Zootaxa 1370: 23–37 (2006)
www.mapress.com/zootaxa/

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

1370

First Asian report of the genus *Chilibathynella* Noodt, 1963 (Bathynellacea, Syncarida), with the description and biogeographic significance of a new species from Kotumsar Cave, India

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Abstract

The genus *Chilibathynella* Noodt, 1963, presently contains two species: *C. clandestina* Noodt, 1963 and *C. australiensis* Schminke, 1973, from Central Chile and southern Australia, respectively. A third species, named *Chilibathynella kotumsarensis* n. sp., is described herein from a cave in India. The new species has a unique combination of morphological characters, which, *inter alia*, include six-segmented antenna, presence of epipodite on thoracopod I and of three endopodal setae on the male thoracopod VIII, inhomonomous row of spines on uropodal sympod, spineless uropodal endopodite, and convex anal operculum. Some of these characters have not only necessitated partial amendment of the generic diagnosis, but could prove of value in phylogenetic studies as well. Furthermore, the discovery of the new species is of interest because it is the first record of *Chilibathynella* from Asia as well as the tropical zone, thus filling a huge gap in the global distribution of this genus.

Key words: Parabathynellidae, *Chilibathynella kotumsarensis* n. sp., cave, India, Gondwanan distribution

Introduction

Bathynellaceans are typical stygobionts, which have been recorded in all the continents except Antarctica. The Order Bathynellacea has two families, Parabathynellidae and Bathynellidae. While Parabathynellidae is globally widespread, with 139 species in 40 genera, Bathynellidae is mostly distributed in the temperate zones of northern and southern hemispheres, with 92 species in 27 genera (Camacho, in press). In India, however, published information as of now is available for just three parabathynellid species; *Habrobathynella nagarjunai* Ranga Reddy 2002, *H. schminkei* Ranga Reddy,

Accepted by R. Dalgleish: 10 Oct. 2006; published: 4 Dec. 2006

2004, and *H. indica* Ranga Reddy & Schminke 2005, and only one bathynellid species, *Serbanibathynella primaindica* Ranga Reddy & Schminke, 2005.

A new parabathynellid species of the genus *Chilibathynella* Noodt 1963 has been found in a cave and is described herein. This genus has long been known only by two species: *Chilibathynella clandestina* Noodt, 1963, from Central Chile, and *C. australiensis* Schminke, 1973, from southern Australia. Though Schminke (1981) reported the genus *Chilibathynella* from Africa, no details are yet available in print.

The discovery of this new species is of interest because it is the first record of the genus *Chilibathynella* from Asia as well as the tropical zone. It thus fills a huge gap in the global distribution of this genus. Also, this species has a unique combination of morphological characters, which have not only necessitated partial amendment of the generic diagnosis, but could prove of value in phylogenetic studies as well.

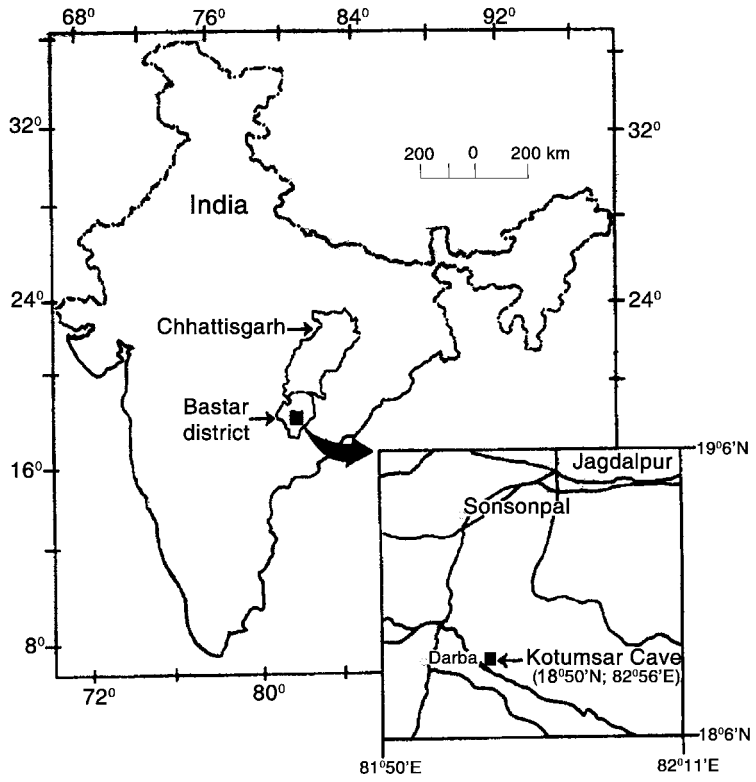

FIGURE 1. Location map of the Kotumsar Cave (adapted from Pati & Agrawal, 2002).

Methods

The specimens studied were found in an interstitial sample collected from the Kotumsar Cave, India. A rigid PVC tube (length 70 cm, diameter 4 cm) was used for coring. The cores, taken from the sediment surface to a depth of about 10 cm of the cave pools, were

put in a bucket and stirred well with the habitat water. The supernatant was filtered through bolting silk plankton net (mesh size 70 μm), and the filtrate fixed in about 5% formaldehyde. Specimens were isolated into 70% alcohol and subsequently transferred into glycerol.

Dissection was done in glycerol under a stereoscope binocular microscope at a magnification of 90 X. Drawings were made with the aid of a drawing tube mounted on Carl Zeiss Axioskop 2 Plus DIC Microscope, equipped with UCA condenser. Anatomical examinations were performed using an oil immersion lens (100 X). The type material has been deposited in the National Museum of Natural History, Paris.

Systematic account

Family Parabathynellidae Noodt, 1964

Genus *Chilibathynella* Noodt, 1963

Chilibathynella kotumsarensis Ranga Reddy n. sp.
(Figs 2–6)

Etymology

The specific epithet alludes to the type locality of the new species.

Type locality

The Kotumsar Cave, a limestone cave, is one of the largest caves in India. It lies on the bank of the River Kanger, flowing through the Kanger Valley National Park (18º52'09" N; 81º56'05" E), at an altitude of 560 m near Jagdalpur town, Bastar District, Chhattisgarh State, India (Fig. 1).

The cave entrance is a vertical fissure in the wall of a hill. It has a narrow, twisted opening, measuring about 15 m in length. The cave is honeycombed in its structure, consisting of several irregular chambers. The main tunnel of the cave is nearly 500 m long and has several lateral and downward passages. The roofs and walls of the different chambers are lined with colorful dripstone formation, resulting from the precipitation of calcite-dissolved carbonate lime. The chambers are floored with either rocks or pebbles of varying dimensions or surface-derived soil/clay deposits.

Some of the abiotic parameters of the cave, as determined by Pati & Agrawal (2002), between May 1987 and March 1988, were as follows: air and water temperatures remained relatively stable, at an annual average of 28.25 ± 1.23 ºC and 26.33 ± 0.96 ºC respectively (range = 25.0–32.7 ºC for air; 22.9–29.3 ºC for water). The water pools were alkaline, with an annual average pH of 8.04 ± 0.36. Conductivity peaked during December, with an annual average of 0.27 ± 0.03 m Mhos. The annual mean for dissolved oxygen and percentage saturation for oxygen in the cave water were 6.42 ± 0.52 mg/l and 74.83 ±

5.91%, respectively. The cave is subject to frequent flooding during monsoon activity, which generally begins in the middle of June.

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Material examined

Holotype, adult male, dissected on four slides. Paratypes, adult male, dissected on four slides, and four juveniles, one of them dissected on two slides, three mounted as whole specimens on a single slide. Type material has been deposited in the National Museum of Natural History, Paris; registration numbers: holotype MNHN-Sy 16 (male); paratypes: MNHN-Sy 17 (male), MNHN-Sy 18 (1 juvenile), MNHN-Sy 19 (3 juveniles). Leg. Y. Ranga Reddy, 01 December 2004.

Diagnosis

Parabathynellid of small size (1.25 mm). Antennal organ small, represented by two contiguous dentate structures. Fifth antennular segment with two aesthetascs. Antenna six-segmented. Thoracopod I with well-developed epipodite. Pleopod I with two setae. Uropodal sympod with inhomonomous row of spines. Uropodal exopodite with three setae, two apical and one lateral, and endopodite without spines. Anal operculum convex.

Description of male (holotype)

Total length 1.25 mm (male paratype 1.28 mm). Body elongate, maximum width at first abdominal segment. Abdominal segments wider than thoracic ones. Head 25% longer than wide and slightly longer than first three thoracic segments combined.

Antennule (Fig. 2d) consisting of seven, somewhat elongate, slender segments, 29% longer than head; length of first three segments only slightly exceeding that of last four segments. First segment longest, 1.7 times longer than wide, with two dorso-medial, simple setae near distal margin; two dorsal plumose setae at about distal outer corner, one tiny seta at distal inner corner, and one plumose seta on sub-distal outer margin. Second segment with two dorsal and one ventral simple setae near distal inner angle; antennal organ much reduced, represented by two conical, dentate and nearly contiguous hyaline structures; one plumose and one simple seta on sub-distal outer margin, one dorsal, plumose seta near distal outer corner, and one ventral plumose seta close to mid-outer margin. Third segment with one seta at sub-distal outer margin and one ventral and one dorsal seta near distal inner corner. Inner flagellum of third segment slightly longer than wide, with three simple setae. Fourth segment with three plumose setae, two unequal setae on the tip of apophysis and one at its base on outer side; apophysis reaching about proximal third of fifth segment. Fifth segment with two aesthetascs and two simple setae dorsally. Sixth segment longer than seventh one and with three aesthetascs and four setae dorsally. Seventh segment with three aesthetascs and four setae.

Antenna (Fig. 3a) six-segmented (basal additional segment, if any, is not discernible with the optics used); right one curved backwards, bending between third and fourth segments; left one nearly straight, antero-laterally directed, 0.7 as long as antennule;

percentage lengths of segments 1–6 as follows: 5:13:20:16:19:27; segments 1 and 4 without seta; segments 2, 3, 5, and 6 with 1, 2, 1, and 4 (3 apical and 1 lateral) setae, respectively.

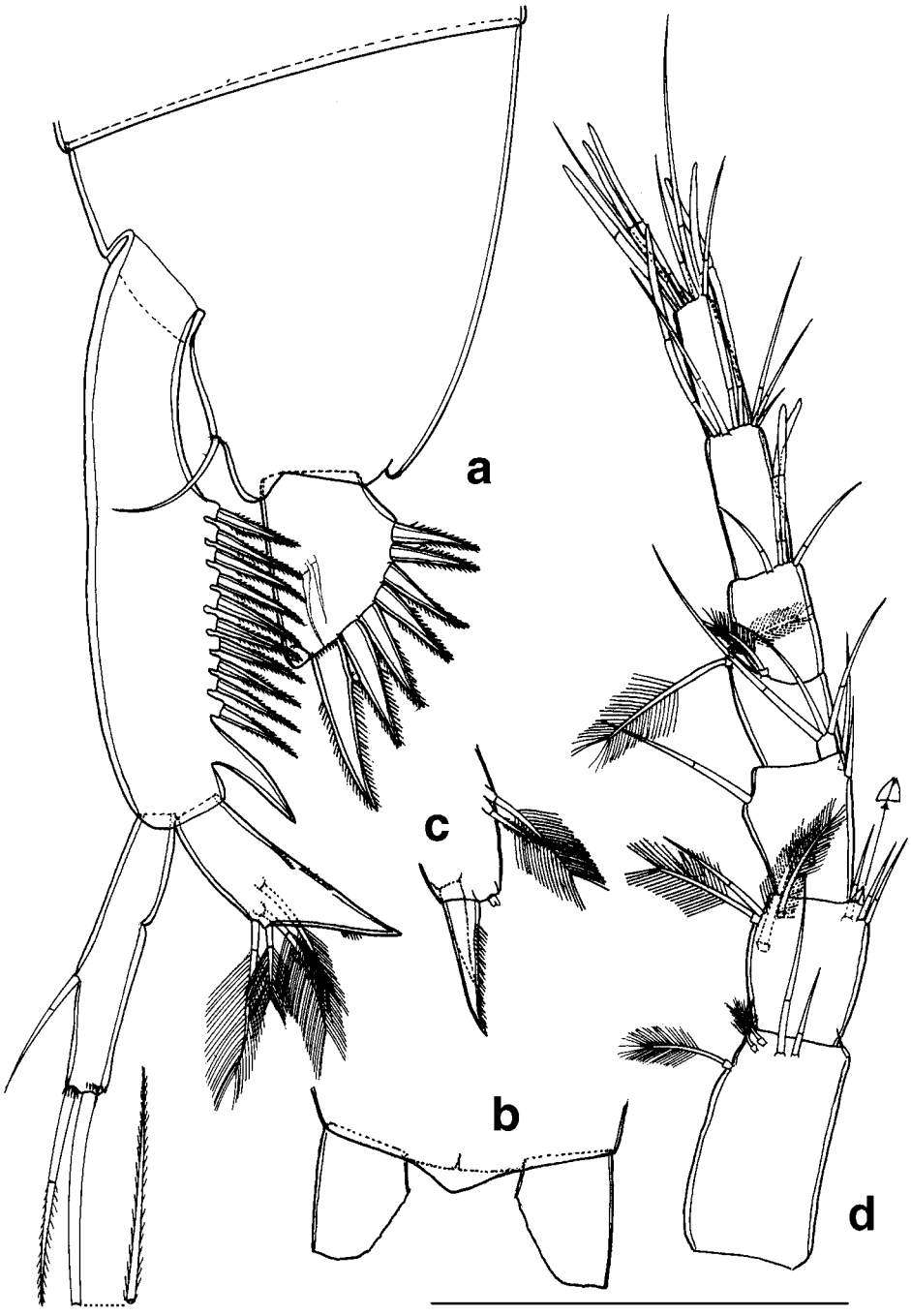

FIGURE 2. *Chilibathynella kotumsarensis* **n. sp.** (adult male: holotype): a. pleotelson, furcal ramus and uropod, lateral (N.B. plumosity of furcal setae not depicted); b, anal operculum, dorsal; c, furcal organ, lateral; d, antennule, dorsal. Scale bar = 100 μm.

Labrum (Fig. 3b,c) flat, symmetrical, free margin straight, bearing eight main, nearly uniform teeth and 1 smaller marginal tooth on each side (N. B. Unfortunately, the labrum was folded in permanent preparation of the holotype as in Fig. 2b).

Mandible (Fig. 3d,e): distal part of *pars incisiva* with 4 teeth, tooth of the ventral edge small and pointed. *Pars molaris* (”Borstenlobus”) with 8 claws, of which the distal two smooth, relatively large, forming a separate group; other claws with fine denticles on proximal margins; proximal outer corner of *pars molaris* with a row of spinules. Palp one-segmented, about three times as long as wide, bearing a terminal seta, slightly exceeding *pars incisiva* in length.

Maxillule (Fig. 3f) with two endites; proximal endite small, somewhat oval in outline, with four apical claw-like spines, distalmost one longest. Distal endite bending inward, gradually tapering posteriad and with two terminal and four inner marginal claws. Outer distal margin with three simple setae.

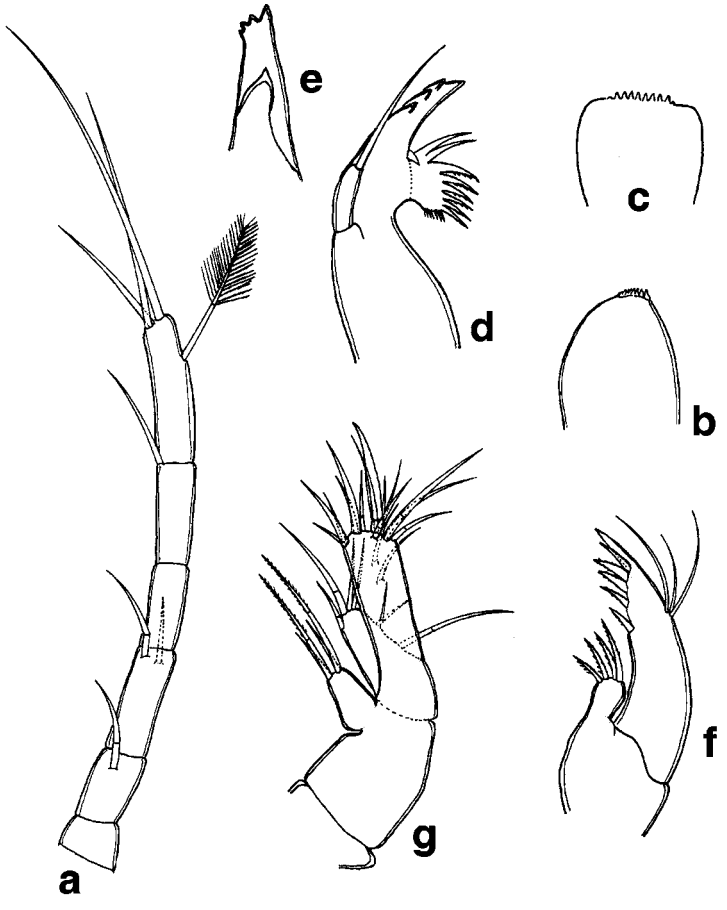

FIGURE 3. *Chilibathynella kotumsarensis* **n. sp.** (adult male: holotype): a, antenna, lateral; b, c labrum (holotype and juvenile paratype, respectively); d, mandible; e, mandible, *pars incisiva*, frontal; f, maxillule; g, maxilla. Scale bar = 100 μm.

Maxilla (Fig. 3g) consisting of four segments. First segment with an elongately oval endite, carrying two elongate plumose and two short simple setae. Second segment with six (four inner-marginal, two medial) and third segment with 13 setae. Fourth segment tiny, with one claw and three setae.

Thoracopods I–VII (Figs 4a–d, 5a–c) well developed; length gradually increasing from pairs I–III. Thoracopods III–VII almost similar in size. Thoracopods I–VII each bearing one-segmented epipodite on coxa and one inner marginal seta on basis. Exopodite one-segmented, with two unequal terminal setae; an additional subterminal seta present on dorsal side of thoracopod V alone (see Variation). Endopodite four-segmented. First and second endopodal segments of thoracopods I–VII with a rudimentary seta each at distal outer corner (not considered for setal formulae). Setal formulae:

Thoracopod I: 2 + 0/2 + 0/2 + 0/3(1)
Thoracopod II: 1 + 0/ 1 + 0/1 + 0/3(1)
Thoracopods III–IV: 1 + 0/ 1 + 0/0 + 0/3(1)
Thoracopods V–VII: 0 + 0/ 1 + 0/0 + 0/3(1)

Thoracopod VIII (Fig. 5d, e) massive, characteristic in shape. Basal segment of protopodite large, oblong, juxtaposing basis and originating at the same level as the basis. Dentate lobe shorter than the rounded inner lobe and with straight or somewhat convex free margin, carrying five or six teeth in a row. Basis roughly conical, extending well beyond the level of dentate lobe and with one subapical seta. Epipodite (external lobe) conical and arising from the basis. Exopodite curved, sharply bending backward and with a row of apical denticles. Endopodite rectangular, with one subapical and two unequal apical setae.

Pleopod I (Fig. 5f) one-segmented, nearly four times as long as wide, with one long apical and one short subapical seta.

Uropod (Fig. 2a). Sympod more than twice the length of endopodite and 4.6 times longer than its own maximum width, with eleven spines, distalmost spine largest and smooth; all other spines acutely pointed, almost similar in size and with serrulate lateral margins. Exopodite almost cylindrical, 5.4 times as long as wide, measuring 52% of sympodite length and bearing two apical setae, each with a row of spinules at base, inner seta twice as long as outer seta, and one short seta at about distal third of outer margin. Endopodite somewhat dagger-shaped, reaching 41% of sympodite length; bearing two unequal plumose setae at about the middle of outer margin and two equal plumose setae medially; spinules occurring on distal outer margin and on inner margin, as illustrated.

Pleotelson (Fig. 2a) with one seta on either side near the base of furcal ramus; seta bare, shorter than furcal ramus. Anal operculum broadly triangular in outline, with rounded tip (Fig. 2b).

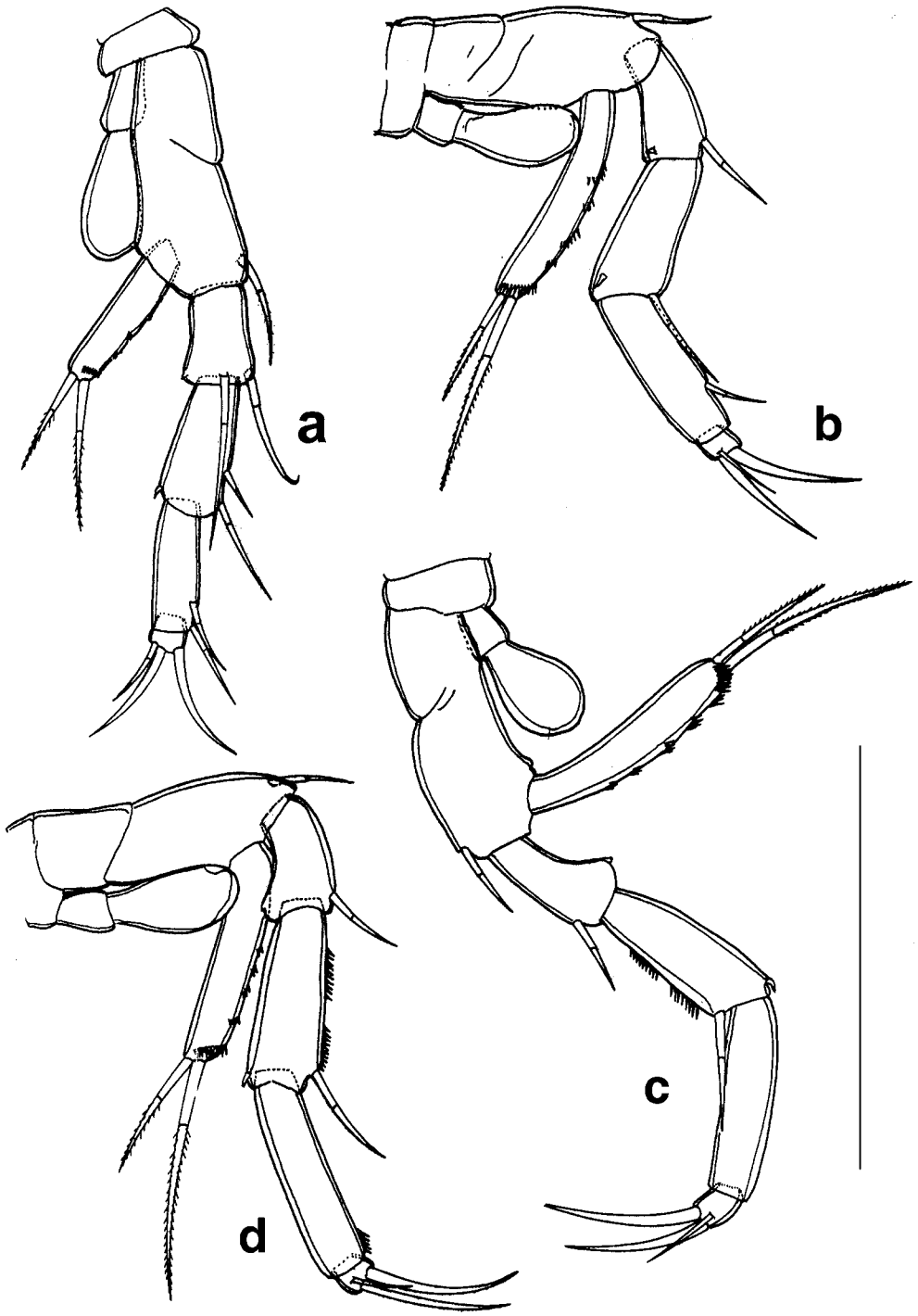

FIGURE 4. *Chilibathynella kotumsarensis* **n. sp.** (adult male: holotype): a, thoracopod I; b, thoracopod II; c, thoracopod III; d, thoracopod IV. Scale bar = 100 μm.

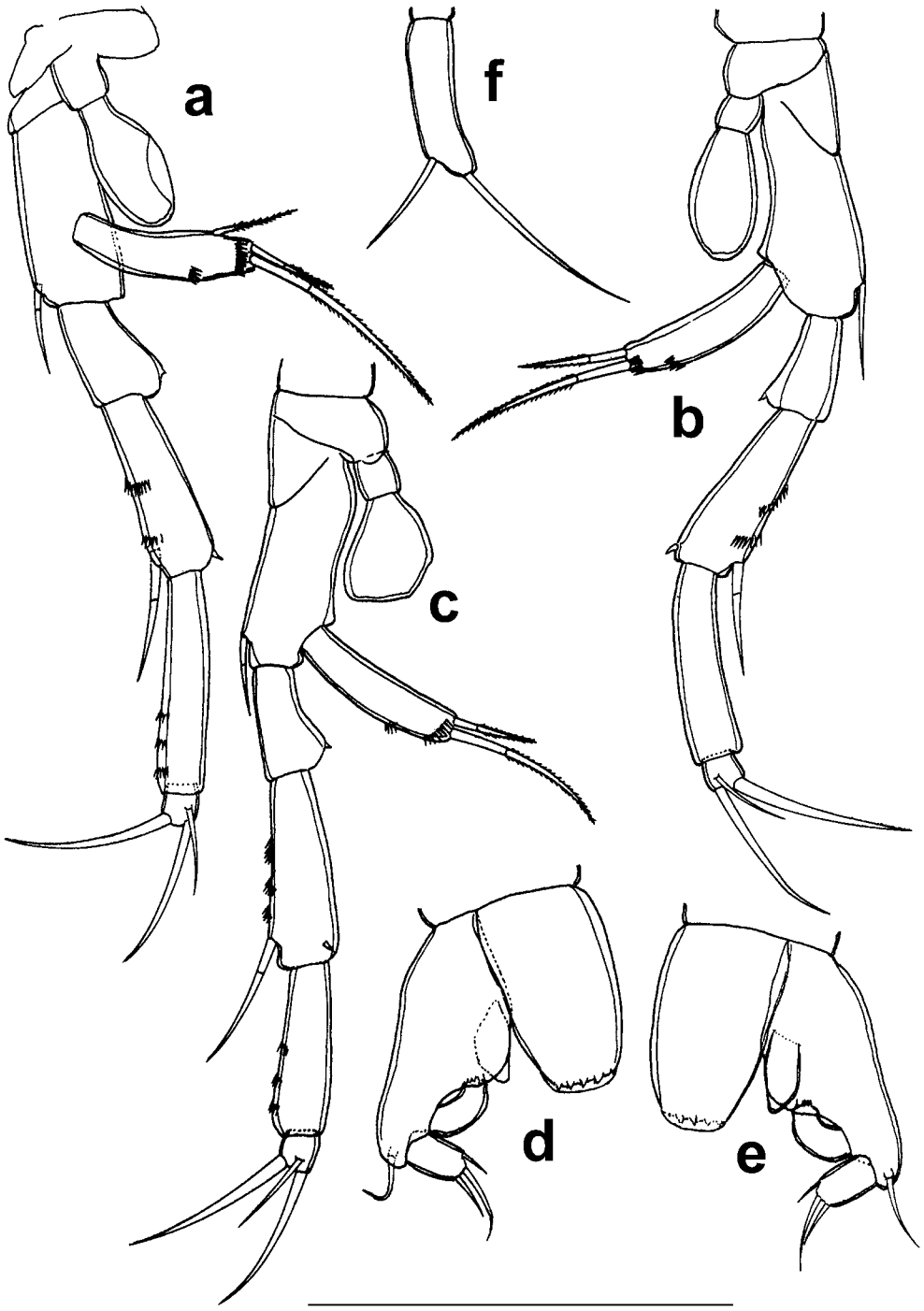

FIGURE 5. *Chilibathynella kotumsarensis* **n. sp.** (adult male: holotype): a, thoracopod V; b, thoracopod VI; c, thoracopod VII; d, thoracopod VIII, latero-internal; e, latero-external; f, pleopod I. Scale bar = 100 μm.

Furcal rami (Fig. 2a) 36.5% longer than maximum width, maximum width occurring at proximal third, outer margin nearly straight and ending in large, blunt ventral projection (furcal organ) (Fig.2c), distal two-thirds of inner margin expanded, with two terminal and five inner, pointed, serrulate spines and two unequal dorsolateral setae; terminal spine largest and with a row of dorsal spinules at its base, other spines gradually decreasing in size, as illustrated.

Female: Not known.

Description of juveniles (Fig. 6a–e)

Four sexually undifferentiated juveniles were recorded.

Juvenile 1 (Fig. 6a, b): Total length 0.96 mm. Body eight times longer than wide. Head 24% longer than wide. Antennule 29% longer than head. Habitus and the various structural details of the cephalic appendages, thoracopods I–V and pleopod I are as in the adult. Sixth and seventh thoracic segments with rounded sternum in lateral view (Fig. 6b), but without any trace of thoracopods. Thoracopod VIII represented by an undifferentiated, triangular lobe. Anal operculum slightly projecting backwards, somewhat rectangular in outline and depressed at the middle. Furcal rami with only six spines, the largest spine of the adult rudimentary, in the form a short, filamentous structure. Uropod as in the adult except for the sympod carrying seven spines, distal most spine largest.

Juveniles 2 and 3 (Fig. 6c, d): Total length 0.83 mm. Both are identical to each other and differ from the juvenile 1 in two respects: thoracopod VIII is a very small crescentic lobe, and pleopod 1 is absent.

Juvenile 4 (Fig. 6e): Total length 0.78 mm, similar to juveniles 2 and 3 except for the absence of any trace of thoracopod VIII.

Variation

The number of spines borne by the uropodal sympod varies between 9 and 11 in the adults and, 5 and 8 in the juveniles. The exopodite of thoracopod V has one dorsal seta in the holotype whereas it is absent in the male paratype as well as juveniles. The anal operculum is different between the adults and juveniles. No variation has been noticed in the armature of caudal furca.

Discussion

Noodt (1963) established the monotypic genus *Chilibathynella,* with the Central Chilean *Chilibathynella clandestina* Noodt, 1963, as its type species. Ten years later, Schminke (1973) added a second species, *Chilibathynella australiensis* Schminke, 1973, from southern Australia and also revised the generic diagnosis. Schminke (1973) rightly stressed that the large balloon-shaped basal segment of protopodite of the male thoracopod

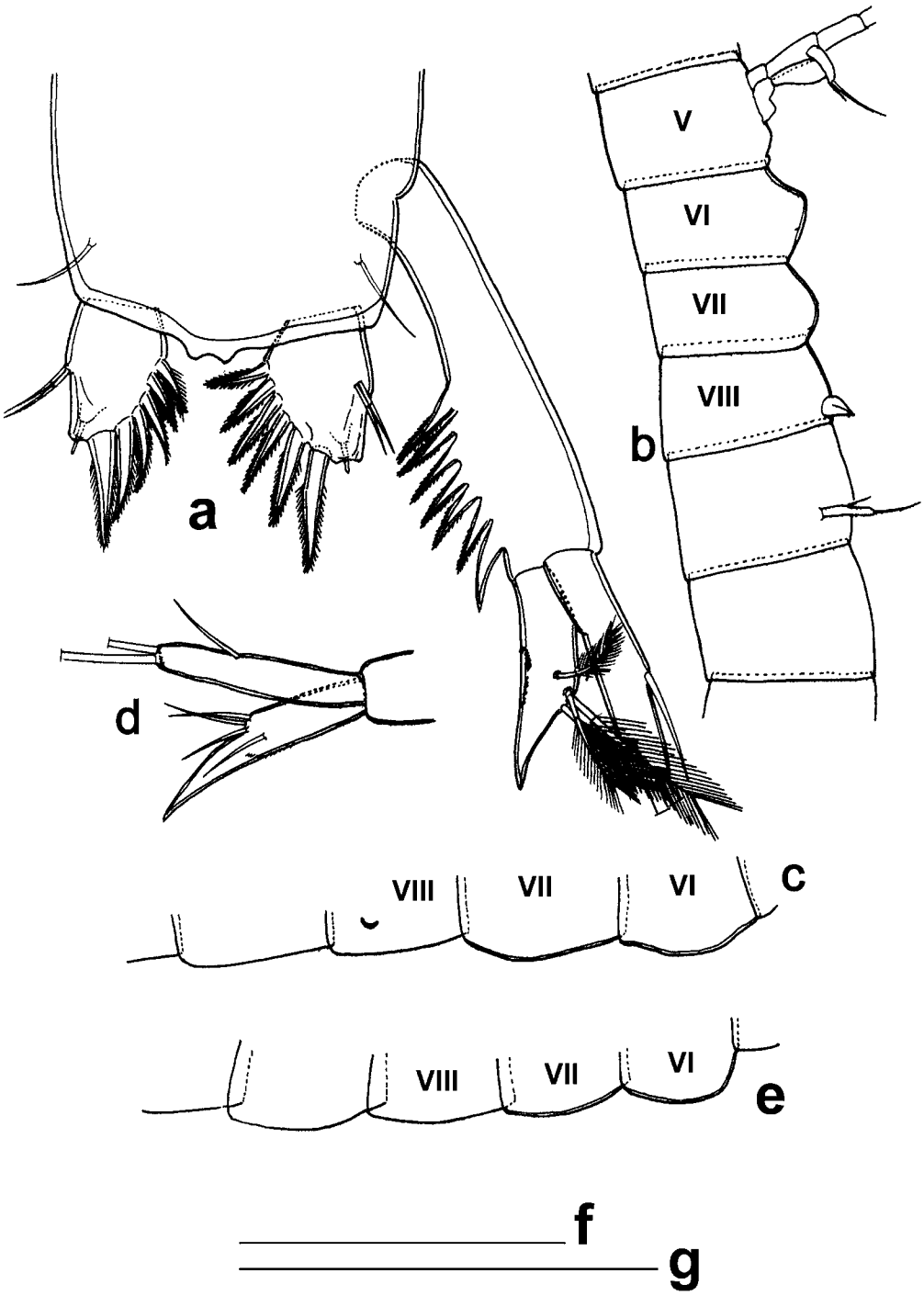

FIGURE 6. *Chilibathynella kotumsarensis* **n. sp.** (juveniles: paratypes**):** a, pleotelson, furcal rami and uropod, dorsal; b, thoracic segments V–VIII; c, thoracic segments VI–VIII and abdominal segment 1; d, uropodal exo- and endopodite e, thoracic segments VI–VIII and abdominal segment 1, lateral. Scale bar f = 200 µm for a, d; scale bar g = 100 µm for b, c ,e = 100 µm.

VIII is an outstanding character of this genus. It is also an easily noticeable feature. The one-segmented exopodite together with the rudimentary or nonexistent outer marginal seta of the second endopodite-segment of thoracopods I–VII, the seven-segmented antennules with antennal organ on the second segment of the male, the one-segmented pleopod I, and the large furcal organ are amongst the other important characters of this genus. Clearly, *C. kotumsarensis* n. sp. fulfils all these generic criteria.

On the other hand, the new species displays at least two characters, which are unique within the genus *Chilibathynella*, i.e. the six-segmented antenna, and the inhomonomous row of spines on the uropodal sympod. In both *C. clandestina* and *C. australiensis*, the antenna is five-segmented, and the spine row on the uropodal sympod is homonomous. At this juncture, when several parabathynellid genera await revision, it appears more appropriate to amend the generic definition of *Chilibathynella* to accommodate the new species than to erect a new genus for it. It may be recalled here that in a parallel case involving the genus *Habrobathynella* Schminke, 1973, the original generic definition had been partially amended for placing three Indian species alongside their Madagascan congeners (see Ranga Reddy, 2002, 2004, Ranga Reddy & Schminke, 2005). Hence, regarding the two characters in question, the original diagnosis of *Chilibathynella* now stands amended as follows: antenna five- or six-segmented, and the spine row on the uropodal sympod is either homonomous or inhomonomous.

Between its two congeners, *C. clandestina* and *C. australiensis*, the new species is somewhat closer to the former, especially in the setal armature of the thoracopods I–VII, pleopod I, and uropodal exopodite. However, it differs from its congeners in several respects (Table 1).

Biogeographically, the new species is a significant find in that it extends the range of *Chilibathynella* to Asia and the northern tropical belt (Fig. 7). Lopretto & Morrone (1998) believed that this genus belonged to the southern temperate track, which connects the southern South America, Australia, Tasmania, and New Zealand, with Pacific basin baseline. Now it is clear that this viewpoint needs to be revised. As one would expect, further investigations are likely to reveal a much more widespread range of chilibathynellids on the Gondwana landmasses.

That the vicariance model is invoked for explaining the worldwide distribution of bathynellaceans is well known (e.g. Schram, 1977, Platnick & Nelson, 1978, Schminke, 1981, Lopretto & Morrone, 1998, Camacho *et al.*, 2000, Cho *et al.*, 2006, and several others). In the present case also, the vicariance event involving the continental drift seems responsible for the apparent Gondwanan distribution of the three disjunct *Chilibathynella* species (Coincidentally, the type locality of *C. kotumsarensis* n. sp. falls within the region inhabited by the original ethnic group, Gond, from which the term Gondwana had been derived).

The actual mechanisms involved in the colonization of the limnic interstitial by parabathynellids are not yet clear (Cho *et al.*, 2006). *C. kotumsarensis* n. sp. inhabits a far-inland locality, which apparently sustained no marine transgression during the Cenozoic.

The new species also occurs with strictly freshwater taxa such as a new family of crangonyctoid amphipods and a new harpacticoid copepod species of the genus *Parastenocaris* Kessler. I do not know if this is a true case of Schminke's (1981) limnicoid origin.

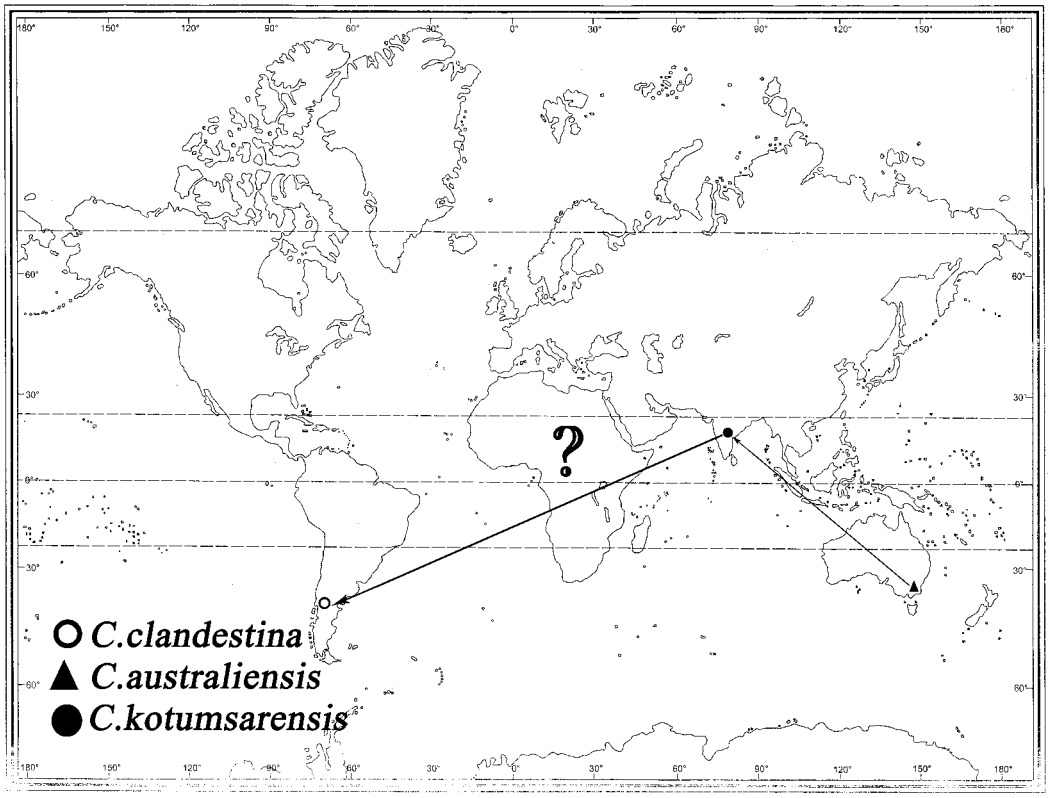

FIGURE 7. Map to show the distribution of the three known species of *Chilibathynella*.

Acknowledgments

I am grateful to the University Grants Commission (UGC), New Delhi, for providing funding support under SAP–DRS Project. Sincere thanks are also due to: Prof. A.K. Pati, Pt. Ravishankar Shukla University, Raipur, for arranging a post-Symposium field visit to Kotumsar Cave; my wife, Vijaya Koteswari, for assisting me in the field; and my student, Mr. B. Elia, for providing necessary technical help with computer. The manuscript has greatly benefited from the helpful comments of Prof. H. K. Schminke, Carl von Ossietzky Oldenburg University, Germany, Dr. A. I. Camacho, Museo Nacional de Ciencias Naturales, Madrid, Spain, and Dr. J. L. Cho, Water Analysis & Research Center, Daejeon, Republic of Korea. Dr. Camacho also answered my query on *Chilibathynella* in addition to providing some pertinent literature.

TABLE 1. Morphological differences between *Chilibathynella* spp.

	C. clandestina	*C. australiensis*	*C. kotumsarensis*
Body length (mm)	1.35 –2.05	2.26	1.25
Number of aesthetascs on fifth antennular segment	0	2	2
Number antennary segments	5	5	6
Number of teeth on labrum	4+8+4	4+8+4	1+8+1
Number of teeth on *pars incisiva*	4	7	4
Number of spines on *pars molaris*	6 –8	7 –10	8
Setation of maxilla	3 –6 –9 –7	3 –6 –11 –7	4 –6 –13 –4
Epipodite on thoracopod I	'Rudimentary'	Absent	Well developed
Setal formula:			
Thoracopod I	2+0/2+0/1+0/3(1)	2+1/2+1/2+0/3(1)	2+0/2+0/2+0/3(1)
Thoracopod II	0+0/1+0/1+0/3(1)	1+1/2+1/1+0/3(1)	1+0/1+0/1+0/3(1)
Thoracopod III	?	1+1/1+1/0+0/3(1)	1+0/1+0/0+0/3(1)
Thoracopod IV	?	0+1/1+1/0+0/3(1)	1+0/1+0/0+0/3(1)
Thoracopod V	0+0/1+0/0+0/3(1)	0+1/1+1/0+0/3(1)	0+0/1+0/0+0/3(1)
Thoracopod VI	?	1+1/1+1/0+0/3(1)	0+0/1+0/0+0/3(1)
Thoracopod VII	0+0/1+0/0+0/3(1)	0,1+1/1+1/0+0/3(1)	0+0/1+0/0+0/3(1)
Thoracopod VIII:			
Basis vs. coxa	Shorter	Shorter	Longer
Number of setae on endopodite	2	2	3
Number of setae on Pleopod I	2	1	2
Number and nature of spines on uropodal sympodite	7, homonomous	11, homonomous	11, inhomonomous
Number of spines on uropodal endopodite	2	1	0
Number and position of setae on uropodal exopodite	2 apical, 1 lateral	2 apical, 2 lateral	2 apical, 1 lateral
Number of spines on caudal furca	6 –9	9 –12	7
Anal operculum	Small, concave	Small, concave	Large, convex
Continent and habitat	S. America; hyporheic	Australia; hyporheic	Asia; cavernicolous

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