites without any expansions; all somites connected by well developed arthrodial membranes. Hyaline fringes of all somites smooth, narrow and hard to distinguish from arthrodial membranes. Integument ornamented with sensilla, some pores and spinules, and also with somewhat obpyriform cuticular double-window on cephalothorax, somewhat close to posterior margin, and 1 elliptical, dorsal cuticular window each in the anterior half of genital somite and next 3 urosomites; window on genital somite smallest. Cephalothorax (Fig. 8a) obovate, about 1.3 times as long as wide in lateral view, representing 16.7% of total body length. Surface of cephalic shield ornamented with 8 pairs of sensilla. Rostrum (Figs. 8a, b, 10a) small, membranous, not demarcated at base, ornamented with 2 dorso-lateral sensilla. Second pedigerous somite as wide as posterior half of cephalothorax in dorsal view, with 2 pairs of large sensilla, 1 pair proximally. Third pedigerous somite slightly longer than second pediger, with 2 pairs of large sensilla. Fourth pedigerous somite as long as third prosomite, with 2 pairs of large posterior sensilla.

Urosome (Fig. 9a, b) gradually narrowing behind. First urosomite as wide as distal half of genital somite, with 2 pairs of dorso-distal sensilla and 1 pair each on ventral surface of urosomites 1–4. Genital somite shorter than first urosomite, also with 3 pairs of sensilla (dorsal, lateral) and 1 sensillum on either side of sixth legs. Third and fourth urosomites nearly as long as genital somite, with 2 pairs of sensilla (dorsal, lateral). Preanal somite without any surface ornamentation. Anal somite about 1.5 times as long as wide in dorsal view, slightly narrower than preanal somite; ornamented with 2 short rows of small spinules at 2/5 of segment length, 1 complete row of very fine spinules close to posterior margin of anal operculum, 8 mid-dorsal, relatively large spinules, 1 pair of large dorsal sensilla at base of anal operculum and 1 cuticular pore proximo-laterally. A single, large, longitudinally placed spermatophore (Fig. 8a) visible through genital somite and next somite, about 2.9 times as long as wide, bean-shaped, with narrow curled neck. Anal operculum moderately developed, with smooth, slightly convex margin, not reaching posterior end of anal somite and representing 74.3% of somite's width. Anal sinus wide, ornamented with 1 short diagonal row of 3–5 spinules on either side postero-ventrally as in Fig. 9a-d.

Caudal rami (Fig. 9a–c): divergent, cylindrical, narrow at base in ventral view; about 4 times as long as greatest width in dorsal view and about 0.7 times as long as anal somite; armed with 6 setae (2 lateral, 1 dorsal, 2 apical, and 1 subapical), and with ventral row of fine spinules along posterior margin, of which 1 spinule at inner distal corner elongate. Lateral setae (I, III) unequal and located slightly anterior to midlength; seta II missing. Dorsal seta (VII) inserted at distal fifth of caudal rami and close to inner margin, slender, plumose, about as long as caudal ramus and biarticulate basally. Inner apical seta (VI) smooth, inserted close to ventral margin, about long as ramus. Middle apical seta (V) stout, without breaking plane, bipinnate, about 6.2 times as long as ramus, pointing distally, with acute tip. Outer apical seta (IV) small, smooth, only about 0.4 times as long as ramus, inserted close to dorsal surface and pointing laterally.

Antennule (Fig. 10b): slightly longer than cephalothorax, slender, 8-segmented, 'coiled type'; digeniculate, geniculation between fourth and fifth, and between sixth and seventh segments. First segment short, ornamented with 1 row of spinules; second segment longest, being about 3 times as long as maximum width; segments 5 and 6 moderately dilated; segment 5 without any proximal spiniform process on anterior surface, with moderately developed aesthetasc, constricted at about midlength, with blunt tip, barely reaching end of ultimate segment, and fused basally with 1 simple seta; ultimate segment with aesthetasc, only slightly smaller than that on segment 5, fused basally with 2 setae (acrotheck). Setal formula: 0.5.4.1.4+aes.0.0.9+aes. All setae slender, smooth; proximalmost seta on second segment unipinnate with long setules along disto-lateral margin; proximalmost seta of segments 2 and 8 articulate basally. Length ratios of segments, from proximal to distal end and along caudal margin 1.0:2.6:0.7:0.4:2.5:1.1:1.7:1.5.

Antenna (Fig. 10c): composed of coxa, allobasis, 1-segmented endopod, and 1-segmented exopod. Coxa very short, ornamented with arched row of short spinules. Allobasis about 3.8 times as long as maximum width and ornamented with 2 arched rows of spinules on anterior surface. Exopod small, somewhat cylindrical, about 3.3 times as long as wide, unornamented, armed with 1 apical seta, which is 3.3 times as long as segment. Endopod 0.6 times as long as allobasis and about 2.3 times as long as wide, with surface frill distally, ornamented with 2 spinular rows on inner margin and armed laterally with 2 short bipinnate unequal spines and apically with 5 strong elements (2 subequal spines, 2 subequal geniculate setae and 1 unipinnate transformed seta).

Mandible (Fig. 10d): cutting edge narrow on elongate coxa and with 2 complex teeth ventrally, 1 unipinnate seta dorsally, and several smaller teeth. Palp 1-segmented, cylindrical, about 3.2 times as long as wide, unornamented and armed apically with 2 smooth apical setae.

Maxillule (Fig. 10e): praecoxal arthrite rectangular, about 2.2 times as long as wide in lateral view, armed with strong lateral seta and 3 weak apical elements. Coxal endite armed with 1 smooth apical seta. Basis; (c) genital field. slightly longer than coxal endite and armed with 2 smooth apical setae.

Maxilla (Fig. 10f): composed of syncoxa, basis and 1-segmented endopod. Syncoxa with 2 endites, proximal one short and armed with 2 smooth apical setae, and distal endite armed with 1 smooth seta and 1 strong pinnate spiniform seta apically. Allobasis prolonged into strong unipinnate claw and without seta at base. Endopod represented by small segment, armed with 2 smooth apical setae.

Maxilliped (Fig. 10g): syncoxa unarmed and unornamented; basis slender, 5.5 times as long as wide; endopod small with unipinnate claw, about 0.6 times as long as basis.

Legs 1–4 (Fig. 11a–c, g): praecoxa and intercoxal sclerite of all legs smooth.

Leg 1 (Fig. 11a): coxa rhomboidal, ornamented with 1 row of small spinules disto-medially. Basis shorter than coxa, trapezoidal, with outer seta and ornamented with 1 row of spinules each near base of exopod and endopod. Exopod 3-segmented; first segment 0.8 times as long as next 2 segments combined; segments 1 and 2 with 1 longitudinal row of spinules each at outer distal corner, and segment 3 with 1 longitudinal row of spinules at about midlength of inner margin; segment 1 armed with 1 short and slender outer bipinnate spine; segment 2 unarmed and segment 3 with 4 elements (1 outer spine, 1 apical seta and 2 apical geniculate setae). Endopod 2-segmented, slightly longer than exopod; first segment 1.6 times as long as second exopodal segment, 3.1 times as long as wide, unarmed and ornamented with 2 rows of elongate spinules on outer margin and 2 longitudinal rows of small spinules on inner margin; segment 2 ornamented with 1 row of spinules on inner margin and armed with 1 spine subapically and 1 long geniculate seta apically; endopodal geniculate seta 1.4 times as long as entire endopod, almost twice as long as outer spine on endopod, 1.2 times as long as inner geniculate seta on exopod. All exopodal and endopodal armature elements except spine on first exopodal segment unipinnate along outer margin.

Leg 2 (Fig. 11b): coxa with 1 arched row of spinules near inner distal corner. Basis smaller than coxa, unarmed and ornamented with 1 row of spinules along outer margin and 1 row of fine spinules at base of endopod. Exopod 3-segmented; ornamented with isolated rows of spinules along outer margins of all segments; segments 1 and 3 with hyaline frill each at inner distal corner, but segment 2 with 1 row of spinules instead. Segment 1 strong, 1.3 times as long as next 2 segments combined, armed with 1 outer spine on segment 1; segment 2 unarmed; segment 3 about as long as segment 2, armed with 3 elements (1 subapical spine and 2 apical plumose setae); innermost seta 1.4 times as long as exopod. Endopod 1-segmented, slender, almost cylindrical, 7.6 times as long as wide, about 0.6 times as long as first exopodal segment, ornamented with 2 large spinules on subdistal outer margin, and apical margin with 2 spinules and armed with 1 smooth seta, which is 1.2 times as long as endopod.

Leg 3 (Fig. 11c–f): coxa trapezoidal, smaller than basis, ornamented with 1 arched row of spinules at inner distal corner. Basis robust, produced at inner distal corner, ornamented with 1 longitudinal row of spinules on inner

margin and 1 pore on anterior surface and armed with long, slender, simple seta on outer margin. Endopod represented by very small, rudimentary seta, inserted at distal fourth of inner margin of basis. Exopod with both segments perfectly fused together; ancestral proximal segment moderately strong, slightly curved inwards, 4 times as long as wide, ornamented with 2 rows of spinules on outer proximal margin; ancestral distal segment (apophysis) ladle-shaped, with hyaline lateral margins, unornamented and unarmed; thumb, longer than apophysis, and with 3 unequal apical lobes lined with hyaline margins (arrowed in Fig. 11c).

Leg 4 (Fig. 11g): coxa rhomboidal, ornamented with arched row of spinules at outer distal corner and 2 modified, elongate spinules, reaching almost distal end of basis and with a hyaline zone around them at inner distal corner. Basis trapezoidal and slightly longer than coxa, ornamented with 1 row of small spinules at base of exopod and armed with moderately long seta on outer margin. Exopod 3-segmented, ornamented with rows of spinules on outer margins of all segments and additional row of spinules along inner distal corner of segment 2, 1 hyaline frill each at inner distal corner of segments 1 and 3; segment 1 slightly curved inwards, 0.7 times as long as next 2 segments combined, armed with strong bipinnate outer spine subdistally; segment 2 with straight inner margin and unarmed; segment 3 slightly longer than second one and armed with 1 outer spine and 1 apical bipinnate seta; apical seta 2.2 times as long as outer spine, 3.9 times as long as third exopodal segment, 1.2 times as long as entire exopod. Endopod claw-like and outcurved and ornamented with 1 spinule at proximal third of its length; 2 equal, large spinules also occurring near the base of endopod on outer side with hyaline zone around them.

Leg 5 (Fig. 9a, b, e): without intercoxal sclerite; legs distinct at base, small, bowl-shaped plate, located at distal half of somite, with acute, minute spinous process at inner distal angle and smooth inner margins; cuticular pore not discernible; armed with 2 unequal smooth setae on distal margin (probably ancestral endopodal armature), inner seta 2.6 times as long as outer one; basal seta missing.

Leg 6 (Fig. 9a, b): smooth, unarmed and unornamented, forming simple operculum covering gonopore, fused with sixth pedigerous somite, hook-like in lateral view, triangular plate-like structure in ventral view.

Description of adult female. Body length, measured as in male, 348 μm. Habitus (Fig. 8b): ornamentation of prosomites, colour and nauplius eye similar to male, except genital somite and first abdominal somite fused into double-somite.

Genital double-somite (Fig. 12a): genital complex located mostly in the anteroventral half of genital double-somite, and broader than high; genital apertures covered by vestigial sixth legs; median copulatory pores also covered by fused sixth legs; seminal receptacles small; copulatory duct very short and sclerotized. All posterior sensilla of third urosomite homologous to those on male, while 2 sensilla from male second urosomite missing. Third, preanal and anal somites very similar to male.

Caudal rami (Fig. 12a–c): slightly divergent, 1.5 times as long as anal somite, about 2.8 times as long as wide in ventral view, gradually tapering; armature and ornamentation as in male.

Antennule (Fig. 10h): 7-segmented; segment 1 short, ornamented with 1 row of spinules on ventral surface; segment 2 longest; segment 4 with short, moderately strong, medially constricted aesthetasc with pointed tip, slightly overreaching distal margin of sixth segment; aesthetasc on segment 7 more slender and shorter than that on segment 4, 0.7 times as long as segment, fused basally to 2 apical setae (acrotheck); setal formula: 0.4.4.2+aes.1.1.9+aes. All setae, except unipinnate proximalmost one on second segment smooth. Length ratios of segments, from proximal to distal end and along caudal margin 1.0:3.0:1.6:1.3:1.2:0.8:1.4.

Antenna, labrum, mandible, maxillule, maxilla, maxilliped, and leg 1 (Fig. 13a) and 5 (Fig. 12a) similar to male.

Leg 2 (Fig. 13b): coxa rhomboidal, ornamented with 2 rows of spinules on medial surface; basis smaller than coxa; ornamentation same as in male. Exopod similar to male. Endopod nearly cylindrical, 0.7 times as long as first exopodal segment and ornamented with 2 spinules on subdistal outer margin; apical margin armed with 1 seta, which is 0.8 times as long as endopod, and ornamented with 2 spines.

Leg 3 (Fig. 13c): coxa with 1 arched row of spinules medially. Basis trapezoidal, ornamented with 4 or 5 large spinules in a row on outer distal margin and armed with long, basally articulate, smooth outer seta, which is 0.8 times as long as entire exopod. Exopod 2-segmented, with large spinules along outer margin, both segments with hyaline frill each at inner distal corner; segment 1 armed with 1 outer spine; segment 2 with outer spine and strong apical seta; seta 3.2 times as long as spine; all armature elements bipinnate. Endopod greatly reduced to small, smooth, knob-like structure (arrowed in Fig. 13c).

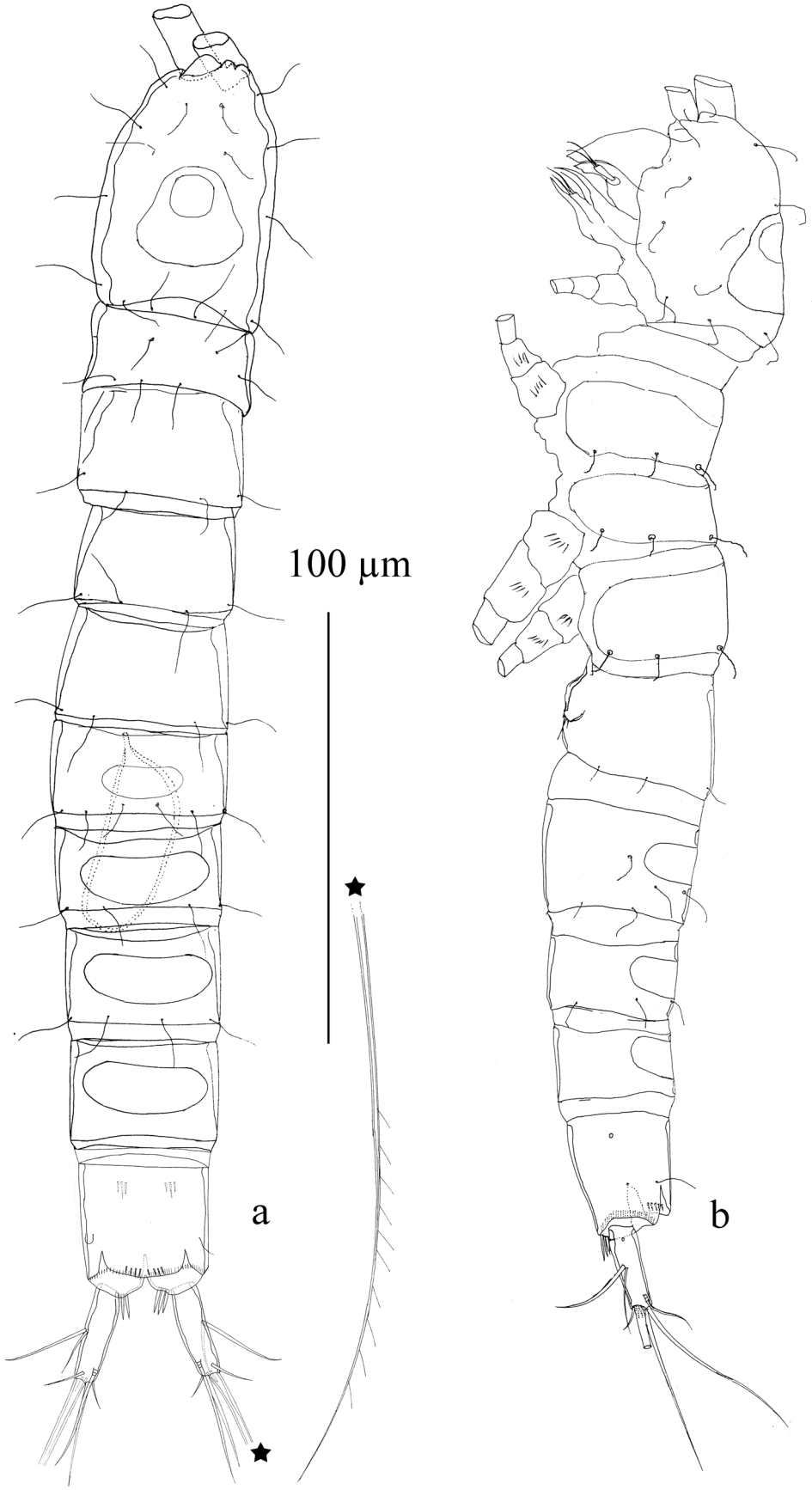

FIGURE 8. *Dussartstenocaris bisetosa* **n. sp.**, (a) paratype male, habitus, dorsal view; (b) paratype female, habitus, lateral view.

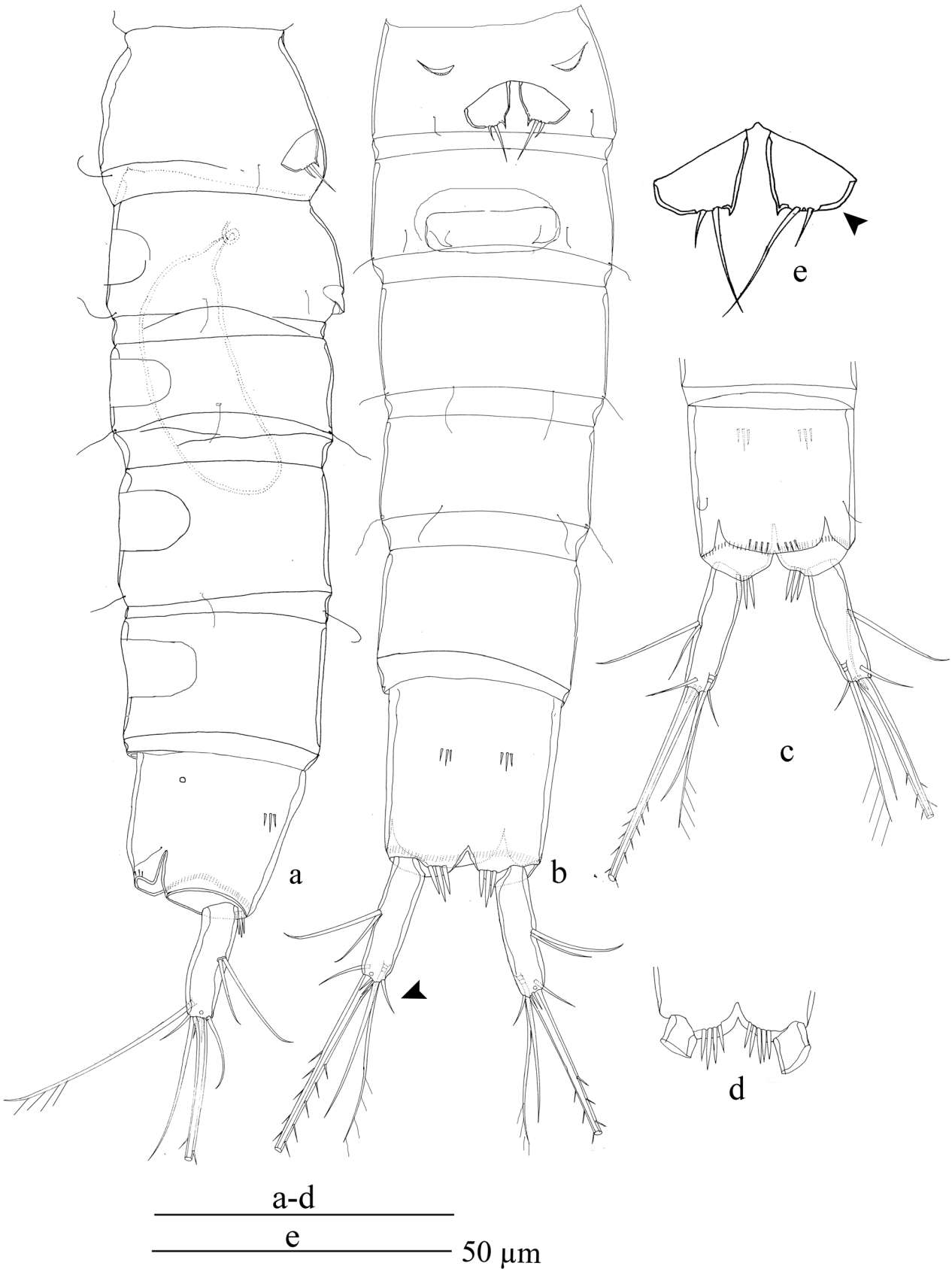

FIGURE 9. *Dussartstenocaris bisetosa* **n. sp.**, holotype male (a–c); paratype male (d, e): (a) urosome, lateral view; (b) same, ventral view (arrow pointing to large setiform spinule); (c) anal somite and caudal rami, dorsal view; (d) postero-ventral part of anal somite (to show large spinules); (e) fifth legs, ventral view (arrow pointing to lack of basal seta).

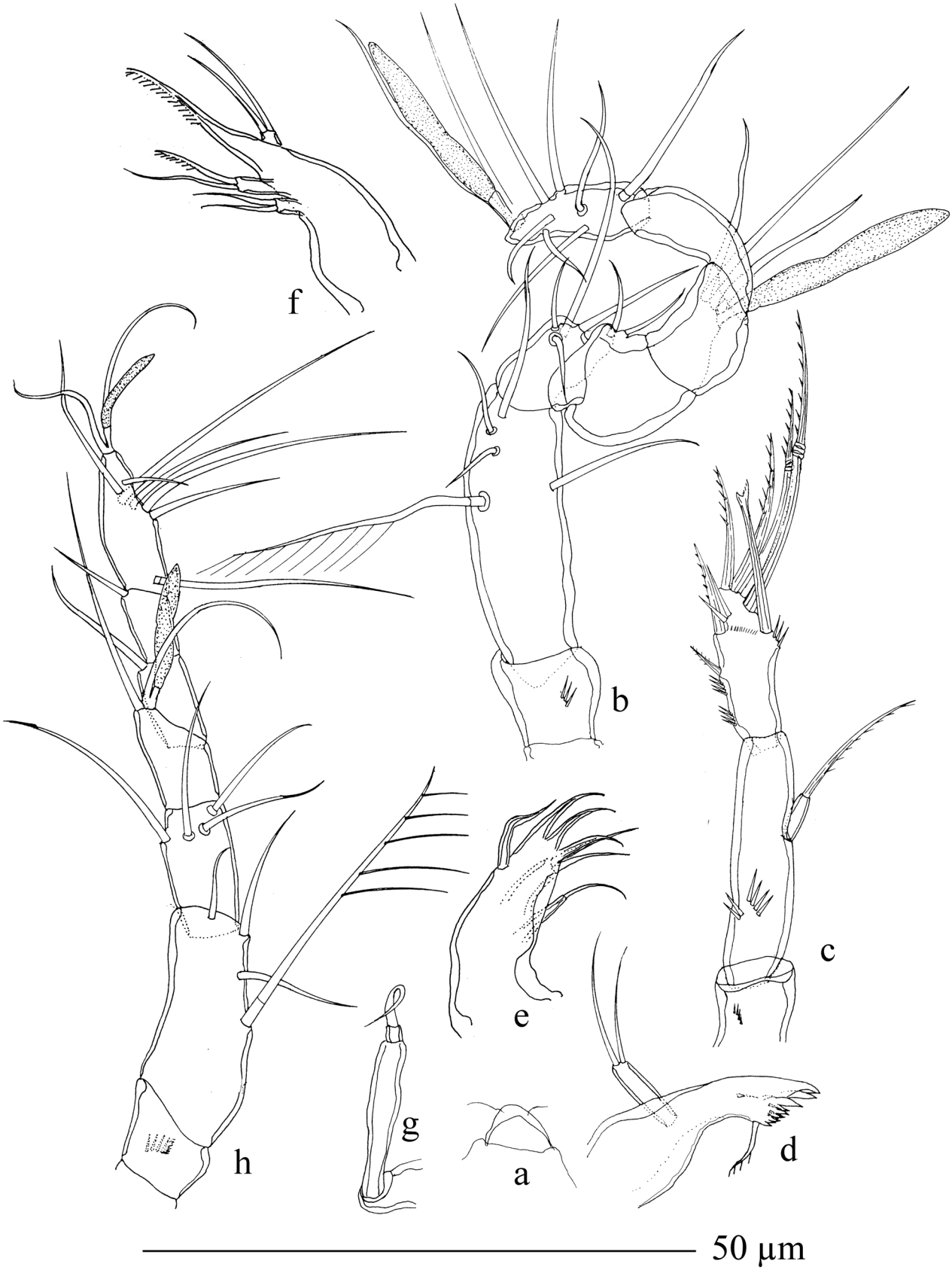

FIGURE 10. *Dussartstenocaris bisetosa* **n. sp.**, holotype male (a–g); allotype female (h): (a) rostrum, ventral view; (b) antennule, dorsal view; (c) antenna, lateral view; (d) mandible, lateral view; (e) maxillule, posterior view; (f) maxilla, lateral view; (g) maxilliped, anterior view; (h) antennule, dorsal view.

FIGURE 11. *Dussartstenocaris bisetosa* **n. sp.**, holotype male (a–c, g); paratype male (d–f): (a) leg 1, anterior view; (b) leg 2, anterior view; (c) leg 3, anterior view (arrow pointing to trilobed thumb); (d) exopod of leg 3; (e, f) apophysis and thumb; (g) leg 4, posterior view.

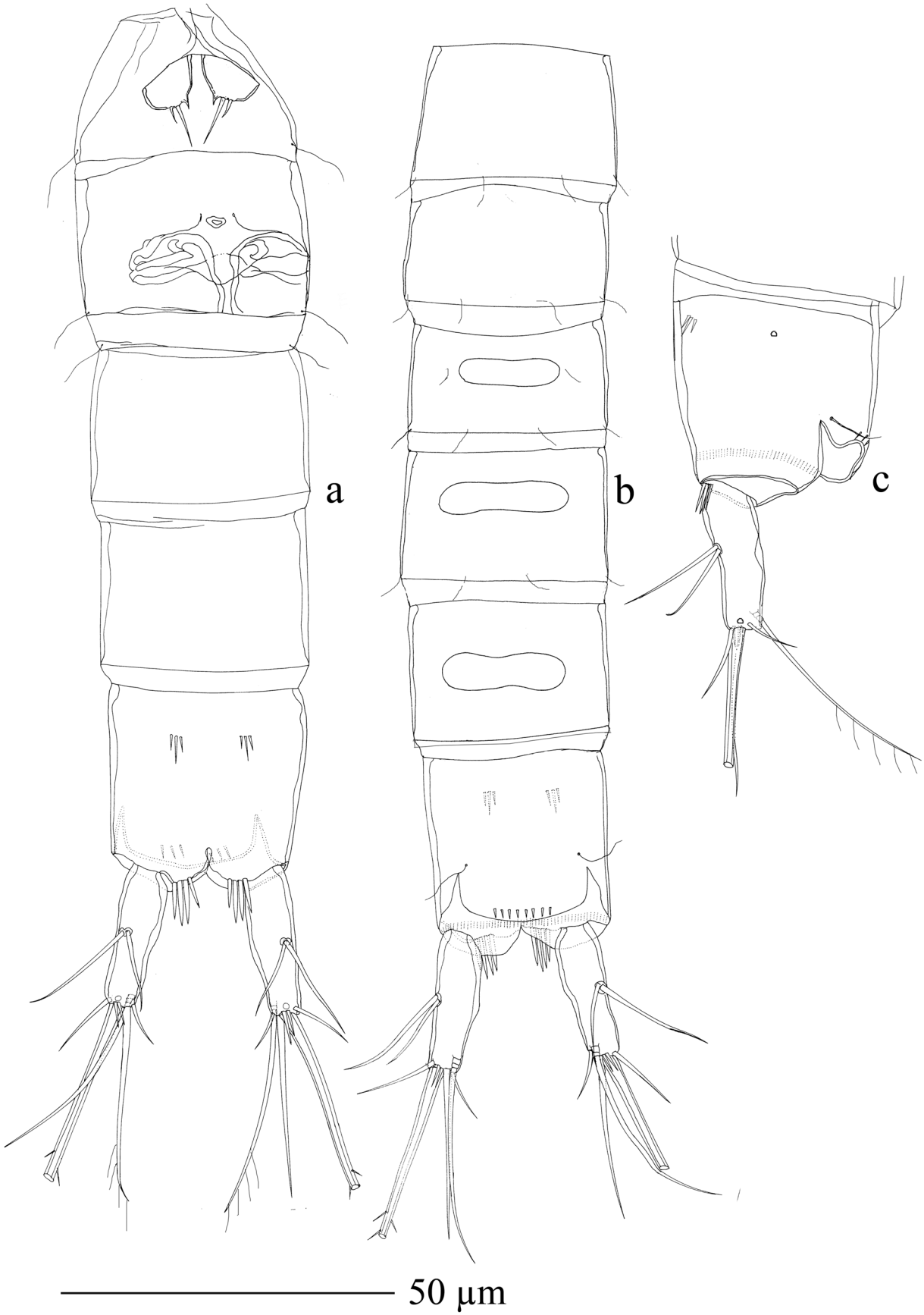

FIGURE 12. *Dussartstenocaris bisetosa* **n. sp.**, allotype female: (a) urosome, ventral view; (b) same, dorsal view; (c) anal somite, lateral view.

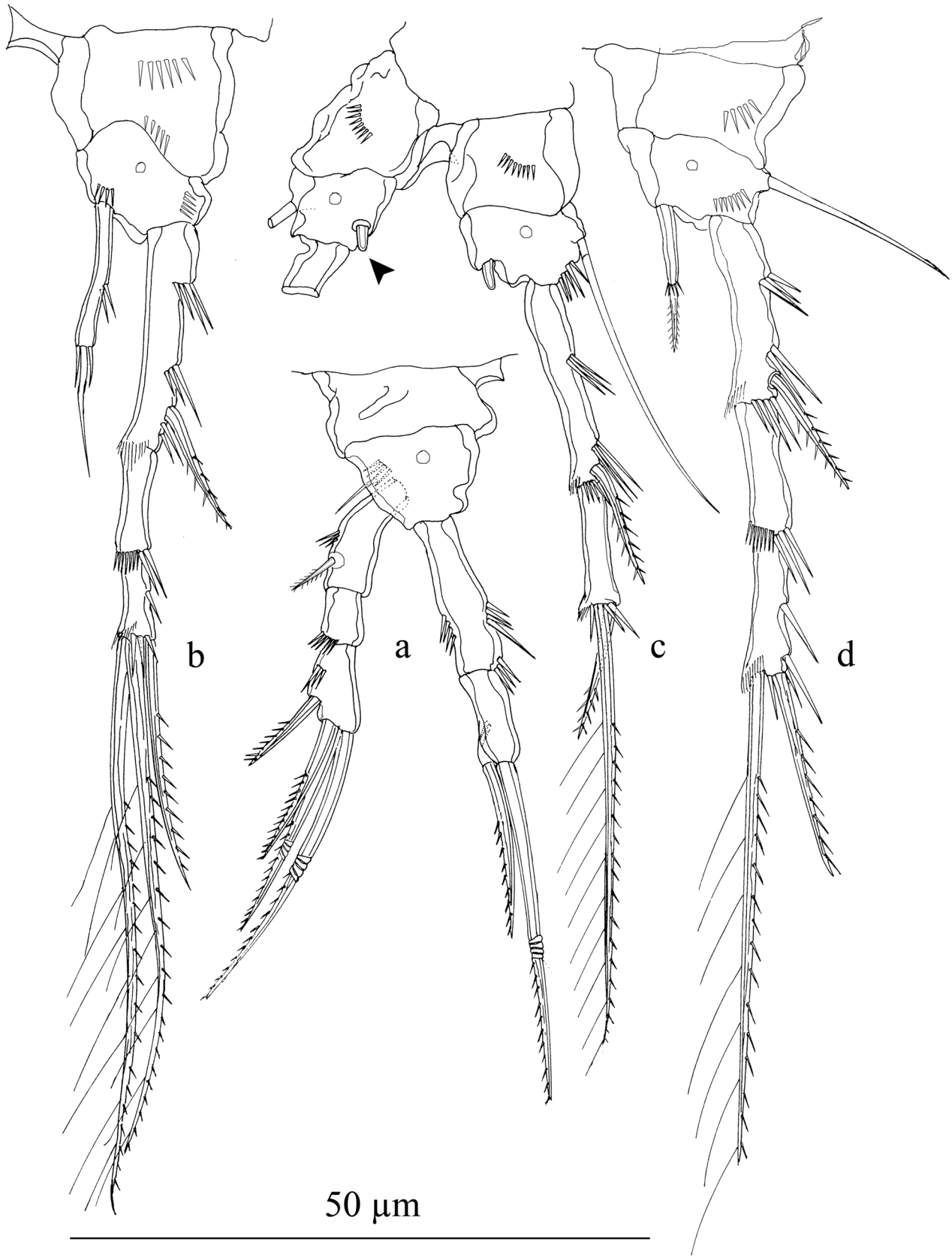

FIGURE 13. *Dussartstenocaris bisetosa* **n. sp.**, allotype female: (a) leg 1, posterior view; (b) leg 2, anterior view; (c) leg 3 anterior (arrow pointing to characteristic endopod); (d) leg 4, anterior view.

Leg 4 (Fig. 13d): exopod similar to male. Endopod 1-segmented, 0.8 times as long as first exopodal segment, straight, ornamented with transverse row of 5 spinules at 3/5 of length, spiniform, ending in acuminate point, and with spinulose disto-lateral margins.

Leg 6 not discernible.

Variation. Number of spinules on ventro-distal margin of anal somite varying between 3 and 5 in male (Fig. 3c, d).

Etymology. The specific epithet, *bisetosa*, from the Latin adjective, *setosu*s, alludes to the presence two setae on leg 5 in both sexes; gender feminine.

Distribution and ecology. The new species is known only from two farm bores, about 50 km apart, in Guntur District, Andhra Pradesh state. It was accompanied by one bathynellacean species only at the type locality (Chintalapudi bore), and one bathynellacean, one cyclopoid species, a new species of a new parastenocaridid genus, and some other unidentified harpacticoids in the other bore.

Discussion

Parastenocaris enckelli **n. sp.** belongs to the *brevipes*-group of Parastenocaridinae Chappuis, 1940, as proposed by Lang (1948) and revised by Reid (1995). This is evident, *inter alia*, from the characteristic endopodal complex of the male leg 4, the long, distally serrulate female leg 4 endopod, and the tapering caudal rami of both sexes with the dorsal and lateral setae inserted at about midlength (see Karanovic 2005). Karanovic & Lee (2012) have recognised, in all, 20 species for this group and provided a key for their identification based on the morphology of males. The inclusion of *Parastenocaris palmerae* Reid, 1992 in the *brevipes*-group by Karanovic & Lee (2012), however, has been questioned by Schminke (2013: 714) on the basis of the complicated structure of its male leg 4 endopod, which according to the same author is "a precursor of the condition in *Stammericaris*". Later, Totakura *et al.* (2014) have added *Parastenocaris edakkal* Totakura, Ranga Reddy & Shaik, 2014, to the *brevipes*-group and also proposed the inclusion of the Indian *Parastenocaris kotumsarensis* Ranga Reddy & Defaye, 2009, in the same group. Based on their cladistic analysis of this group, Karanovic & Lee (2012) inferred that this group is well founded on at least three synapomorphies associated with the male leg 4: the basis has two hyaline processes, the same are located on the inner margin of the basis, and the inner margin of the first exopodal segment is deeply concave. And, based on their reconstructed phylogeny, Karanovic & Lee (2012) have put forward a more plausible interpretation of the distribution of the *brevipes*-group of species in place of Reid's (1995) hypothesis about its tropical Asian origin (see below).

Parastenocaris enckelli has such a unique constellation of morphological features that, in the present scenario, it is rather difficult to find out its sister species within the *brevipes*-group. However, based on the morphology of the male leg 4 endopod, which is vitally important in the phylogeny of Parastenocarididae, this species is closely related to certain species in the terminal clade of the cladogram in Karanovic & Lee (2012: fig. 12). For example, the male leg 4 endopod is proximally bulbous and distally tapering to an acute point and ornamented with a diagonal row of spinules at about midlength as in the incompletely characterized Sri Lankan *P. brincki*, and also the Indian *P. edakkal* (not included in the said cladistic analysis). Another character shared by all the three species is the presence of a short or long spiniform process at the inner distal corner of leg 5 in both sexes (female as yet unknown for *P. brincki*). This condition also occurs in *P. irenae*, *P. muvattupuzha, P. oshimaensis* Miura, 1962*, P. palmerae,* and *P. sutlej.* In general, the lack of sexual dimorphism in the fifth legs has been recognised as a plesiomorphic state in Parastenocarididae (Schminke 2010; Karanovic Lee 2012). It is to be noted here that the leg 5 in the *brevipes*-group of species is small in size (only relatively large in females), generally not extending beyond the somite's limit. We consider this feature plesiomorphic for Parastenocarididae because leg 5 is also small in most groundwater Ameiridae, which are a reasonable sister-group of Parastenocarididae (see Ranga Reddy *et al.* 2014). Interestingly, the leg 5 in both sexes of *P. enckelli* is slender and elongate, overreaching the posterior margin of the somite. A similar situation can be noticed at least in the female of *P. edakkal* as well.

Most parastenocaridids lack an inner spine/seta on the leg 1 basis (Galassi & De Laurentiis, 2004). Of the 22 species so far known on the Indian subcontinent, the male leg 1 basis has an inner armature element in as many as six species, viz., *P. enckelli*, *P. edakkal*, *P. savita, P. muvattupuzha, P. gundlakamma* and *P. tirupatiensis* Ranga Reddy 2012 (see Ranga Reddy & Defaye 2009, Ranga Reddy 2001, 2011a, 2012). According to Galassi & De

Laurentiis (2004), the said armature element on the leg 1 basis of females and/or males could be present in certain species belonging to different phylogenetic lineages. However, this feature, when present, is seen only in the species of Parastenocaridinae, but not in any of Fontinalicaridinae (Schminke 2010).

Parastenocari enckelli can be separated from both *P. edakkal* and *P. brincki* mainly by the male leg 3 apophysis and its terminal seta being completely fused together, typifying the apomorphic condition of Parastenocaridinae. In the latter two species, on the other hand, the seta is distinct from the apophysis—an important phylogenetic criterion for Fontinalicaridinae. Incidentally, the apophysis in *P. enckelli* is rather characteristic in form and more or less identical to the corresponding structure in *P. sutlej* (see Ranga Reddy 2011, fig. 4c). This is probably a case of evolutionary convergence. The new species also differs from *P. edakkal* as well as *P. brincki* in two other respects: (i) the male leg 4 endopod is shorter than the first exopodal segment vs. longer than or as long as the first exopodal segment; and (ii) the thumb on the male leg 3 is long and slender vs. short and strong. On the whole, a critical comparison done by us shows that *P. enckelli* is somewhat closer to *P. edakkal* than to *P. brincki*, as borne out by the caudal rami, which are shorter than the anal somite, the long and thin male P3 exopod, the elongate female leg 5, and the various details of the male legs 1 and 2 and the female legs 1–4. However, Dr. P. H. C. Corgosinho (pers. commun.) puts forward an altogether different viewpoint that *P. enckelli* could be a member of the yet-to-be validated *Michelicaris* Jakobi, 1972, because of its following morphological affinities: on the male leg 3, the exopod is long and thin, the apophysis is also long and thin and tapering distally, and the thumb is thin and slightly shorter than apophysis; and the male leg 4 endopod is lamelliform and the basis has spines (some of them modified) at or above the insertion of endopod. A thorough systematic revision of the huge *Minutacaris* Jakobi, 1972 and its closely allied genera such as *Michelicaris*, *Italicocaris* Jakobi, 1972, etc., is necessary to further clarify whether the *brevipes*-group is monophyletic or not. And, there is no denying the fact that a lot more of revisionary work is essential for resolving the various phylogenetic conundrums in the Parastenocarididae.

Parastenocari enckelli stands out in the *brevipes*-group as a whole by a combination of the following characters: caudal ramus about three times as long as greatest width in dorsal view; lateral three setae inserted near the middle of ramus at the level of dorsal seta; aesthetascs on male and female antennules rather slender; male leg 3 ancestral proximal segment elongate and dilated at subproximal outer margin; thumb spiniform and only slightly shorter than the ladle-shaped apophysis; male leg 4 basal complex consisting of a chitinous plate together with two small hyaline lobes at its outer distal angle, and a moderately strong claw-like spine at its inner distal corner; endopod membranous, conical, shorter than first exopodal segment, and ornamented with 3 spinules at about midlength of anterior surface; leg 5 elongate, extending beyond the somite's limit, sexually isomorphic, bearing three smooth setae along oblique distal margin and an acute, spiniform process at inner distal corner; and female leg 4 endopod slender, about as long as proximal exopodal segment and with serrulate disto-lateral margins.

The hitherto known 12 species of the *brevipes*-group on the Indian subcontinent represent a blend of both primitive and derived taxa (see Karanovic & Lee 2012), and are distributed in the hyporheic and phreatic habitats in the tropical zone of Sri Lanka, the coastal deltaic belt of southeast and southwest Indian peninsula, and the subtropical Himalayas (*P. sutlej*). This distribution pattern in conjunction with the already known Gondwanan hyporheic taxa, viz. *Kinnecaris godavari* Ranga Reddy and Schminke, 2009, and *Siolicaris sandhya* (Ranga Reddy, 2001) on the southeastern Indian Peninsula (both these species often occur sympatrically with *P. gayatri* and/or *P. savita*), and *Himalayacaris alaknanda* Ranga Reddy, Totakura & Corgosinho, 2014, in the temperate zone of Himalayas (see also Ranga Reddy, 2011b), corroborates the viewpoint expressed by Karanovic & Lee (2012) that the *brevipes*-group originated not in the "tropical Asia", as hypothesised by Reid (1995), but "somewhere in the Gondwanaland in the rift valley between India and Western Australia, just before the separation of the Indian plate." Their further assertion that the disjunct distribution of the *brevipes*-group of species has come about by both vicariance and subsequent dispersal events sounds quite tenable, too. As one would expect, the Sri Lankan species are closely related to their Indian counterparts, and, as already mentioned, the Sri Lankan *P. curvispinus* is most common on the Indian peninsula.

The genus *Dussartstenocaris* was initially not assigned to either Parastenocaridinae or Fontinalicaridinae by Karanovic & Cooper (2011) for want of sound phylogenetic criteria. However, after performing the cladistic analysis of the *brevipes*-group of *Parastenocaris*, with *Proserpinicaris young* Karanovic, Cho & Lee, 2012, *Dussartstenocaris idioxenos* Karanovic & Cooper, 2011, and *Kinnecaris lakewayi* Karanovic & Cooper, 2011, as out-group taxa, Karanovic & Lee (2012) have found this genus to be "more closely related to *Proserpinicaris* than

to *Kinnecaris* or the *brevipes*-group" and hence provisionally placed it in Fontinalicaridinae. Similarly, a critical look at the morphology of *Dussartstenocaris bisetosa* shows that it also has a puzzling mix of the characters of both the subfamilies. Clearly, the phylogenetic validity of Schminke's (2010) subfamilial criteria needs a more incisive scrutiny (see Karanovic & Cooper 2011; Karanovic & Lee 2012; Ranga Reddy *et al*. 2014).

Within the family Parastenocarididae, *D. bisetosa* has the following criteria of Fontinalicaridinae: (i) coiled type of the male antennule with the ultimate segment pointing terminally. This character state, however, represents a plesiomorphy because it also occurs in most groundwater Ameiridae; (ii) female leg 3 endopod without apical seta; (iii) male leg 4 coxa with two large, modified inner spinules albeit not a row of small spinules; and (iv) caudal ramus with the lateral group of setae located at about midlength and the dorsal seta distally. On the other hand, its apparent relationships with the subfamily Parastenocaridinae include: (i) male leg 3 apophysis fused with apical seta; (ii) female genital field broader than high; (iii) fifth legs in both sexes small instead of being large; and (iv) male leg 1 basis bearing an inner seta.

Given its unique combination of characters, *D. bisetosa* entails the amendment of three of the seven putative autapomorphies of the genus *Dussartstenocaris* (see Karanovic & Cooper 2011b: 323) as follows: (i) the chitinous bulb on the inner margin male leg 3 exopod is either present or absent; (ii) the inner margin of leg 5 is either spinulose or smooth; and (iii) the female leg 3 endopod is either linguiform and ornamented or knob-like and smooth. These amendments together with the diagnostic characters of the new species are discussed below.

Caudal setae: both *D. bisetosa* and *D. idioxenos* have only two lateral setae, and the dorsal seta is inserted far distally. The lateral setae are located slightly anterior to the midlength of the ramus in the former species vs. 1/3 of ramus length in the latter. Such species-specific differences can be seen among the members of *brevipes*-groups as well. In other words, *D. bisetosa* satisfies the autapomorphy of *Dussartstenocaris* concerning the number and position of the caudal setae.

Male leg 3 exopodal thumb: though not elongate as in *D. idioxenos*, the thumb in the new species is complex but in its own unique way, consisting of three unequal apical lobes with hyaline margins, and somewhat longer than apophysis. We are of the opinion that since the complexity of the thumb is an important autapomorphy of the genus, its character state in the new species reflects a similar taxonomic content, thus fulfilling another autapomorphy of the genus.

According to Karanovic & Cooper (2011), the chitinous bulb on the inner margin of the male leg 3 exopod of *D. idioxenos* (absent in *D. bisetosa*) is an autapomorphy of the genus. We do not think that it is justifiable to assign *a priori* weight of a generic autapomorphy to this "bulb" because similar structures often prove to be only species-specific criteria. For example, a similar structure can be seen in *Parastenocaris brincki* and *Parastenocaris gundlakamma*. The proximal outer corner of the said segment in *Parastenocaris sutlej*, another member of the *brevipes*-group, has a prominent lobate structure (tubercle), which does not occur in any other species of the group, and so on.

Female leg 3 endopod: it is greatly reduced in both the species, being short, knob-like and unornamented in *D. bisetosa* vs. "linguiform" and ornamented in *D. idioxenos*. On the whole, the diminutive endopod seems to be diagnostic of the genus. Coincidentally, the character state of the endopod in *D. bisetosa* is just identical to what we have found in an undescribed Indian species belonging to a new genus of Parastenocaridinae (Ranga Reddy *et al*., in press)—an obvious case of convergent evolution.

Male leg 4: the construction of the endopod *per se* is essentially the same, i. e. claw-like, in both the species, barring the presence of one outer proximal spinule in *D. bisetosa*. The new species, however, differs from *D. idioxenos* by having two relatively long, modified outer spinules close to the base of endopod vs. four or five "large" spinules right at the base of endopod. Another spectacular apomorphy of the new species is the presence of two long modified spinules at the inner distal corner of coxa. Similar character state has also been reported in different phylogenetic lineages of the South American Fontinalicaridinae such as *Murunducaris dactyloides* (Kiefer, 1967), *Siolicaris sioli* (Noodt, 1963), *Siolicaris jakobi* (Noodt, 1963), etc. According to Corgosinho *et al.* (2010), the presence of two strong, blunt spinules on the anterior margin of the coxa surrounded by a hyaline region is an important autapomorphy of the typical South American genus *Brasilibathynellocaris* Jakobi, 1972. The character state in the new species is yet another case of convergence.

Leg 5: the fifth legs in *D. bisetosa* as well as *D. idioxenos* are sexually isomorphic, each leg bearing a short spiniform process at the inner distal corner—two autapomorphies of the genus, according to its original authors. However, *D. bisetosa* is apparently much different from its congener in that the fifth legs in both sexes are much

reduced in size vs. only relatively large, with smooth vs. ornamented inner margins, and each leg has two setae (outermost/ancestral basal seta missing) vs. three setae together with outermost seta. As already mentioned, the leg 5 is small in most groundwater Ameiridae. Hence this feature is a plesiomorphy for the species and also for Parastenocarididae (see Ranga Reddy *et al.* 2014). Also, treating the presence of spinules on the inner margins of the fifth legs of *D. idioxenos* as an autapomorphy of *Dussartstenocaris* is untenable because this feature is yet another species-level criterion. For example, even within the *brevipes*-group of species, the said spinules, though absent in both sexes of most species, can be seen in the males of *Parastenocaris noodti* (female not known) and in the females of *Parastenocaris savita*.

Leg 5 in Parastenocarididae, when present, carries a total of three or four, rarely five, setae, which include one outermost (ancestral basal) seta, and the remainder are ancestral endopodal setae. Additionally, a short or long spiniform process at the inner distal corner can occur in either males or both sexes. A reduction of the armature to only two setae, with or without the outermost seta, is seen only in a few species of certain genera. For example, in the *brevipes*-group, leg 5 has three or four setae, but only two endopodal setae in *P. brincki*. Similar is the case with *D. bisetosa*, *Parastenocaris toeroekae* Pónyi, 1957, etc. The outermost seta and only a single endopodal seta occur in both sexes of *Himalayacaris alaknanda*, *Kinnecaris arenicola* (Chappuis, 1954*), Parastenocaris fossoris* Fryer, 1956, etc., in the females of *Stammericaris amyclaea* (Cottarelli, 1969) (three setae in male*s)*, etc. Hence, the reduction in the number of armature elements on leg 5 appears to be a case of secondary loss, signifying no definite phylogenetic value.

The other important characters in which the new species differs from *D. idioxenos* include, respectively: animals small vs. large in size (body length 296–352 μm vs. 475–512 μm); cuticular windows on cephalothorax and on urosomites 2–5 in male and 2–4 in female are well delineated vs. "hardly visible"; anal somite with vs. without mid-ventral ornamentation; presence vs. absence of large ventral spinules on either side of anal sinus; and female leg 2 endopodal seta long vs. short.

Biogeographically, most of the typical Gondwanan derivatives of India occur in the peninsular region where its ancient, original floras and faunas evolved (Mani 1974: 700). In the area under the present investigation, *Dussartstenocaris* is the fifth Gondwanan stygobiotic copepod taxon so far known to be common to India and Australia. The other four taxa include *Allocyclopina* Kiefer, 1954, *Anzycyclops* Karanovic, Eberhard & Murdoch, 2011, *Halicyclops* Norman, 1903, and *Kinnecaris* (see Totakura & Ranga Reddy, 2015). *Chilibathynella* Noodt, 1963 and *Atopobathynella* Schminke, 1973 are the only known bathynellacean taxa common to the Indian plate and Australia (Ranga Reddy, 2011b). Phreatoicidean isopods are another well-known Gondwanan group distributed in India, Africa, Australia and New Zealand (Wilson, 2008). Both vicariance and subsequent dispersal events might have triggered the present distribution pattern of these taxa, as in the case of the *brevipes*-group of species. Future research in other parts of the Indian peninsula is likely to bring to light a host of other Gondwanan stygobiotic taxa.

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