BRILL

Crustaceana 89 (14) 1649-1667

CRUSTACEANA

FIRST RECORD OF THE GENUS *NITOCRELLA* CHAPPUIS, 1923 (COPEPODA, HARPACTICOIDA, AMEIRIDAE) FROM INDIA, WITH A NEW PHREATIC SPECIES

BY

Y. RANGA REDDY[1]) and V. R. TOTAKURA

Department of Zoology, Acharya Nagarjuna University, Nagarjunanagar 522 510, India

ABSTRACT

Nitocrella galassiae n. sp. is described from phreatic waters in Andhra Pradesh state located in southeastern peninsular India. This is the first representative of the genus *Nitocrella* Chappuis, 1923, described from the Indian subcontinent. Following Petkovski's (1976) revision of the genus *Nitocrella* s. str., the new species is assigned to the *chappuisi*-group of species. It differs from all other members of this group by a unique combination of the following characters: the male leg 1 basis has a short claw-like inner spine; the second exopodal segment of legs 1-4 has an inner seta; the apical endopodal segment of legs 2 and 4 has a single seta; leg 5 exopod in both sexes has three setae, and the baseoendopodal lobe has three setae in the female and two setae in the male; the male fifth antennular segment has a large aesthetasc; and the caudal ramus is 1.5 times as long as its greatest width and about 0.7 times as long as the anal somite. Among the hitherto known species of the *chappuisi*-group, the new species shows an allegedly close relationship with the Iranian *N. petkovskii* Pesce, 1980. A brief note on the ecology of the new species is also added.

ZUSAMMENFASSUNG

Nitocrella galassiae sp. n. wird aus dem Grundwasser des Bundesstaates Andhra Pradesh im Südosten der indischen Halbinsel beschrieben. Es handelt sich um den ersten Vertreter der Gattung, der vom indischen Subkontinent beschrieben wird. Gemäß Petkovskis Revision der Gattung *Nitocrella* s. str. wird die neue Art der *chappuisi*-Artengruppe zugeordnet. Sie unterscheidet sich von den anderen Mitgliedern dieser Gruppe durch eine einzigartige Kombination der folgenden Merkmale: die Basis des ersten Beines der Männchen trägt eine kurze, klauenartige innere Borste; das zweite Exopoditensegment der Beine 1-4 hat eine innere Borste; das apikale Endopoditensegment der Beine 2 und 4 hat eine einzelne Borste; der Exopodit der fünften Beine hat drei Borsten in beiden Geschlechtern, und der baseoendopodale Lobus dieser Beine trägt beim Weibchen drei, beim Männchen fünf Borsten; das fünfte Antennenglied der Männchen trägt einen mächtigen Aesthetasken; die Furkaläste sind 1,5 mal länger als ihre größte Breite und 0,7 mal so lang wie das Analsegment. Von den bisher bekannten Arten der *chappuisi*-Gruppe scheint die neue Art der iranischen *N. petkovskii* Pesce, 1980 nahe zu stehen. Abschließend folgt eine kurze Bemerkung zur Ökologie der neuen Art.

[1]) Corresponding author; e-mail: yrangareddyanu@gmail.com

DOI 10.1163/15685403-00003590

INTRODUCTION

Our ongoing investigations on the stygobiotic crustaceans of hyporheic and phreatic habitats and some caves of India, especially in the coastal deltaic belt of the Rivers Krishna and Godavari in the Andhra Pradesh state of the southeastern peninsular zone, have so far yielded about 80 new species. Of these, 60 species have been described formally (see Totakura & Ranga Reddy, 2014, 2015; Totakura et al., 2014, 2016; Wilson et al., 2015; Elia et al., 2016; Ranga Reddy et al., 2016), but none of them belongs to the predominantly marine family Ameiridae Monard, 1927. A new stygobiotic species of the ameirid genus *Nitocrella* Chappuis, 1923, viz. *Nitocrella galassiae* n. sp., has been collected for the first time in the phreatic freshwaters of certain bore wells in the Andhra Pradesh state of the southeastern peninsular India. The new species belongs to Petkovski's (1976) *chappuisi*-group of *Nitocrella* Chappuis s. str.

This paper gives an illustrated description of *Nitocrella galassiae* n. sp. and discusses its morphologic relationships with allied members of the *chappuisi*-group. A brief note on the ecology of the new species is also given.

MATERIAL AND METHODS

At the type locality, a bore well, the specimens studied were collected by filtering the groundwater through a bolting-silk plankton net (mesh size 70 μm); the net was tied to the end of the inlet delivery tube that opens into an overhead storage tank and left it there for five or six hours, until the tank was filled to the brim (fig. 1b). At other localities where the water was pumped out of farm bores (depth ca. 10 m) filtering was done by manually holding the plankton net against the water current for 20-30 min at each time of sampling (see Ranga Reddy & Totakura, 2012, fig. 1B). The filtrate was fixed in 5% formaldehyde.

Back in the laboratory, the specimens were sorted under a dissecting microscope, stored in 70% alcohol, and later immersed in glycerol. Dissection was carried out in glycerol under a binocular stereomicroscope 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 a UCA condenser, IC objective prism and 1-2× magnification changer. Permanent preparations were mounted in glycerol. The type material was deposited in the Muséum national d'Histoire naturelle (MNHN), Paris, France.

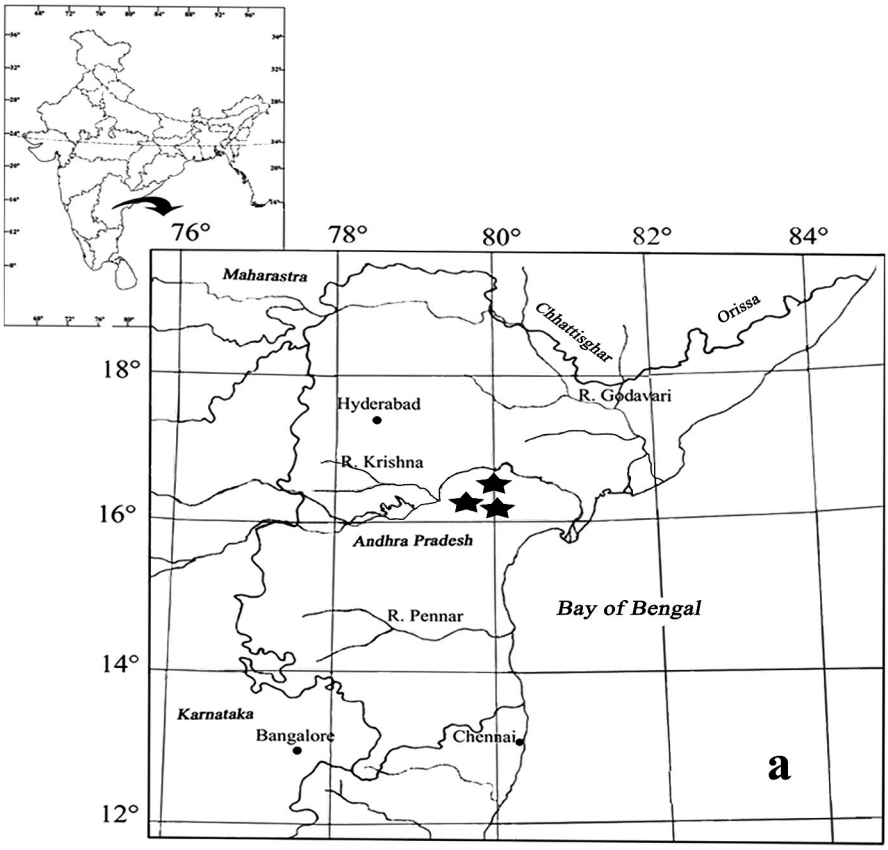

Fig. 1. (a) Map showing the distribution of *Nitocrella galassiae* n. sp. (★); (b) sampling of type locality. This figure is published in colour in the online edition of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/15685403.

SYSTEMATIC ACCOUNT

Order HARPACTICOIDA Sars, 1903
Family AMEIRIDAE Monard, 1927
Subfamily AMEIRINAE Monard, 1927
Genus *Nitocrella* Chappuis, 1923
Nitocrella galassiae n. sp. (figs. 2-8)

Type locality.— India, Andhra Pradesh, Guntur district, bore well, Block-II, Acharya Nagarjuna University campus at Nagarjunanagar (16°22′41.0″N 80°31′39.4″E; elevation 19.8 m; water temperature 24-34°C; pH 7.0-7.5; DO 3.9 mg/l; conductivity 955 μS/cm; TDS 557 mg/l; turbidity 0.96 NTU; salinity 0.69‰), approximately 12 km from Guntur city in Guntur District, Andhra Pradesh, South India (fig. 1). The well is about 55 m deep and accesses an aquifer developed in garnet-sillimanite gneiss ("khondalite") bedrock, belonging to the Eastern Ghats group, which is approximately 3000 million years old. There is good evidence that the type locality was exposed to marine waters at one or more times during the Cenozoic (see Distribution and ecology).

Type material examined.— Female holotype (MNHN-IU-2013-11902), dissected on 4 slides; male allotype (MNHN-IU-2013-11903) dissected on 3 slides; 9 paratypes: 1 female (MNHN-IU-2013-11904) dissected on 4 slides, 1 male (MNHN-IU-2013-11905), dissected on 3 slides, 1 female (MNHN-IU-2013-11906) and 1 male (MNHN-IU-2013-11907), whole-mounted on 1 slide each, and 2 males and 3 females in junior author's personal collections; January 2006-January 2008, Coll. Y. Ranga Reddy.

Other localities and material examined.— India, Andhra Pradesh, Guntur district, bore at Neerukonda village (16°32′19.8″N 80°39′17.6″E; elevation 30 m, water temperature 27°C; pH 7.0), 3 July 2008: 3 females; bore at Kaza village (16.3906°N 80.5425°E; elevation 22 m) near Nagarjunanagar, 24 December 2010: 2 females (water temperature 27°C; pH 7.0); Coll. V. R. Totakura.

Description of adult female.— Total body length, measured from tip of rostrum to posterior margin of caudal rami (excluding caudal setae) 439-506 μm. Preserved specimen colourless. Nauplius eye absent. Habitus (fig. 2a, b) cylindrical and slender, with thin, slightly perforated cuticle, and without distinct demarcation between prosome and urosome; prosome/urosome ratio about 0.8 in dorsal view and greatest width in dorsal view occurring in distal half of cephalothorax. Free pedigerous somites without lateral or dorsal expansions, and ornamented as depicted in fig. 2a. Integument without windows. Body length/width ratio about 5.4; all somites connected by well-developed arthrodial membranes. Genital-double somite and succeeding somites with 1 transverse row of spinules ventro-distally and dorso-laterally as in fig. 2a, b; prosomites with narrow hyaline fringes dorsally and ornamented with sensilla and pores (no cuticular pits). Rostrum (fig. 2b) very small, subtriangular, membranous, fused to cephalothorax and ornamented with 2 long sensilla on dorsal surface.

Cephalothorax (fig. 2a): subquadrate, somewhat swollen distally, about 1.2 times as long as wide in dorsal view, representing 19% of total body length; surface of cephalic shield ornamented with 12 pairs of sensilla as illustrated (no

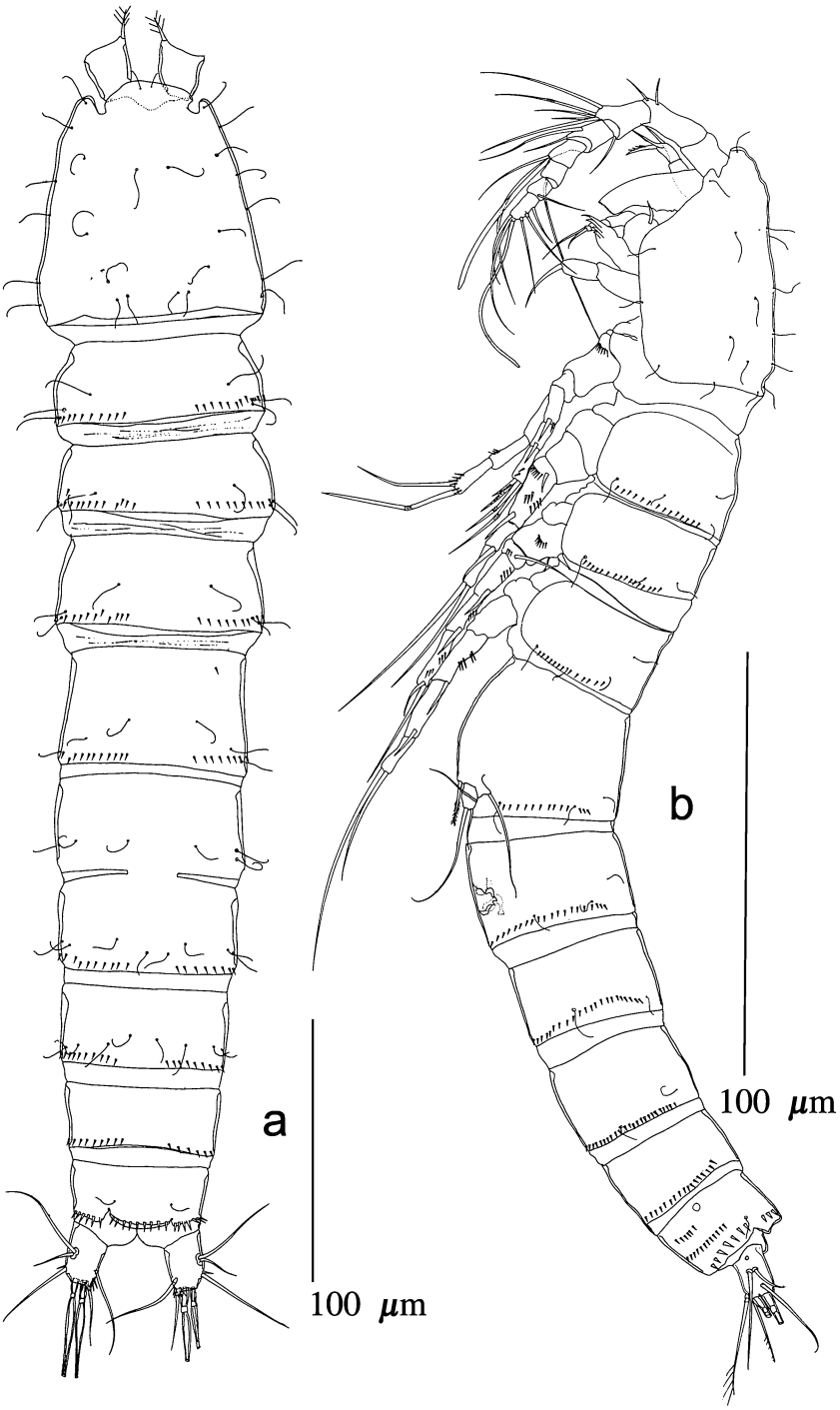

Fig. 2. *Nitocrella galassiae* n. sp., female paratype habitus. (a) dorsal; (b) lateral.

other ornamentation). Second pedigerous somite slightly shorter than third one, with 3 pairs of large sensilla. Prosomites 2-4 gradually increasing in length behind and ornamented with 3 pairs of large posterior sensilla each.

Urosome (fig. 2a): genital double-somite widest and other urosomites gradually narrowing behind. Hyaline fringes on urosomites narrow and smooth; first urosomite longer than fourth prosomite and ornamented with 3 pairs of sensilla. Genital double-somite 1.2 times as long as wide in dorsal and ventral views, subdivided by chitinous stripe on dorso-lateral and ventro-lateral regions; dorso-lateral stripe interrupted at midlength, but complete ventro-laterally; ornamented with 1 irregular transverse row of small spinules on postero-ventral surface, 6 pairs of sensilla (3 proximal pairs, 3 distal pairs) dorsally and 1 pair of larger sensilla ventrally. Genital field as shown in fig. 3a. Third urosomite shorter than first one, ornamented with 1complete transverse row of small spinules on ventral surface and 5 pairs (4 pairs dorsal and 1 pair ventral) of long sensilla. Preanal somite about as long anal somite, with transverse row of spinules on ventral surface near posterior border and as usual without sensilla. Anal somite with 2 short transverse spinular rows dorso-laterally, 1 transverse spinular row mid-ventrally, and also at base of each ramus ventrally and 2 pores ventro-distally. Anal operculum moderately developed, representing 49.2% of somite's width, ornamented with 1 row of relatively large spinules dorso-distally and hyaline frill on free margin. Anal sinus wide, smooth.

Caudal rami (figs. 2a, 3a): slightly divergent, short, 1.5 times as long as greatest width (dorsal), and about 0.7 times as long as anal somite; distal region slightly narrow; with full complement of 7 setae (3 lateral, 1 dorsal and 2 apical, 1 subapical) and with small spinules on postero-ventral region and 1 spinule at base of disto-lateral seta. Dorsal seta (VII) slender and simple, inserted at distal-third of ramus length, about 1.5 times as long as caudal ramus articulate at base. Inner apical seta (VI) smooth, arising from small protrusion, about as long as ramus. Middle apical seta (V) slender, with breaking plane, about 10.8 times as long as ramus, curved outwards distally and with acute tip. Outer apical seta (IV) relatively strong, also with breaking plane and bipinnate, about 4.9 times as long as ramus, inserted close to dorsal surface and sparsely bipinnate; setae IV and V slightly dilated just beyond fracture plane. Proximo-lateral setae (I-II) and disto-lateral seta (III) smooth and unequal.

Antennule (fig. 3b): 8-segmented, slender, approximately 1.2 times as long as cephalothorax; aesthetasc on fourth segment very long, reaching beyond ultimate segment; setal formula as follows: 1.10.5.3 + ae.1.2.4.6 + ae; first segment with spiniform, strong and bipinnate seta; all other setae smooth; 1 seta on second segment and 4 setae on eighth segment articulate basally, and 1 seta on sixth

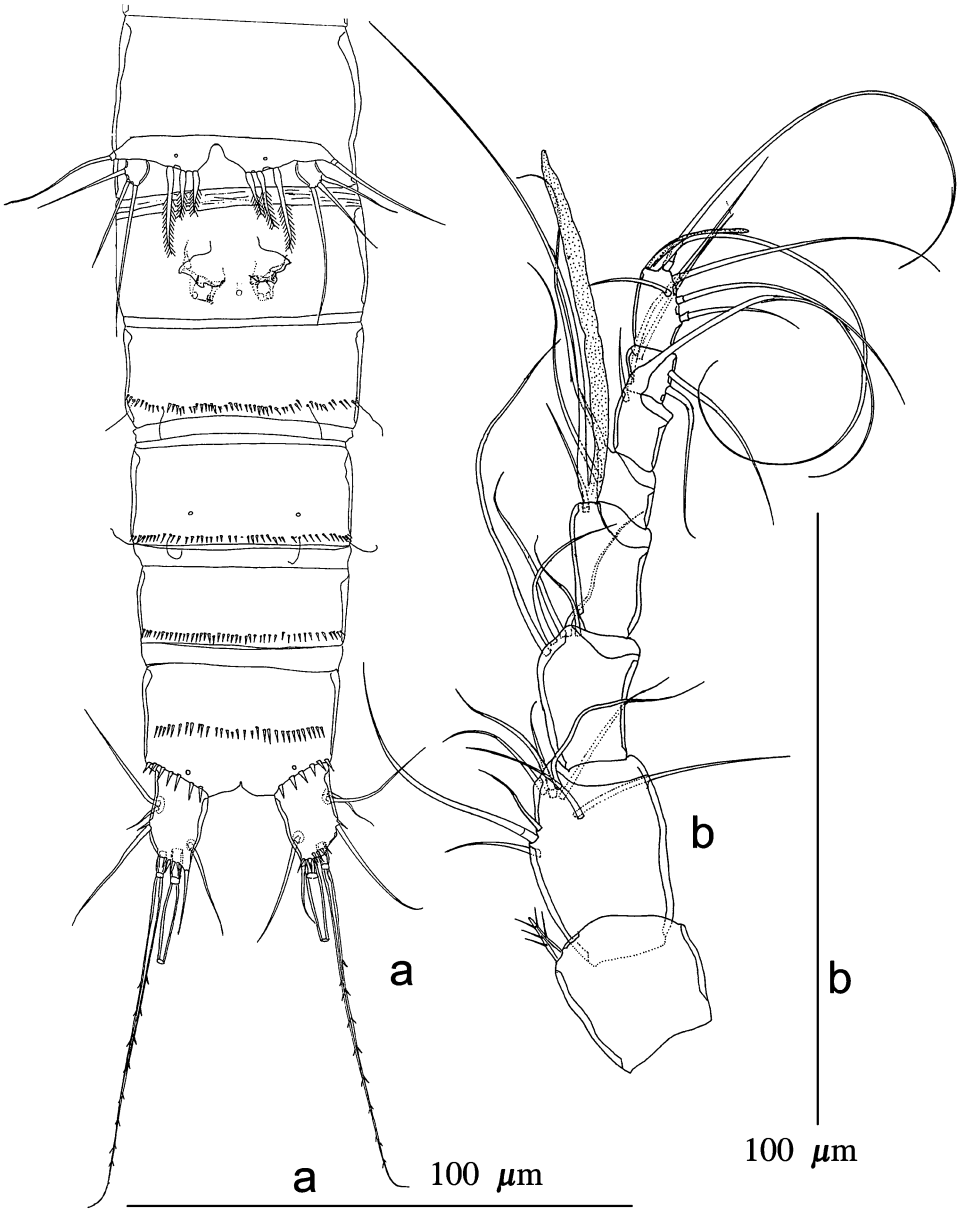

Fig. 3. *Nitocrella galassiae* n. sp., female holotype. (a) urosome ventral; (b) antennule, ventral.

segment with dilated base. Length ratio of antennular segments along middle axis 1.0 : 1.5 : 1.0 : 0.9 : 0.4 : 0.5 : 0.4 : 0.6.

Antenna (fig. 4a): moderately strong, composed of coxa, basis, 2-segmented endopod and 1-segmented exopod. Coxa very short, unornamented. Basis about

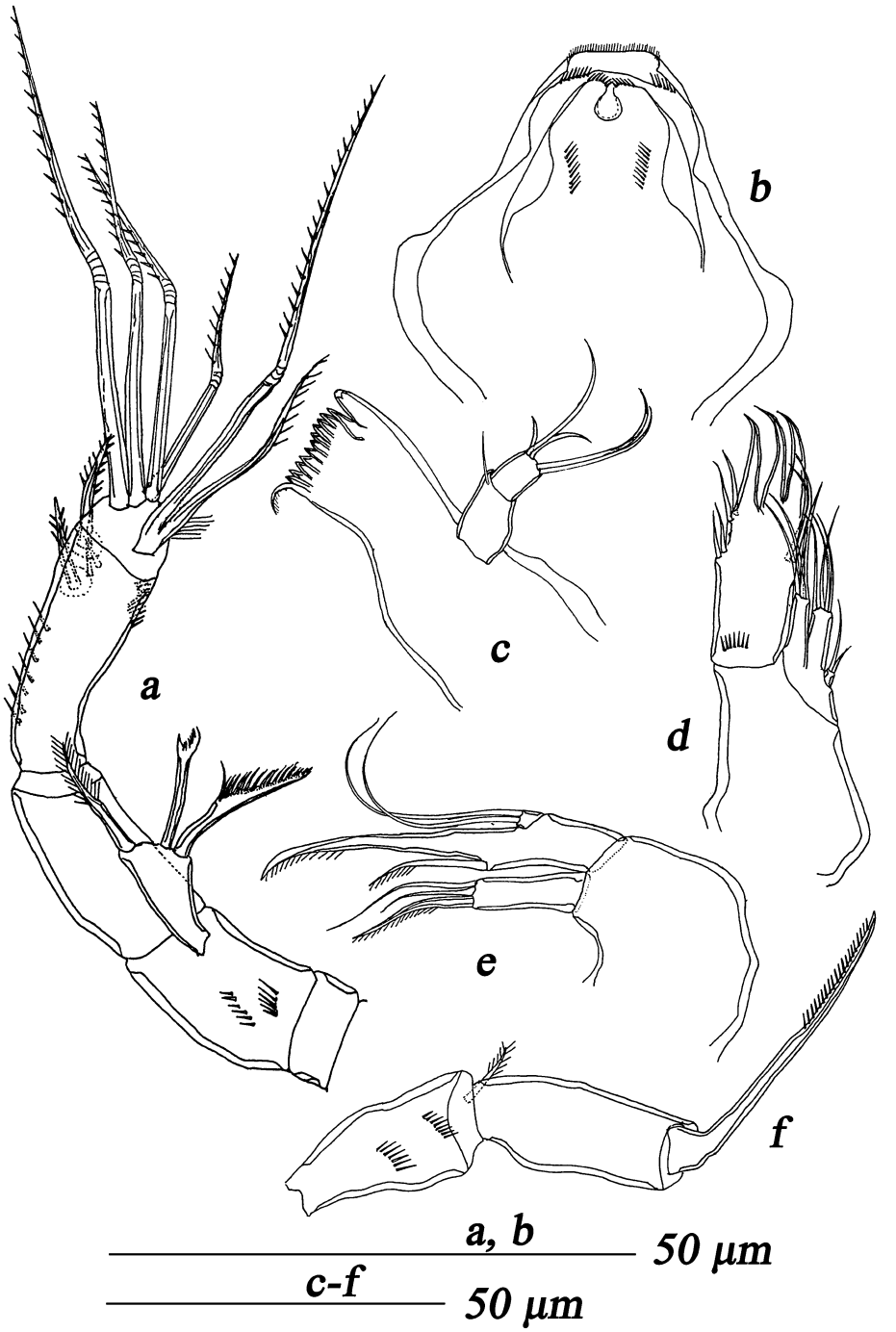

Fig. 4. *Nitocrella galassiae* n. sp., female holotype. (a) antenna, lateral; (b) labrum, ventral; (c) mandible, lateral; (d) maxillule, lateral; (e) maxilla, lateral; (f) maxilliped, lateral.

1.7 times as long as wide, ornamented with 2 medial rows of spinules on proximal surface. First endopodal segment 1.4 times as long as basis, unornamented and unarmed. Second endopodal segment longest, 1.3 times as long as first endopodal segment and 2.8 times as long as wide, armed with 2 ventro-lateral spines near inner margin and 5 strong and geniculate setae, anterior one fused basally to smaller seta, bearing tuft of fine setules proximally and unipinnate distally; ornamentation consisting of moderate spinules along inner margin and 2 rows of small spinules on subdistal outer margin. Exopod 1-segmented, distinctly dilated distally, fan-like, 2.2 times as long as maximum width, 0.6 times as long as first endopodal segment and armed with 1 apical, bipinnate seta and 2 subapical, modified setae; inner subapical seta about as long as apical seta, but shorter than outer subapical seta, which is strong and somewhat comb-like.

Labrum (fig. 4b): subtriangular, sclerotized, with relatively broad and convex cutting edge, ornamented apically with hair-like spinules, and subapically with 2 rows of stronger spinules; 2 oblique rows of spinules on sub-proximal ventral surface.

Mandible (fig. 4c): coxal gnathobase moderately long; cutting edge with 2 coarse teeth ventrally, 1 unipinnate seta dorsally and several small teeth in between. Palp uniramous, comprising basis and 1-segmented endopod. Basis slightly longer than wide, 1.4 times as long as wide, 1.7 times as long as endopod and armed with 1 small seta near inner distal corner. Endopod rectangular and armed with 5 slender, smooth setae apically.

Maxillule (fig. 4d): large praecoxa, arthrite of which rectangular, ornamented with 1 crescentic row of spinules basally and with 2 anterior surface setae, 2 lateral elements and 5 apical elements: 3 fused spines and 2 setae. Coxal endite armed with 1 curved pinnate spine and 2 smooth setae. Basis slightly shorter than coxal endite, armed with 4 smooth setae apically. Endopod represented by minute segment, bearing 2 smooth, apical setae, outer seta 0.6 times as long as inner one.

Maxilla (fig. 4e): syncoxa unornamented and with just distal endite, proximal endite being completely reduced; distal endite well developed, highly mobile, armed with 1 curved pinnate spine and 2 smooth, unequal setae. Basis drawn out into long claw, bearing short spiniform and curved seta at base. Endopod represented by small but distinct segment, having 2 smooth equal apical setae.

Maxilliped (fig. 4f): syncoxa ornamented with 2 arched rows of strong spinules, and armed with 1 bipinnate seta subapically. Basis 2.3 times as long as wide, unornamented and unarmed. Endopod represented by a long curved claw, which is serrulate on inner distal margin, and 1.6 times as long as basis.

Legs 1-4 (figs. 5a-b, 6a-b): exopod 3-segmented; leg 1 endopod also 3-segmented (fig. 5a), while endopod of legs 2-4 2-segmented (figs. 5b, 6a-b). Legs 1-4

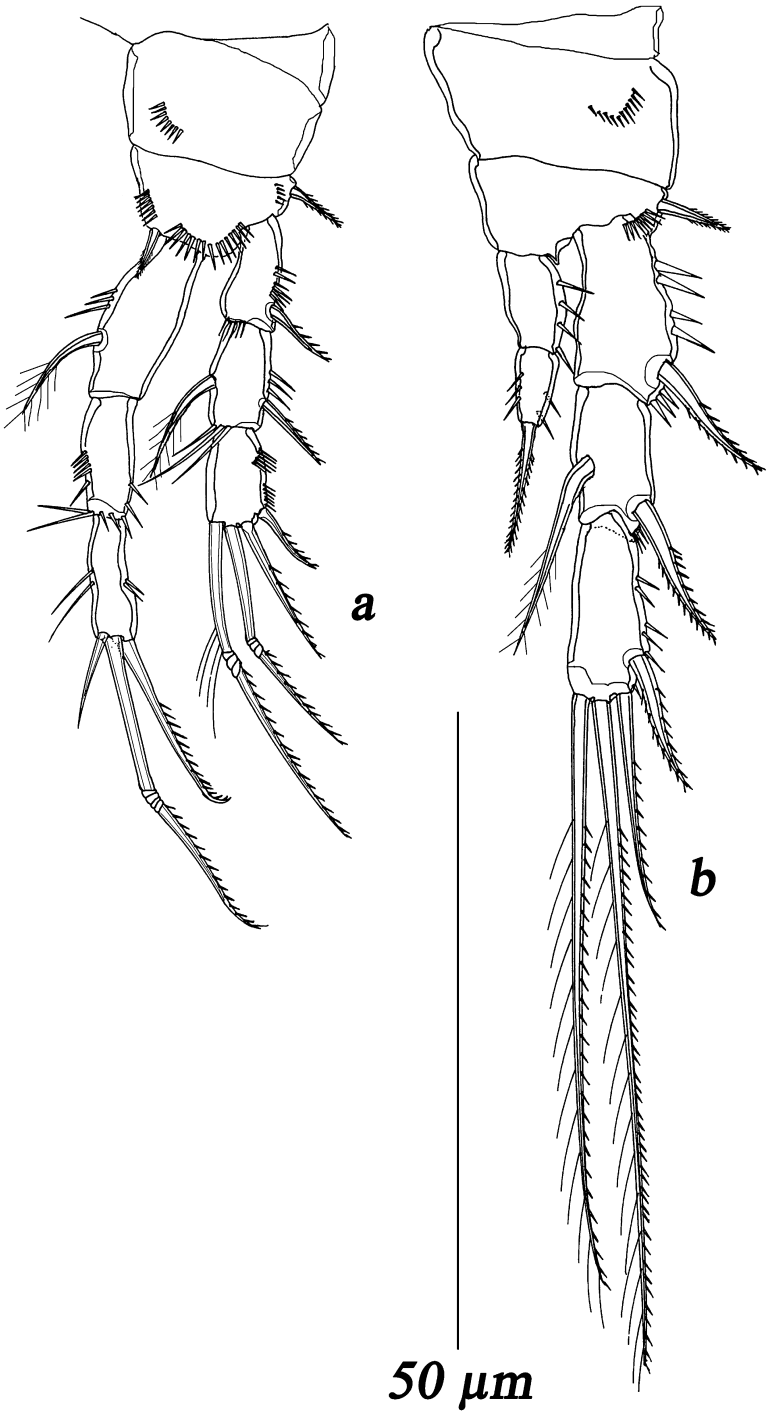

Fig. 5. *Nitocrella galassiae* n. sp., female holotype. (a) leg 1, anterior; (b) leg 2, anterior.

armature formula as follows (legend: inner/outer spine or seta; inner/apical/outer):

	Exopod			Endopod		
	1	2	3	1	2	3
Leg 1	0/1	1/1	0/2/2	1/0	0/0	1/2/0
Leg 2	0/1	1/1	0/2/2	0/0	0/1/0	–
Leg 3	0/1	1/1	0/2/2	0/0	1/1/0	–
Leg 4	0/1	1/1	1/2/2	0/0	0/1/0	–

Intercoxal sclerite of legs 1-4 with concave distal margin and without surface ornamentation (illustrated for leg 3 only; fig. 6a). Praecoxa small, unornamented. Coxa with 1 arched row of spinules on anterior surface. Basis ornamented with long spinules near outer distal corner, but leg 1 basis with 2 additional rows of spinules: 1 row at inner distal corner and 1 row between exopod and endopod, and armed with bipinnate outer spiniform seta on legs 1 and 2, and with outer smooth seta on legs 3 and 4; basis of first leg with short spine on inner distal corner. Almost all exopodal and endopodal segments of legs 1-4 ornamented with long spinules along outer margins. First exopodal segment of legs 1-4 about as long as second segment. Leg 1 (fig. 5a) first endopodal segment of stout, about twice as long as wide, 0.7 times as long as first 2 exopodal segments combined; endopod 1.2 times as long as exopod. Endopod of legs 2-4 about 0.6 times as long as first 2 exopodal segments combined.

Leg 5 (fig. 3a): biramous, baseoendopods fused basally. Basal seta of baseoendopod long and simple and arising from long setophore. Baseoendopodal lobe nearly flat, not extending up to middle of exopod, unornamented and armed with 3 unequal bipinnate setae, increasing in length from inner to outside, inner one being shortest. Exopod ovate, unornamented and armed with 1 lateral and 2 apical setae; length ratio of setae (from inner side) 1.0 : 1.2 : 2.0.

Leg 6 (fig. 3a): greatly reduced, with 1 short seta and 2 rather tiny spinules.

Description of adult male.— Body length, excluding caudal setae, 431-492 μm. Habitus (fig. 7a), ornamentation of prosomites, rostrum, colour and nauplius eye as in female. Hyaline fringes of all somites smooth; spinular ornamentation of urosomites as in fig. 7a, b.

Caudal rami (fig. 7a, b): subovate, cylindrical, parallel, with basal space between them as long as ramus width and 1.6 times as long as greatest width; armature and ornamentation almost as in female. A single large, longitudinally placed spermatophore (fig. 7b) visible through somites 5-7, about 3.7 times as long as wide, bean-shaped, with narrow and curved neck.

Antennule (fig. 8a): long, moderately strong, 10-segmented and strongly geniculate between segments 7 and 8. A massive aesthetasc on apical acrotheck of fifth

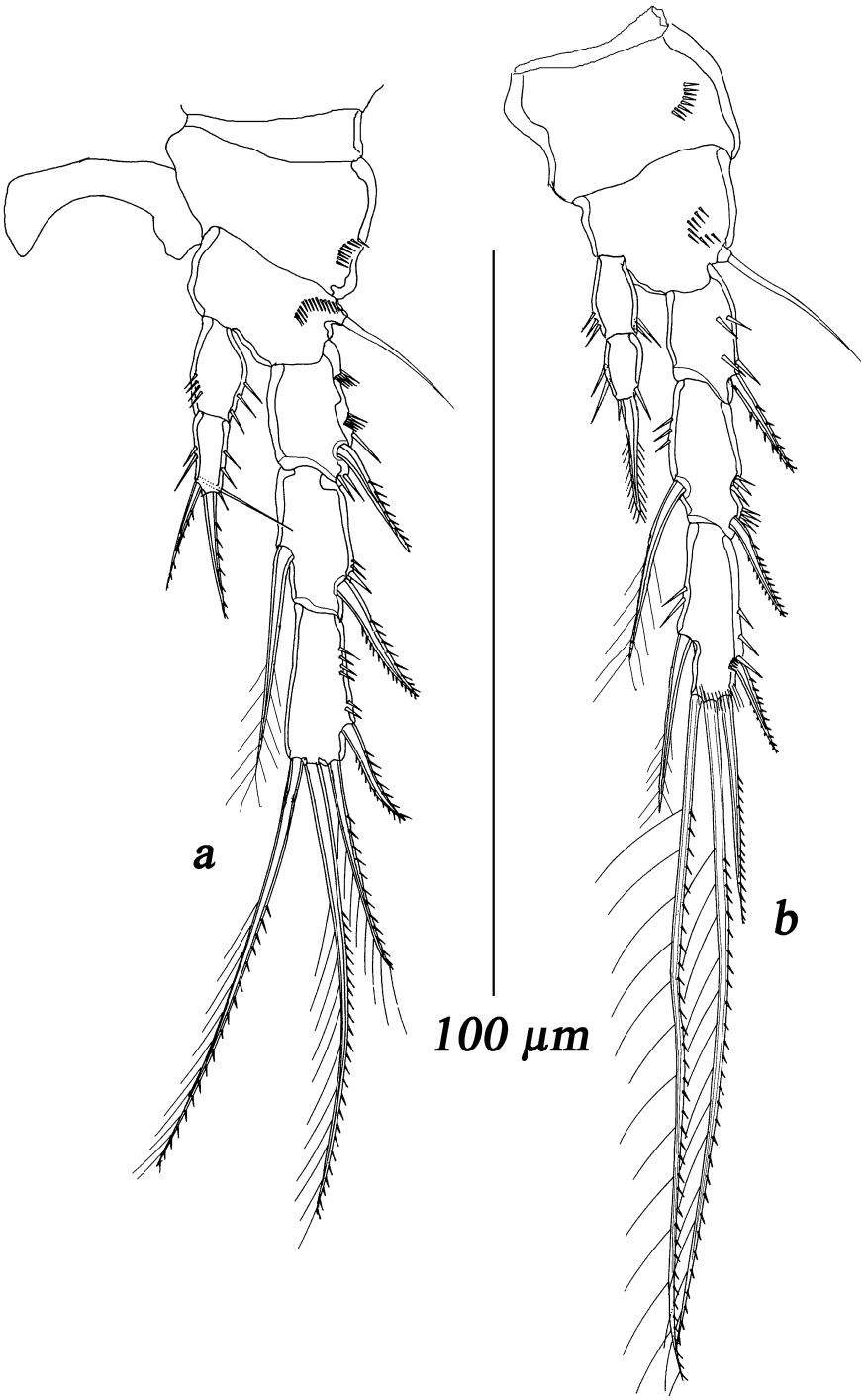

Fig. 6. *Nitocrella galassiae* n. sp., female holotype. (a) leg 3, anterior; (b) leg 4, anterior.

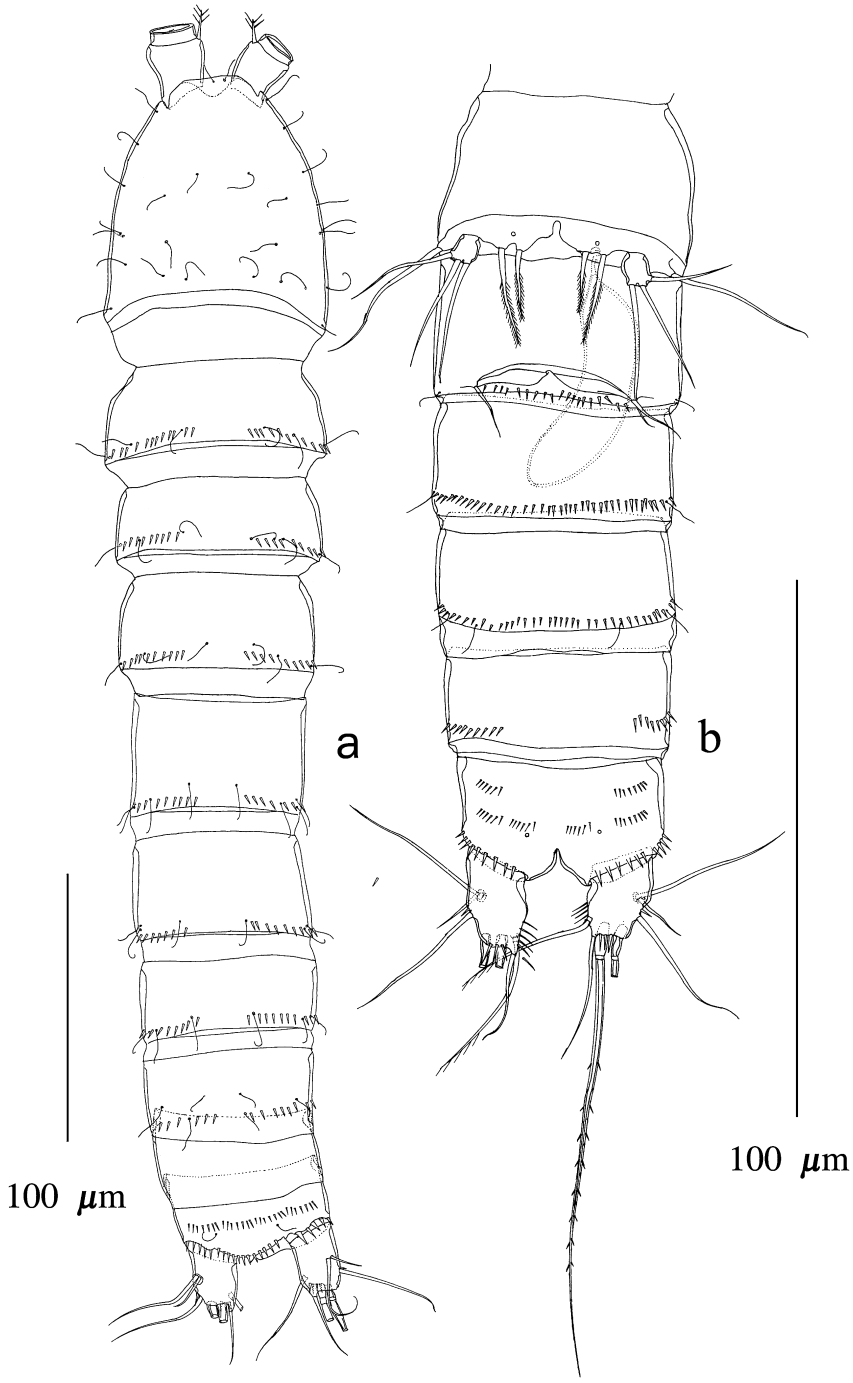

Fig. 7. *Nitocrella galassiae* n. sp., (a) male paratype, habitus, dorsal; (b) male allotype, urosome, ventral.

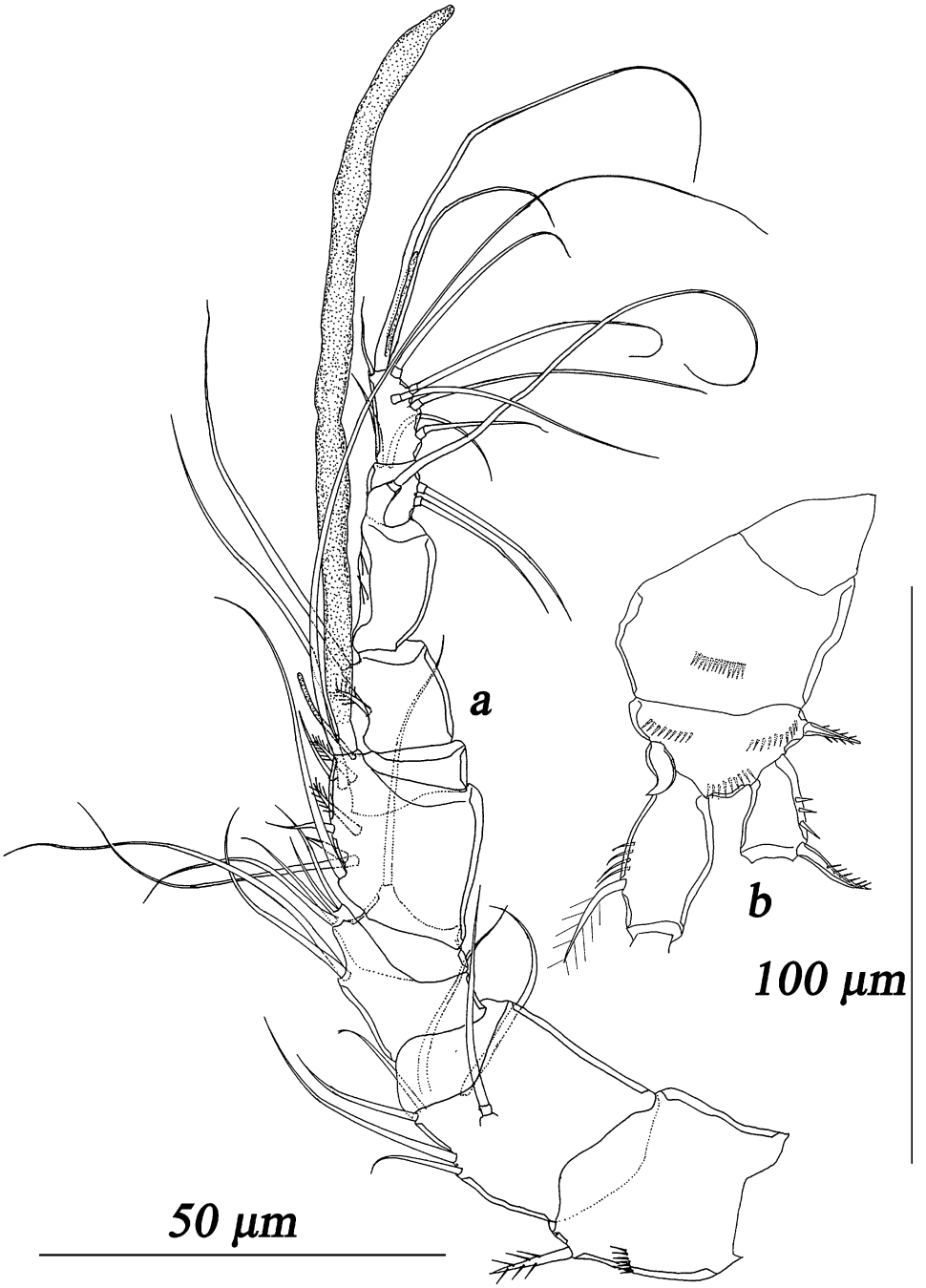

Fig. 8. *Nitocrella galassiae* n. sp., male allotype. (a) antennule, ventral; (b) leg 1 (in part), anterior.

segment, homologous to aesthetasc on fourth segment in female; sixth segment with slender aesthetasc subapically. Setal formula as follows: 1.7.6.1.8 + aes.1 + aes.2. 3.4.8 + aes. All setae smooth, except 1 spiniform seta each on segments 5, 6 and 7, 2 spinous processes on segment 8, and 1 bipinnate seta on segment 1. Segments 2, 6, 9 and 10 with basally articulate 1, 1, 2 and 4 setae, respectively. First segment ornamented with transverse row of spinules on anterior surface; other segments unornamented, except spiniform cuticular processes on seventh and eighth segments. Length ratios of antennular segments from medial axis 1.0 : 1.2 : 0.6 : 0.3 : 0.9 : 0.4 : 0.6 : 0.8 : 0.4 : 0.6.

Leg 1 (fig. 8b): inner spine on basis modified, hook-like and smooth. Other details similar to female.

Leg 5 (fig. 7b): baseoendopods of both legs fused medially. Baseoendopodal lobe almost flat, armed with 2 unequal pinnate setae, inner seta shorter. Exopod same as in female.

Leg 6 (fig. 7b): small, narrow, symmetrical chitinous plate, bearing only 1 smooth seta.

Antenna, labrum, mandible, maxillule, maxilla, maxilliped and legs 2-4 similar to female.

Etymology.— The new species is named in honour of Dr. D. M. P. Galassi, in recognition of her significant contributions to the systematics of groundwater copepods. The name thus is a noun in the genitive singular.

Distribution and ecology

The new species was collected on several occasions from the phreatic waters of the type locality between 2000 and 2010. In addition, it was found in two other bores, both of which are within a radius of 5-10 km of the type locality, and all the three wells are about 40 km from the present coastline of the Bay of Bengal. The region around the type locality is underlain by an ancient metamorphic basement rock called Charnockite. Relatively recent (Holocene) lateritic formations of up to 6 m thick occur above the basement formation, and exposed remnants of Upper Gondwana formations (sandstones ca. 90 million years before present) occur approximately 12 km southeast of the type locality. Based on the studies of onshore sediments in the nearby Repalle area (Appajee & Prabhakar, 1985) and paleostrandline (ancient beach ridges) positions in the Krishna River delta as delineated by aerial photography (Nageswara Rao & Vaidyanadhan, 1978), it is clear that during the Holocene the sampling sites were submerged under shallow marine waters. Additional satellite image studies and surface expressions in the form of beach ridges (cf. Gupta, 1989) indicate that marine transgressions occurred in the vicinity of the basin between the Krishna and Godavari Rivers and extended

inland up to 40 km from the present coastline. The presence of the new species in freshwater bores near the coast of the Bay of Bengal in areas that sustained marine transgressions during the Cenozoic seems to corroborate the viewpoint expressed by Galassi & De Laurentiis (1997) that the predominant occurrence of *Nitocrella* species in subterranean freshwaters is a case of secondary invasion.

At the type locality, the new species was accompanied on different occasions by several stygobiotic crustaceans, viz., *Habrobathynella nagarjunai* Ranga Reddy, 2002 (Bathynellacea), *Haplocyclops* (*Kiefercyclops*) *fiersi* Karanovic & Ranga Reddy, 2005, *Indocaris imbricata* Ranga Reddy, Totakura & Shaik, 2016, and *Rybocyclops* sp. (Copepoda), *Bogidiella indica* Holsinger, Ranga Reddy & Messouli, 2006 (Amphipoda), *Indocandona nagarjuna* Karanovic & Ranga Reddy, 2008 (Ostracoda), *Andhracoides* sp. (Isopoda), besides the stygoxenic/stygophilic ostracod, *Strandesia purpurascens* (Brady, 1886), and some unidentified nematodes and mites.

REMARKS

It was Lang (1965) who first revised the genus *Nitocrella* Chappuis, 1923. The systematics of this genus were subsequently reviewed by Petkovski (1976), who, inter alia, recognized *Nitocrella* Chappuis s. str. simply on the basis of two-segmented endopod of legs 2-4, and divided all the then known 35 species and subspecies into three broad specie-groups by a simple and sole criterion of the number of setae on the apical exopodal segment of leg 4: (i) the "*vasconica*"-group with six setae; (ii) the "*chappuisi*"-group with five setae; and (iii) the "*hirta*"-group with three or four setae. Petkovski (1976) also provided identification keys to the then known species and subspecies of these groups. Thereafter, several new species have been added to this genus. The latest World Copepoda database (Walter, 2016) lists under it 87 species and subspecies, which are relatively widely but discontinuously distributed in the subterranean freshwater and brackish environments of the world (Galassi & De Laurentiis, 1997). The systematics of the genus *Nitocrella* s. str. as a whole are on shaky grounds (see Lee & Huys, 2002; Karanovic, 2004; Cottarelli et al., 2007), and so the rationale behind the phylogenetic criteria proposed by the early revisers needs a more critical scrutiny. Pending a thorough systematic revision of the genus based on pithy phylogenetic characters, including mouthparts morphology as well, Petkovski's species-groups, as rightly observed by Karanovic (2004) and Cottarelli et al. (2007), can be used for "a first taxonomic screening of the species".

Nitocrella galassiae n. sp. fits Petkovski's (1976) *chappuisi*-group by possessing five setae on leg 4 third exopodal segment. It can be easily separated from all

other species of this group by a unique combination of the following characters: body characteristically ornamented, as already described; leg 1 basis with a short claw-like inner spine in male, but this element is less transformed if compared to its character state in other *Nitocrella* species such as *N. ensifera* Cottarelli, Bruno & Berera, 2007, *N. pescei* Galassi & De Laurentiis, 1997 and *N. kunzi* Galassi & De Laurentiis, 1997, even if belonging to different "groups"; first endopodal segment of leg 1 with inner seta and third segment with three armature elements; second exopodal segment of legs 1-4 with inner seta; apical endopodal segment of legs 2-4 with 1, 2 and 1 setae, respectively; leg 5 exopod in both sexes with three setae, and baseoendopodal lobe with three setae in female and two setae in male; male fifth antennular segment with large aesthetasc; and caudal ramus 1.5 times as long as greatest width and about 0.7 times as long as anal somite.

At this juncture it is difficult to identify which among the known members of the *chappuisi*-group could be the sister species of the new species. *N. galassiae* n. sp. has very close morphologic resemblance with *N. petkovskii* Pesce, 1980 from Iran, especially in the overall armature details of legs 1-5. The new species, however, can be easily distinguished from *N. petkovskii* mainly by the following features: caudal ramus 1.5 times as long as wide vs. as long as maximum width; female genital-double somite long vs. short; subapical (proximal) setae of antennary exopod modified vs. normal; inner seta on second exopodal segment of leg 1 present vs. absent; first endopodal segment of leg 1 short vs. long; second endopodal seta or setae short vs. long; and P5 exopod with three vs. four setae (see Pesce, 1980). The new species is also somewhat closely related to the Chinese *N. hypogaea* Shen & Tai, 1973, in having identical setal armature on the second endopodal segment of the legs 2-4, and a large aesthetasc on the fourth segment of the male antennule. In all other respects, however, the two species are distinctly different from each other (see Shen & Tai, 1973). The new species also resembles certain European species, viz., *N. rhodiensis* Pesce, 1983, *N. achaiae* Pesce, 1981, *N. stammeri* Chappuis, 1938 and *N. ensifera*, in the setal armature of the third exopodal segment of legs 2-4 and of the first endopodal segment of leg 1. However, it is quite distinct from the European species, inter alia, in the following features: the number of armature elements on leg 5 baseoendopod and exopod; length-width ratio of caudal ramus; the position of the lateral caudal setae; the details of the body ornamentation. Since the details of the oral parts are not available for all the aforementioned species except *N. ensifera*, no detailed comparison is possible. The new species differs from *N. ensifera*, mainly by having one seta vs. none on the basis of the mandibular palp, two setae vs. one seta on the endopod of maxillule, and three vs. two setae on the endite of the syncoxa of maxilla. Similar setal differences in the oral parts corroborate their phylogenetic value in the systematics of *Nitocrella*, as already highlighted by Galassi & De Laurentiis (1997), Karanovic (2004), Cottarelli et al.

(2007) and others. Future research in peninsular India is quite likely to bring to light several species that are more decisively allied to the new species.

ACKNOWLEDGEMENTS

We gratefully acknowledge the funding support provided by the Department of Science and Technology, Ministry of Science and Technology, and the Ministry of Environment, Forests and Climate Change, Government of India, New Delhi, under the Research Projects, SR/SO/AS-21/2011, and 22018/08/2010-CS(Tax), respectively. We express our sincere gratitude to Prof. Dr. V. Cottarelli and Prof. Dr. Apostol Apostolov for their valuable comments on the first draft of the manuscript; the former provided some relevant literature as well. We also express our sincere thanks to the anonymous reviewers for their constructive comments.

REFERENCES

APPAJEE, Y. & D. PRABHAKAR, 1985. Environmental analysis of the Holocene coastal sediments between Repalle and Nizamptnam, Andhra Pradesh. J. Indian Assoc. Sedimentologists, **5**: 49-57.

COTTARELLI, V., M. C. BRUNO & R. BERERA, 2007. Interstitial harpacticoids from groundwater in Tuscany (central Italy): *Parastenocaris reidae* sp. nov., *Nitocrella ensifera* sp. nov., and notes on the morphology of *Parastenocaris* cf. *glacialis* Noodt (Crustacea: Copepoda). Ital. J. Zool., **74**: 83-99.

ELIA, B., S. SHAIK & Y. RANGA REDDY, 2016. Two new species of the genus *Habrobathynella* Schminke, 1973 (Syncarida, Parabathynellidae) from the southwestern peninsular India. Zootaxa, **4150**: 149-167.

GALASSI, D. M. P. & P. DE LAURENTIIS, 1997. Two new species of *Nitocrella* from groundwaters of Italy (Crustacea, Copepoda, Harpacticoida). Ital. J. Zool., **64**: 367-376.

GUPTA, A. K., 1989. Marine regression along parts of the Indian coast during the Quaternary — a study using satellite images. J. Indian Soc. Remote, **17**: 45-53.

KARANOVIC, T., 2004. Subterranean copepods (Crustacea, Copepoda) from arid western Australia. Crustaceana Monographs, **3**. (Brill, Leiden).

LANG, K., 1965. Copepoda Harpacticoidea from the Californian Pacific coast. K. Svenska Vetens Akad. Handl., **10**: 1-560.

LEE, W. & R. HUYS, 2002. A new genus of groundwater Ameiridae (Copepoda, Harpacticoida) from boreholes in western Australia and the artificial status of *Stygonitocrella* Petkovski, 1976. Bull. Nat. Hist. Mus. Zool., **68**: 39-50.

NAGESWARA RAO, K. & R. VAIDHYANADHAN, 1978. Geomorphic features in the Krishna river delta and its evolution of landforms. In: Proc. Morphol. Evol. Landforms Symp.: 120-130. (Univ. Delhi).

PESCE, G. L., 1980. Two new species of phreatic harpacticoids from Iran (Crustacea: Copepoda). Bijdr. Dierkd., **30**: 364-368.

PETKOVSKI, T. K., 1976. Drei neue *Nitocrella* — Arten von Kuba, zugleich eine Revision des Genus *Nitocrella* Chappuis (s. rest.) (Crustacea, Copepoda, Ameiridae). Acta Mus. Macedonici Sci. Nat., **15**: 1-26.

RANGA REDDY, Y. & V. R. TOTAKURA, 2012. *Indobathynella prehensilis* n. gen., n. sp., an aberrant species of Bathynellacea (Eumalacostraca) from India. J. Crust. Biol., **32**: 281-293.

RANGA REDDY, Y., V. R. TOTAKURA & P. H. C. CORGOSINHO, 2014. *Himalayacaris alaknanda* n. gen., n. sp. (Copepoda: Harpacticoida: Parastenocarididae) from the hyporheic zone of a Himalayan river, northern India. J. Crust. Biol., **34**: 801-819.

RANGA REDDY, Y., V. R. TOTAKURA & S. SHAIK, 2016. Two new species of Parastenocarididae (Copepoda, Harpacticoida) from India. Zootaxa, **4066**: 125-151.

SHEN, C. J. & A. Y. TAI, 1973. Preliminary analysis of the characteristics of the harpacticoid Copepoda-fauna of China and description of some new species. Acta Zool. Sin., **18**: 365-384. [In Chinese, English translation of diagnoses of new taxa.]

TOTAKURA, V. R. & Y. RANGA REDDY, 2014. Three new species of the genus *Habrobathynella* Schminke, 1973 (Syncarida, Parabathynellidae) from the peninsular India. Zootaxa, **3821**: 501-517.

— — & — —, 2015. Groundwater cyclopoid copepods of peninsular India, with description of eight new species. Zootaxa, **3945**: 1-93.

TOTAKURA, V. R., Y. RANGA REDDY & S. SHAIK, 2014. Three new species of Parastenocarididae (Crustacea, Copepoda, Harpacticoida) from India. Zootaxa, **3821**: 501-537.

TOTAKURA, V. R., V. SUBHASHINI & Y. RANGA REDDY, 2016. Two hyporheic species of the genus *Cerconeotes* Huys, 1992: *C. euryhalinus* (Krishnaswamy, 1957) and *C. huysi* n. sp. (Copepoda, Harpacticoida, Leptastacidae) from India. Crustaceana, **89**: 175-208.

WALTER, T. C., 2016. *Nitocrella* Chappuis, 1923. In: T. C. WALTER & G. BOXSHALL, World of Copepods database. Available online at http://www.marinespecies.org/copepoda/aphia.php?p=taxdetails&id=150040 (accessed 23 April 2016).

WILSON, G. D. F., S. SHABUDDIN & Y. RANGA REDDY, 2015. A new species of *Andhracoides* Wilson & Ranga Reddy, 2011 (Isopoda: Hypsimetopidae) from Belum Cave, Andhra Pradesh, India, with a phylogenetic review of the family. J. Crust. Biol., **35**: 216-240.

First received 29 June 2016.
Final version accepted 24 August 2016.