RESULTS

Family **Cyclopidae** Rafinesque, 1815

Subfamily **Halicyclopinae** Kiefer, 1927

Genus **Halicylops** Norman, 1903


Recently, Karanovic (2006) subdivided this large genus into two subgenera: i) the widespread **Halicylops (Halicylops)** s. str., and ii) the Australian **Halicylops (Rochacyclops)**. **Halicylops (Halicylops)** s. str., has eight groups (Groups A–H) based on the spine formula of the third exopodal segment of legs 1–4 (see Pesce, 2013). In India, as of now, the groups A, B and F alone exist, showing the spine formula 4.4.4.3, 3.4.4.3, and 2.3.3.3, respectively. The latest World of Copepods database on the genus **Halicylops** contains a list of 93 species and 13 subspecies from around the world (Boxshall, 2013).

Of these only 6 valid species are known from India:

1. **Halicylops (Halicylops) tenuispina** Sewell, 1924
2. **Halicylops (Halicylops) spinifer** Kiefer, 1935
3. **Halicylops (Halicylops) canui** Lindberg, 1941
4. **Halicylops (Halicylops) electus** Lindberg, 1943
5. **Halicylops (Halicylops) konkanensis** Lindberg, 1949
6. **Halicylops (Halicylops) pilifer** Lindberg, 1949
Of these above-listed Indian taxa, only 2 taxa, viz. *Halicyclops (H.) spinifer* Kiefer, 1935, and *Halicyclops (H.) pilifer* Lindberg, 1949 have been met in this study.

*Halicyclops (Halicyclops) spinifer* Kiefer, 1935
(Figs 4–8)

**Synonymy**

*Halicyclops thermophilus spinifer* Kiefer, 1935: 13, Fig.7.


*Halicyclops thermophilus spinifer*, Yeatman, 1983: 59, Fig. 2a–f; Dussart & Defaye, 1985: 17.


**Locality.** River Krishna at Hamsaladeevi (15°58′39″N, 81°05′59″E; elevation 7 m), Krishna District, Andhra Pradesh, South India.

**Material examined.** 3 voucher specimens: 1 female (MNHN-IU-2013-9780) whole-mounted on 1 slide; 1 female (MNHN-IU-2013-9781) dissected on 9 slides and 1 male (MNHN-IU-2013-9782) dissected on 2 slides; 8 females and 7 males in author’s personal collections; 03 January 2004, Coll. V. Subhashini.

**Other material examined.** Krishnapatnam basin at Eddulanka (14°16′59″N, 80°07′01″E; elevation 3 m), Nellore district, Andhra Pradesh, South India, 14 January 2005: 4 females and 1 male; Maddi Revu (14°16′59″N, 80°07′01″E; elevation 3 m), Nellore district, Andhra Pradesh, 15 January 2005: 2 females. Coll. V. Subhashini.

Valluri Cheruvu, Muthukuru Road, (14°28′03″ N, 80°11′07″E; elevation 4 m), Nellore district, Andhra Pradesh, South India, 15 January 2005: 3 females. Coll. V. Subhashini.
Chilka Lake at Satapada village (19°44'00"N, 85°39'00" E; elevation 25 m), Puri District, Odisha State, South India, 26 October 2004: 6 females and 2 males. Coll. D. Ambedkar.

**Redescription of adult female.** Habitus robust (Fig. 4a); total body length measured from base of rostrum to posterior margin of caudal rami (excluding caudal setae) 0.66 mm. Prosome/urosome ratio about 1.4 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.6. Free pedigerous somites without pronounced lateral expansions. Colour of preserved specimen’s yellowish. Nauplius eye not visible. Cephalothorax 0.86 times as long as its greatest width, 2.8 times as wide as genital double-somite and representing 32% of total body length. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite with a smooth fringe dorsally and ventrally, ornamented with 5 cuticular pores: 3 in the middle and 2 laterally (Fig. 4b).

Genital double-somite (Fig. 4b) 1.06 times as long as wide, ornamented with 2 pores at posterior margin ventrally; 2 large spiniform processes laterally with their tips pointed posteriorly and reaching 2/3 of the double-somite’s length; 2 cuticular recesses ventro-laterally on posterior half of genital double-somite. Hyaline fringes of genital double-somite and succeeding 2 somites serrulated dorsally and ventrally. Copulatory pore oval, copulatory duct rigidly sclerotized. Seminal receptacle small, situated around pore and duct, and heart-shaped (Fig. 4b). Ovipores situated dorso-laterally and covered by reduced sixth legs. Hyaline fringe of fourth urosomite (Fig. 4a, c) extended dorsally into serrulated pseudo-operculum, with dorso-medial denticulations much longer and stouter than lateral ones, reaching beyond the anterior part of anal operculum. Anal somite with smooth, broad, slightly convex anal operculum (covered by pseudo-operculum), representing 55% of somite’s width;
ornamented with a pair of cuticular pores dorsally and with minute spinules dorsally and ventrally overlying the base of caudal rami (Fig. 4a, c, d). Anal sinus widely open; ornamented with 2 rows of minute spinules (Fig. 4c).

Caudal rami (Fig. 4c, d) divergent, 1.2–1.6 times as long as wide, with space between them about 1.2 times of ramus width. Dorsal seta 1.8–2.2 times as long as ramus, inserted at distal end of ramus and arising from subapical papilla, uniarticulate at base and plumose distally. Lateral seta situated at 40% length of caudal ramus, positioned dorsally and 0.7 times as ramus width. Outermost apical seta stout, spiniform, 0.8 times as long as ramus; innermost apical seta minute, slender, plumose, 0.5 times as long as outermost apical seta. Principal apical setae with breaking planes, inner median apical seta 2.1 times as long as outer median apical seta and 0.76 times as long as body. Ornamentation heterogeneous on principal apical setae (Fig. 4a).

Antennule (Fig. 5a) 6-segmented, short, reaching one third of cephalothorax, with 1 aesthetasc on fourth and sixth segments each and setal formula: 8.12.5.6+ae.2.10+ae. One stout seta on first segment, 2 on second, 1 on fourth and 4 on sixth segment articulating on basal part. Segments 1–6 with 3, 4, 1, 2, and 4 plumose setae respectively. One seta on third segment spiniform and short, 1 on fourth unipinnate at midlength, all other setae smooth. First segment ornamented with short row of spinules.

Antenna (Fig. 5b) 3-segmented, comprising coxobasis and 2-segmented endopod. Coxobasis 1.5 times as long as wide, ornamented with slightly curved, short row of small spinules along proximal inner corner and 2 rows of small spinules along proximal outer corner; a short row of spinules on outer and inner margins proximally on caudal surface; armed with 2 bipinnate setae at distal inner corner and with a short bipinnate seta representing exopod at distal outer corner, overreaching the tip of the
first endopodal segment. First endopodal segment unornamented, armed with 1 bipinnate seta at middle. Second endopodal segment 3.2 times as long as wide, about 1.5 times as long as first, ornamented with a proximal arched row of spinules, distal longitudinal row of spinules, and armed with 5 lateral and 7 apical setae.

Labrum (Fig. 5c) trapezoidal, ornamented with 10 long spinules on ventral surface and finely serrulated along disto-lateral margin. Cutting edge straight, with 12 teeth at mid margin; second tooth on each side stronger and longer than the others.

Mandible (Fig. 6a) with palp reduced, armed with 2 unequal setae, distal one pinnate terminally, 2.4 times as long as proximal smooth seta. Gnathobase with 6 strong teeth and 1 outermost unipinnate seta.

Maxillule (Fig. 6b) composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 4 strong apical spines, anterior one much stronger and longer than others. Praecoxa armed with 7 armature elements along inner margin, the longest one plumose. Palp apically with 2 slender, smooth setae and 1 robust, strong, unipinnate spine; endopod distinct, bearing 2 apical and 1 subapical pinnate setae; exopodal seta pinnate.

Maxilla (Fig. 6c) 4-segmented but praecoxa fused to coxa on posterior surface. Proximal endite of praecoxa armed with 2 pinnate setae, distal endite small and unarmed. Proximal endite of coxa with 1 strong, short, smooth seta; distal endite highly mobile, bearing 1 proximal completely fused, strong seta, and 1 distal, smaller pinnate seta. Seta fused to endite ornamented with 1 elongated spinule. Basis drawn out into robust claw unornamented and armed with 2 setae, strong seta unipinnate, about as long as claw, small seta at base. Endopod armed with 2 spinulose and 3 smooth setae.
Maxilliped (Fig. 6d) 2-segmented, armed with 3 setae on protopod, 5 setae on endopod, and ornamented with 2 long spinules near distal margin of protopod. Proximal protopodal seta unornamented, middle seta strong and smooth and 1.5 times as long as proximal one; distal protopodal seta shorter than proximal one and ornamented with 2 spinules. Endopod one-third as long as protopod armed with 2 lateral and 2 apical strong, spinulose setae and 1 smooth apical seta.

Legs 1–4 (Fig. 7a–d) with 3-segmented exo- and endopod. Coxa of second and fourth legs ornamented with a row of spinules on outer distal margin, and coxa of all legs armed with a pinnate seta at inner distal corner; pinnate seta shortest on fourth leg. Intercoxal sclerites of all legs with rounded protrusions on both sides, ornamented with an apical row of spinules. Third exopodal segment spine formula: 3.4.4.3 and setal formula: 5.5.5.5. Basis of each leg armed with outer plumose seta and ornamented with a row of spinules at inner distal corner and between exopod and endopod; basis of leg 1 with additional spinules at base of inner spine. Exopod and endopodal setae of legs 1–4 slender and plumose, except for 2 modified setae on endopod of fourth leg. Leg 4 third endopodal segment (Fig. 7d) 1.8 times as long as wide; inner apical spine 1.3 times as long as outer one; 2 inner setae plumose at proximal end and spinulose at distal end. Legs 1–4 armature formula as follows (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Leg 1</td>
<td>1-0</td>
<td>I-1</td>
<td>I-I</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1-0</td>
<td>0-1</td>
<td>I-I</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1-0</td>
<td>0-1</td>
<td>I-I</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1-0</td>
<td>0-1</td>
<td>I-I</td>
<td>4, 1+I, II</td>
</tr>
</tbody>
</table>
Leg 5 (Fig. 4b) with basis and endopod completely fused to somite; outer basal seta inserted on short basal protuberance. Exopod about 1.6 times as long as wide, ornamented with long spinules on both outer and inner margins and minute spinules at bases of spines; armature consists of 3 strong spines and 1 plumose seta; inner apical spine 1.2 times longer than segment, about 1.1 times longer than proximal outer spine and 1.3 times longer than outer apical spine. Exopodal apical seta plumose except for short distance proximally, about 1.2 times as long as segment and 0.8 times as long as basal seta.

Leg 6 (not figured) indistinct, trapezoidal plate, armed with 2 almost equal, smooth spines, which are fused to the plate, and 1 smooth, much longer seta.

**Redescription of male.** Total body length, excluding caudal setae 0.47mm. Habitus (Fig. 8a) slenderer than female; prosome/urosome ratio 1.4 and greatest width near posterior end of cephalothorax. Body length/width ratio about 2.6. Cephalothorax (Fig. 8a) about 2.8 times as wide as genital somite; 0.8 times as long as its greatest width, representing 32% of total body length. Ornamentation of prosomal somites, colour and nauplius eye similar to those of female. Hyaline fringe of fifth pedigerous somite smooth; that of genital somite and other urosomites serrulated both dorsally and ventrally. Dorsal hyaline fringe of preanal somite slightly produced posteriorly in the form of pseudo-operculum and serrulated. Third urosomite ornamented with a pair of ventro-lateral cuticular recesses (Fig. 8b). Anal somite with smooth, broad, slightly convex anal operculum armed with transverse row of spinules on posterior margin. Anal sinus widely open, ornamented with 2 diagonal rows of minute spinules. Caudal rami (Fig. 8a) almost as long as wide, parallel, with little space between them. Armature and ornamentation as in female.
Antennule (Fig. 8c) 14-segmented, digeniculate, with geniculations between 6 and 7, 12 and 13 segments. Armature formula as follows:

$$8+3ae.4.4+ae.2.1.2+ae.0.1.1+ae.1+1spine.1+1spine+ae.1spine.1+ae.11+2ae.$$  

Segments 9, 10, and 11 with modified, small, bipinnate setae. Antenna, labrum, mandible, maxillule, maxilla, maxilliped and legs 1–4 as in female.

Leg 5 (Fig. 8b) exopod 1.8 times as long as wide, ornamented with large spinules on both outer and inner margins. Armature consisting of 3 spines and 2 spiniform setae. Inner apical spine 1.5 times as long as the segment, about 1.8 times as long as outer apical spine, and 1.3 times as long as outer proximal spine. Exopodal inner seta about 0.8 times as long as apical seta and 1.1 times as long as segment; both setae pinnate.

Leg 6 (Fig. 8b) distinct, armed with 1 serrulated spine and 2 plumose spiniform setae; innermost spine 2.6 times as long as middle seta and 1.8 times as long as outer seta.

**Distribution and ecology.** This species is widely distributed in Asia, South America and Western Australia (Dussart & Defaye, 2006). In India, it was reported from West Coast Bandra near Mumbai (erstwhile Bombay) by Lindberg 1941; from Lake Kolleru at Kolletikota by Ranga Reddy & Radhakrishna 1984. *Halicyclops spinifer* is mostly available in several kinds of surface brackish water bodies, estuarine coasts, interstitial and sandy beaches habitats, as well as ponds and marshes. In the present study it was accompanied by few diaptomids and very few ostracods.

**Discussion.** The members of the genus *Halicyclops* are planktonic, predominantly inhabiting brackish waters. Of the 8 groups in the subgenus *Halicyclops* (*Halicyclops*) s. str., group A is represented only by *H. tenuispina* Sewell, 1924 from Lake Chilka; group B by *H. spinifer* Kiefer, 1935 from Bandra.
(Mumbai), L. Chilka, L. Kolleru, \textit{H. electus} Lindberg, 1943 from Mahim, Bombay, and \textit{H. konkanensis} Lindberg, 1949 and \textit{H. pilifer} Lindberg, 1949 from West coast; and group F by \textit{H. canui} Lindberg, 1941, also from West coast (a swamp at Bandra, West Mumbai (erstwhile Bombay).

\textit{Halicyclops (H.) spinifer} Kiefer, 1935 with the spine formula 3.4.4.3 fits into \textit{thermophilus} group (B group), which is characterized, inter alia, by the presence of a well developed, curved chitinous spiniform process on each side of the genital double-somite, as originally suggested by Herbst (1983) and subsequently accepted by Pesce et al. (1996) and Baribwegure & Dumont (2000). A perusal of the existing literature shows that there is still enormous confusion about the validity of this species (see Karanovic 2009; Chang & Lee, 2012). According to the latest version of Chang & Lee (2012), \textit{Halicyclops (H.) spinifer} Kiefer 1935 and \textit{Halicyclops (H.) thermophilus} Kiefer 1929 “should be regarded as \textit{species inquirendae}”. Having studied several populations of \textit{H. (H.) spinifer} from India, I thought it advisable to provide its detailed illustrated description here and uphold the taxonomic validity of this species. Although Karanovic (2009: 276) is of the opinion that this species is synonymous with \textit{H. (H) thermophilus}, the present critical study leaves no doubt that they are indeed distinctly different from each other in several important morphological criteria: i) leg 4 endopod 3 is 1.7–1.8 vs. 1.4–1.5 times longer than wide, inner apical spine 1.3 vs. 1.5 times as long as outer one, and inner 2 setae plumose proximally and strongly pinnate distally, i. e. modified vs. spiniform and strongly bipinnate, i. e. normal; ii) innermost caudal setae 0.6 vs. 0.4 times as long as outermost caudal setae; iii) lateral seta arising at 40% length vs. mid length of caudal ramus, and positioned dorsally vs. slightly dorso-laterally; iv) antennular fourth segment with vs. without an aesthetasc; v) antennal coxobasis with 2 rows of short
spinules vs. none on the outer margin of caudal surface; vi) inner apical spine of leg 5 almost equal in length to vs. shorter than apical seta; and vii) intercoxal sclerites of legs 1–4 vs. only leg 1 with distal hairs.

**Table 1. Morphometric data of Halicyclops (Halicyclops) spinifer Kiefer, 1935**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total length in mm</td>
<td>0.64</td>
<td>0.76</td>
<td>0.70</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.2</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>0.94</td>
<td>1.20</td>
<td>1.07</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal rami length: width</td>
<td>1.2</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>2.0</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>0.50</td>
<td>0.58</td>
<td>0.56</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outermost apical seta</td>
<td>1.60</td>
<td>1.74</td>
<td>1.67</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 3, length: width</td>
<td>1.70</td>
<td>1.80</td>
<td>1.75</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, inner apical spine: outer spine</td>
<td>1.25</td>
<td>1.35</td>
<td>1.30</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, length of the segment: inner apical spine</td>
<td>0.82</td>
<td>0.86</td>
<td>0.84</td>
</tr>
</tbody>
</table>
Halicyclops (Halicyclops) pilifer Lindberg, 1949
(Figs 9–13)

Synonymy
Halicyclops (H.) pilifer Lindberg, 1949: 6, Fig. 1f–h.

Locality. River Krishna at Hamsaladeevi (15°58′39″N, 81°05′59″E; elevation 7 m), Krishna District, Andhra Pradesh, South India.

Material examined. 4 voucher specimens: 1 female (MNHN-IU-2013-9783) and 1 male (MNHN-IU-2013-9785) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9784) dissected on 8 slides and 1 male (MNHN-IU-2013-9786) dissected on 2 slides; 2 females and 1 male in author's personal collections; 03 January 2004, Coll. V. Subhashini.

Redescription of adult female. Habitus robust (Fig. 9a), total body length, measured form base of rostrum to posterior margin of caudal rami (excluding caudal setae) 0.64mm. Prosome/urosome ratio about 1.4 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.4. Free pedigerous somites without pronounced lateral expansions. Nauplius eye not visible. Rostrum well developed, membranous and broadly rounded. Cephalothorax 0.85 times as long as its greatest width, 2.2 times as wide as genital double-somite, and representing 35% of total body length. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite with a smooth fringe dorsally and ventrally, ornamented with 2 pairs of cuticular pores dorsally and few spinules laterally (Fig. 9c).

Genital double-somite (Fig. 9b, c) 1.2 times as long as wide; with two small obtuse processes laterally in the middle of the segment; ornamented with 2 pairs of cuticular pores dorsally. Hyaline fringe of genital double-somite and succeeding 2 somites serrulated dorsally and ventrally. Copulatory pore round, copulatory duct.
rigidly sclerotized; seminal receptacle reduced into two narrow lateral arms that form a letter “T” with copulatory duct (Fig. 9b). Ovipores situated dorso-laterally and covered by reduced sixth legs. Hyaline fringe of fourth urosomite with shorter dorso-median denticulations than lateral ones, not extending on to the anal operculum. (Fig. 9c). Anal somite split profoundly (Fig. 9c) with broad anal operculum representing 55% of somites width, ornamented with transverse row of spinules on posterior margin dorsally and ventrally. Anal sinus widely open, ornamented with 2 diagonal rows of minute spinules, 2 rows of hair like spinules and 1 transverse row of minute spinules.

Caudal rami (Figs 9a, c, 10a) cylindrical, divergent, almost as long as wide, with space between them about 1.6 times of ramus width; ornamented with spinules at inner and outer distal margins. Dorsal seta uniarticulate, relatively long, 1.8 times as long as ramus, inserted little beyond the posterior end of the ramus, arising from a subapical papilla and plumose distally. Lateral seta situated at 30% length of caudal ramus, positioned dorsally and 0.8 times as ramus width. Outermost apical seta spiniform, almost as long as ramus, 0.65 times as innermost apical seta. Innermost apical seta long, slender, plumose, and 1.4 times as long as ramus, 0.7 times as dorsal seta and 1.5 times as outermost apical seta. Principal apical setae bipinnate, inner median apical seta 2.4 times as long as outer median apical seta and 0.64 times as long as the body.

Antennule (Fig. 10b) 6-segmented, short, reaching anterior one third of cephalothorax, with 1 slender aesthetasc on fourth and sixth segments each and setal formula: 8. 11. 5. 6+ae. 2. 9+ae.

Antenna (Fig. 10c) 3-segmented, comprising coxobasis and 2-segmented endopod. Coxobasis cylindrical, about 2.2 times as long as wide, ornamented with a
small row of spinules along the proximal outer margin, armed with 2 smooth setae at
distal inner corner; seta representing exopod small and smooth. First endopodal
segment shorter than coxobasis, armed with 1 smooth seta in the middle, ornamented
with a row of spinules along outer distal margin. Second endopodal segment 2.7 times
as long as wide, slightly longer than first, ornamented with a longitudinal row of
spinules along outer distal margin, armed with 5 lateral and 7 apical smooth setae.

Labrum (not figured) trapezoidal, not clearly visible for observation.

Mandible (Fig. 11a) with palp reduced, armed with 2 unequal setae; distal one
pinnate terminally, much longer than proximal smooth seta. Coxal gnathobase with 6
strong teeth and 1 outermost unipinnate seta.

Maxillule (Fig. 11b) composed of well developed praecoxa and 2- segmented
palp. Arthrite of praecoxa with 4 strong apical spines, anterior one much stronger and
longer than others. Praecoxa armed with 7 armature elements along inner margin, the
longest one plumose. Palp apically, with 2 slender (1 smooth, the other pinnate) setae
and 1 robust, strong bipinnate seta. Endopod distinct, bearing 2 apical and 1 subapical
pinnate setae; exopodal seta pinnate.

Maxilla (Fig. 11c, d) 4-segmented but praecoxa fused to coxa on posterior
surface. Proximal endite of praecoxa armed with 2 pinnate setae; distal endite small
and unarmed. Proximal endite of coxa with 1 short smooth seta; distal endite bearing
1 proximal, completely fused strong seta ornamented with 2 elongated spinules and 1
distal slightly shorter, stout seta. Basis expanded into a robust claw, unornamented
and armed with 2 setae, strong seta shorter than claw, unornamented; small seta at
base. Endopod armed with 2 strong and 3 slender smooth setae.

Maxilliped (Fig. 11e) 2-segmented, armed with 3 setae on protopod and 5
setae on endopod. Proximal protopodal seta unornamented, middle seta smooth and
strong, 1.7 times as long as proximal one; distal seta slightly shorter than middle one and ornamented with 2 long spinules. Endopod 0.8 times as long as protopod, armed with 2 lateral setae; 1 unipinnate median apical seta and 2 unequal subapical setae.

Legs 1–4 (Fig. 12a–d) with 3-segmented exo-and endopod. Coxa of all legs ornamented with a short row of spinules along outer distal margin. Coxa of leg 1 (Fig. 12a) with a row of long spinules along outer posterior margin; and leg 4 with an arched row of spinules on proximal outer corner (Fig. 12d); and armed with a pinnate seta at inner distal corner; this seta short on leg 4 (Fig. 12d). Intercoxal sclerites of legs 1–4 with round protrusions on both sides, bearing long delicate hairs at distal end. Third exopodal segment spine formula: 3.4.4.3 and setal formula 5.5.5.5. Basis of each leg armed with outer plumose seta, ornamented with a row of long spinules at inner distal corner. Spine inserted at inner corner of basis of leg 1 reaching beyond the middle of third endopodal segment, ornamented with long spinules at proximal end and bare at distal end (Fig. 12a). Exopodal and endopodal setae slender and plumose, except for 2 modified setae on endopod 3 of leg 4. Third endopodal segment of leg 4 (Fig. 12d) 1.5 times as long as wide; inner apical spine 1.7 times as long as outer one; 1.6 times as long as the segment; 2 inner setae spiniform, bipinnate and almost as long as inner apical spine. First exopodal segment of legs 1–4 with spinules along outer margin; their inner margins without ornamentation. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals=spines; Arabic numerals=setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>1-0</td>
<td>I-I</td>
<td>4, 1+I, II</td>
<td>1-0, 1-0, 3, 1+I, I</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1-0</td>
<td>0-I</td>
<td>4, 1+I, III</td>
<td>1-0, 2-0, 2, 1+I, II</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1-0</td>
<td>0-I</td>
<td>4, 1+I, III</td>
<td>1-0, 2-0, 2, 1+I, II</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1-0</td>
<td>0-I</td>
<td>4, 1+I, II</td>
<td>1-0, 2-0, II, II, I</td>
</tr>
</tbody>
</table>
Leg 5 (Fig. 9b, c) with basis and endopod completely fused to somite, outer basal seta inserted on protuberance, pinnate at distal end. Exopod 1.5 times as long as wide, ornamented with spinules on both outer and inner margins. Armature consists of 3 strong spines and 1 apical plumose seta; inner apical spine 1.2 times longer than segment, about 1.1 times as long as proximal outer spine, and 1.3 times longer than outer apical spine. Exopodal apical seta plumose and 1.6 times as long as segment and 1.4 times as long as inner apical spine.

Leg 6 (not figured) indistinct, armed with 2 almost equal smooth spines, and 1 slender much longer seta.

**Description of adult male.** Total body length, excluding caudal setae 0.48mm. Habitus (Fig. 13a) slenderer than female with prosome/urosome ratio 1.8 and greatest width near posterior end of cephalothorax. Body length/width ratio about 2.6. Cephalothorax about 2.8 times as wide as genital somite. Rostral expansion well developed. Cephalothorax 0.8 times as long as its greatest width, representing 38% of total body length. Ornamentation of prosomites, colour and nauplius eye similar to those of female. Hyaline fringe of fifth pedigerous somite smooth both dorsally and ventrally; that of genital somite and other urosome somites (Fig. 13a, c) serrulated dorsally and ventrally.

Genital somite (Fig. 13a, c) almost as long as wide; third urosomite without cuticular recesses. Anal somite with smooth, broad, slightly convex anal operculum with transverse row of spinules at posterior margin dorsally and ventrally. Anal sinus widely open, ornamented with diagonal rows of spinules as in female. Caudal rami (Fig. 13a, c) about 1.2 times as long as wide, almost parallel, with little space between them. Armature and ornamentation similar as in female.
Antennule (Fig. 13b) 14-segmented, digeniculate with geniculations between 6 and 7 and 12 and 13 segments. Armature formula as follows: 8+3ae.4.3+ae.4.1.2+ae.0.1.2+ae.2.3+ae.1.1+ae.11+2ae. Antenna, labrum, mandible, maxillule, maxilla, maxillipeds and legs 1–4 as in female.

Leg 5 (Fig. 13c) exopod 1.7 times as long as wide ornamented with large spinules on outer margin. Armature consists of 3 spines and 2 setae; inner apical spine 1.6 times as long as the segment, about twice as long as outer apical spine, and 1.4 times as long as outer proximal spine. Exopodal inner seta about 0.7 times as long as apical seta and 1.2 times as long as segment; both setae pinnate.

Leg 6 (Fig. 13c) armed with 2 pinnate spines and 1 plumose seta; innermost spine 2.8 times as long as middle spine and 1.7 times as long as outer seta.

**Distribution and ecology.** *Halicyclops pilifer* is available in surface brackish water bodies and estuarine coasts. This species is endemic to India (Dussart & Defaye, 2006) and was reported from West Coast Bandra at Thana, near Bombay (now Mumbai) by Lindberg, 1949. In the present study the species was found in a single sample taken from River Krishna at Hamsaladeevi, and was accompanied by *Halicyclops spinifer*, few diaptomids and very few ostracods.

**Discussion.** Lindberg’s (1949) original account of *Halicyclops* (*Halicyclops*) *pilifer* is rather brief. The existing literature shows that there is no subsequent report of this species. Its male is not yet known. Now both sexes are described and illustrated in detail. The material under study perfectly agrees with Lindberg’s original account in various principal criteria, especially in regard to the i) length/width ratios of caudal rami, caudal setae, female genital double-somite; ii) shape of the double-somite; iii) ornamentation of anal operculum; iv) length/width ratios of third endopodal segment of leg 4, its outer and inner apical spines; v) ornamentation on
principal apical setae and antennule. However, the minor differences noticed relate to i) length/width ratios of leg 5 apical seta and spines; ii) more pronounced lateral projections on genital double-somite; and iii) presence of pseudo-operculum.

*Halicyclops (H.) pilifer* differs from *Halicyclops (H.) spinifer* in the following respects: i) shape of the lateral projections on genital double somite; ii) absence of cuticular recesses on genital somite; iii) shape of pseudo-operculum iv) length/width ratios of genital double-somite, outermost and innermost apical setae, leg 5 seta and its spine v) ornamentation of principal apical caudal setae and vi) the inner setae of third endopodal segment of leg 4 are spinulose completely vs. not so in *H. spinifer*.

**Table 2. Morphometric data of Halicyclops (H.) pilifer Lindberg, 1949**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>0.58</td>
<td>0.65</td>
<td>0.62</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome ratio</td>
<td>1.4</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal rami length: width</td>
<td>1.10</td>
<td>1.20</td>
<td>1.15</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>2.4</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.30</td>
<td>1.60</td>
<td>1.45</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outer apical seta</td>
<td>2</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 3, length: width</td>
<td>1.4</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>1.7</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, length of the segment: inner apical spine</td>
<td>1.70</td>
<td>1.80</td>
<td>1.75</td>
</tr>
</tbody>
</table>
Key to the Indian species of genus *Halicyclops* Norman, 1903.

1. Legs 1–4 exopod 3 spine formula 3.4.4.3………………………………………………………….. 2
   Legs 1–4 exopod 3 spine formula 4.4.4.3 ..... ..... *H. (H.) tenuispina* Sewell, 1924

2. Genital double-somite with short angular/obtuse process laterally .................3
   Genital double-somite with spiniform process laterally........... *H. (H.) spinifer*
   Kiefer 1935

3. Innermost apical seta shorter than outermost apical seta ....................... 4
   The same longer than outermost apical seta.........*H. (H.) pilifer* Lindberg, 1949

4. Dorsal seta less than twice as long as caudal rami .................................5
   Dorsal seta thrice as long as caudal rami.......... *(H.) konkanensis* Lindberg, 1949

5. Leg 1 exopod 3 with 3 spines............................... *H. (H.) electus* Lindberg, 1943
   Leg 1 exopod 3 with 2 spines............................. *H. (H.) canui* Lindberg, 1941
Subfamily **Eucyclopinae** Kiefer, 1927

Genus **Eucyclops** Claus, 1893

**Generic diagnosis.** Body ovoid in the anterior part. Fifth thoracic somite ornamented laterally with more or less long hair-setae. Genital double-somite broad in its anterior part and narrow posteriorly. Seminal receptacle dilated anteriorly, posterior part narrow. Caudal rami long, slender, most often with denticles on the outer edge in female (constituting a **serra**). Outermost apical seta spiniform. Antennule 11 or 12-segmented, last 3 segments most often bearing a hyaline membrane. Legs 1–4 biramous, each ramus 3-segmented. Leg 4 third endopodal segment ending in 2 spiniform, short setae. (Dussart & Defaye 2001)

Three subgenera have been recognized under the genus **Eucyclops** Claus, 1893:

**Eucyclops** s. str., **Stygocyclops** Plesa, 1971 (for the species **E. (S.) teras** Graeter, 1907) and **Isocyclops** Kiefer, 1957 (endemic of L. Tanganyika). According to the latest World of Copepods database, the genus **Eucyclops** contains a total of 108 nominal species and subspecies in the world (Chad, 2013), some of them strongly requiring revision or redescription (Alekseev & Defaye, 2011). The following 10 species are known from India:

1. **Eucyclops (Eucyclops) serrulatus** (Fischer, 1851)
2. **Eucyclops (Eucyclops) speratus**, Kiefer, 1929
3. **Eucyclops (Eucyclops) agiloides** (G. O. Sars, 1909)
4. **Eucyclops (Eucyclops) indicus** (Kiefer, 1927)
5. **Eucyclops (Eucyclops) permixtus** Kiefer, 1928
6. **Eucyclops (Eucyclops) productus** Kiefer, 1936
7. **Eucyclops (Eucyclops) serrulatus defecta** Lindberg, 1937
8. **Eucyclops (Eucyclops) microdenticulatus** Lindberg, 1939


Of these taxa, *Eucyclops (Eucyclops) semidenticulatus* Lindberg, 1939 alone has been met in this study and it is redescribed herein. Furthermore, a new subspecies, *Eucyclops (Eucyclops) bryophilus mahanandiensis* n. ssp. is being described.

*Eucyclops (Eucyclops) semidenticulatus* Lindberg, 1939
(Figs 15–19)

**Synonymy**

*Eucyclops semidenticulatus* Lindberg, 1939: 379; 1940: 523: Fig. 3a–f.

**Locality.** River Krishna at Kanaka Durga Varadhi (16°30'22"N, 80°36'18"E; elevation 11.88 m), Vijayawada, Krishna District, Andhra Pradesh, South India.

**Material examined.** 4 voucher specimens: 1 female (MNHN-IU-2013-9787) and 1 male (MNHN-IU-2013-9789) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9788), dissected on 7 slides and 1 male (MNHN-IU-2013-9790) dissected on 2 slides; 10 females and 2 males in author’s personal collections; 09 July 2005: Coll. V. Subhashini.

**Other material examined.** Agricultural pond at Sempatti village (10°21'00"N, 77°57'00"E; elevation 268 m), Dindigul District, Tamil Nadu, South India, 31 December 2005: 6 females and 2 males, Coll. Y. Ranga Reddy and D. Ambedkar.

Reservoir at Acharya Nagarjuna University Campus, Nagarjuna Nagar (16°30'38"N, 80°43'05"E; elevation 30 m), Guntur District, Andhra Pradesh, South India, 11 August 2007: 4 females and 2 males, Coll. V. Subhashini.

Pond at Vengalayapalem village (16°17'41"N, 80°21'55"E; elevation 37 m), Guntur District, Andhra Pradesh, South India, 12 September 2007: 6 females and 2 males, Coll. D. Ambedkar.
**Redescription of adult female.** Habitus robust (Fig. 15a), total body length, measured from base of rostrum to posterior margin of caudal rami (excluding caudal setae) 0.82 mm. Prosome/urosome ratio about 1.4 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.3. Free pedigerous somites with slightly pronounced lateral expansions. Colour of preserved specimens rusty brown. Cephalothorax 0.9 times as long as its greatest width, 2.7 times as wide as genital double-somite and representing 26% of total body length. Fifth pedigerous somite with lateral group of short hair-like setae (Fig. 15b).

Genital double-somite (Fig. 15b) 0.7 times as long as wide. Hyaline fringes of genital double-somite and succeeding 2 somites smooth dorsally and serrated ventrally. Copulatory pore round, copulatory duct rigidly sclerotized. Seminal receptacle situated at anterior half of genital double-somite, with distinctly divided anterior and posterior expansions; anterior expansion shorter than posterior one. Ovipores situated dorso-laterally and covered by reduced sixth legs. Anal somite with smooth, broad, convex anal operculum, representing 80% of somites width; ornamented with spinules dorsally and ventrally overlying the base of caudal rami. Anal sinus widely open and smooth.

Caudal rami (Fig. 15c, d) cylindrical, slightly divergent, 4.8 times as long as wide, with space between them about 1.4 times of ramus width, ornamented with a longitudinal row of about 24–32 spinules, along most of the outer edge of each rami, proximal spinules smaller than distal ones. Dorsal seta 0.54 times as long as ramus, uniarticulate at base and plumose distally. Lateral seta situated at 80% length of caudal ramus, positioned dorso-laterally and almost as long as ramus width. Outermost apical seta stout, spiniform, 0.55 times as long as ramus, distinctly shorter than innermost apical seta, ornamented with dense, strong setules on outer margin, but
longer setules on inner margin. Innermost apical seta 1.7 times as long as outermost apical seta. Inner median apical setae 1.38 times as long as outer median apical seta and about half as long as the body. Ornamentation on principal apical setae heterogeneous.

Antennule (Fig. 16a) 12-segmented, long, reaching the end of second pedigerous somite with a serrated hyaline membrane along 3 distal most segments; with 1 aesthetasc each on segments 9 and 12; setal formula 8.4.2.6.4.2.3.2+ae.2.3.7+ae. First segment with curved row of spinules at base.

Antenna (Fig. 16b, c) 4-segmented comprising coxobasis and 3-segmented endopod. Coxobasis 1.8 times as long as wide, ornamented with 1 arched row of median tiny spinules, 2 short rows of spinules along inner proximal region, 2 rows along outer margin on caudal surface; 1 longitudinal row of spinules at proximal end, 1 oblique row in the middle and 1 row of outer marginal spinules on frontal side; armed with 2 setae at distal inner corner; long bipinnate seta representing exopod at distal outer corner, overreaching the tip of third endopodal segment. First endopodal segment armed with 1 smooth seta at midlength, ornamented with 1 row of spinules along proximal inner and outer margins. Second endopodal segment twice as long as wide, ornamented with 1 longitudinal row of spinules along outer margin, armed with 5 lateral, 2 subapical and 2 apical setae. Third endopodal segment about twice as long as wide armed with 7 apical setae.

Labrum (Fig. 17a) ornamented with 4 groups of long spinules on ventral surface; cutting edge with 11 large medial teeth and 2 groups of 3 small teeth laterally.

Mandible (Fig. 17b) with distinct palp, armed with 2 very long, finely plumed setae and 1 short, smooth seta on distal end. Coxa ornamented with 1 row of spinules
at proximal inner margin and another row at distal outer margin; gnathobase with 9 strong teeth and 1 outermost unipinnate seta.

Maxillule (Fig. 16d, e, f) composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines, anterior one much stronger than others. Praecoxa armed with 6 armature elements along inner margin, the longest one plumose. Palp (Fig. 16e) apically with 2 pinnate setae and 1 robust, strong spine; endopod distinct, bearing 2 apical and 1 subapical pinnate setae; exopodal seta pinnate.

Maxilla (Fig. 17c) 4-segmented, proximal endite of praecoxa armed with 2 pinnate setae, distal endite small and unarmored. Proximal endite of coxa with 1 strong bipinnate seta; distal endite bearing proximal bipinnate seta, and 1 distal, smaller smooth seta. Basis expanded into robust claw, ornamented with strong teeth at midlength of concave margin, armed with 2 setae, strong bipinnate seta, slightly shorter than claw, small seta at base. Endopod 2-segmented, first segment with 2 strong pinnate setae and second segment with 1 strong seta and 2 smooth setae.

Maxillipede (Fig. 17d) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa unornamented, armed with 3 pinnate setae; middle seta strongest and longest, almost as long as proximal one and about 2.2 times as distal one. Basis 1.7 times as long as wide, ornamented with 2 transverse rows of spinules, medially and sub distally along outer margin and armed with 2 strong setae. First endopodal segment unornamented, armed with 1 unipinnate seta. Second endopodal segment unornamented, armed with 1 strong bipinnate seta and 2 unipinnate setae.

Legs 1–4 (Fig. 18a–d) with 3-segmented rami. Coxa of all legs ornamented as figured; armed with a plumose seta at inner distal corner. Intercoxal sclerites of legs 1–4 with broad, round protrusions, ornamented with 2 transverse rows of small
denticles around midway, and a group of thin spinules on main body of protuberances, not extending beyond their edges; leg 1 with 1 transverse row of small denticles. Third exopodal segment spine formula 3.4.4.3 and setal formula 5.5.5.5. Basis of each leg armed with outer plumose setae, ornamented with 2–3 spinules at outer distal margin; leg 1 with pinnate spine inserted at inner protruded corner, reaching beyond the middle of third endopodal segment (Fig. 18a). All exopodal and endopodal setae slender and plumose, except 1 seta on the third exopodal segment of leg 1, with tiny spinules on one side; all endopodal segments with long hair-like spinules along outer margin. Leg 4 third endopodal segment, 2.6 times as long as wide; inner apical spine 1.5 times as long as outer one as well as the segment itself. Legs1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>1-0</td>
<td>1-1</td>
<td>1-1 1-I 4, 1+I, II</td>
<td>1-0 2-0 3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1-0</td>
<td>0-1</td>
<td>1-I 1-I 4, 1+I, III</td>
<td>1-0 2-0 3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1-0</td>
<td>0-1</td>
<td>1-I 1-I 4, 1+I, III</td>
<td>1-0 2-0 3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1-0</td>
<td>0-1</td>
<td>1-I 1-I 4, 1+I, II</td>
<td>1-0 2-0 2, II, 1</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 15b) 1-segmented, with slender, slightly curved inner spine, and 2 setae; outer seta 2.3 times and middle seta about 3 times as long as spine.

**Redescription of adult male.** Total body length, excluding caudal setae 0.68 mm. Habitus (Fig. 19a) less robust than in female, with prosome/urosome ratio 1.5 and greatest width near posterior end of cephalothorax. Body length/width ratio about 3. Cephalothorax (Fig. 19a) almost as long as its greatest width, representing 37% of total body length and 2.8 times as wide as genital somite. Fifth pedigerous somite smooth, without lateral group of short setules; urosomites smooth dorsally and
serrulater ventrally. Anal somite with smooth, broad, convex anal operculum, which
represents 60% of somites width. Posterior end of anal somite with spinules dorsally
and ventrally.

Caudal rami parallel, 3.2 times as long as wide, with lateral spinules confined
to posterior margin. Outermost apical seta 0.5 times as long as innermost apical seta,
ornamented with long hair-like setules on both sides. Dorsal seta 1.6 times as long as
outermost apical seta.

Antennule (Fig. 19c) 15-segmented, digeniculate with geniculations between
segments 7 and 8, and 13 and 14. Armature formula as follows: 8+3ae.4.2.2+ae.2.
2.2.2.4.2.2.0.2.11+ae. Antenna, labrum, mandible, maxillule, maxilla, maxilliped
and legs 1–5 as in female.

Leg 6 (Fig. 19b) armed with 1 serrulated spine and 2 plumose setae; innermost
spine stout, almost equal in length to middle seta and 0.85 times of outer seta.

**Distribution and ecology.** Lindberg’s (1939) original description of
*Eucyclops semidenticulatus* from India was based on freshwater plankton samples
collected from the following localities: Salsette (Bombay, now Mumbai), Gharipouri
(Deccan), Kotagiri (Mountain Nilgiris), and Pandharpour (Deccan). Subsequently, it
has remained unreported up till now from anywhere else. In the present study, it was
found in the states of Andhra Pradesh and Tamil Nadu. The species is endemic to
India and inhabits the surface water bodies like ponds, reservoirs and rivers. In the
material examined, it was accompanied by abundant diaptomids, a few cladocerans,
and rotifers.

**Discussion.** Lindberg’s (1939) original account of *Eucyclops semidenticulatus*
is rather brief (illustrated only leg 5 and 6 for male) but accurate. As there is no
subsequent report of this species, a detailed illustrated redesription of the species is
given here. The material under study perfectly agrees with Lindberg’s original account in various principal criteria, especially in regard to the following: i) length/width ratio of caudal ramus, female genital double-somite, ii) details of the genital field, iii) length ratio between innermost and outermost apical setae, dorsal seta and innermost apical seta, and leg 5 inner spine and middle seta. However, the minor differences noticed relate to: i) the length/width ratio of leg 4 third endopodal segment less than 3 times (maximum 2.8) vs. 3 times ii) length of its inner apical spine and outer apical spine 1.7 vs 2.0 iii) and length of segment and inner apical spine 0.9–1.1 vs. 0.85.

E. semidenticulatus resembles E. serrulatus in the following respects: i) the presence of a longitudinal row of spinules along most of the outer edge of the ramus, ii) the shape of the seminal receptacle, iii) the length/width ratios of caudal setae, iv) the ornamentation of leg 4 coxa, v) and length/width ratios of leg 4 third endopodal segment. The former, however, differs from the latter in having i) stronger and longer denticles on caudal rami, ii) the denticles gradually increase in size towards the distal end in E. semidenticulatus whereas they are of the same size in E. serrulatus, iii) the hyaline membrane on the distalmost three segments of antennule serrated vs. smooth, iv) length ratio of innermost and outermost apical setae almost twice vs. less than 1.5 v) leg 4 coxal seta is bipinnate vs. unipinnate, vi) leg 5 with slender vs. stout inner spine, vii) outer seta more than twice the length of inner spine vs. subequal in length, viii) middle seta 3 times vs. 1–1.2 times as long as inner spine, ix) inner spine of third endopodal segment of leg 4 almost as long as vs. shorter than distal segment.

E. semidenticulatus also shares some close affinities with E. euacanthus (G.O. Sars, 1909) in the following characters: i) presence of a thin spine on leg 5; ii) proximal denticles on caudal rami positioned towards inner dorsal side rather than on
the margin; iii) ornamentation of coxa of leg 4 and its intercoxal sclerites; iv) and serrated hyaline membrane on last 3 segments of antennules. However, both species differ from each other in the following respects: i) ornamentation of innermost apical seta, ii) the length of antennule, iii) ornamentation of intercoxal sclerites of leg 4 and of antenna, and  iv) length/width ratios of spine and setae on leg 5.

Table 3. Morphometric data of *Eucyclops semidenticulatus* Lindberg, 1939

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>0.80</td>
<td>1.10</td>
<td>0.95</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.2</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>0.70</td>
<td>0.80</td>
<td>0.75</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal rami length: width</td>
<td>4.6</td>
<td>6.2</td>
<td>5.4</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.20</td>
<td>1.50</td>
<td>1.35</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.6</td>
<td>2.2</td>
<td>1.9</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: caudal ramus</td>
<td>0.50</td>
<td>0.72</td>
<td>0.61</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 3, length: width</td>
<td>2.2</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>1.3</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>0.9</td>
<td>1.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>
**Eucyclops (Eucyclops) bryophilus mahanandiensis n. ssp.**
(Figs 21–25)

**Type locality.** Mahanandi koneru (a small shallow man-made basin filled with groundwater) at Mahanandi (15°28'48"N, 78°28'48"E; elevation 268 m), a pilgrim centre near Nandyal town, Kurnool district, Andhra Pradesh, South India.

**Type material.** Holotype, female (MNHN-IU-2013-9791) and allotype male (MNHN-IU-2013-9793) whole-mounted on 1 slide each; 2 paratypes: 1 female (MNHN-IU-2013-9792) dissected on 8 slides and 1 male (MNHN-IU-2013-9794) dissected on 2 slides, 2 females in author’s personal collections; 31 October 2005, Coll. D. Ambedkar.

**Etymology.** The new subspecies is named after the type locality, Mahanandi, a pilgrim village in Kurnool district of Andhra Pradesh state. The name is an adjective for the place and ends in the Latin suffix “-ensis”.

**Diagnosis.** Genital double-somite almost as long as wide; seminal receptacle located in the anterior half of the genital double-somite; anterior margin slightly depressed at mid length. Caudal rami cylindrical and parallel, 3 times as long as wide, with a longitudinal row of spinules along distal half of outer edge of ramus. Dorsal seta 0.6–0.73 times the length of innermost apical seta. Outermost apical seta with fine setules on both sides. Antennule 12-segmented with a smooth hyaline membrane along 3 distal most segments. Frontal side of coxobasis of antenna with 3 oblique rows of spinules and 2 groups of marginal spinules. Third endopodal segment of leg 4, 1.6 times as long as wide; inner apical spine 1.4 times as long as outer apical spine, and 1.3 times as long as the segment. Third exopodal segment spine formula 4.4.4.3 and setal formula 5.5.5.5. Leg 5, 1-segmented, with somewhat strong inner spine, and 2 setae; outer seta subequal in length to spine, middle seta about twice as long as spine.
**Description of adult female (Holotype).** Habitus slender (Fig. 21a); total body length, measured from base of rostrum to posterior margin of caudal rami, excluding caudal setae 0.84 mm. Prosome/urosome ratio about 1.5 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.8. Free pedigerous somites without pronounced lateral expansions; colour of the preserved specimens pale yellow. Cephalothorax 0.93 times as long as its greatest width, representing 32% of total body length and 3 times as wide as genital double-somite. Fifth pedigerous somite distinctly produced laterally, with lateral group of long hair-like setules (Fig. 21a, b).

Genital double-somite (Fig. 21b) 0.9 times as long as wide; hyaline fringe of genital double-somite and succeeding 2 somites smooth dorsally and serrulated ventrally. Copulatory pore oval, broad; copulatory duct rigidly sclerotized. Seminal receptacle situated at anterior half of the genital double-somite, with distinctly divided anterior and posterior expansions; anterior expansion shorter than posterior one. Ovipores situated dorso-laterally covered by reduced sixth legs. Anal somite with smooth, concave anal operculum, representing 80% of somite’s width. Anal sinus widely open with 2 diagonal rows of small spinules. Posterior end of anal somite ornamented with spinules dorsally and ventrally overlying the base of caudal rami.

Caudal rami (Fig. 21 a, c, d) cylindrical, parallel, 3.1 times as long as wide, with little space between them, ornamented with a longitudinal row of spinules along distal half of outer edge. Dorsal seta 0.6 times the length of innermost apical seta and plumose distally. Lateral seta situated at 73% length of ramus, positioned dorsally but close to outer margin and almost as long as ramus width. Outermost apical seta stout, spiniform 0.6 times as long as ramus, ornamented with hair-like setules on both sides. Innermost apical seta 1.2 times as long as outermost apical seta. Principal apical setae
with breaking planes; inner median apical seta 1.6 times as long as outer median apical seta and about 0.4 times as long as the body.

Antennule (Fig. 22a) 12-segmented, reaching posterior 2/3 of cephalothorax with a smooth hyaline membrane along 3 distal most segments. Antennule with 1 aesthetasc each on segments 9, 11, and 12 and with setal formula: 8.4.2.6.4.2.3.2+ae.2.3+ae.7+ae. First segment with a row of spinules at its base.

Antenna (Fig. 22b, c) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis 1.8 times as long as wide, ornamented with 3 oblique rows of spinules on frontal side; 1 row of tiny median spinules, an isolated group of proximal minute spinules, few spinules near exopodal seta on caudal surface; armed with 2 smooth setae at distal inner corner and 1 long bipinnate seta representing exopod at distal outer corner, overreaching the tip of third endopodal segment. First endopodal segment armed with 1 smooth seta in the middle, ornamented with a row of spinules along outer distal margin. Second endopodal segment 1.5 times as long as wide, ornamented with 1 longitudinal row of spinules along outer margin, with 5 lateral, 2 subapical and 2 apical setae. Third endopodal segment about twice as long as wide armed with 7 apical setae.

Labrum (Fig. 22d) cutting edge slightly concave, with 11 teeth, ornamented with 4 groups of long spinules on ventral surface.

Mandible (Fig. 23a) with distinct palp, armed with 2 very long, finely plumed setae and 1 short smooth seta at distal end. Coxa ornamented with a small row of tiny spinules at proximal inner margin and gnathobase with 8 strong teeth and 1 outermost unipinnate seta.

Maxillule (Fig. 23b) composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines. Praecoxa armed with 7
armature elements along inner margin, the longest one plumose. Palp apically bearing 2 smooth setae and 1 robust pinnate, strong spine; endopod distinct, bearing 2 apical, (1 unipinnate, 1 smooth) and 1 subapical smooth setae; exopodal seta pinnate.

Maxilla (Fig. 23c) 4-segmented, proximal endite of praecoxa armed with 2 setae, distal endite small and unarmed. Proximal endite of coxa with 1 long, strong, bipinnate seta; distal endite bearing proximal bipinnate seta, and 1 distal, smaller, smooth seta. Basis expanded into robust claw, ornamented with spinules at midlength of inner margin and armed with 2 setae; strong seta unipinnate, slightly longer than claw, and small seta at base. Endopod 2-segmented, first segment with 2 smooth, strong spines and second segment with 1 strong, smooth spine and 2 long smooth setae.

Maxilliped (Fig. 23d) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa unornamented, armed with 3 pinnate setae; middle seta strongest and longest, 1.4 times as long as proximal one, 1.5 times as distal one. Basis 1.8 times as long as wide, ornamented with 2 transverse rows of spinules medially and sub distally along outer margin, and a row of strong spinules close to proximal seta. First endopodal segment ornamented with 1 row of spinules and armed with 1 bipinnate seta. Second endopodal segment unornamented, armed with 1 strong unipinnate seta and 2 smooth, slender setae.

Legs 1–4 (Fig. 24a–d) with 3-segmented rami. Coxa of all legs ornamented with a row of spinules along outer distal margin; a transverse row of spinules at distal end of legs 2 and 4; armed with a plumose seta at inner distal corner. Intercoxal sclerites of legs 1–4 with broad, round protrusions on both sides, with transverse row of long denticles around midway of distal end. Third exopodal segment spine formula 4.4.4.3 and setal formula 5.5.5.5. Basis of each leg armed with outer plumose seta,
and ornamented with a group of long setules at inner edge. Spine inserted at inner corner of leg 1 basis, bipinnate, reaching the anterior part of third endopodal segment (Fig. 24a). All exopodal and endopodal setae slender and plumose, except one seta on third endopodal segment of leg 1 with tiny spinules on one side, and all endopodal segments with long, hair-like spinules along outer margin. Third endopodal segment of leg 4 (Fig. 24d) 1.6 times as long as wide; inner apical spine 1.4 times as long as outer one. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/ terminal /outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th>Leg</th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1  2  3</td>
<td>1  2  3</td>
</tr>
<tr>
<td>Leg 1</td>
<td>1-0</td>
<td>I-1</td>
<td>I-I 4, 1+I, III</td>
<td>1-0 2-0 3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1-0</td>
<td>0-1</td>
<td>I-I 4, 1+I, III</td>
<td>1-0 2-0 3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1-0</td>
<td>0-1</td>
<td>I-I 4, 1+I, III</td>
<td>1-0 2-0 3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1-0</td>
<td>0-1</td>
<td>I-I 4, 1+I, II</td>
<td>1-0 2-0 2, II, 1</td>
</tr>
</tbody>
</table>

Leg 5 (Figs 21b, 24e) 1-segmented, with somewhat strong inner spine, and 2 setae; outer seta subequal in length to spine, middle seta about 2 times as long as spine.

**Description of adult male (Allotype).** Total body length, excluding caudal setae 0.68 mm. Habitus (Fig. 25a) slenderer, with prosome/urosome ratio 1.7 and greatest width near posterior end of cephalothorax. Body length/width ratio about 3 times as wide as genital somite. Cephalothorax almost as long as its greatest width, representing 40% of total body length. Fifth pedigerous somite smooth, without lateral group of small spinules. Hyaline fringes of urosomites smooth dorsally and serrulated ventrally. Anal somite with smooth, broad, slightly concave anal operculum which represents 85% of somite’s width.

Caudal rami 2.8 times a long as wide, without lateral spinules. Outermost apical seta 0.8 times as long as innermost apical seta, ornamented with long, hair-like
setules on both sides. Dorsal seta twice as long as outermost apical seta.

Antennule (Fig. 25c) 16-segmented, digeniculate with geniculations between segments 8 and 9, and 14 and 15. Armature formula as follows: 8+2ae.4.2.2+ae.2.3.1.2.1.1.4.2.2.0.2.11+ae. Antenna, labrum, mandible, maxillule, maxilla, maxilliped and legs 1–5 similar to those of female.

Leg 6 (Fig. 25b) distinct, armed with 1 inner spine and 2 setae; spine stout, serrulate, 1.1–1.2 times as long as middle seta and 1.4 times as outermost unipinnate seta.

**Distribution and ecology.** The new subspecies was found in a single sample taken from a small, shallow man-made concrete basin, which is fed with groundwater continually. The basin is used for the pilgrims to take a holy dip. Water was crystal clear. Dense populations of loach-like fishes were found in this basin.

**Discussion.** Lindberg (1950) originally described the typical *Eucyclops bryophilus* based on a single female specimen and not adequately. Its male is not yet known. The material examined closely resembles Lindberg’s (1950) original female description and figures of this species. However, a critical comparison reveals that the present females have some definitive morphological differences:

- Habitus: fourth and fifth pedigerous somites more pronounced laterally; third pedigerous somite shorter and anal somite longer.
- Caudal rami longer.
- Innermost caudal seta shorter and the outer margin of outermost apical seta typically plumose instead of being serrulate.
- Leg 4 third endopodal segments relatively short and its apical spines long; inner setae not extending beyond the inner apical spine unlike in the case of female *E. bryophilus*. 
- Leg 5 inner spine slenderer and longer.

In addition to the above-mentioned morphological differences, the present population and that of *Eucyclops (E.) bryophilus* possibly show geographical separation in that the former is from the southern part of peninsular India whereas the latter is from the northeastern part of India, which is adjacent to the Southeast Asian border. Hence I am of the opinion that both these morphological and geographical differences warrant the description of a new subspecies, named *Eucyclops (Eucyclops) bryophilus mahanandiensis* n. ssp.

**Table 4. Morphometric data of *Eucyclops bryophilus mahanandiensis* n. ssp.**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>0.82</td>
<td>0.86</td>
<td>0.84</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.4</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>0.9</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal rami length: width</td>
<td>3.0</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.6</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: caudal ramus</td>
<td>0.58</td>
<td>0.60</td>
<td>5.90</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 3, length: width</td>
<td>1.5</td>
<td>1.7</td>
<td>1.6</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>1.30</td>
<td>1.40</td>
<td>1.35</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>0.70</td>
<td>0.80</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Key to the identification of Indian species of genus Eucyclops Kiefer, 1929

1. Caudal rami without lateral denticles (serra); only 1–4 spinules present near the insertion of lateral setae ................................................................. 2

   The same with more or less developed serra .................................. 3

2. Caudal rami 3 times as long as wide; leg 4 endopod 3 inner apical spine considerably shorter than segment .............................................. *E. indicus* Kiefer, 1927

   Caudal rami more than 3 times as long as wide; leg 4 endopod 3 inner apical spine as long as or longer than segment ......................... *E. defectus* Lindberg 1937

3. Leg 5 spine slender ............................................................................. 4

   Leg 5 spine stronger ........................................................................... 6

4. Caudal ramus 5 times as long as wide; spines of leg 4 exopod and endopod lanceolate ................................................................. *E. permixtus* Kiefer, 1928

   Caudal ramus 3 times as long as wide; spines of the same normal .......... 5

5. Leg 4 enp 3 longer than inner apical spine ................................. *E. bryophilus* Lindberg, 1950

   Leg 4 enp 3 shorter than inner apical spine ........................................ *E. bryophilus mahanandiensis* n. ssp.

6. Serra confined only to posterior region ................................. *E. speratus*, Lilljeborg, 1901

   Serra present along entire outer margin ............................................. 7

7. Caudal ramus 8–9 times as long as wide ......................... *E. productus* Kiefer, 1936

   Caudal ramus less than 8 times as long as wide ............................... 8

8. Leg 4 third endopodal segment inner spine shorter than distal segment

   ................................................................. *E. serrulatus* Fischer, 1851

   The same inner spine equal to or longer than distal segment .......... 9
9. Ventral surface of genital double-somite with minute pits in short regular rows


E. microdenticulatus Lindberg, 1939

Ventral surface of genital double-somite smooth .................................................. 10

10. Leg 5 middle seta less than 3 times as long as spine; coxa-basis of antenna with

one group of spinules on frontal side .... ..................E. agiloides G. O. Sars, 1909

Leg 5 middle seta 3 times as long as spine, coxa-basis of antenna with more than

one group of spinules on frontal side .......... E. semidenticulatus Lindberg, 1939
Genus *Paracyclops* Claus, 1893

**Generic diagnosis.** Dussart & Defaye (2001), following Karaytug (1999), provided the following generic diagnosis: Body distinctly tapering at its posterior part. Fifth pedigerous somite with a lateral fringe of long hair-like setules along postero-lateral margin. Seminal receptacle usually divided into anterior and posterior parts, generally symmetrical with a median constriction at upper and lower margins. Caudal rami lacking longitudinal row of spinules, but usually with transverse or oblique spinular row on dorsal surface of each ramus at base of lateral seta. Antennules short, with 6–12 segments, without hyaline lamella on last 2 segments. Antenna 4-segmented, endopod 3-segmented with setation 1, 9, 7. Legs 1–4 biramous, each ramus 3-segmented; endopod of leg 1 with only 1 seta on inner margin. Leg 5 reduced to a plate bearing 1 inner spine and 2 setae.

This genus, with *Paracyclops fimbriatus* (Fischer, 1853) as the type species, is represented by 32 species in the world according to the latest World of Copepods database (Chad, 2013). Of these, the following 3 species are known from India:

1. *Paracyclops fimbriatus* (Fischer, 1853)
2. *Paracyclops affinis* (G. O. Sars, 1863)
3. *Paracyclops poppei* (Rehberg, 1880)

In the present study, I have come across only *Paracyclops fimbriatus*.

*Paracyclops fimbriatus* (Fischer, 1853)  
(Figs 27–31)

**Synonymy**


Paracyclops fimbriatus f. typica, Kiefer, 1929 a: 1–56.

Paracyclops abnobensis, Kiefer, 1929 b: 46–49.

Paracyclops vagus, Lindberg, 1939 a: 45–56.


Locality. River Krishna at Kanaka Durga Varadhi, Vijayawada (16°30'22"N, 80°36'18"E; elevation 11.88 m), Krishna District, Andhra Pradesh, South India.

Material examined. 4 voucher specimens: 1 female (MNHN-IU-2013-9795) and 1 male (MNHN-IU-2013-9797) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9796), dissected on 8 slides and 1 male (MNHN-IU-2013-9798) dissected on 3 slides; 12 females and 4 males in author’s personal collections; 23 July 2002, Coll. V. Subhashini.

Other material examined. Ramnagar colony tank at Ongole (15°30'00"N, 80°03'00"E; elevation 30 m), Prakasam District, Andhra Pradesh, South India, 10 November 2002: 6 females and 2 males, Coll. V. Subhashini.

Rangnayakula pet check dam at Nellore (14°25'59"N, 79°58'00"E; elevation 18 m), Nellore District, Andhra Pradesh, South India, 14 January 2003: 2 females and 2 males, Coll. D.Ambedkar.

River Penna at Nellore (14°34'46"N, 80°14'44"E; elevation 18 m), Nellore District, Andhra Pradesh, South India, 16 January 2003: 4 females, Coll. D.Ambedkar.

Pond at Acharya Nagarjuna University Campus, Nagarjuna Nagar (16º30'38"N, 80º43'05"E; elevation 30 m), Guntur District, Andhra Pradesh, South India, 27 July 2005: 4 females and 2 males, Coll. V. Subhashini.

Cumbum Cheruvu at Cumbum (15º34'00"N, 79º07'00"E; elevation 184 m), Prakasam District, Andhra Pradesh, South India, 28 July 2006: 3 females, Coll. D. Ambedkar.

Bore well at Rajahmundry (16º58'59"N, 81º46'59"E; elevation 14 m), East Godavari District, Andhra Pradesh, South India, 23 April 2005: 4 females and 2 males, Coll. D. Ambedkar.

**Distribution and ecology:** This species has wide-spread distribution in the world (Dussart & Defaye, 2006). In India, it was reported from Karli, Pandharpur (River Bhima), Ridora (River Sina), Latour near Hyderabad, Aurangabad, Ellora, Coonoor, Nilgiris (Lindberg, 1939), Lake Kolleru at Manguluru, River Krishna at Vijayawada, reservoir in Acharya Nagarjuna University. (Ranga Reddy & Radha Krishna, 1984). Though the species is available in surface water bodies of ponds, it is mostly benthic. In the material examined it was accompanied by a few rotifers, cladocerans, and ostracods.

**Remarks.** The present material perfectly agrees with the detailed description of *Paracyclops fimbriatus* (Fischer, 1853) already available in the literature (see Karaytug, 1999). Hence, only the figures made and the essential morphological data collected during the present study are given here.

In Rajahmundry specimens, leg 5 inner spine is unipinnate vs. bipinnate in Acharya Nagarjuna University specimens. Leg 5 inner and middle seta of Acharya Nagarjuna University specimens has spinules at their bases vs. all 3 setae have spinules in Rajahmundry specimens. Variation is observed in the length ratios of inner
spine of leg 5 of both populations. The seta next to outermost seta on third endopodal segment of leg 1 with tiny spinules on one side.

**Table 5. Morphometric data of *P. fimbriatus* (Fischer, 1853)**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>0.72</td>
<td>0.84</td>
<td>0.78</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.2</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>0.8</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal rami length: width</td>
<td>5.2</td>
<td>5.6</td>
<td>5.4</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.7</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: caudal rami</td>
<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 3, length: width</td>
<td>1.7</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>1.8</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>0.60</td>
<td>0.70</td>
<td>0.65</td>
</tr>
</tbody>
</table>

**Key to the identification of Indian species of genus Paracyclops Claus, 1893**

1. Antennule 8-segmented; caudal rami long…………………. …………………….2
   Antennule 11 segmented; caudal rami short…………………………………………3

2. Spinular row at base of lateral seta of caudal rami transverse and extending to ventral side; leg 5 inner spine distinctly shorter than outer seta…….*P. fimbriatus* (Fischer, 1853)
   The same longitudinal for some distance on dorsal surface of rami; leg 5 inner spine and outer seta almost equal in length ……………*P. poppei* (Rehberg, 1880)

3. Spinular row at base of lateral seta of caudal rami entire on dorsal width of rami; leg 5 inner spine longer than outer seta ……. ….*P. affinis* (G. O. Sars, 1863)
Genus *Tropocyclops* Kiefer, 1927

**Generic diagnosis.** Fifth pedigerous somite fringed laterally with hair like setae. Genital double-somite weakly bulged anteriorly. Seminal receptacle ‘T’-shaped, with anterior distorted branches. Caudal rami short, without marginal spinules. Antennule 12-segmented with long setae on first and fourth segments and a narrow hyaline membrane on 10–12 segments. Legs with 3-segmented rami. Endopodite 3 of leg 4 with spiniform and relatively long apical setae, the median terminal always longer than the length of the segment. Spine formula of exopodite variable: 3.4.4.3. (“quaterni” group of Kiefer, 1931). 3.4.3.3 (“terni” group of Kiefer, 1931), 3.3.3.3, or 2.3.3.3. Leg 5 composed of a broad, free segment with an anterior margin more or less triangular, bearing an external and a terminal seta and an internal spiniform seta. (Dussart & Defaye 2001).

According to the World Directory of Crustacean Copepod of Inland waters II – Cyclopiformes, the genus *Tropocyclops* contains a total of 36 nominal species and subspecies from around the world (Dussart & D. Defaye, 2006). The following 5 species are known from India:

1. *Tropocyclops prasinus prasinus* (Fischer, 1860)
2. *Tropocyclops confinis confinis* (Kiefer, 1930)
3. *Tropocyclops confinis frequens* (Kiefer, 1931)

Of these taxa *Tropocyclops multicolor* (Lindberg, 1935) alone has been met in this study and it is redescribed herein.
**Tropocyclops multicolor** (Lindberg, 1935)  
(Figs 33–37)

**Synonymy**


*Eucyclops (Tropocyclops) multicolor*, Lindberg, 1939b: 2, Fig. 1a–c.


**Locality.** Kotamsar Cave pool at Kotamsar village (18°52'09"N, 81°56'05"E; elevation 560 m), Bastar District, Chhattisgarh, India.

**Material examined.** 4 voucher specimens: 1 female (MNHN-IU-2013-9799) and 1 male (MNHN-IU-2013-9801) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9800), dissected on 7 slides and 1 male (MNHN-IU-2013-9802) dissected on 2 slides; 10 females and 8 males in author’s personal collections; 01 December 2004, Coll. Y. Ranga Reddy.

**Other material examined.** Open well Ammayanakanur village (10°37'12"N, 76°00'37"E; elevation 101 m), Madurai District, Tamil Nadu, South India, 31 December 2005: 8 females and 4 males, Coll. Y. Ranga Reddy and D. Ambedkar. Canal near Varatar village (10°01'00"N, 77°45'00"E; elevation 100 m), Theni District, Tamil Nadu, South India, 31 December 2005: 4 females and 3 males, Coll. Y. Ranga Reddy and D. Ambedkar. Pond at S. N. Puram Panchayat, Thrissur (10°37'12"N, 76°00'37"E; elevation 47 m), Thrissur District, Kerala, South India, 30 December 2005: 6 females and 4 males, Coll. Y. Ranga Reddy and D. Ambedkar.

**Redescription of adult female.** Habitus robust (Fig. 33a), total body length measured from base of rostrum to posterior margin of caudal rami (excluding caudal setae) 0.67mm. Prosome/urosome ratio about 1.8 and greatest width near posterior
end of cephalothorax. Body length/width ratio about 2.4. Free pedigerous somites without pronounced lateral expansions. Preserved specimens yellowish in colour.

Cephalothorax almost as long as its greatest width, representing 25% of total body length. Cephalothorax 3.6 times as long as genital double-somite, with a dark band at its posterior end. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite with lateral hairs. Genital double-somite (Fig. 33b) 1.2 times as long as wide. Hyaline fringe of genital double-somite and succeeding 2 somites smooth. Seminal receptacle relatively large, ‘I’ shaped, clearly divided into anterior and posterior expansions, representing 66% of double-somites width. Anal somite with smooth, broad, convex anal operculum, which represents 74% of somites width; ornamented with a pair of cuticular pores dorsally (Fig. 33c), armed with 9–10 spinules dorsally and ventrally overlying the base of caudal rami (Figs 33c, d). Anal sinus widely open and smooth.

Caudal rami (Figs 33a, c, d) cylindrical, 3.2 times as long as wide, without hairs along inner margin. Lateral seta unipinnate, inserted dorso-laterally at 60% length of caudal ramus. Dorsal seta 0.8 times as long as ramus inserted at 80% of ramus length and plumose distally. Outermost apical seta stout, spiniform 0.6 times as long as ramus. Innermost apical seta 1.3 times as long as outermost one. Principal apical setae with breaking planes, inner median apical seta 1.4 times as long as outer median apical seta, and 0.34 times as long as body.

Antennule (Fig. 34a) 12-segmented, long reaching middle of fifth pedigerous somite, distal 3 segments with smooth hyaline membrane. Segments 9 and 12 each with 1 aesthetasc, segment 8 elongate, segment 6 with short, spiniform seta near antero-distal corner. First segment with ventral spinular row in proximal half. Setal formula as follows: 8.5.3.5.3.1+1spine.2.3.2+ae.2.3.7+ae.
Antenna (Fig. 34b, c) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis 4 times as long as wide, ornamented with a group of spinules at proximal outer region, on caudal surface; 1 transverse row of small spinules at proximal region, 3 to 4 spinules at proximal inner region, 1 group of spinules along proximal outer and inner margins each on frontal side; armed with 2 smooth setae at distal inner corner, bipinnate seta representing exopod at distal outer corner reaching anterior one third of third endopodal segment. First endopodal segment armed with 1 smooth seta and unornamented. Second endopodal segment 3.2 times as long as wide, ornamented with an outer longitudinal row of spinules and armed with 9 setae. Third endopodal segment ornamented with 2 groups of spinules along outer side, few spinules distally, armed with 7 setae.

Mandible (Fig. 34d) with small palp (not figured) consisting of 2 long plumose setae and 1 thin small seta. Gnathobase cutting edge with 6 strong teeth and 1 outer bipinnate seta.

Maxillule (Fig. 35a) composed of well developed praecoxa and 2 segmented palp. Arthrite of praecoxa with 3 strong apical spines, anterior one much stronger and longer than others. Praecoxa armed with 7 armature elements, along inner margin, the longest one plumose. Palp apically with 2 setae (1 smooth and 1 bipinnate) and 1 robust, strong, spine; endopod distinct, bearing 3 pinnate setae; exopodal seta also pinnate.

Maxilla (Fig. 35b) 5-segmented comprising praecoxa, coxa, basis and 2-segmented endopod. Proximal endite of praecoxa armed with 2 bipinnate setae, distal endite, small and unarmed. Proximal endite of coxa with 1 bipinnate seta; distal endite bearing 2 pinnate setae. Basis expanded into robust claw, ornamented with spinules at midlength of inner margin, armed with 2 setae, strong seta sparsely
pinnate, slightly shorter than claw, small seta at base. Endopod 2-segmented, first segment with 1 strong unipinnate seta and 1 smooth seta; second segment with 1 strong seta and 2 smooth setae.

Maxilliped (Fig. 35c) 4-segmented comprising syncoxa, basis and 2-segmented endopod. Syncoxa armed with 3 bipinnate setae, middle seta longest, 1.2 times as proximal one and 1.8 times as distal one. Basis ornamented with 1 row of long spinules along inner margin and 3 short rows of spinules at medial outer region and armed with 1 bipinnate seta and 1 smooth seta. First endopodal segment ornamented with a row of long spinules along inner margin and armed with 1 strong bipinnate seta. Second endopodal segment armed with 1 strong bipinnate seta and 2 smooth setae.

Legs 1–4 (Fig. 36a–d) biramous with 3-segmented rami. Coxa of all legs armed with a seta on inner margin, that of leg1 plumose, and 2, 3, 4, plumose proximally and spinulose distally. Coxae of legs 1 and 3 ornamented with short longitudinal row of spinules along outer distal margin. Intercoxal sclerites of legs 1–4 with rounded protrusions on both sides; ornamented with long hair like spinules on posterior border except on leg 1; legs 3 and 4 with another row of short spinules distally. Basis of each leg armed with an outer plumose seta and ornamented with 2 groups of small spinules between exopod and endopod. Spine inserted at the inner corner of basis of leg 1, pinnate reaching almost the tip of third endopodal segment. All exopodal and endopodal setae slender and plumose, except 1 seta on the third exopodal segment of leg1, with tiny spinules on one side. Third endopodal segment of leg 4 twice as long as wide; inner apical spine 1.8 times as long as outer one. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):
<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>1-0</td>
<td>I-1</td>
<td>1-I</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1-0</td>
<td>0-1</td>
<td>1-I</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1-0</td>
<td>0-1</td>
<td>1-I</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1-0</td>
<td>0-1</td>
<td>1-I</td>
<td>4, 1+I, II</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 33b) 1-segmented, ornamented laterally with a small, distal row of short spinules, armed with inner unipinnate spine, middle long bipinnate seta and outer smooth seta; middle seta about 2.3 times as long as inner spine and twice as long as outer seta.

Leg 6 (not figured) located dorso-laterally with 1 short inner spine and 2 long outer spines.

Redescription of adult male. Total body length, excluding caudal setae 0.52mm. Habitus (Fig. 37a) less robust than in female with prosome/urosome ratio 1.6 and greatest width near posterior end of cephalothorax. Body length/width ratio about 3. Cephalothorax 1.3 times as long as its greatest width, representing 45% of total body length and 3.6 times as wide as genital somite. Ornamentation of prosomites similar to female. Fifth pedigerous somite laterally fringed with hair like setae. Genital somite and other urosomites smooth dorsally and ventrally. Anal somite with broad, convex, anal operculum ornamented posteriorly with a spinular row dorsally and ventrally.

Caudal rami (Fig. 37a) 2 times as long as wide, almost parallel, with little space between them. Armature and ornamentation similar as in female.

Antennule (Fig. 37c) 16-segmented, digeniculate with geniculations between segments 8 and 9, and 13 and 14. Armature formula as follows: 7+3ae.4.2.3+ae.1.2.0.2+ae.0.4+1 spine.2+1 spine.2.1+ae.2.3.6+ae. Antenna, labrum, mandible, maxillule, maxilla, maxilliped and legs 1–5 similar to female.
Leg 6 (Fig. 37 b) distinct, armed with 1 inner strong spine, 1 long plumose seta, and outer smooth seta. Middle seta twice as long as inner seta and 1.5 times as long as outer one.

**Distribution and ecology.** *Tropocyclops multicolor* is endemic to India (Dussart & Defaye, 2006) and widely distributed in the northern and southern parts of India. Lindberg’s (1935) original description of *T. multicolor* from India was based on freshwater plankton samples collected from the following localities: Gharipouri, Kotagiri, Pandharpour, Udaipur, Ghatkopar, Jogeswari, Aurangabad, Ramaling, Hyderabad, Ajanta, Kuruduvadi, Bhosra, Danoli, Vengurla, Coonoor and Mettupalem. Subsequently, it was reported by Ranga Reddy & Radha Krishna (1984) from Vengalayapalem pond, and Lake Kolleru at Manguluru. In the present study, it was collected from Chhattisgarh, Tamil Nadu and Kerala states. In the material examined it was accompanied by a few representatives of *Mesocyclops isabellae*, *Moina* sp. and rotifers.

**Remarks.** Lindberg’s (1935) original account of *Tropocyclops multicolor* is rather brief. Now the species is redescribed and illustrated in detail. The material under study perfectly agrees with Lindberg’s original account in various principal criteria, especially in regard to: i) length/width ratios of caudal rami and female genital double-somite; ii) length ratio of innermost to outermost apical seta; iii) length ratio of inner median apical seta to outer median apical seta; iv) length/width ratio of third endopodal segment of leg 4. However, the minor differences noticed relate to: i) length/width ratios of leg 4 third endopodal segment’s inner apical spine vs. outer apical spine; ii) leg 4 third endopodal segment inner apical spine vs. segment; and iii) leg 5 inner spine vs. outer seta.
Table 6. Morphometric data of *Tropocyclops multicolor* (Lindberg, 1935)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>0.58</td>
<td>0.69</td>
<td>0.64</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.7</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.10</td>
<td>1.20</td>
<td>1.15</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal rami length: width</td>
<td>3.0</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.3</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: caudal ramus</td>
<td>0.6</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 3, length: width</td>
<td>2.0</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>1.8</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>0.43</td>
<td>0.50</td>
<td>0.46</td>
</tr>
</tbody>
</table>

**Key to the identification of Indian species of genus *Tropocyclops* Kiefer, 1927**

1. Exopodal spine formula of legs 1–4, 3.4.4.3……………………………………….. 2
   Exopodal spine formula of legs 1–4, 3.4.3.3 ………………………………………….. 4
2. Inner spine of P5 well developed …………….. *T. prasinus prasinus* Fischer, 1860
   Inner spine of P5 less developed ………………………………………………………… 3
3. Caudal ramus 3 times as long as wide…………………. *T. multicolor* Lindberg, 1935
   Caudal ramus 2 times as long as wide ……. *T. prasinus palniensis* Lindberg, 1946
4. Dorsal seta longer than caudal ramus; leg 4 enp 3 inner apical spine 2 times as long as outer apical spine …………………………….*T. confinis frequens* Kiefer, 1931
   Dorsal seta shorter than caudal ramus; leg 4 enp 3 inner apical spine more than 2 times as long as outer apical spine ………………….*T. confinis confinis* Kiefer, 1930
Subfamily **Cyclopinae** Kiefer, 1927

Genus **Cyclops** O. F. Müller, 1776

**Generic diagnosis.** Dussart & Defaye (2001) defined the genus *Cyclops* O. F. Müller, 1776 thus: Body robust. Fifth pedigerous somite without particular lateral ornamentation. Seminal receptacle generally rounded. Caudal rami long, at least 4 times as long as wide, hairy on its inner edge and with a dorsal chitinous ridge. Innermost apical seta longer than outermost apical seta. Antennule 17-segmented. Legs 1–4 biramous, each ramus 3-segmented, third exopodal segment with 5 plumose setae. Leg 5, 2-segmented, first segment with a seta at distal outer angle and second one bearing an apical plumose seta and a short spine, inserted at middle of inner margin of segment.

According to the latest Pesce website (2013), this Palaearctic genus has so far been represented by 54 species and subspecies in the world. Of these, only the following 3 species are known from Kashmir lakes in India:

1. *Cyclops vicinus* Uljanin, 1875
2. *Cyclops ladakanus* Kiefer, 1936
3. *Cyclops hutchinsoni* Kiefer, 1936

Of these 3 Indian taxa, only *Cyclops vicinus* alone has been met in this study.

**Cyclops vicinus** Uljanin, 1875  
(Figs 39–43)

**Synonymy**

*Cyclops vicinus* Uljanin, 1875: 23–41.

*Cyclops pulchellus* (non Koch), Brady, 1878: 1–148.

*Cyclops vicinus*, Lande, 1890: 307–308.


Localities. Mansar lake at Upper Dachigam, Kashmir (32°41′46″N, 75°08′49″E elevation 3,200 m), Srinagar District, Jammu and Kashmir, North India.

Material examined. 4 voucher specimens: 1 female (MNHN-IU-2013-9803) and 1 male (MNHN-IU-2013-9805) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9804), dissected on 8 slides and 1 male (MNHN-IU-2013-9806) dissected on 2 slides; 22 females and 15 males in author’s personal collections; 9 September 1984, Coll. M. H. Balkhi.

Other material examined. Alpather Lake at Kilanmarg, Kashmir (34°03′27″N, 74°23′09″E elevation 4,280 m), Gulmarg District, Jammu and Kashmir, North India, 24 September 1984: 12 females and 08 males, Coll. M. H. Balkhi.

Redescription of adult female. Habitus robust (Fig. 39a), total body length, measured from base of rostrum to posterior margin of caudal rami (excluding caudal setae) 1.63 mm. Prosome/urosome ratio about 1.5 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.8. Lateral lobes of second prosomite slightly lobose in dorsal view; fourth prosomite with wide wings, fifth one broadly pointed outward. Colour of the preserved specimen yellowish. Rostrum well developed, membranous and broadly rounded. Cephalothorax slightly longer than its greatest width, representing 37% of total body length and 2.8 times as wide as genital double-somite. Hyaline fringes of first 3 prosomites narrow and smooth, that of fourth prosomite finely serrulated; fifth pedigerous somite with a smooth fringe dorsally and ventrally.
Genital double-somite (Fig. 39b) almost as long as wide; hyaline fringe of genital double-somite and succeeding 2 somites smooth dorsally and serrated ventrally. Copulatory pore round, copulatory duct rigidly sclerotized. Seminal receptacle with indistinctly divided anterior and posterior expansions (Fig. 39b); ovipores situated dorso-laterally, covered by reduced sixth legs. Preanal somite ornamented with 2 cuticular pores and sensilla dorsally (Fig. 39c). Anal somite with smooth, broad, slightly convex anal operculum, representing 52% of somites width; ornamented with a pair of cuticular pores and sensilla dorsally. Anal sinus widely open and smooth. Posterior end of anal somite armed with spinules dorsally and ventrally overlying the base of caudal rami.

Caudal rami (Fig. 39c, d) long, divergent, 7 times as long as wide; hairy on its inner margin, with dorsal chitinous ridge extending up to 7/8 of ramus; with space between them about 2 times as ramus width. Dorsal seta about 0.6 times as long as ramus, inserted at distal end of the ramus, uniarticulate at base and plumose distally. Lateral seta situated at 3/4 of caudal ramus length, positioned dorso-laterally and pinnate distally. Outermost apical seta stout, spiniform, 0.6 times as long as ramus. Lateral and outermost apical setae with spinules at implantations. Innermost apical seta long, plumose, 2.4 times as long as outermost apical seta and 1.3 times as long as ramus. Principal apical setae with breaking planes; inner median apical seta 1.5 times as long as outer median apical seta and 0.33 times as long as the body.

Antennule (Fig. 40a) 17-segmented, long, reaching anterior end of second pedigerous somite, with 1 aesthetasc each on segments 12 and 17 with setal formula: 8.4.2.6.4.1+1spine.2.1.1.0.1.1+ae.0.1.2.3.7+ae; 1 seta on segment 6 spiniform, 1 seta on segment 17 articulated at base, all other setae pinnate. First segment ornamented
with 1 short row of spinules. Hyaline fringe on segments 15, 16 and 17 well developed and serrulated.

Antenna (Fig. 40b) 4-segmented comprising coxobasis and 3-segmented endopod. Coxobasis 2.2 times as long as wide, ornamented with short spinules along inner distal end, 1 arched row and 1 longitudinal row of spinules along outer region on caudal surface; armed with 2 smooth setae at distal inner corner and with 1 long bipinnate seta representing exopod and over reaching the tip of third endopodal segment. First endopodal segment armed with 1 smooth seta, ornamented with a row of spinules at outer distal margin. Second endopodal segment twice as long as wide, ornamented with 1 longitudinal row of spinules on outer margin, armed with 5 lateral, 2 subapical and 2 apical setae; third endopodal segment with 1 row of spinules on outer margin, armed with 7 apical setae.

Labrum (Fig. 40c) trapezoidal, cutting edge straight with 12 teeth at mid margin and 2 large lateral teeth.

Mandible (Fig. 40d, e) with distinct palp, armed with 2 very long, finely plumed setae and 1 short smooth seta on distal end. Gnathobase cutting edge with 10 teeth, and 1 outermost unipinnate seta.

Maxillule (Fig. 41a, b) composed of praecoxa and 2-segmented palp. Arthrite of praecoxa with 4 strong apical spines, armed with 7 armature elements along inner margin, the longest one plumose. Palp apically with 2 slender, smooth setae and 1 robust, strong, bipinnate spine; endopod distinct, bearing 2 apical and 1 subapical pinnate setae; exopodal seta smooth.

Maxilla (Fig. 41c) 4-segmented but praecoxa fused to coxa on posterior surface. Proximal endite of praecoxa armed with 2 pinnate setae, distal endite small and unarmed. Proximal endite of coxa with 1 long bipinnate seta; distal endite bearing
1 proximal pinnate seta and 1 completely fused distal bipinnate seta. Basis drawn out into robust claw, ornamented with longitudinal row of spinules along concave margin and armed with 2 setae, strong seta bipinnate, slightly longer than claw, and 1 small seta at base. Endopod 2-segmented, first segment with 2 pinnate setae and second segment with 3 smooth setae.

Maxilliped (Fig. 41d) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa ornamented with arched row spinules on distal outer margin, armed with 3 bipinnate setae; middle seta strongest and longest, 1.7 times as long as proximal one, and 1.4 times as long as distal one. Basis 1.6 times as long as wide, ornamented with 2 longitudinal and 2 transverse rows of spinules, armed with 2 strong setae. First endopodal segment ornamented with 3 transverse rows of spinules, armed with 1 strong seta. Second endopodal segment without any ornamentation, armed with 1 bipinnate and 2 smooth setae.

Legs 1–4 (Fig. 42a–d) with 3-segmented exopod and endopod. Coxa of all legs ornamented with 1 row of spinules on outer distal margin, 2 rows of spinules at proximal and distal corners; armed with 1 plumose seta at inner distal corner. Intercoxal sclerites of legs 1–4 with protrusions on both sides, unornamented except for leg 4 with 1 row of few spinules. Third exopodal segment spine formula. 2.3.3.3 and setal formula 5.5.5.5. Basis of each leg armed with outer plumose seta and ornamented with 1 row of spinules at the base of endopod; leg 1 with additional spinules at base of inner spine. Spine inserted at inner, protruded corner of leg 1, pinnate, reaching the anterior part of third endopodal segment (Fig. 42a). All exopodal and endopodal setae slender and plumose; all endopodal segments with long, hair-like spinules along outer margin. First endopodal segment of leg 4 with indentation, third endopodal segment (Fig. 42d) 3 times as long as wide; inner apical
spine 1.8 times as long as outer one and almost as long as segment. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal /outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Leg 1</td>
<td>1-0</td>
<td>1-1</td>
<td>1-1</td>
<td>4, 1+I, I</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1-0</td>
<td>0-1</td>
<td>1-1</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1-0</td>
<td>0-1</td>
<td>1-1</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1-0</td>
<td>0-1</td>
<td>1-1</td>
<td>4, 1+I, II</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 42e) 2-segmented, protopodal segment armed with 1 outer distally-pinnate seta, and ornamented with small spinules at inner distal corner near base of seta. Free exopodal segment 1.7 times as long as wide, ornamented with 1 row of spinules on outer distal margin, armed with 1 long distally pinnate seta, and 1 short pinnate spine.

Leg 6 (Fig. 42f) distinct, triangular plates, armed with 2 unequal smooth spines and 1 distally pinnate seta.

**Redescription of male.** Habitus (Fig. 43a) less robust than in female, total body length, excluding caudal setae 1.3 mm. Prosome/urosome ratio 1.9 and greatest width near posterior end of cephalothorax. Body length/width ratio 3.0. Cephalothorax about 3.6 times as wide as genital somite; 1.2 times as long as its greatest width, representing 26% of total body length. Ornamentation of prosomites, similar to female. Fourth pedigerous somite without lateral wings. Fifth pedigerous somite not pointed outwards. Hyaline fringe of fourth and fifth pedigerous somites smooth dorsally and ventrally; that of genital somite and other urosomites smooth dorsally and serrulated ventrally. Anal somite with smooth, broad, slightly convex anal operculum, which represents 52% of somites width; ornamented with a pair of
cuticular pores and sensilla dorsally. Anal sinus widely open and smooth. Caudal rami slightly divergent, 4.7 times as long as wide, hairy on inner margins, without dorsal chitinous ridge.

Antennule (Fig. 43c) 15-segmented, digeniculate with geniculations between segments 8 and 9, and 13 and 14. Armature formula as follows: 8+3ae.3.2.2.1.1.0.3.4.1.1+1ae.1.2.11+ae. Segments 9 and 11 with 1 spiniform seta.

Antenna (Fig. 43d) 4-segmented, ornamentation of coxobasis slightly different from that of female and with 2 rows of small spinules at proximal end and 1 row of small spinules along proximal outer margin on caudal surface. Second endopodal segment armed with 7 setae at inner margin. Labrum, mandible, maxillule, maxilla, maxilliped and legs 1–5 similar to female.

Leg 6 (Fig. 43b) distinct, armed with 1 small serrulate spine and 2 plumose setae; innermost spine half the length of median seta; outer seta 2 times as long as median seta.

**Distribution and ecology.** This species is widely distributed in Asia, Europe, and North America (see Dussart & Defaye, 2006). In India, it is confined to Kashmir lakes at an altitude of 1,580–4,686 m. None of the *Cyclops* spp. are known from the peninsular India including the elevated localities such as Nilgiris Hills with an altitude of 2,637 m.

**Remarks.** From India, *Cyclops vicinus* was laconically described from the Wular and Manasbal Lakes of Kashmir by Kiefer (1939). Subsequently, Lindberg (1941, 1957a) and Einsle (1996) also briefly dealt with this species. Here, a detailed description of this species including the cephalic appendages is presented. The present material almost perfectly agrees with Kiefer’s (1939) account barring some intraspecific variation, as outlined in Table 7.
### Table 7. Morphometric data of *Cyclops vicinus* Uljanin, 1875

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total length in mm</td>
<td>1.6</td>
<td>2.2</td>
<td>1.9</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.50</td>
<td>1.80</td>
<td>1.65</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.0</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>6.8</td>
<td>8.0</td>
<td>7.2</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.50</td>
<td>1.80</td>
<td>1.65</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>2.20</td>
<td>2.50</td>
<td>2.35</td>
</tr>
<tr>
<td>7.</td>
<td>Innermost apical seta: dorsal seta</td>
<td>1.9</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>8.</td>
<td>Innermost apical seta: caudal ramus</td>
<td>0.8</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 2, length: width</td>
<td>2.5</td>
<td>3.1</td>
<td>2.8</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 2, inner apical spine: outer apical spine</td>
<td>1.7</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td>11.</td>
<td>Leg 4 enp 2, inner apical spine: length of segment</td>
<td>0.9</td>
<td>1.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Key to the identification of the Indian species of genus *Cyclops* O. F. Müller 1776

1. Legs 1–4 exopodal spine formula, 2.3.3.3……………………………………………………2

   Legs 1–4 exopodal spine formula, 2.4.3.3……………………………………………………3

2. Antennule 17-segmented, inner apical spine of third endopodal segment of leg 4, 2–3 times as long as outer apical spine…………………. *Cyclops vicinus* Uljanin, 1875

   Antennule 16-segmented, inner apical spine of third endopodal segment of leg 4, 2 times as long as outer apical spine…………………. *Cyclops hutchinsoni* Kiefer 1932

3. Caudal ramus with hairs on dorsal surface and also on inner margin…………………..

   …………………………………………………………………………………... *Cyclops ladakanus* Kiefer, 1936

68
Genus *Microcyclops* Claus, 1893

**Generic diagnosis.** Dussart & Defaye (2001) provided the following generic diagnosis: Leg 5 consisting of basal segment fused to fifth pedigerous somite, represented by 1 lateral seta and 1 free elongated segment, bearing 1 apical seta with or without tiny inner spine, inserted at middle or tip of segment. Seminal receptacle expanded posteriorly. Innermost apical seta, as long as, or little longer than, outermost apical seta. Antennule 10–12 segmented. Legs 1–4, biramous, each ramus 2-segmented. Endopod of leg 4 ending in 2 well developed apical spines; coxa with a plumose seta at distal inner angle.

Based on the chetotaxy of leg 4 endopod, two subgenera have been recognized under the genus *Microcyclops* Claus, 1893: *Microcyclops* sensu stricto and *Microcyclops* (*Mediocyclops*); the latter is endemic to Indonesia (Dussart & Sarnita 1986). Up till now, this genus is represented by 66 species and subspecies according to the latest World of Copepods database (Chad, 2013). Of these, the following 9 taxa are already known from India:

1. *Microcyclops* (*Microcyclops*) *varicans* *varicans* (G.O. Sars, 1863)
2. *Microcyclops* (*Microcyclops*) *varicans* *subequalis* (Kiefer, 1928c)
3. *Microcyclops* (*Microcyclops*) *rubellus* (Lilljeborg, 1901)
4. *Microcyclops* (*Microcyclops*) *karvei* (Kiefer & Moorthy, 1935)
5. *Microcyclops* (*Microcyclops*) *davidi* var. *subtropicus* (Lindberg, 1937)
7. *Microcyclops* (*Microcyclops*) *pachyspina* Lindberg, 1937
8. *Microcyclops* (*Microcyclops*) *indolusitanus* Lindberg, 1938
And of the above-listed Indian taxa, only three taxa, viz. *Microcyclops* (Microcyclops) varicans varicans, *Microcyclops* (Microcyclops) rubellus, and *Microcyclops* (Microcyclops) karvei have been met in this study. Besides, the Afghan *Microcyclops* (Microcyclops) rechtiae Lindberg, 1960 is now being reported for the first time from India.

*Microcyclops* (Microcyclops) varicans varicans (G.O. Sars, 1863)
(Figs 45–49)

**Synonymy**

*Cyclops* varicans Sars, 1863: 252; 1921: 54, pl. 33.

*Cyclops* (Diacyclops) varicans, Pesta, 1928: 119, Fig. 101.


*Cyclops* (Diacyclops) varicans, Pesta, 1928: 119, Fig. 101.

*Cyclops* (Microcyclops) varicans, Kiefer, 1929 a: 66, Fig. 24a, b; Kiefer, 1933: 567, Figs 96–97; Kiefer, 1934: 162, Figs 104,105; Gurney, 1933: 1–334; Stephanides, 1948: 50, Figs 184–187; Yeatman 1944: 1–90; Yeatman in Edmondson, 1959: 795–815.

*Microcyclops varicans varicans*, Damian-Georgescu, 1963: 162, Fig. 83; Reid, 1985: 140, Figs 298–300.


*Microcyclops varicans*, Dussart,1969: 180, Fig. 89; Ueno, 1973: 434–455; Dussart 1982; 54, pl. 12b ; Einsle 1993: 1–209; Ishida, 2002: 37–106; Karanovic, 2004: 121, Fig. 51.

**Locality.** River Krishna at Amravati (16°34'48"N, 80°21'36"E; elevation 8 m), Guntur District, Andhra Pradesh, South India.
Material examined. 4 voucher specimens: 1 female (MNHN-IU-2013-9807) and 1 male (MNHN-IU-2013-9809) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9808), dissected on 7 slides and 1 male (MNHN-IU-2013-9810) dissected on 2 slides; 8 females and 6 males in author’s personal collections; 04 January 2003: Coll. V. Subhashini.

Other material examined. Agricultural pond at Sempatti village (10°21'00"N, 77°57'00"E; elevation 268 m), Dindigul District, Tamil Nadu, South India, 31 December 2005: 6 females and 2 males, Coll. Y. Ranga Reddy and D. Ambedkar.

Pond at Vallabhapuram (17°03'36"N, 79°18'00"E; elevation 17 m), Nalgonda District, Andhra Pradesh, South India, 03 April 2005: 8 females and 5 males, Coll. D. Ambedkar.

Valluri Cheruvu at Muthukuru Road, Nellore (14°25'48"N, 79°58'12"E; elevation 4 m), Nellore District, Andhra Pradesh, South India, 14 January 2005: 12 females and 8 males, Coll. D. Ambedkar.

Fresh water bore well at Acharya Nagarjuna University Campus, Nagarjuna Nagar (16°30'38" N, 80°43'05"E; elevation 30 m), Guntur District, Andhra Pradesh, South India, 29 July 2005: 4 females and 2 males, Coll. V. Subhashini.

River Krishna at Kanaka Durga Varadhi, Vijayawada (16°30'22"N, 80°36'18"E; elevation 11.88 m), Krishna District, Andhra Pradesh, South India, 24 July 2002: 4 females and 2 males, Coll. V. Subhashini.

Pond at Talikulum village (10°31'12"N, 76°12'36"E; elevation 13 m), Thrissur District, Kerala, South India, 29 December 2005: 10 females and 7 males.

River Bharatpuzha at Cheruthuruthi village (10°47'23"N, 75°55'17"E; elevation 5 m), Thrissur District, Kerala, South India, 28 December 2005: 10 females and 7 males.
Tank at Trikakudam Kollum (10°31'12"N, 76°12'36"E; elevation 13 m), Thrissur District, Kerala, South India, 29 December 2005: 10 females and 7 males.

**Distribution and Ecology.** This species has wide-spread distribution in the world (See Henry, 1923; Lindberg, 1953; Pesce et al., 1996a; D. Laurentis et.al., 1999, 2001; Dussart & Defaye, 2006). In India, it was reported mainly by Kiefer (1929) and Lindberg (1939) from the following places: Nagpur, Tchanda, Nadiad, Ellora, Aurangabad, Hyderabad, Bombay, Ghatkopar, Karli, Gharipouri, Mahasigaon, Pandharpour, Dandy, Vengurla, Goa, Pondicherry, Ootacamund, Kodaikanal, Sohawa and Lucknow. It was also reported by Ranga Reddy (1978) from River Krishna at Vijayawada, Lake Kolleru at Kolletikota and Manguluru; Vengalayapalem pond; Guntur and its environs, Acharya Nagarjuna University Campus, Kondaveedu, Visakhapatnam, Akaveedu and Nallamalai forests. In the material examined it was accompanied by abundant ostracods, few cyclopoids and strays of harpacticoids.

**Remarks.** The present material perfectly tallies with the detailed description of *Microcyclops varicans varicans* already available in the literature (see Lindberg 1939; Defaye, 1987; Karanovic, 2004). Hence, only the figures made and the essential morphological data collected during the present study are given here.

Lindberg (1939) observed wide variation in the seminal receptacle in different populations in India. In the present study, it has been found to be different in river and bore well populations (see Fig. 45b, c). Furthermore, the bulbous nature of the inner apical spine of the second endopodal segment of leg 4 has been found to be consistent in all the different populations studied during the present study. The same character state was reported by Lindberg (1939) in Pondicherry specimens. However, Karanovic (2004) depicted none such in the Australian populations.
Table 8. Morphometric data of *Microcyclops* (*Microcyclops*) varicans varicans (G. O. Sars, 1863)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total length in mm</td>
<td>0.78</td>
<td>0.84</td>
<td>0.81</td>
</tr>
<tr>
<td>2</td>
<td>Prosome: urosome ratio</td>
<td>1.24</td>
<td>1.68</td>
<td>1.46</td>
</tr>
<tr>
<td>3</td>
<td>Genital double somite length: width</td>
<td>0.8</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>4</td>
<td>Caudal ramus, length: width</td>
<td>3.2</td>
<td>3.4</td>
<td>3.3</td>
</tr>
<tr>
<td>5</td>
<td>Innermost apical seta: caudal ramus</td>
<td>1.27</td>
<td>1.30</td>
<td>1.28</td>
</tr>
<tr>
<td>6</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.4</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>7</td>
<td>Innermost apical seta: dorsal seta</td>
<td>1.6</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>8</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.5</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>9</td>
<td>Leg 4 enp 2 length: width</td>
<td>2.7</td>
<td>3.6</td>
<td>3.2</td>
</tr>
<tr>
<td>10</td>
<td>Leg 4 enp 2 inner apical spine: outer apical spine</td>
<td>1.6</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>11</td>
<td>Leg 4 enp 2, inner apical spine: length of segment</td>
<td>1.4</td>
<td>1.7</td>
<td>1.6</td>
</tr>
</tbody>
</table>
**Microcyclops (Microcyclops) rubellus** (Lilljeborg, 1901)
(Figs 50–53)

**Synonymy**

*Cyclops rubellus* Lilljeborg, 1901: 35–118. Lowndes, 1928a; Smirnov, 1930: 281–286.


*Cyclops rubellus*, Lowndes, 1928a; Smirnov, 1930: 281–286.

*Cyclops (Microcyclops) davidi*, Kiefer, 1933a: 519–621.


**Locality.** Domestic bore-well in Hyderabad city at Panjagutta colony (53°49'50"N, 80°59'44"E; elevation 542 m), Hyderabad District, Andhra Pradesh, South India.
Material examined. 6voucher specimens: 4 females (MNHN-Cp-2348,50,51,53) dissected on 1 slide each and 2 males (MNHN-Cp-2349,52) dissected on 1 slide each. 15 March 2006: Coll. Y. Ranga Reddy.

Other material examined. None

Redescription of female. Habitus (Fig. 50a) somewhat robust, total body length measured from base of rostrum to posterior margin of caudal rami (excluding caudal setae) 0.5mm. Prosome/urosome ratio 1.2 and greatest width at posterior end of cephalothorax. Body length/width ratio 2.7. Cephalothorax 3.1 times as wide as genital double-somite not produced postero-laterally. Free pedigerous somites without produced lateral corners. Cephalothorax 0.9 as long as its greatest width and 34% of total body length. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite with smooth fringe dorsally and ventrally.

Genital double-somite (Fig. 50b) 1.3 times as long as wide, expanded anteriorly, with rounded lateral sides. Hyaline fringe of genital double-somite and next two somites smooth dorsally and ventrally. Seminal receptacle composed of anterior and posterior parts, anterior part slightly larger and wider than posterior one, middle region expanded laterally. Copulatory pore small, round. Ovipores situated dorso-laterally, covered by reduced sixth legs. Anal somite (Fig. 50c) with smooth, broad, flat anal operculum representing 75% of somites width; ornamented with transverse row of spinules on dorsal and ventral posterior margins. Anal sinus widely open, without any visible ornamentation.

Caudal rami (Figs 50a, c) parallel, 2.4 times as long as wide, armed with 6 setae. Dorsal pinnate seta almost as long as ramus, inserted at 5/6 of ramus length. Lateral seta unipinnate, arising from dorso-lateral surface at distal third of ramus length and slightly longer than ramus width. Outermost apical seta spiniform, 0.7
times as long as ramus, inserted sub terminally and provided with 2 spinules at base. Innermost apical seta slender, 2.2 times as long as outermost apical seta and 1.5 times as long as caudal ramus. Principal apical setae plumose, with breaking planes; inner median apical seta 1.5 times as long as outer median apical seta.

Antennule (Fig. 50d) 11-segmented, extending up to mid length of cephalothorax, with 1 slender aesthetasc on segments 8 and 11 each. Setal formula: 8.4.8.4.1+1spine.2.4.2.2.2.7. One seta on segment 5 spiniform and short.

Antenna (Fig. 50e) 4-segmented, consisting of coxobasis and 3-segmented endopod. Setal formula of endopod: 1, 9 and 7. Coxobasis twice as long as wide, ornamented on caudal surface with 3 short rows of spinules medially and 2 rows of spinules along external margin; armed with 2 smooth setae at distal inner corner. Seta representing exopod small and smooth, reaching the distal part of second endopodal segment. First endopodal segment 1.8 times as long as wide, ornamented with 1 row of spinules on outer distal margin and armed with 1 smooth seta at about mid length of inner margin. Second segment 1.3 times as long as wide, ornamented with a row of spinules at distal outer corner and armed with 9 setae. Third segment 2.4 times as long as wide, ornamented with 1 longitudinal row of spinules at distal outer margin, armed with 7 unequal setae.

Labrum (Fig. 51a) anterior edge almost straight, with 8 teeth (lateral teeth relatively long) between slightly produced rounded lateral corners.

Mandible (Fig. 51b) with small, distinct palp, armed with 2 long pinnate setae and 1 short, smooth seta. Cutting edge of gnathobase with 10 teeth and 1 outermost bipinnate seta.

Maxillule (Fig. 51c) composed of praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines; armed with 6 armature elements along inner
margin. Palp (Fig. 51d) apically bearing 2 slender, smooth setae and 1 stout, unipinnate spine; endopod distinct, bearing 2 apical bipinnate setae and 1 smooth sub apical seta; exopodal seta smooth.

Maxilla (Fig. 51e) 5-segmented, composed of praecoxa, coxa, basis and 2-segmented endopod. Praecoxa fused to coxa on posterior surface and with well developed proximal endite bearing 2 plumose setae, distal endite small and unarmed. Proximal endite of coxa with one smooth seta; distal endite elongated and armed apically with 2 setae. Basis expanded into robust claw, ornamented with 1 longitudinal row of spinules along proximal concave margin and armed with 2 setae, strong seta as long as claw and pinnate; small seta at base. Endopod 2-segmented, proximal segment armed with 2 unequal strong smooth setae, distal segment with 1 robust apical seta and 2 slender sub apical setae.

Maxilliped (Fig. 51f) 4-segmented, composed of syncoxa, basis and 2 segmented endopod. Syncoxa unornamented, with 1 pinnate and 2 smooth setae. Basis twice as long as wide, ornamented with 2 transverse rows of spinules, and armed with 2 setae. First endopodal segment unornamented, armed with 1 strong pinnate seta; second endopodal segment armed with 2 smooth and 1 unipinnate seta.

Legs 1–4 (Fig. 52a–d) with 2-segmented rami. Coxa of all legs armed with plumose seta at inner distal corner. Inter coxal sclerites of legs 1–4, unornamented, with smooth protrusions at each side of distal margin. Second exopodal segment spine formula 3.4.4.3 and setal formula 5.5.5.5. Basis of all legs ornamented with hair like spinules along inner margin and armed with outer plumose seta. Spine inserted at inner protruded corner of leg 1 reaching the middle of second endopodal segment (Fig. 52a). Second endopodal segment of legs 3 and 4 ornamented with few spinules in the middle region; leg 4, second endopodal segment 1.7 times as long as wide;
inner apical spine 0.6 times as long as segment and 1.4 times as long as outer apical spine. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal /outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>1 – 0</td>
<td>1 – 1</td>
<td>1 – 1</td>
<td>4, 1+ I, II</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>1 – 1</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>1 – 1</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>0 – 1</td>
<td>4, 1+I, II</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 52e) with basal segment fused to somite, outer basal seta pinnate and inserted dorsally on somite. Distal segment twice as long as wide, armed with 1 apical seta, plumose distally.

Leg 6 (Fig. 52e) small cuticular plates, armed with 2 unequal smooth spines and 1 long smooth seta.

**Redescription of male.** Total body length excluding caudal setae 0.53 mm. Habitus (Fig. 53a) relatively slender. Prosome/urosome ratio 1.5 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.8. Cephalothorax almost as long as its greatest width, representing 36% of body length, about thrice as wide as genital somite. Ornamentation of prosomites similar to that of female. Genital somite (Fig. 53b) about 1.6 times as wide as long; hyaline fringe of genital somite and 3 subsequent somites serrulated ventrally. Anal somite with smooth, broad and straight anal operculum which represents 70% of somites width, ornamented with a row of spinules on posterior margin ventrally and dorsally. Anal sinus narrow and unornamented. Caudal rami parallel (Fig. 53a) 1.8 times as long as wide, with small space between them. Armature and ornamentation similar to female.
Antennule (Fig. 53 c) 16-segmented, digeniculate, with geniculations between segments 8 and 9, 14 and 15; 3 aesthetascs on segment 1, and 1 each on segments 4, 13 and 16. Armature formula as follows: 8+3ae.3.2.1+ae.0.2.1.2.2.1.2.1+ae.0.1. 10+ae. Labrum, mandible, maxilla, maxilliped and legs 1–5 similar to female. 

Leg 6 (Fig. 53b) distinct, with flat flaps armed with 1 spine and 2 setae; outer pinnate seta 1.3 times as long as middle smooth seta and thrice as long as inner spine.

**Distribution.** *Microcyclops rubellus* is widely distributed species in the world (Dussart & Defaye, 2006). In India, it was reported by Lindberg (1957). It is probably for the first time that the species is being reported from a bore-well.

**Remarks.** *Microcyclops* (*Microcyclops*) *rubellus* (Lilljeborg, 1901) is a well known member of the genus *Microcyclops*. Though originally this species was described as a distinct species, it was subsequently considered a subspecies of *M. varicans* (Yeatman, 1944; Pennak & Ward, 1985). Eventually, Einsle (1993) and Reid (1992) considered it as a distinct species and this view has been upheld by the later worker (see Monchenko & Samchyshyna, 2009).

The present material tallies well with the recent account of this species by Reid (1992), which, however, is incomplete in certain respects. The present material differs from Reid’s (1992) account in having: i) homogeneous instead of heterogeneous ornamentation on inner and outer principal apical caudal setae; ii) absence vs. presence of the spinules at the insertion of lateral seta; iii) the dorsal seta is plumose vs. bare; and iv) the innermost apical caudal seta is longer. Also, the fine spinules along the postero-ventral margin of anal somite are alike, but not as depicted by Reid (1992).
**Microcyclops (Microcyclops) karvei** (Kiefer & Moorthy, 1935)  
(Figs 54–57)

**Synonymy**


*Cyclops (Microcyclops) karvei*, Lindberg, 1939c: 235–238; 1939d: 121, Figs 1–4,


**Locality.** Ramnagar Colony Tank at Ongole (15º30'00"N, 80º03'00"E; elevation 10 m), Prakasam District, Andhra Pradesh, South India.

**Material examined.** 4 voucher specimens: 1 female (MNHN-IU-2013-9811) and 1 male (MNHN-IU-2013-9813) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9812), dissected on 7 slides and 1 male (MNHN-IU-2013-9814) dissected on 2 slides; 16 females and 7 males in author’s personal collections; 10 November 2002, Coll. V. Subhashini.

**Other material examined.** Nelabhelum Caves at Banganapalli (15º31'67"N 78º23'33"E; elevation 209 m), Kurnool district, Andhra Pradesh, South India, 3 Oct 2005: 4 females and 3 males, Coll. Y. Ranga Reddy & D. Ambedkar

Agricultural open well at Ammayanayakanur village, Madurai (09º48'00"N, 78º06'00"E; elevation 101 m), Madurai District, Tamil Nadu, 31 December 2005: 4 females and 1 male, Coll. Y. Ranga Reddy & Ambedkar.

Open well at Bathuladundu village, Dindigul, (10º09'56"N, 77º45'33"E; elevation 268 m), Madurai District, Tamil Nadu, 31 December 2005: 4 females and 1 male, Coll. Y. Ranga Reddy & D. Ambedkar.

**Redescription of adult female.** Habitus (Fig. 54a) robust, total body length, measured from base of rostrum to posterior margin of caudal rami, excluding caudal
setae, 0.58 mm. Prosome/urosome ratio 1.3 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.4. Free pedigerous somites without pronounced lateral expansions.

Cephalothorax almost as long as its greatest width, representing 39% of total body length. Fifth pedigerous somite with smooth fringe dorsally and ventrally. Genital double-somite (Fig. 54b) almost as long as wide, hyaline fringe of genital double-somite and next 2 somites finely denticulate dorsally and ventrally. Copulatory pore oval; copulatory duct rigidly sclerotized; seminal receptacle large, divided into anterior and posterior expansions, posterior expansion somewhat larger than anterior one. Ovipores situated somewhat dorso-laterally, covered by reduced sixth legs, bearing 2 minute spines and 1 pinnate seta. Anal somite with smooth, broad, concave anal operculum (Fig. 54c), representing 63% of somite’s width, with spinules at base of caudal rami dorso-laterally and ventrally. Anal sinus widely open, ornamented with 2 long diagonal rows of spinules.

Caudal rami (Fig. 54b, c) parallel, 3.3 times as long as wide, with space between them less than ramus width; ornamented with few spinules at base of lateral and outermost caudal seta. Dorsal seta uniarticulate, 3 times as long as ramus width, inserted at 5/6 of ramus length, and plumose distally. Lateral seta situated dorso-laterally at 3/5 of ramus length. Outermost caudal seta spiniform, 0.8 times as long as ramus, ornamented with few spinules at the base. Innermost apical seta bipinnate, slender, slightly longer than outermost apical seta, dorsal seta shorter than caudal rami. Principal apical setae with breaking planes; inner median apical seta 1.9 times as long as outer median apical seta and 0.5 times as long as the body.

Antennule (Fig. 54d) not reaching posterior margin of cephalothorax, 10-segmented, ornamented with a row of spinules at middle of first segment, with 1
slender aesthetasc each on segments 9 and 10, setal formula as follows: 8.5.8.5.1.3.2.2.2+ae.7+ae. One seta on segment 4 spiniform, short; most setae smooth and slender; segments 3 and 4 with transverse grooves.

Antenna (Fig. 55a, b) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis considerably longer than endopodal segments, about twice as long as wide, ornamented on caudal surface with 2 rows of long spinules along external margin, (one at proximal end and other at distal end) and 2 short rows of spinules proximally along inner margin; 3 rows of spinules along external margin (middle row with diagonally arranged spinules), and 1 row of spinules along inner margin proximally on frontal surface. Coxobasis armed with 2 setae along inner margin, inner seta smooth, outer seta plumose; seta representing exopod shorter than segment and bipinnate. First endopodal segment armed with 1 smooth seta, ornamented with slender row of spinules along external margin. Second endopodal segment almost as long as wide, ornamented with longitudinal row of spinules along external margin, armed with 7 smooth setae. Third endopodal segment 1.8 times as long as wide, armed with 7 smooth apical setae and ornamented along external margin with fine spinules.

Labrum (Fig. 55c) trapezoidal, cutting edge straight, with 6 teeth between produced, pointed lateral corners.

Mandible (Fig. 55d) with small, distinct palp, armed with 2 long setae and 1 short seta. Gnathobase cutting edge with 10 strong teeth and 1 outermost unipinnate seta.

Maxillule (Fig. 55e) composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 4 strong and smooth apical spines. Praecoxa armed with 6 armature elements along inner margin, longest one plumose. Palp apically
bearing 2 smooth slender setae and 1 robust, bipinnate spine; endopod distinct, bearing 2 apical and 1 subapical pinnate setae; exopodal seta pinnate.

Maxilla (Fig. 55f) unornamented, 5-segmented. Proximal endite of praecoxa well developed, armed with 2 pinnate setae; distal endite small, unarmred. Proximal endite of coxa with 1 short smooth seta, distal endite elongate and armed apically with 2 setae. Basis expanded into robust claw, ornamented with few teeth on inner margin, armed with 2 setae; strong seta somewhat shorter than claw, ornamented with 1 spinule proximally, and 1 small seta at base. Endopod 2-segmented, proximal segment armed with 2 setae, distal segment small, armed with 1 robust apical seta and 2 slender smooth subapical setae.

Maxilliped (Fig. 55g) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa about 2.3 times longer than wide, unornamented and armed with 3 setae, proximal seta pinnate, middle seta strongest, distal one smooth. Basis 1.5 times as long as wide, unornamented and armed with 2 setae, proximal seta strong and unipinnate, distal one smooth and slender. First endopodal segment unornamented and armed with 1 strong seta; second endopodal segment small, unornamented and armed with 3 setae.

Legs 1–4 (Fig. 56 a–d) with 2-segmented rami. Coxa of all legs ornamented with few spinules at outer distal corner; armed with strong pinnate seta at inner distal corner, the length of which decreasing from first to fourth leg. Intercoxal sclerites of all swimming legs unornamented, with smooth rounded distal margins. Second exopodal segment spine formula 3.4.4.3 and setal formula 5.5.5.5. Inner margins of basis of legs 1–4 ornamented with hair-like long spinules, and armed with outer plumose seta. Spine inserted at the inner protruded corner of leg 1 reaching beyond the second endopodal segment. (Fig. 56a) All exopodal and endopodal setae slender
and plumose; exopodal spines of leg 1 longer than others. All exopodal and endopodal segments ornamented with a spinular row between segments 1 and 2. Second endopodal segment of all legs except leg 1 ornamented with 4–6 spinules in the middle region. All exopodal spines with few spinules at their bases. Second endopodal segment of leg 4, 2.2 times as long as wide; inner apical spine 0.7 times as long as segment and twice as long as outer apical spine. Legs 1–4 armature formula as follows (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>4, 1+I, II</td>
<td>3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 1</td>
<td>1</td>
<td>1</td>
<td>1 - I</td>
<td>1 - 0</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1</td>
<td>0</td>
<td>4, 1+I, III</td>
<td>4, 1+I, 1</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1</td>
<td>0</td>
<td>4, 1+I, III</td>
<td>4, 1+I, 1</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1</td>
<td>0</td>
<td>4, 1+I, II</td>
<td>3, II, 1</td>
</tr>
</tbody>
</table>

Leg 5 (Figs 54b, 56e) with basal segment fused to somite; outer basal seta bipinnate stout and inserted dorsally on somite. Distal segment 2.3 times as long as wide, with 1 apical seta; apical seta 3.8 times as long as the segment and 0.62 times as long as basal seta; no spinous process present on medial surface.

Leg 6 (Fig. 56e) small cuticular plates armed with 3 unequal smooth spines, median spine much shorter than others.

**Redescription of male.** Total body length excluding caudal setae 0.62 mm. Habitus (Fig. 57a) relatively slender with prosome/urosome ratio 1.4 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.5. Cephalothorax about 2.6 times as wide as genital somite and almost as long as its greatest width, representing 38% of body length. Ornamentation of prosomites similar to that of female. Hyaline fringe of fifth pedigerous somite smooth. Genital somite (Fig. 57b) 1.5 times as wide as long. Hyaline fringe of genital somite and 3
subsequent somites serrated ventrally. Anal somite with smooth, broad and concave anal operculum representing 50% of somites width, ornamented with spinules on posterior margin ventrally and dorsally. Anal sinus narrow, ornamented with 2 diagonal rows of minute spinules. Caudal rami parallel (Fig. 57a), 2.9 times as long as wide, with small space between them. Armature and ornamentation similar to female.

Antennule (Fig. 57 c) 16-segmented, digeniculate, with geniculations between segments 8 and 9, 14 and 15; 3 aesthetascs on segment 1, and 1 each on segments 5 and 16. Segment 3 with a transverse groove. Armature formula as follows: 8+3ae.4.2.2.2+ae.2.0.2.0.2.0.0.0.2.7+ae.

Antenna (Fig. 57d) as in female, except second endopodal segment with 5 instead of 7 setae. Labrum, mandible, maxillule, maxilla, maxilliped and legs1–5 similar to female.

Second endopodal segment of leg 4, 2.8 times as long as wide as, relatively longer than that of females. Inner apical spine 2.3 times as long as outer spine and 0.7 times as long as segment.

Leg 5 (Fig. 57b) also similar to female except for the distal free segments being ornamented with a tiny spine on inner side.

Leg 6 (Fig. 57b) distinct large plates, with flat flaps armed with 1 spine and 2 pinnate setae; outer seta 1.6 times as long as middle seta and twice as long as inner spine.

**Distribution and ecology.** *Microcyclops karvei* is an Asian species having been reported from Cambodia (Lindberg, 1952), Iran (Hemsen, 1952), Tajikistan (Ulomsky, 1959), Uzbekistan (Mukhamediev, 1986; Mirabdullayev, 2006). In India, it was reported from a step-well at Kelgote in Chitaldrug town in Mysore district by Kiefer & Moorthy (1935), and from a reservoir in Ellora in the former state of
Hyderabad, and the River Krishna at Sangli in Maharashtra state (Lindberg, 1939a). This species is reported from tanks and open wells and is for the first time it is now being reported from an Indian cave (Nelabhelum Cave). In the material examined it was accompanied with *Thermocyclops decipiens*, and few cladocerans.

**Remarks.** *Microcyclops karvei* (Kiefer & Moorthy, 1935) is one of the rare and poorly known representatives of the genus *Microcyclops*. The present material accords well with the recent account of this species by Mirabdullayev (2006), which is incomplete in certain respects. Hence the species is redescribed in detail here. The only point in which the present material differs from Mirabdullayev (2006) treatment is that the inner coxal seta of legs 1–4 is relatively long with prominent setules. There is also a minor difference in the shape of seminal receptacle between the present material and Lindberg’s (1939a & 1942) description and figures. The other intraspecific morphometric variations of the species are as outlined in Table 9.

**Table 9. Morphometric data of *Microcyclops karvei* (Kiefer & Moorthy, 1935)**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total length in mm</td>
<td>0.58</td>
<td>0.72</td>
<td>0.65</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.28</td>
<td>1.46</td>
<td>1.37</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double somite length: width</td>
<td>0.84</td>
<td>0.90</td>
<td>0.87</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>3.10</td>
<td>3.40</td>
<td>3.25</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.40</td>
<td>1.70</td>
<td>1.55</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.08</td>
<td>1.10</td>
<td>1.09</td>
</tr>
<tr>
<td>7.</td>
<td>Innermost apical seta: Dorsal seta</td>
<td>1.28</td>
<td>1.30</td>
<td>1.29</td>
</tr>
<tr>
<td>8.</td>
<td>Innermost apical seta: Caudal ramus</td>
<td>0.80</td>
<td>0.82</td>
<td>0.81</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 2, length: width</td>
<td>2.20</td>
<td>2.38</td>
<td>2.29</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 2, inner apical spine: outer apical spine</td>
<td>1.84</td>
<td>2.20</td>
<td>2.05</td>
</tr>
<tr>
<td>11.</td>
<td>Leg 4 enp 2, inner apical spine: length of segment</td>
<td>0.64</td>
<td>0.78</td>
<td>0.71</td>
</tr>
</tbody>
</table>
Table 10. Morphometric data of females of *Microcyclops Karvei* from some localities in India and Uzbekistan

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Mysore India</th>
<th>Sangli India</th>
<th>Ongole India</th>
<th>Nelabhirum cave</th>
<th>Uzbekistan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Body length in mm</td>
<td>0.62</td>
<td>0.70</td>
<td>0.58–0.72</td>
<td>0.62–0.74</td>
<td>0.7–0.8</td>
</tr>
<tr>
<td>2.</td>
<td>No. of antennular segments</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>3.</td>
<td>No. of setae on the second segment of antenna</td>
<td>7</td>
<td>_</td>
<td>7</td>
<td>7</td>
<td>6–7</td>
</tr>
<tr>
<td>4.</td>
<td>Inner median apical seta: caudal ramus</td>
<td>0.80</td>
<td>0.65</td>
<td>0.80–0.84</td>
<td>0.78–0.82</td>
<td>0.7–0.8</td>
</tr>
<tr>
<td>5.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.28</td>
<td>1.06</td>
<td>1.08–1.10</td>
<td>1.0–1.1</td>
<td>1.0–1.1</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: dorsal seta</td>
<td>1.18</td>
<td>1.33</td>
<td>1.28–1.30</td>
<td>1.25–1.28</td>
<td>1.25</td>
</tr>
<tr>
<td>7.</td>
<td>Leg 4 enp 2, length: width</td>
<td>2.36</td>
<td>2.23</td>
<td>2.2–2.4</td>
<td>2.2–2.3</td>
<td>2.1–2.4</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 2, inner apical spine: outer apical spine</td>
<td>1.9</td>
<td>2.0</td>
<td>2.0</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 2, inner apical spine: length of segment</td>
<td>0.65</td>
<td>0.79</td>
<td>0.64–0.78</td>
<td>0.72–0.76</td>
<td>0.6–0.7</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 5 length: width</td>
<td>2.3</td>
<td>2.4</td>
<td>2.3–2.4</td>
<td>2.2–2.4</td>
<td>2.6–2.8</td>
</tr>
</tbody>
</table>
*Microcyclops (Microcyclops) rechtyae* Lindberg, 1960  
(Figs 59–63)

**Synonymy**


**Locality.** Nelabhelum Caves at Banganapalli (15°31'67"N, 78°23'33"E; elevation 209 m), Kurnool district, Andhra Pradesh, South India.

**Material examined.** 4 voucher specimens: 1 female (MNHN-IU-2013-9815) and 1 male (MNHN-IU-2013-9817) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9816), dissected on 7 slides and 1 male (MNHN-IU-2013-9818) dissected on 2 slides; 6 females and 2 males in author’s personal collections; 3 Oct 2005, Coll. Y. Ranga Reddy & D. Ambedkar.

**Other material examined.** Pond at Alurukona (14°56'25"N, 78°04'31"E; elevation 223 m), Anantapur District, Andhra Pradesh, South India, 04 Oct 2005: 4 females and 3 males, Coll. Y. Ranga Reddy & D. Ambedkar

**Redescription of adult female.** Habitus robust (Fig. 59a); total body length, measured from base of rostrum to posterior end of caudal rami, excluding caudal setae, 0.76 mm. Colour of the preserved specimens pale yellow. Rostrum well developed, membranous and broadly rounded. Prosome/urosome ratio 1.4 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.3. Cephalothorax 3.2 times as wide as genital double-somite and 0.8 times as long as its greatest width, representing 38% of total body length. Second and third pedigerous somites with lateral corners slightly protruded. Fifth pedigerous somite with smooth fringe dorsally and ventrally.

Genital double-somite (Fig. 59b) 1.2 times as long as wide. Hyaline fringes of genital double-somite and 2 subsequent somites smooth dorsally and serrulated.
ventrally. Copulatory pore oval, copulatory duct rigidly sclerotized. Seminal receptacle clearly divided into a large and wide anterior expansion, and a short posterior one. Ovipores situated somewhat dorso-laterally, covered by reduced sixth legs. Anal somite (Fig. 59c) with smooth, broad, somewhat concave anal operculum, representing 60% of somite’s width, ornamented with a transverse row of spinules on posterior margindorsally and ventrally. Anal sinus narrow without ornamentation.

Caudal rami (Fig. 59c, d) short, almost parallel, about 3.5 times as long as wide, ornamented with 2 minute spinules at the base of outermost apical seta. Dorsal seta short, 0.6 times as long as ramus, inserted at 5/6 of ramus length, uniarticulate at base and plumose distally. Lateral seta, unipinnate, arising at 2/3 of ramus length. Innermost apical seta plumose, 1.4 times as long as outermost apical seta. Principal apical setae plumose with breaking planes, inner median apical seta 1.4 times as long as outer one and 0.44 times as long as body.

Antennule (Fig. 60a) 12-segmented, reaching 2/3 of cephalothorax, with 1 slender aesthetasc on segments 8, 11 and 12 each and setal formula: 8.4.2.6.4.2.2.3+ae.2.2.2+ae.7+ae. One seta on segment 6 short and spiniform; 1 terminal seta on segment 12 articulating at basal part; longer setae mostly pinnate, other setae slender and naked; ornamentation consisting of short row of spinules on first segment.

Antenna (Fig. 60b, c) 4-segmented, comprising coxobasis and 3-segmented endopod; coxobasis twice as long as wide; ornamented with 1 row of spinules both on outer and inner margins of frontal surface proximally, 2 rows of spinules on inner margin; caudal surface with 2 arched rows of spinules (one in the middle, other in the distal region) and 1 transverse row of minute spinules in the proximal region. Coxobasis armed with 2 smooth setae at distal inner corner, and seta representing
exopod small and pinnate. First endopodal segment armed with 1 smooth seta, ornamented with distal longitudinal row of spinules along external margin. Second endopodal segment about 1.6 times as long as wide, ornamented with 1 longitudinal row of spinules, armed with 8 smooth setae. Third endopodal segment about 2.1 times as long as wide armed with 7 apical setae and ornamented along external margin with fine spinules.

Labrum (Fig. 61a) with flat cutting edge, 8 teeth between 2 small protuberances, ornamented with 2 small spinules.

Mandible (Fig. 61b) with distinct palp, armed with 2 long and 1 short, smooth setae. Coxal gnathobase cutting edge, with 8 small teeth and 1 outermost unipinnate short seta; ornamentation consisting 2 transverse rows of spinules proximally and 1 row of spinules on outer margin.

Maxillule (Fig. 61c, d) composed of well-developed praecoxa with 2-segmented palp. Articite of praecoxa with 4 strong apical spines; praecoxa armed additionally with 7 armature elements along inner margin. Palp apically bearing 2 slender setae and 1 robust unipinnate spine; endopod distinct, with 2 apical and 1 sub apical setae; exopodal seta unipinnate.

Maxilla (Fig. 61e) unornamented, 5-segmented, composed of praecoxa, coxa, basis and 2-segmented endopod. Proximal endite of praecoxa elongate, slender, armed with 2 pinnate setae; distal endite small, unarmed. Proximal endite of coxa with 1 strong smooth seta; distal endite elongate and armed apically with 2 pinnate setae. Basis expanded into robust claw, ornamented with longitudinal row of strong spinules along middle concave margin and armed with 2 setae; strong seta almost as long as claw, ornamented with 3 spinules proximally. Endopod 2-segmented, proximal
segment armed with 2 setae, distal segment with 1 robust apical seta and 2 slender subapical setae.

Maxilliped (Fig. 61f) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa ornamented with few small distal spinules, armed with 3 setae, proximal unipinnate, middle bipinnate and distal smooth one; middle seta strongest and longest, 1.7 times as long as proximal one and 1.8 times as long as distal one. Basis 2.2 times as long as wide, ornamented with 1 arched row of spinules, 1 transverse row of long spinules at distal end, and armed with 2 pinnate setae. First endopodal segment unornamented, armed with 1 strong, proximally bipinnate seta, and tiny spinules along distal outer margin. Second endopodal segment without any ornamentation and armed with 1 smooth and 2 pinnate setae.

Legs 1–4 (Figs 62 a–d) with 2-segmented rami; coxa of all legs ornamented with 2 groups of spinules along outer margin proximally and distally, other rows of spinules as figured; and armed with a plumose seta at inner distal corner. Intercoxal sclerites of legs 1–4 with protrusions on both sides; legs 1–3 without ornamentation and leg 4 with 1 row of long spinules on caudal side (Fig. 62d). Exopodal segment spine formula 3.4.4.3 and setal formula 5.5.5.5. Basis of legs 1–3 ornamented with a row of hair like spinules at the inner edge, leg 4 with short, strong spinules and all legs armed with outer plumose seta. Spine inserted at inner, protruded corner of basis of leg 1, pinnate reaching almost the end of second endopodal segment, ornamented with few spinules at base (Fig. 62a). All exopodal and endopodal setae slender and plumose. Leg 4 second endopodal segment 2.2 times as long as wide, inner apical spine 0.7 times as long as segment and 1.8 times as long as outer apical spine (Fig. 62d). Legs1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):
<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>1 – 0</td>
<td>I – 1</td>
<td>1 - I</td>
<td>4,1+ I, II</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>1 - I</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>1 - I</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>0 - I</td>
<td>4, 1+I, II</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 62 e) with basal segment fused to somite, outer basal seta smooth and inserted dorsally on somite. Distal segment 2.4 times as long as wide and with 1, distally-plumose apical seta ornamented with a tiny median spinule.

Leg 6 (Fig. 62 f) small cuticular plates armed with 2 unequal small, smooth spines and 1 long bipinnate seta.

**Redescription of adult male.** Total body length, excluding caudal setae 0.58 mm. Habitus (Fig. 63a) slender than female, with prosome/urosome ratio 1.5 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.7; cephalothorax about 2.4 times as wide as genital somite and 1.2 times as long as its greatest width representing 45% of total body length. Genital somite 0.7 times as long as wide; hyaline fringes of genital somite and subsequent somites serrated ventrally. Anal somite with broad, concave anal operculum and ornamented with a row of spinules on posterior margin both dorsally and ventrally.

Caudal rami (Fig. 63a) parallel, 2.8 times as long as wide, with little space between them. Armature and ornamentation as in female.

Antennule (Fig. 63c) 16-segmented, digeniculate with geniculations between segments 8 and 9, and 14 and 15. First segment with 3 aesthetasc and segments 4 and 16 with 1 aesthetasc each. Armature formula as follows: 8+3ae.3.2.2+ae.1.2.1.2.4.2.2.2.2.0.1.10+ae.

Antenna (Fig. 63d) 4-segmented; second endopodal segment with 7 setae instead of 8 setae; otherwise as in female. Labrum, mandible, maxilla, maxillule, maxilliped and legs 1–4 similar as in female.
Leg 5 (Fig. 63b) similar to female, distal segment narrower, 2.8 times as long as wide, with a small median spinule.

Leg 6 (Fig. 63b) distinct, with flat flaps armed with 1 inner spine, middle smooth spine like seta and outer bipinnate seta; outer seta 1.7 times longer than inner spine.

**Distribution and ecology.** *Microcyclops rechtyae* is an Asian species having been originally described from Afghanistan by Lindberg (1960). Subsequently, Mirabdullayev (1998) reported this species from Uzbekistan. It is for the first time that this species is now being reported from India. In the material collected from Nelabhelum Cave where the water flow was more, and the bottom was covered with stones and pebbles *Thermocyclops decipiens, Tropodiaptomus* sp., *Paradiaptomus greeni* and a few fishes were observed along with *M. rechtyae*. At Alurukona, algal filaments were present.

**Remarks.** *Microcyclops rechtyae* Lindberg 1960 is one of the poorly known representatives of the genus *Microcyclops*. It was originally described by Lindberg 1960 based on a single female. Recently, while reporting it from Uzbekistan, Mirabdullayev (1998) provided an incomplete ‘redescription’ of the same, but rightly recognized that Sri Lankan *Microcyclops elegans* Dussart & Fernando 1985 as the probable synonym of *M. rechtyae*. The present material accords well with the recent account of this species by Mirabdullayev (1998). The species is redescribed in detail here. The present material slightly differs from Mirabdullayev’s (1998) treatment in the length /width ratio of caudal rami. Also, the lateral lobes of seminal receptaculum are straight instead of being ‘slightly curved posteriorly’. The morphometric variation present in the different populations of the species is as outlined in Table12.
Table 11. Morphometric data of *Microcyclops rechytae* Lindberg, 1960

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>0.74</td>
<td>0.82</td>
<td>0.78</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.1</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>3.30</td>
<td>3.60</td>
<td>3.45</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.3</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>7.</td>
<td>Innermost apical seta: dorsal seta</td>
<td>1.70</td>
<td>1.80</td>
<td>1.75</td>
</tr>
<tr>
<td>8.</td>
<td>Innermost apical seta: caudal ramus</td>
<td>0.9</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 2 length: width</td>
<td>2.2</td>
<td>2.4</td>
<td>2.3</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 2 inner apical spine: outer apical spine</td>
<td>1.8</td>
<td>2.0</td>
<td>1.9</td>
</tr>
<tr>
<td>11.</td>
<td>Leg 4 enp 2 inner apical spine: length of segment</td>
<td>0.70</td>
<td>0.80</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Key to the identification of the Indian species of genus *Microcyclops* Claus, 1893

1. Antennule 11 segmented ................................................................. 2

Antennule 12 segmented ................................................................. 4

2. Seminal receptaculum bicolor type .......................*M. tricolor* Lindberg, 1939

Seminal receptaculum varicans type.................................................. 3

3. Innermost apical seta 2 times as outermost apical seta; leg 4 enp 2 inner apical spine 3 times as outer apical spine..................*M. indolusitanus* Lindberg, 1938

The same seta more than 2 times as outermost apical seta; leg 4 enp 2 inner apical spine less than 3 times as outer apical spine.........*M. rubellus* (Lilljeborg, 1901)

4. Inner apical spine of leg 4 endopodite 2 enlarged at base........... *M. varicans varicans* (G.O.Sars, 1863)

The same spine not enlarged at base.................................................. 5
5. Caudal rami short, less than 3 times as long as wide……………………………………. \textit{M. davidi var. subtropicus} (Lindberg, 1937)
   Caudal ramus more than 3 times as long as wide……………………………………6

6. Leg 5 distal segment without spinule………………………………………\textit{M. pachyspina}
   Lindberg, 1937
   The same segment with spinule……………………………………………………………..7

7. Intercoxal sclerites of leg 4 with spinules………………………………….\textit{M. rechytae} Lindberg, 1960
   Intercoxal sclerites of leg 4 without spinules ……………………8

8. Caudal rami more than 3 times as long as wide; antennule 12 segmented……………
   …………………………………………………………………………………\textit{M. varicans subequalis} (Kiefer, 1928)
   Caudal rami less than 3 times as long as wide; antennule 10 segmented………………9

9. Seminal receptacle bicolor type…………………………\textit{M. diminutus} (Lindberg, 1937)
   Seminal receptacle varicans type……………………\textit{M. karvei} (Kiefer & Moorthy, 1935)

\textbf{Table 12. Comparative morphometric data of females of \textit{Microcyclops} (\textit{Microcyclops} rechytae).} The data in parentheses are derived from published figures (Sources: Afghanistan, Lindberg 1960; Sri Lanka, Dussart & Fernando 1985; Uzbekistan, Mirabdullayev 1998, India, present study).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Afghanistan</th>
<th>Sri Lanka</th>
<th>Uzbekistan</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Body length in mm</td>
<td>0.83</td>
<td>0.66</td>
<td>0.77 – 0.90</td>
<td>0.74 – 0.82</td>
</tr>
<tr>
<td>2</td>
<td>Caudal ramus length: width</td>
<td>4.16</td>
<td>3.50</td>
<td>3.85 – 4.28</td>
<td>3.30 – 3.60</td>
</tr>
<tr>
<td>3</td>
<td>Innermost apical seta: caudal ramus</td>
<td>1.05</td>
<td>0.96</td>
<td>0.90 – 1.07</td>
<td>0.88 – 0.92</td>
</tr>
<tr>
<td>4</td>
<td>Innermost apical seta: inner median apical seta</td>
<td>0.26</td>
<td>0.22</td>
<td>0.21 – 0.23</td>
<td>0.23</td>
</tr>
<tr>
<td>5</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.45</td>
<td>1.25</td>
<td>1.19 – 1.38</td>
<td>1.32 – 1.50</td>
</tr>
<tr>
<td>6</td>
<td>Innermost apical seta: dorsal seta</td>
<td>1.65</td>
<td>1.87</td>
<td>1.67 – 1.38</td>
<td>1.60 – 1.80</td>
</tr>
<tr>
<td>7</td>
<td>Leg 4 enp 2 length: width</td>
<td>1.93</td>
<td>2.20</td>
<td>1.90 – 2.18</td>
<td>2.20 – 2.40</td>
</tr>
<tr>
<td>8</td>
<td>Leg 4 enp 2 inner apical spine: outer apical spine</td>
<td>1.8</td>
<td>2.0</td>
<td>1.8 – 2.0</td>
<td>1.8– 2.0</td>
</tr>
<tr>
<td>9</td>
<td>Leg 4 enp 2 inner apical spine: length of segment</td>
<td>0.73</td>
<td>0.60</td>
<td>0.68–0.85</td>
<td>0.70 – 0.80</td>
</tr>
</tbody>
</table>
New morphological characters useful in the taxonomy of the genus Microcyclops

Claus, 1893 (Copepoda, Cyclopoida)

Certain morphological features such as the number of antennular segments, the length/width ratio of caudal rami, the ornamentation of legs 1–4, and the length/width ratio of the second endopodal segment of leg 4 and the relative length ratios of its two apical spines have been conventionally used for separating the individual species of Microcyclops. For the first time, Rocha (1998) recognized certain new additional morphological characters like the nature of the border ornamentation of prosomites, the shape and ornamentation of terminal spine on the endopod of leg1, the presence and number of integumental pores on the terminal endopodal segment of leg1, and the ornamentation details of the principal apical caudal setae for separating five Brazilian species of Microcyclops. Taking it into consideration all these characters and further adding some more new characters, viz. i) the length of the spine on leg 1 basis, ii) chetotaxy on the caudal surface of coxobasis of antenna, and iii) ornamentation on the strong seta of maxillary claw, I have found it to be possible to separate four species of Microcyclops, viz. M. varicans, M. karvei, M. rechtyae and M. rubellus. All the above-mentioned micro-characters are illustrated and their taxonomic usefulness discussed hereunder.

1. Ornamentation of the posterior margins of prosomites

The posterior margins of prosomites 2–4 in M. karvei (Fig. 65a) are ornamented with a row of regular minute denticles each, whereas the said margins in M. varicans are smooth except for a small mid-dorsal indentation on each of them (Fig. 65c). The nature of ornamentation in M. rechtyae is same as in M. karvei except for the denticles being still finer on the posterior border of the fourth prosomite alone (Fig. 65b).
2. Ornamentation of the principal apical caudal setae

The principal apical caudal setae in all the four species are homogenously ornamented, but some interspecific variations could be observed in them. In *M. rechtyae* (Fig. 66a) both margins of median caudal seta have setules in the proximal region, but the setules are confined to inner proximal margin only in *M. karvei* (Fig. 66b); *M. varicans* has setules on both proximal margins, but the setules at about midlength are longer (Fig. 66c) whereas *M. rubellus* has homogeneously arranged setules.(Fig. 66d).

3. Chetotaxy of the caudal surface of antennal coxobasis

The arrangement and number of groups of spinules on the caudal surface of coxobasis of antenna in the four species is different as illustrated in the Figs 66e–h.

4. Length and ornamentation of spine on leg 1 basis

The spine present on the inner protruded corner of leg 1 basis subtly differs in its length and ornamentation in different species as illustrated in Fig 67a–d. In *M. karvei*, the spine reaches 1/3 of the length of terminal spine of the second endopodal segment (Fig. 67a) whereas, it extends almost up to the end of the segment in *M. rechtyae* (Fig. 67b), beyond the end of the segment (Fig. 67c) in *M. varicans*, and distinctly short, barely reaching the anterior 1/3 of the second endopodal segment in *M. rubellus* (Fig. 67d). The implantation of the spine is without ornamentation in *M. karvei* and *M. rubellus* but with a row of spinules in *M. varicans* and *M. rechtyae*.

5. Second endopodal segment of leg 1

Fig. 67a–d also illustrate the differences in the shape of the terminal spine of second endopodal segment of leg 1 and the presence/absence of integumental pores on the anterior surface of the same segment. The tip of the spine is rounded in *M. karvei* (Fig. 67a), blunt in *M. rechtyae* (Fig. 67b), pointed in *M. varicans* (Fig. 67c)
and slightly bent outwards in *M. rubellus* (Fig. 67d). No pores were observed in *M. karvei* and *M. rubellus* (Figs 67a, d); whereas *M. rechtyae* and *M. varicans* (Fig. 67b, c) have one pore each near the mid-dorsal point and outer disto-dorsal margin of the segment, respectively.

6. Ornamentation of the strong seta of maxillary claw

Basis of maxilla expanded into a robust claw, armed with 2 setae, the stronger one with one proximal strong spinule in *M. karvei* (Fig. 67g), two strong spinules in *M. varicans* (Fig. 67e), three strong spinules in *M. rechtyae* (Fig. 67f); and none such in *M. rubellus* (Fig. 67h).

**Discussion.** As already mentioned, the separation of *Microcyclops* spp., like in other cyclopoid taxa, has been based on the following conventional morphological characters, mainly in the females: (1) the presence, size and position of the spinule on the inner surface of free segment of leg 5; (2) proportions of caudal rami and their setae; (3) proportions of the second endopodal segment of leg 4 and its terminal spines; (4) the ornamentation of the intercoxal sclerites of leg 4; (5) number of segments of the antennules; and (6) the presence of a seta on the inner corner of the basis of leg 1. Except for the last-mentioned character, all the others are variable, and so care must be bestowed on depicting the range of each of the variable characters while determining the species identities.

According to Lindberg (1955), remarkable intraspecific variations are observed in the ornamentation of the intercoxal sclerites and the inner border of the basis of leg 4, as well as in the seta implanted on the coxa of this leg. Reid (1986), in a detailed table, compiled great variations of the above-mentioned characters in the females of *M. ceibaensis*. These examples make it clear that the features used until
now to distinguish *Microcyclops* spp. vary so much that their value as diagnostic characters has become questionable in taxonomy.

The importance of the morphology and ornamentation on the coxobasis of antenna in the systematics of cyclopidae was in a way pioneered by Fiers & Van de Velde (1984). The antennae of 45 species and subspecies belonging to 14 cyclopoid genera and subgenera were examined by them, and their study revealed that the distinct spinular patterns found on the coxobasis of antenna have taxonomic and phylogenetic value. Hence, due attention has to be paid in accurately mapping these patterns while examining various taxa.

No doubt, figuring out the aforementioned new micro-characters is a tedious and difficult job, but most of the characters have the advantage of being constant and consistent and highly useful in the taxonomy of the various species of the cyclopoid genera (Fiers & Van de Velde, 1984).
Genus *Mesocyclops* G. O. Sars, 1914

**Generic diagnosis.** Holyńska, Reid & Ueda (2003) provided the following generic diagnosis: Leg 5, 2-segmented, terminal segment bearing an apical seta and a long spine, inserted laterally. Seminal receptacle hammer-shaped; handle of hammer dilated and almost sac-like. Caudal rami elongated. Lateral caudal seta inserted at about distal 1/3 of caudal ramus. Antennule 17-segmented. Antenna armed with 3 setae on coxobasis and 1, 6–9, 7 setae on 1–3 endopodal segments, respectively. Mandibular palp bearing 2 long and 1 short setae. Arthrite of maxillule with 3 strong apical spines. Maxilla with 1–2 segmented endopod. Legs 1–4 with 3-segmented rami. Basis of leg 1 with or without seta on its inner margin.

Holyńska & Fiers (1998) divided the genus *Mesocyclops* into 2 groups, viz. *thermocyclopoides*-group and *leuckarti*-group. Based on this, Alekseev (2002) divided all *Mesocyclops* species into 2 large sections on the basis of presence or absence of a spine on the basis of leg 1. He used two patterns of hair distribution, one on the fifth pedigerous somite and the other on the caudal ramus, on the basis of which, he further recognized four groups of species in each section: i) forms with hairs only on fifth thoracic segment; ii) forms with hairs only on caudal rami; iii) forms with both patterns of hairs; and iv) hairless forms. Up till now, this genus is represented by 125 nominal species and subspecies according to the latest World of Copepods database (Chad 2013). Of these, the following 11 taxa are already known from India:

1. *Mesocyclops aspericornis* (Daday, 1906)
2. *Mesocyclops annae* Kiefer, 1930
3. *Mesocyclops pehpeiensis* Hu, 1943
5. *Mesocyclops granulatus* Dussart & Fernando, 1988

Of these 11 species, *Mesocyclops rectus* Lindberg, 1937 rightly belongs to the genus *Thermocyclops* (see Herbst, 1986). *Mesocyclops ruttneri* Kiefer, 1981 has been synonymized with *M. Pehpeiensis* by Guo (2000). Hence, according to Dussart & Defaye (2006) nine species are distributed in India, of which only two species, viz. *Mesocyclops aspericornis*, and *Mesocyclops isabellae*, have been met in this study besides a new species, *Mesocyclops ornatus* n. sp.

*Mesocyclops aspericornis* (Daday, 1906)
(Figs 68–72)

**Synonymy**

*Cyclops aspericornis* Daday, 1906: 18; Pl.14, Figs 1–6; 1910: 60, Figs 27–29.


*Mesocyclops aspericornis*, Kiefer, 1981: 172–173, Pl.10; Van de Velde, 1984: 42–45, Fig. 29A–G, Ghenne & Fiers, 2000: 93–98; Suarez-Morales & Gutiérrez-Aguirre, 2001:1–202; Gutiérrez- A. Aguirre et al., 2002:1349–1362; Holyńska, Reíd & Ueda in Ueda & Reíd, 2003: 148, Fig. 61A–O; 149, Fig. 62A–F.

**Locality.** Fish farms near Vuyyuru (16º22'04"N, 80º50'84"E; elevation 11 m), Krishna District, Andhra Pradesh, South India.

101
**Material examined.** 3 voucher specimens: 1 male (MNHN-IU-2013-9820) whole-mounted on 1 slide; 1 female (MNHN-IU-2013-9819), dissected on 6 slides and 1 male (MNHN-IU-2013-9821) dissected on 2 slides; 20 females and 8 males in author’s personal collections; 12 September 2006, Coll. V. Subhashini.

**Other material examined.** Pond at Ammulapalem village near Draksharamam (16°47’ 34”N, 82°03’49” E; elevation 10 m), East Godavari District, Andhra Pradesh, South India, 16 October 2005: 6 females and 2 males, Coll. T. V. Rao

Pond at Timmareddi Cheruvu, Kandukuru (15°13'00" N, 79°55'00" E; elevation 632 m), Prakasam District, Andhra Pradesh, South India, 09 January 2005: 5 females and 2 males, Coll. D. Ambedkar.

Meduru Cheruvu near Tripurantakam (15°58'60"N, 79°27'00"E; elevation 100 m), Prakasam District, Andhra Pradesh, South India, 28 July 2005: 6 females, Coll. D. Ambedkar.


Rain fed pond in paddy fields, Kuthirappura Village, (10°31'12” N, 76°12'36” E; elevation 7 m), Palakkad District, Kerala, South India, 26 December 2005: 8 females, 2 males Coll. Y. Ranga Reddy & D. Ambedkar

Kothakulam Pond, Thrissur town (10°31'12"N, 76°12'36"E; elevation 2.83 m), Kerala, South India 26 December 2005: 13 females and 2 males, Coll. Y. Ranga Reddy & D. Ambedkar

Fish farms at Penamaluru (16°27'42"N, 80°43'07" E; elevation 7 m), Vijayawada, Krishna District, Andhra Pradesh, South India, 11 July 2006: 16 females, Coll. V. Subhashini.
**Distribution and ecology.** This species has wide-spread distribution in Africa, Asia, South America, and Australia (Dussart & Defaye, 2006). In India, it was reported from freshwater fish ponds by Kasaiah (1987) and Zehra & Altaff (2002) in Andhra Pradesh and Tamilnadu, respectively. Though not common, it seems to be widely distributed in peninsular India. In the material examined it was accompanied by *Heliodiaptomus viduus, Thermocyclops decipiens*, few cladocerans and some rotifers like *Brachionus caudatus*, and *Brachionus falcatus*.

**Discussion.** *Mesocyclops aspericornis* belongs to the *aspericornis*-group, which, inter alia, is characterized by the presence of hairs on caudal ramus and fifth pedigerous somite, and without inner spine on the basis of leg1. The present material perfectly agrees with the detailed description of this species already available in the literature (see Kiefer, 1981; Van de Velde, 1984; Ghenne & Fiers, 2000; Zehra & Altaff, 2002; Holyńska, et al., 2003, and others). It is noteworthy that the second endopodal segment of antenna consistently shows seven setae in all the populations under the present study, as was also reported earlier by Zehra & Altaff (2002). On the other hand, Holyńska, (2000) opined that the eastern and western populations differed in having 7–9 and 8–9 setae, respectively, but ruled out the presence of seven setae. The distal row of the spinular pattern on the coxobasis of antenna is likewise as in the West African population (Holyńska, 2000).

*M. aspericornis* closely resembles *M. dadayi* reported from Calcutta (now Kolkata), India. The caudal rami in both these species have hairy inner margins (dorsal hairs also present in the latter). *M. aspericornis*, however, differs from the latter in the ornamentation of fifth pedigerous somite, caudal surface of coxobasis of antenna, intercoxal sclerites of leg 4, and coxa of maxilla, and absence of spinules on the outer edge of inner apical spine of third endopodal segment of leg 4.
Table 13. Morphometric data of *Mesocyclops aspericornis* Daday, 1906.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average n=20</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total length in mm</td>
<td>1.2</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.4</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.1</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>2.7</td>
<td>3.6</td>
<td>3.2</td>
</tr>
<tr>
<td>5.</td>
<td>Inner medial apical seta: outer median apical seta</td>
<td>1.3</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>2.8</td>
<td>3.2</td>
<td>3.0</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outermost apical seta</td>
<td>0.7</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 3, length: width</td>
<td>2.4</td>
<td>3.0</td>
<td>2.7</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>1.1</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>1.1</td>
<td>1.3</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Mesocyclops isabellae Dussart & Fernando, 1988
(Figs73–77)

Synonymy

Mesocyclops isabellae Dussart & Fernando, 1988: 247, Figs 12–17

Mesocyclops isabellae, Holyńska, Reid & Ueda in Ueda & Reid, 2003:174, Figs 74 A–O.

Locality. Rain-fed pond, Phanidram, near Guntur (16º13'00"N, 80º27'00"E; elevation 33 m), Guntur District, Andhra Pradesh, South India.

Material examined. 4 voucher specimens: 1 female (MNHN-IU-2013-9822) and 1 male (MNHN-IU-2013-9824) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9823), dissected on 9 slides and 1 male (MNHN-IU-2013-9825) dissected on 2 slides; 10 females and 6 males in author’s personal collections; 22 October 2004, Coll. D. Ambedkar & V. Subhashini.

Other material examined. Temple Pond, Tadikonda (16º25'00"N, 80º27'15"E; elevation 37 m), Guntur District, Andhra Pradesh, 06 June 2005: 10 females and 6 males, Coll. V. Subhashini & D. Ambedkar.
Road-side small reservoir, Pedakakani, (16º20'57"N, 80º29'25"E; elevation 29 m), Guntur District, Andhra Pradesh, 27 July 2004: 6 females and 2 males, Coll. V. Subhashini.
Timmareddi Cheruvu, Kandukuru, (15º21'50"N, 79º91'07"E; elevation 632 m), Prakasam District, Andhra Pradesh, 9 January 2005: 5 females and 1 male, Coll. V. Subhashini.
Pond at Kakibangarupalem, Kandukuru, (15º21'50"N, 79º91'07"E; elevation 632 m), Prakasam District, Andhra Pradesh, South India, 09 Jan 2005: 16 females and 6 males, Coll. V. Subhashini.
Pond at Velupucherla, 20 km from Nuzivid (16°40'48"N, 80°51'00"E; elevation 16 m), Krishna District, Andhra Pradesh, South India, 29 May 2005: 8 females and 2 males, Coll. V. Subhashini.

Chillakollu tank at Nawabpeta near Jaggaiahpeta (16°53'31"N, 80°05'51"E; elevation 45 m), Krishna District, Andhra Pradesh, South India, 12 July 2005: 6 females and 2 males Coll. V. Subhashini.

Husain Sagar, Hyderabad (17°21'58"N, 78°28'34"E; elevation 536 m), Hyderabad District Andhra Pradesh, South India, 10 October 2005: 6 females and 2 males Coll. D. Ambedkar,

**Redescription of adult female.** Total body length excluding caudal setae 1.07 mm. Habitus robust (Fig. 73a); prosome/urosome ratio 1.8 and greatest body width near posterior end of cephalothorax. Body length/width ratio 1.7. Free pedigerous somites without pronounced lateral expansions. Rostrum well developed, membranous and broadly rounded. Colour of the preserved specimens light brown. Cephalothorax almost as long as wide, representing 40% of total body length and 3.3 times as wide as genital double-somite. Fifth pedigerous somite with smooth fringe dorsally and ventrally, ornamented with dorsal hairs, lateral row of spinules, 2 rows of short spinules ventro-laterally and 2 sensilla dorsally (Fig. 73b).

Genital double-somite (Fig. 73b) 1.3 times as long as wide, dorsal surface pilose on anterior half, ornamented with 2 sensilla ventrally at the posterior end. Hyaline fringe of genital double-somite smooth dorsally and ventrally. Seminal receptacle relatively large, representing 75% of somite’s width, divided into proximal and distal parts; proximal part has distinct anterior and posterior margins as short and wide lateral arms; anterior margin of proximal part deeply sinuate in middle, distal part elongated and sac-like. Transverse ducts meeting at straight angle, fused near
round copulatory pore; copulatory duct slightly curved with transverse bands along entire length. Ovipores situated dorso-laterally, covered by reduced sixth legs. Hyaline fringes of subsequent urosomites smooth dorsally and slightly serrulate ventrally. Anal somite (Fig. 73c, d) with smooth, broad, anal operculum representing 61% of somite’s width, ornamented with 2 sensilla dorsally and 1 row of spinules at base of caudal rami ventrally (Fig. 73c). Anal sinus widely opens without ornamentation.

Caudal rami (Figs 73c, d) 3.4 times as long as wide, parallel, with small space between them and without hairs on inner margin. Dorsal seta 1.3 times as long as ramus and outermost apical seta, inserted at 6/7 of ramus length, uniarticulate at base and plumose distally. Lateral seta arising from about 60% of ramus length, bipinnate, 1.5 times as long as ramus width. Outermost apical seta, stout, spiniform and shorter than ramus. Innermost apical seta plumose, 3 times as long as outermost apical seta. Principal apical setae plumose with breaking planes; inner median apical seta 1.3 times as long as outer median apical seta and 0.32 times as long as body. Implantations of lateral and outermost apical seta not provided with spinules.

Antennule (Fig. 74a) reaching the end of second pedigerous somite, 17-segmented, with 1 slender aesthetasc each on segments 12, 16, and 17; setal formula as follows: 8.4.2.6.4.2.2.1.1.0.1.1+ae.0.1.2.2+ae.7+ae. Most setae long and plumose. Hyaline lamella extending beyond the level of lateral seta with 1 notch; spinules present on segments 1, 4–5, and 7–14.

Antenna (Figs 74b, c) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis 2.3 times as long as wide, armed with 2 smooth setae at distal inner corner; seta representing exopod pinnate, reaching beyond the tip of the appendage. Coxobasis ornamented with 1 row of short spinules proximally, a
longitudinal row of 10–12 spinules along outer rim and 5–6 long, stout spinules at the implantation of exopod; a field of spinules at the level of inner setae; an oblique row of 15–17 spinules medially and a short row of 5 - 6 spinules between oblique and longitudinal rows on caudal surface; 1 longitudinal row of 19–21 spinules along outer edge and 1 short row of spinules along inner edge proximally on frontal surface. First endopodal segment armed with a smooth seta, ornamented with a longitudinal row of spinules along distal half of outer margin. Second endopodal segment 2.8 times as long as wide, also ornamented with a longitudinal row of spinules, armed with 7 setae. Third endopodal segment 3.5 times as long as wide, ornamented with 1 longitudinal row of spinules and armed with 7 apical setae.

Labrum (Fig. 74d) trapezoidal, ornamented with 4 groups of long, slender spinules (2 groups of 9 each, 2 groups of 6 each); cutting edge straight with 11 teeth (second tooth of each side long and strong) between produced, rounded lateral corners.

Mandible (Fig. 75a) with distinct palp, armed with 2 long pinnate setae and 1 short smooth seta. Coxal gnathobase cutting edge with 6 strong teeth and 1 outermost unipinnate seta.

Maxillule (Figs 75b, c) composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines, 1 spiniform seta at base on ventral surface. Praecoxa armed with 6 elements along inner margin, longest one plumose. Palp (Fig. 75c) apically bearing 2 slender setae (1 distally pinnate, 1 smooth) and 1 robust, unipinnate seta; endopod distinct, bearing 2 apical and 1 subapical pinnate setae; exopodal seta smooth.

Maxilla (Fig. 75d) 4-segmented, composed of praecoxa, coxa, basis and endopod. Praecoxa unornamented, with elongated proximal endite, armed with 2
equal long pinnate setae, distal endite small, unarmed. Coxa ornamented with 1 row of tiny spinules along inner margin. Proximal endite of coxa with 1 strong, long, bipinnate seta; distal endite elongate and armed apically with 1 proximal strong, pinnate seta and 1 distal smooth, slender seta. Basis expanded into robust claw, ornamented with longitudinal row of spinules along concave margin and armed with 2 setae, strong seta almost as long as claw, ornamented with 2 spinules proximally and unipinnate distally; short seta at its base. Endopod armed with 2 strong and 3 slender setae.

Maxilliped (Fig. 75e) 4-segmented composed of syncoxa, basis and 2 segmented endopod. Syncoxa ornamented with 2 rows of tiny spinules at outer margin, armed with 3 strong, unipinnate setae; middle seta strongest and longest, 3 times as long as proximal one and 1.5 times as long as distal seta. Basis 2.5 times as long as wide, ornamented with 1 group of spinules proximally and 2 rows of spinules along outer margin, 1 arched row of 6–8 long spinules along inner margin; armed with 2 pinnate setae, proximal seta 1.2 times as long as distal one. First endopodal segment armed with 1 strong bipinnate seta, with 2 spinules at its base. Second endopodal segment small, unornamented but armed with 3 setae, innermost seta bipinnate and strongest, about 1.5 times as long as middle smooth seta and 7 times as long as outermost smooth seta.

Legs 1–4 (Fig. 76a–d) with 3-segmented exopod and endopod. Coxa of all legs ornamented with 6–8 long spinules along outer margin, that of leg 4 (Fig. 76d) with 5 groups of spinules on caudal surface, armed with 1 plumose seta along inner edge. Intercoxal sclerites of legs 1–4 unornamented, with smooth rounded protrusions on each side, that of leg 4 with acute prominences. Third exopodal segment spine formula 2.3.3.3 and setal formula 4.4.4.4. Basis of leg 1 (Fig. 76a) without medial spine,
ornamented with 2 rows of spinules, that of legs 2–3 (Fig. 76b, c) unornamented and armed with 1 row of proximal hairs, 2 rows of distal hairs; inner margin of basis of leg 1–4 with hairs and armed with outer pinnate seta. All exopodal and endopodal setae slender and plumose. Third endopodal segment of leg 4 (Fig. 76d) 3.2 times as long as wide; inner apical spine ornamented with small spinules on outer edge and long spinules on inner edge; 0.9 times as long as outer apical spine and 0.8 times as long as the segment. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>1-0</td>
<td>0-1</td>
<td>1-1</td>
<td>1-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3, 1+I, I</td>
<td>1-0</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>2-0</td>
<td>3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1-0</td>
<td>0-1</td>
<td>1-1</td>
<td>1-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3, 1+I, II</td>
<td>1-0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2-0</td>
<td>3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1-0</td>
<td>0-1</td>
<td>1-1</td>
<td>1-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3, 1+I, II</td>
<td>1-0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2-0</td>
<td>3, 1+I, 1</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1-0</td>
<td>0-1</td>
<td>1-1</td>
<td>1-1</td>
</tr>
<tr>
<td></td>
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<td>3, 1+I, II</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2-0</td>
<td>2, II, 1</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 73b) 2-segmented, basal segment slightly wider than long, armed with 1 plumose seta. Distal segment 2.4 times as long as wide, unornamented, armed with 1 apical seta and 1 inner spiniform seta; apical seta plumose, 1.6 times as long as inner spiniform seta and 2.6 times as long as plumose seta.

Leg 6 (Fig. 76e) distinct cuticular plate, armed with 2 unequal smooth spines, and 1 long pinnate seta.

**Redescription of male.** Total body length excluding caudal setae 0.73 mm. Habitus (Fig. 77a) relatively slender, prosome/urosome ratio 1.8 and greatest width at posterior end of cephalothorax. Body length/width ratio about 3.2; cephalothorax about 3 times as wide as genital somite, 1.2 times as long as its greatest width, representing 36% of body length. Ornamentation of prosomites as in female. Hyaline fringes of prosomites and fifth pedigerous somite smooth dorsally and ventrally.
Genital somite (Fig. 77b) almost as long as wide, ornamented with smooth hyaline fringe dorsally and ventrally. Anal somite with smooth, broad anal operculum, representing 56% of somite’ width. Caudal rami 2.8 times as long as wide, parallel, with little space between them and without hairs on inner margin. Implantations of lateral and outermost apical seta without spinules.

Antennule (Fig. 77c) 16-segmented, digeniculate with geniculations between segments 8 and 9, and 13 and 14. Three aesthetascos on segment 1, and 1 aesthetasc each on segments 4, 9, and 16. Armature formula as follows: 8+3ae.4.2.2+ae.2.3.2.2.1+1sp+1ae.2.2.1.0.1.1.8+ae. Labrum, mandible, maxillule, maxilla, maxilliped and legs 1–5 as in female.

Sixth leg (Fig. 77b) distinct large plate, with flat flaps armed with 1 spine and 2 pinnate setae; outermost seta longest and 2.2 times as long as middle seta, and 3.3 times as inner spine.

**Distribution and ecology.** *Mesocyclops isabellae* is an Asian species having been reported from India, Sri Lanka and Nepal by Dussart & Fernando in 1988. There were no subsequent reports of this species from India. In India, it was reported from Bhiloda tank on Damaha near Jabalpur. It is now being reported from different localities of Andhra Pradesh. Overall, this species appears to be common and widespread in peninsular India. Dussart & Fernando (1988: 248) distinguished *M. isabellae* from Nepal as *M. isabellae* var. *nepalensis* by its shorter body length and relatively long dorsal caudal seta. In the material examined, it was accompanied by few unidentified cladocerans, calanoids, and some rotifers.

**Discussion.** The present specimens almost completely agree with the original female description of *Mesocyclops isabellae* Dussart & Fernando, 1988, which is rather brief but accurate and based only on conventional characters. It is puzzling that
though Dussart & Fernando (1988) designated the male as the allotype and deposited the same along with the female holotype in the Natural History Museum, Ottawa, Canada, no description of the male was provided by them nor is it described up until now. Hence the species is described in full along with the male based on the present material from different localities.

The only subtle difference between the original female description and the present females is the presence vs. absence of transverse bands/ridges on the copulatory duct. *M. isabellae* belongs to *thermocyclopoides*-group as redefined by Holyńska & Fiers (1994) and to *dussarti*-clade Holyńska, (2006). The other Indian species that belong to the *thermocyclopoides*-group and *dussarti*-clade are: *M. granulatus, M. parentium, M. dussarti, M. thermocyclopoides, and M. dadayi.*

**Table 14. Morphometric data of Mesocyclops isabellae Dussart & Fernando, 1988**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total length in mm</td>
<td>1.0</td>
<td>1.5</td>
<td>1.25</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.75</td>
<td>1.90</td>
<td>1.82</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.1</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>3.0</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td>5.</td>
<td>Inner medial apical seta: outer median apical seta</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>3.0</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outermost apical seta</td>
<td>1.30</td>
<td>1.40</td>
<td>1.35</td>
</tr>
<tr>
<td>8.</td>
<td>Dorsal seta: caudal ramus</td>
<td>1.20</td>
<td>1.40</td>
<td>1.32</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, length: width</td>
<td>3.1</td>
<td>3.3</td>
<td>3.2</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>0.80</td>
<td>0.90</td>
<td>0.85</td>
</tr>
<tr>
<td>11.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>0.80</td>
<td>0.90</td>
<td>0.85</td>
</tr>
</tbody>
</table>
Mesocyclops ornatus n. sp.
(Figs 79–85)

**Type locality.** Nelabhelum Caves at Banganapalli village (15°31'67"N, 78°23'33"E; elevation 209 m), Kurnool District, Andhra Pradesh, South India.

**Type material.** Holotype, female (MNHN-IU-2013-9826) and allotype male (MNHN-IU-2013-9828) whole-mounted on 1 slide each; 2 paratypes: 1 female (MNHN-IU-2013-9827) dissected on 6 slides and 1 male (MNHN-IU-2013-9829) dissected on 2 slides, 2 female paratypes (MNHN-IU-2013-9830, 9831); 8 females and 2 males in author’s personal collections; 31 October 2005, Coll. Y. Ranga Reddy & D. Ambedkar.

**Etymology.** The specific epithet *ornatus* is the Latin adjective, meaning “decorated” and alluding to the distinctive ornamentation of the body and certain appendages of the new species.

**Diagnosis.** Female fifth pedigerous somite ornamented with fine hair-like spinules laterally and ventro-laterally, and caudal rami with still tinier spinules along entire inner margins; similar spinules in 1 group near dorso-proximal margin and another group near dorso-distal margin. Lateral arms of seminal receptacle short and wide; either transverse ducts ending in a v-shaped curve and fusing near copulatory pore; copulatory duct slightly curved with tiny transverse bands along entire length. Posterior margin of anal somite without ornamentation dorsally, but with 1 row of ventral spinules at base of caudal rami. Serrulate hyaline membrane on last antennulary segment with 3 notches. Distal endite of maxillary coxa with 1 tiny spinule at base of its proximal seta. Basis of leg 1 without spine and ornamented with arched group of spinules. Third endopodal segment of leg 4, 2.8 to 3.0 times as long as wide; inner apical spine almost as long as outer apical spine and 0.8 times as long as the segment. Intercoxal sclerites of legs 1–3 unornamented, with rounded
protrusions; that of leg 4 with 2 small acute prominences. Leg 5 ornamented with fine
spinules on basal and distal segments.

**Description of adult female (Holotype).** Total body length excluding caudal
setae 1.32 mm. Habitus robust (Fig. 79a), with prosome/urosome ratio 1.6 and
greatest width near posterior end of cephalothorax. Body length/width ratio 2.5. Free
pedigerous somites without pronounced lateral expansions. Rostrum well developed,
membranous and broadly rounded. Cephalothorax about 0.9 times as long as wide,
representing 41% of total body length and 3.2 times as wide as genital double-somite.
Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite with fine
hair-like spinules laterally and ventro-laterally.

Genital double-somite (Fig. 79b) slightly longer than wide. Hyaline fringes of
genital double-somite and 2 subsequent somites smooth dorsally and serrulate
ventrally. Copulatory pore round, occurring on mid-ventral surface of genital double-
somite. Seminal receptacle large, representing 74% of somite’s length and divided
into proximal and distal parts. Proximal part with distinct anterior and posterior
margins as short and wide lateral arms; anterior margin of proximal part deeply
sinuate in middle, distal part sac-like. Transverse ducts ending in ‘v’ and fusing near
copulatory pore. Copulatory duct slightly curved with small bands along entire length.
Ovipores situated dorso-laterally covered by reduced sixth legs. Anal somite with
smooth, broad, slightly concave anal operculum, representing 50% of somite’s width;
ornamented with 3 pairs of sensilla dorsally near proximal border; and with relatively
large spinules ventrally at base of caudal rami. Anal sinus widely open, ornamented
with 2 rows of spinules medially and small hair-like spinules posteriorly.

Caudal rami (Fig. 80a, b) 3.1 times as long as wide, slightly divergent at
posterior end, with tinier hairy spinules along entire inner margins; similar spinules in
1 group near dorso-proximal margin and another group near dorso-distal margin. Dorsal seta 0.86 times as long as ramus, 1.2 times as long as outermost apical caudal seta, inserted at distal end of ramus and plumose distally. Lateral seta about 60% length of caudal ramus, 1.2 times more than ramus width. Outermost apical seta stout, spiniform, 0.7 times as long as ramus; innermost apical seta 2.1 times as long as outermost apical seta. Principal apical setae with breaking planes; inner median apical seta 1.4 times as long as outer median apical seta and 0.44 times as long as the body.

Antennule (Fig. 81a) reaching the middle of second pedigerous somite, 17-segmented, with one aesthetasc each on segments 12 and 17 and setal formula as follows 8.4.2.6.4.1+1sp.2.1.1.0.1.1+ae.0.1.2.2.7+ae. First segment ornamented with 1 row of spinules proximally, 1 seta on segment 6 spiniform, 1 seta on segment 17 articulating at base, most of the setae long and plumose; segments 1, 4–5, and 7–14 ornamented with pits. Hyaline lamella extending beyond the level of lateral seta on segment 17 with 3 notches (Fig. 81d). Penultimate segment 1.2 times as long as last segment.

Antenna (Fig. 81b, c) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis 2.7 times as long as wide, ornamented with few long spinules on proximal outer margin, 1 oblique row of 7–8 spinules, 1 longitudinal row of tiny spinules along medial margin, 16–17 robust spinules along outer lateral margin on caudal surface; 1 longitudinal row of 22–28 spinules along outer margin, 2 rows of small spinules along inner margin and 1 transverse row of distal spinules on frontal surface. Coxobasis armed with 1 bipinnate and 1 smooth seta at distal inner corner; seta representing exopod pinnate, reaching tip of appendage. First endopodal segment 2.3 times as long as wide, armed with 1 smooth seta in the middle, ornamented with 1 row of spinules along outer distal margin. Second endopodal segment 2.4 times as
long as wide, ornamented with 1 longitudinal row of spinules along distal outer margin, armed with 9 setae. Third endopodal segment 3.5 times as long as wide, ornamented with 1 longitudinal row of spinules and armed with 7 apical setae.

Labrum (Fig. 80c) ornamented with 2 groups of 9 long slender spinules and 2 groups of small spinules; cutting edge flat with 10 teeth between produced, rounded lateral corners; second tooth on each side stronger and longer than others.

Mandible (Figs 82a, b) with distinct palp, armed with 2 long finely plumed setae and 1 short smooth seta, ornamented with 3 groups of spinules and 1 short row of small spinules near palp. Gnathobase cutting edge with 13 strong teeth and 2 setae, outermost unipinnate, and inner smooth.

Maxillule (Figs 82c, d) composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines, smooth seta at their base on ventral surface. Praecoxa armed with 7 armature elements along inner margin, the longest one plumose. Palp apically bearing 2 slender setae (1 unipinnate, 1 smooth) and 1 robust, strong bipinnate spine; endopod distinct, bearing 2 apical setae (outer seta pinnate, inner one smooth), and 1 subapical smooth seta; exopodal seta smooth.

Maxilla (Fig. 83a) 4-segmented with praecoxa, coxa, basis and 1-segmented endopod. Praecoxa ornamented with 2 groups of spinules at sub distal outer region, 1 row of small spinules on inner side; proximal endite of praecoxa elongate, armed with 2 pinnate setae, distal endite small and unarmed. Coxa ornamented with 1 row of small spinules along inner margin on frontal surface. Proximal endite of coxa with 1 strong, bipinnate seta, distal endite with 1 long, bipinnate proximal seta, and 1 distal slender, plumose seta; bipinnate seta with a spiniform process at its base, with distally placed spinules on inner surface and close-set spinules on outer surface. Basis
expanded into robust claw, ornamented with longitudinal row of spinules along concave margin and armed with 2 setae, strong seta shorter than claw with 4–5 proximal fine teeth along inner surface; another small seta at its base. Endopod armed with 2 claw-like setae and 3 smooth setae.

Maxilliped (Fig. 83b) 4-segmented with syncoxa, basis and 2-segmented endopod. Syncoxa ornamented with 1 arched row of spinules near mid-outer margin; armed with 3 pinnate setae; middle seta strongest, 2.8 times as long as proximal one and 1.4 times as distal seta. Basis 2.5 times as long as wide, ornamented with 1 proximal and 1 distal longitudinal group of spinules along outer margin; 1 row of long spinules along inner margin; armed with 2 pinnate setae, proximal one 1.4 times as long as distal seta. First endopodal segment unornamented, armed with 1 strong unipinnate seta. Second endopodal segment small, unornamented, armed with 3 setae, innermost one bipinnate and relatively strong, 1.5 times as long as middle smooth seta and 4.3 times as long as outermost smooth seta.

Legs 1–4 (Fig. 84a–d) with 3-segmented exopod and endopod. Coxa of leg 1 ornamented with 5 groups of spinules, that of legs 2–3 with 4 groups of spinules and leg 4 with 6 groups of spinules, on caudal surface and 2 groups of small spinules on frontal surface, as illustrated. Coxae of legs 1–4 with 10–12 long spinules along lateral margin; armed with a plumose seta at inner distal corner. Intercoxal sclerites of legs 1–3 with unornamented rounded protrusions; that of leg 4 with 2 small acute prominences. Third exopodal segment spine formula 2.3.3.3 and setal formula 4.4.4.4. Basis of each leg armed with outer plumose seta. Leg 1 basis without spine, ornamented with 1 arched group of spinules; legs 2–3 without ornamentation; leg 4 ornamented as figured. All exopodal and endopodal setae plumose. Leg 4 first exopodal segment ornamented with 4 rows of spinules on caudal surface close to outer margin; third endopodal segment 2.8
times as long as wide, with well-produced latero-distal corners, ornamented with few
spinules at base of apical spines; inner apical spine almost as long as outer apical spine
and 0.8 times as long as segment. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic
numerals = setae):

<table>
<thead>
<tr>
<th>Leg</th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-0</td>
<td>0-1</td>
<td>1-I 1-I</td>
<td>3 1+I I</td>
</tr>
<tr>
<td>Leg 1</td>
<td>1-0</td>
<td>0-1</td>
<td>1-I 1-I</td>
<td>3 1+I I</td>
</tr>
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<td>1-0</td>
<td>0-1</td>
<td>1-I 1-I</td>
<td>3 1+I I</td>
</tr>
<tr>
<td>Leg 2</td>
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<td>0-1</td>
<td>1-I 1-I</td>
<td>3 1+I I</td>
</tr>
<tr>
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<td>1-0</td>
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<td>1-I 1-I</td>
<td>3 1+I I</td>
</tr>
<tr>
<td>Leg 3</td>
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<td>3 1+I I</td>
</tr>
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<td>1-0</td>
<td>0-1</td>
<td>1-I 1-I</td>
<td>3 1+I I</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1-0</td>
<td>0-1</td>
<td>1-I 1-I</td>
<td>3 1+I I</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 79b) 2-segmented, basal segment wider than long, ornamented
with fine hairs along inner margin and armed with lateral plumose seta. Distal
segment twice as long as wide, ornamented with 4–5 spinules along inner margin, and
armed with 1 apical seta and 1 medial seta; apical seta plumose distally, about 1.5
times as long as lateral seta and 1.2 times as long as medial seta.

Leg 6 (Fig. 79c) distinct, flat cuticular plates armed with 2 unequal smooth
spines and 1 plumose seta, reaching almost the end of genital somite.

**Description of male (allotype).** Total body length excluding caudal seta 1.2
mm. Habitus (Fig. 85a) slenderer than female; prosome/urosome ratio 1.9 and greatest
width at posterior end of cephalothorax. Body length/width ratio about 2.6;
cephalothorax 3.3 times as wide as genital somite. Free pedigerous somites without
lateral expansions. Rostrum well developed, membranous and broadly rounded.
Cephalothorax almost as long as its greatest width, representing 38% of total body
length. Hyaline fringes of prosomites, fifth pedigerous somite, and genital somite
smooth dorsally and ventrally; those of other urosomites smooth dorsally and
serrulate ventrally. Anal somite (Fig. 85a) with broad, slightly concave anal
operculum with spinules at base of caudal rami ventrally. Anal sinus widely open and unornamented.

Caudal rami (Fig. 85a) thrice as long as wide, parallel with little space between them and without hairs on inner margin. Dorsal seta 0.9 times as long as ramus and almost as long as outermost apical seta. Inner median apical seta 1.4 times as long as outer seta.

Antennule (Fig. 85b) 16-segmented digeniculate with geniculations between segments 8 and 9, and 14 and 15. Armature formula as follows: 8+3ae.4.2.2+ae.2.2.2.1+1spine.2.2.2.1.2.8+ae. First segment of the antennule with 3 aesthetasc, segments 4 and 16 with 1 aesthetasc each. Antenna of male structurally similar to that of female, but second endopodal segment has only 8 setae instead of 9 as in female. Armature of mandible, maxillule, maxilla, maxilliped and legs 1–5 identical to female.

Leg 6 (Fig. 85c) distinct, large plates, armed with 1 stout spine and 2 plumose setae; outermost seta longest and 1.7 times as long as middle seta and inner spine.

**Distribution and ecology.** The new species is known from its type locality only. In the material collected from Nelabhelum Cave where the water flow was more, and the bottom was covered with stones and pebbles, *Mesocyclops ornatus* n. sp. was accompanied by *Microcyclops rechtyae*, *Paradiaptomus greeni* and a few fishes.

**Discussion.** *Mesocyclops ornatus* n. sp. clearly fulfills all the generic criteria (see generic diagnosis). Within the genus *Mesocyclops*, this species has a unique combination of characters as mentioned under its diagnosis. The absence of spine on the basis of leg 1 and the presence of hair-like spinules on the fifth pedigerous somite and caudal ramus are two important characters that the new species shares with the
following six congener:

- *M. spinosus* Van de Velde, 1984
- *M. pilosus* Kiefer, 1930
- *M. aspericornis* (Daday, 1906)
- *M. dadayi* Holyńska, 1997
- *M. microlasis* Kiefer, 1981
- *M. geminus* Holyńska, 2000

It is to be noted that though the second differentiating character mentioned above is common to all the species in its gross state, it indeed shows subtle but significant differences between these congeres. A critical comparison of *M. ornatus* n. sp. with all these species reveals closest morphological as well as biogeographical affinity with its Indian endemic *M. dadayi* Holyńska, 1997, as borne out by a combination of the following characters:

1. The female genital double-somite is dorsally pilose;
2. The spinules are absent at the implantations of outermost apical and lateral caudal setae;
3. The female antennular segments 1, 4, 5, and 7–14 ornamented with pits;
4. The lateral arms of the seminal receptacle are short and wide and deeply sinuate in the middle;
5. The copulatory duct is ridged/banded;
6. The leg 4 third endopodal segment is alike in its length-width ratio;
7. The type localities of these two Indian endemics fall within the peninsular part of India and are not very far from each other.

However, *M. ornatus* n. sp. and *M. dadayi* are distinctly different from each other mainly in the following respects:

1. The dorsal pilosity of the female genital double-somite occupies the entire surface vs. the anterior half only;
2. The caudal rami with tinier hair-like spinules along the entire inner margin plus dorso-lateral parts vs. longer hair-like spinules along inner margins plus ventral surface;
3. The second endopodal segment of antenna has nine vs. seven setae;
4. The transverse ducts of seminal receptacle fusing near copulatory pore and ending in a v-shape vs. in a straight angle;
5. The antennulary hyaline lamella has three notches vs. a single notch;
6. Leg 4 first exopodal segment is ornamented with four rows of spinules on caudal surface vs. without ornamentation;
7. The inner apical spine of the third endopodal segment of leg 4
slightly shorter vs. longer than the outer apical spine; vii) leg 4 intercoxal sclerites 
without vs. with ornamentation; and viii) the antennary coxobasis without vs. with a 
field of spinules near inner distal setae.

The new species also has a somewhat close resemblance with the Australian 
*Mesocyclops pubiventris* Holyńśka & Brown, 2002, notwithstanding the fact that the 
caudal rami are without medial hairs in the latter species. The new species shares 
many characters with *M. pubiventris* like i) the dorsal pilosity of fifth pedigerous 
somite and of genital double- somite, ii) the length/width ratios of the genital double-
somite, caudal rami and third endopodal segment of leg 4, iii) the coxal ornamentation 
of leg 4 and the presence of spinules on the first exopodal segment of leg 4. But *M. 
ornatus* n. sp. differs from *M. pubventris* in the following points: i) the absence vs. 
presence of hairs on the ventral surface of all urosomites; ii) the absence vs. presence 
of spinules at the implantations of outermost apical seta; iii) the differing length/width 
ratios of dorsal seta and outermost apical seta; iv) the spinular ornamentation of 
antennular segments on 1, 4–5 and 7–14 vs. 1, 4–5, 7–13; v) the antennary 
coxobasis without vs. with a field of spinules near inner distal setae; vi) the presence 
of nine vs. seven setae on the second endopodal segment of antenna, vii) the shorter 
vs. longer inner median spine of third endopodal segment of leg 4, and viii) posterior 
margin of anal somite with incomplete vs. complete row of spinules.
Table 15. Morphometric data of *Mesocyclops ornatus* n. sp.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>1.30</td>
<td>1.40</td>
<td>1.35</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.5</td>
<td>1.7</td>
<td>1.6</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.0</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>2.8</td>
<td>3.4</td>
<td>3.1</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.4</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>2.30</td>
<td>2.60</td>
<td>2.45</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outermost apical seta</td>
<td>1.20</td>
<td>1.30</td>
<td>1.25</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 3, length: width</td>
<td>2.8</td>
<td>3.0</td>
<td>2.9</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>0.92</td>
<td>0.96</td>
<td>0.94</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>1.3</td>
<td>1.5</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Key to the identification of Indian species of genus *Mesocyclops*.

1. Leg 1 basis with medial spine ................................................................. 2
   Leg 1 basis without medial spine ................................................................. 3
2. Leg 4 third endopodal segment 3 times as long as wide; inner apical spine shorter than or almost equal to outer apical spine; transverse ducts close to anterior margin of seminal receptacle ........................................... *M. annae* Kiefer, 1930
   The same segment, less than 3 times as long as wide; inner apical spine larger than outer apical spine, transverse ducts close to posterior margin of seminal receptacle ................................................................. *M. splendidus* Lindberg, 1943
3. Fifth pedigerous somite without hairs ...................................................... 4
   Fifth pedigerous somite with hairs ............................................................. 5
4. Lateral arms of seminal receptacle sinuate in middle; leg 4 enp 3 inner apical spine shorter than outer one..................*M. ferjemurami* Holyńska & Nam, 2000
The same not sinuate in middle, leg 4 enp 3 inner apical spine longer than outer one
.................................................................*M. pehpeiensis*, Hu, 1943

5. Caudal rami with hairs.................................................................6
Caudal rami with out hairs...............................................................9

6. Genital double-somite bare.............................................................7
Genital double-somite pilose...............................................................8

7. Coxobasis of antenna with tiny group of spinules between proximal, oblique and longitudinal spine rows; transverse ducts directed towards each other at acute angle.................................................................*M. aspericornis*, Daday, 1906

8. Antenna coxobasis with field of spinules close to inner distal setae; transverse ducts of seminal receptacle fusing at straight angles..........*M. dadayi* Holyńska, 1997
Antenna coxobasis without field of spinules; second endopod segment with 9 setae; transverse ducts fusing into ‘V’ like point.......................*M. ornatus* n. sp.

9. Antennary coxa basis with field of spinules.................................................10
The same without field of spinules........................................................11

10. Transverse ducts of seminal receptacle meeting at straight angle; leg 4 third endopodal segment inner apical spine shorter than or almost equal to outer apical spine.................................................................*M. isabellae* Dussart & Fernando, 1988
The same fusing into ‘V’ like point; leg 4 third endopodal segment inner apical spine longer than outer apical spine.........................*M. parentium* Holyńska, 1997

11. Copulatory duct with granules, genital double-somite ornamented with transverse rows of tiny spinules.........................*M. granulatus* Dussart & Fernando, 1985
Genus *Cryptocyclops* G. O. Sars, 1927

**Generic diagnosis.** Dussart and Defaye’s (2001) definition of the genus is now slightly amended as follows: fifth pedigerous somite with lateral seta. Leg 5 consisting of a single elongated free segment, bearing an apical seta and with or without a tiny lateral spinule at about midlength of inner margin. Seminal receptacle characteristic, expanded on its anterior part. Innermost apical caudal seta as long as or longer than outermost apical seta. Legs 1–4 with 2-segmented rami. Leg 4 with short, broad intercoxal plate; coxa with short seta at inner distal angle; second endopodal segment ending in 2 unequal spines, outer one being very short.

This genus is represented by 21 species and subspecies in the world (Dussart and Defaye 2006) of which only two taxa, viz. *Cryptocyclops tricolor* (Lindberg, 1937) and *Cryptocyclops linjanticus linjanticus* (Kiefer, 1928), are known from India.

*Cryptocyclops tricolor* (Lindberg, 1937)  
(Figs 87–91)

**Synonymy**

* Cyclops (Microcyclops) tricolor* Lindberg, 1937: 101–102, Pl. 2, Figs 5–9, pl. 3, Fig.10.  
* Cyclops (Microcyclops) tricolor*, Lindberg, 1939c: 237–288, Fig. 2a–e.  
* Microcyclops (Cryptocyclops) tricolor*, Tai & Chen, 1979: 389, Fig. 231a–e.

**Locality.** River Krishna at Amravati (16°34′48″N, 80°21′36″E; elevation 8 m), Guntur District, Andhra Pradesh, South India.

**Material examined.** 4 voucher specimens: 1 female (MNHN-IU-2013-9832) and 1 male (MNHN-IU-2013-9834) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9833), dissected on 9 slides and 1 male (MNHN-IU-2013-9835) dissected on 2
slides; 8 females and 4 males in author’s personal collections; 22 April 2005: Coll. V. Subhashini.

Other material examined. Talikulum canal water, Talikulum (10°26'49"N, 76°05'29"E; elevation 13 m), Thrissur District, Kerala, South India, 26 December 2005: 8 females and 3 males, Coll. Y. Ranga Reddy and D. Ambedkar.


Nagari Tank 15Km. from Madurai, Nagari (09°55'11"N, 78°07'10"E; elevation 185 m), Madurai District, Tamil Nadu, South India, 31 December 2005: 9 females and 2 males, Coll. Y. Ranga Reddy and D. Ambedkar.

Pond water, Nallapadu (16°18'13"N, 80°22'28"E; elevation 37 m), Guntur District, Andhra Pradesh, South India, 23 July 2005: 14 females and 6 males, Coll. D. Ambedkar.

Pond water, Repalle, (16°01'00"N, 80°51'00"E; elevation 7 m), Guntur District, Andhra Pradesh, South India, 13 April 2006: 6 females and 2 males, Coll. V. Subhashini.

Agricultural Canal, Pithapuram, (17°07'00"N, 82°16'00"E; elevation 10 m), E. Godavari District, Andhra Pradesh, South India, 4 January 2007: 14 females and 6 males, Coll. V. Subhashini.

Redescription of female. Total body length excluding caudal setae 0.54 mm. Habitus short and robust (Fig. 87a) with prosome/urosome ratio 1.3 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.1. Free pedigerous somites without pronounced lateral expansions. Preserved specimens yellow in colour. Cephalothorax almost as long as wide, representing 23% of total body length.
and 3 times as wide as genital double somite. Fifth pedigerous somite with smooth fringe dorsally and ventrally.

Genital double-somite (Fig. 87b) almost as long as wide, expanded anteriorly with rounded lateral sides. Hyaline fringe of genital double-somite and 2 subsequent somites smooth dorsally and serrulate ventrally. Copulatory pore small, ovoid, situated anteriorly in the proximal 1/3rd of double-somites length. Seminal receptacle situated at anterior half of genital double-somite, with distinctly divided anterior and posterior expansions; anterior expansion slightly larger than posterior one. Ovipores situated dorso-laterally, covered with reduced sixth legs. Anal somite with smooth, broad, flat anal operculum, representing 43% of somites width, not extending beyond anterior half of somites length, ornamented with transverse row of spinules on posterior margin dorsally and ventrally.

Caudal rami (Fig. 87c, d) parallel, unornamented, 2.8 times as long as wide, with little space between them. Dorsal seta 1.2 times as long as outermost apical seta, 0.8 times as ramus, inserted at 80% ramus length, non-articulate at base and plumose distally. Lateral seta situated dorso-laterally at 70% of caudal ramus length, 1.2 times as long as ramus width and 0.43 times as long as ramus. Outermost apical seta stout, spiniform about 0.6 times as long as ramus, bipinnate. Implantations of lateral and outermost apical seta provided with spinules. Innermost apical seta twice as long as outermost apical seta and 1.2 times as dorsal seta. Principal apical setae bipinnate with breaking planes; inner median apical seta 1.5 times long as outer median apical seta and 0.4 times as long as body.

Antennule (Fig. 88a) 11-segmented, reaching up to two thirds of cephalothorax, ornamented with a row of minute spinules at the base of first segment;
with 1 slender aesthetasc on segment 11 and a spine like seta on fifth segment. Setal formula as follows: 8.3.7.3.2.2.3.2.2.2.7+ ae.

Antenna (Fig. 88b) 4-segmented comprising coxobasis and 3 segmented endopod. Coxobasis about twice as long as wide, ornamented with 1 oblique row of spinules proximally at outer corner, a group of minute spinules below inner setae on caudal surface; a row of minute spinules along inner margin distally on frontal surface; armed with 2 pinnate setae at inner distal corner, seta representing exopod pinnate, reaching almost the tip of the appendage. First endopodal segment armed with 1 smooth seta, ornamented with 1 longitudinal row of spinules along outer distal margin. Second endopodal segment 1.8 times as long as wide, also ornamented with 1 longitudinal row of spinules along outer margin, armed with 7 setae. Third endopodal segment thrice as long as wide, ornamented with 1 longitudinal row of spinules and armed with 7 apical setae.

Labrum (Fig. 88c) trapezoidal, coxal gnathobase cutting edge straight with 8 teeth, between produced lateral corners.

Mandible (Fig. 89a) with distinct palp armed with 2 long and 1 short smooth setae; ornamented with a row of minute spinules near outer distal margin. Coxal gnathobase cutting edge with 8 strong teeth, second tooth strongest and 1 outermost unipinnate seta.

Maxillule (Fig. 89b) composed of well-developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 4 strong apical spines, 1 spiniform seta at base on ventral surface. Praecoxa armed with 6 elements along inner margin. Palp apically bearing 2 slender and 1 robust smooth seta; endopod distinct, bearing 2 apical and 1 subapical seta; exopodal seta pinnate.
Maxilla (Fig. 89c) 5-segmented, composed of praecoxa, coxa, basis and 2-segmented endopod. Proximal endite of praecoxa elongated, armed with 2 pinnate setae; distal endite small, unarmed. Proximal endite of coxa with 1 pinnate seta; distal endite elongate and armed apically with 1 pinnate and 1 smooth setae. Basis expanded into a robust claw, ornamented with longitudinal row of spinules along proximal concave margin, and armed with 2 setae, strong seta smooth, almost as long as claw and short seta at base. Endopod 2-segmented, proximal segment armed with 2 strong pinnate seta; distal segment with 1 robust apical seta and 2 slender sub apical setae.

Maxilliped (Fig. 89d) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa unornamented, armed with 3 setae; middle seta strongest and longest, 1.7 times as long as proximal one and 2.2 times as long as distal seta. Basis twice as long as wide, ornamented with a longitudinal row of spinules along distal outer margin, 5–6 long spinules along inner margin and 3–4 spinules medially; armed with a pinnate and a smooth seta; pinnate seta 1.2 times as long as smooth seta. First endopodal segment unornamented, armed with 1 strong pinnate seta. Second endopodal segment small, unornamented, armed with 3 setae, innermost seta bipinnate and strongest, about 1.2 times as long as middle pinnate seta and 2.7 times as outermost smooth seta.

Legs1–4 (Fig. 90a–d) with 2-segmented rami. Coxa of legs 1–4 ornamented with a longitudinal row of small spinules along outer margin; that of 2–3 legs with 2 rows of spinules along inner distal margin; armed with a plumose seta along inner edge. Intercoxal sclerites of legs 1–4 unornamented with smooth rounded protrusions. Second exopodal segment spine formula 3.4.4.3 and setal formula 5.5.5.5. Inner protruded corner of basis of leg 1 with a distal unipinnate spine, reaching 1/3 length of second endopodal segment and ornamented with hairs along inner margin. Legs 3 and
leg 4 unornamented with spinules. Basis of all swimming legs armed with a plumose seta at outer margin. Legs 1–4 armature formula as follows (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg1</td>
<td>1−0</td>
<td>1−1</td>
<td>1−I 4,1+I, II</td>
<td>1−0 3,1+I, 1</td>
</tr>
<tr>
<td>Leg2</td>
<td>1−0</td>
<td>0−1</td>
<td>1−I 4,1+I, III</td>
<td>1−0 4,1+I, 1</td>
</tr>
<tr>
<td>Leg3</td>
<td>1−0</td>
<td>0−1</td>
<td>1−I 4,1+I, III</td>
<td>1−0 4,1+I, 1</td>
</tr>
<tr>
<td>Leg4</td>
<td>1−0</td>
<td>0−1</td>
<td>0−I 4,1+I, II</td>
<td>1−0 3,II, 1</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 87b) with basal segment fused to somite; outer basal seta inserted dorsally on somite and plumose distally. Distal segment about twice as long as wide and armed with 1 apical seta, which is twice as long as segment.

Leg 6 (Fig. 90e) distinct, semicircular cuticular plates, armed with 2 unequal short spines and 1 long outer seta.

**Redescription of male.** Total body length excluding caudal setae 0.44 mm. Habitus (Fig. 91a) relatively slender, prosome/urosome ratio 1.6 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.7. Cephalothorax 3.2 times as wide as genital somite, 1.2 times as long as its greatest width and representing 43% of total body length. Hyaline fringe of fifth pedigerous somite smooth dorsally and ventrally.

Genital somite (Fig. 91b) 0.8 times as long as wide. Hyaline fringe of genital somite and subsequent urosomites smooth dorsally and serrulate ventrally. Anal somite smooth, broad, flat anal operculum, ornamented with a continuous row of spinules on posterior margin. Anal sinus widely open and unornamented.

Caudal rami (Fig. 91a) 2.8 times as long as wide, with little space between them and without ornamentation. Spinules present at implantations of outermost apical seta. Inner median apical seta 1.2 times as long as urosome.
Antennule (Fig. 91c) 16-segmented, digeniculate with geniculations between segments 8 and 9, 14 and 15. First segment with 3 aesthetascs, segments 4 and 16 with one each; aesthetasc long and club shaped except that on sixteenth segment which is short and slender. Setal formula: 8+3ae.2.4.1+ae.1.0.0.1.0.0.0.0.1.7+ae.

Antenna (Fig. 91d) second endopodal segment with only 5 setae; otherwise as in female. Labrum, mandible, maxillule, maxilla, maxilliped and legs 1–5 similar to female.

Leg 6 (Fig. 91b) distinct, armature composed of 2 spines and 1 seta; outer spine shorter than inner one; seta 5 times as long as middle spine and 3.6 times as long as inner spine.

**Distribution and ecology.** *Cryptocyclops tricolor* is an Asian species having been reported from India by Lindberg (1937, 1939c), Kiefer (1938) and from China by Tai & Chen (1979). In India, Lindberg (1937, 1939c) recorded this species in different habitats like a pond in Cansaulim in Goa, Elephanta Caves near Bombay, a reservoir near Ellora, Khauldabad near Hyderabad, River Gharipouri near Barsi, River Bhima at Pandharpur, Arkonam near Madras (Chennai), Pondicherry, a lake in Ootacamund of Nilgiris. Later it was reported by Ranga Reddy (1978) from the River Krishna at Vijayawada, Vengalayapalem pond and rain-fed ponds at Nallapadu near Guntur, ponds on Nagarjuna University campus and at Visakhapatnam. Overall, this species appears to be common and widespread in peninsular India. In the material examined this species was accompanied with abundant calanoids, few ostracods and rotifers.

**Remarks.** The present specimens almost completely agree with the original description of *Cryptocyclops tricolor* (Lindberg, 1937), subsequently dealt by Lindberg (1939c). However, the existing account of the species is still rather brief but
accurate and based only on conventional characters. Though Chen & Tai (1979) recorded this species in China, they did not add any further details to Linberg’s (1937, 1939c) treatment of this species. Hence the species has been described and illustrated here in full along with all its appendages and their micro-characters. Morphologically, this species is very close to *Cryptocyclops linjanticus linjanticus* (Kiefer 1928), but differs from it: i) shape of seminal receptacle, ii) leg 4 inner apical spine more than three times vs. less than three times as long as outer apical spine, iii) leg 4 second endopodal segments less than 3 times vs. more than 3 times, and iv) the absence vs. presence of median spinule on leg 5 segment.

**Table. 16. Morphometric data of *Cryptocyclops tricolor* (Lindberg, 1937)**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total length in mm</td>
<td>0.52</td>
<td>0.60</td>
<td>0.56</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double- somite length: width</td>
<td>1.0</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>2.8</td>
<td>3.0</td>
<td>2.9</td>
</tr>
<tr>
<td>5.</td>
<td>Inner medial apical seta: outer median apical seta</td>
<td>1.4</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost seta</td>
<td>2.0</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outermost apical seta</td>
<td>1.20</td>
<td>1.36</td>
<td>1.28</td>
</tr>
<tr>
<td>8.</td>
<td>Leg 4 enp 2, length: width</td>
<td>3.0</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 2, inner apical spine: outer apical spine</td>
<td>3.24</td>
<td>3.36</td>
<td>3.30</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 2, inner apical spine: length of segment</td>
<td>0.66</td>
<td>0.70</td>
<td>0.68</td>
</tr>
</tbody>
</table>
Key to the identification of Indian species of genus *Cryptocyclops* G. O. Sars, 1927

1. P5 distal segment without median spine .................................................. 2
   P5 distal segment with median spine ...................................................... 3

4. Seminal receptacle bicolor type; leg 4 enp 2, 2.4–2.6 times as long as wide; inner
   apical spine more than 3 times as outer apical spine. .................. ..............
   .............................................................................. *Cryptocyclops tricolor* Lindberg, 1937

3. Seminal receptacle lobed; leg 4 enp 2, 3.0–3.2 times as long as wide; inner apical
   spine less than 3 times as outer apical spine............................................
   .............................................................................. *Cryptocyclops linjanticus* Kiefer, 1928
Genus Metacyclops Kiefer, 1927

Generic diagnosis. Dussart & Defaye (2001) provided the following generic diagnosis: seminal receptacle more developed in the posterior part than in the anterior part. Antennule 9–13 segmented in female, 17-segmented in male. Legs 1–4 biramous, each ramus 2-segmented. Leg 5, 1-segmented, basal segment fused to fifth pedigerous somite and consisting of a seta, directly inserted on the segment laterally; free segment of leg 5 short, bearing an outer distal seta and an apical or subapical thin spine, most often reduced and sometimes difficult to observe.

Up till now, this genus is represented by 62 nominal species and subspecies according to World Directory of Dussart & Defaye (2006). Of these, Metacyclops communis (Lindberg 1938) and Metacyclops margaretae (Lindberg 1938) are known from India besides a doubtful record of Metacyclops gracilis (Lilljeborg, 1853). During this study, M. margaretae alone has been met and studied in detail.

Metacyclops margaretae (Lindberg, 1938)
(Figs 93–97)

Synonymy

Cyclops (Metacyclops) margaretae Lindberg, 1938: 290, Fig. 1, 294, Fig. 2.

Cyclops (Metacyclops) gracilis var. margaretae, Lindberg1940a: 567–588.


Locality. Small pond at Akaveedu village near Giddalur town (15°21'00"N, 78°55'00"E; elevation; 231 m), Prakasam District, Andhra Pradesh, South India.

Material examined. 4 voucher specimens: 1 female (MNHN-IU-2013-9836) and 1 male (MNHN-IU-2013-9838) whole-mounted on 1 slide each; 1 female (MNHN-IU-
2013-9837), dissected on 10 slides and 1 male (MNHN-IU-2013-9839) dissected on 2 slides; 10 females and 3 males in author’s personal collections; 23 January 2004; Coll. Y. Ranga Reddy.

**Other material examined.** Rain-fed pond at Bandarlapalle near Kolimigundla (15°05'00''N 78°07'00''E; elevation 243 m), Kurnool District, Andhra Pradesh, South India, 02 October 2005: 8 females and 2 males, Coll. Y. Ranga Reddy and D. Ambedkar.

Pond at Alurukona (15°18'31"N, 78°30'50" E; elevation 223 m), Kurnool district, Andhra Pradesh, 30 October 2005, 4 females and 2 males, D. Ambedkar.

Pond at Vegendla, (16°41'23"N, 80°31'29"E; elevation 22 m), Guntur District, Andhra Pradesh, 05 November 2005; 4 females and 2 males, Coll. D. Ambedkar.

**Redescription of female.** Habitus robust (Fig. 93a), total body length, excluding caudal setae 0.82 mm, prosome/urosome ratio 1.4 and greatest width near posterior end of cephalothorax. Body length/width ratio 3. Free pedigerous somites without pronounced lateral expansions. Cephalothorax almost as long as wide, representing 28% of total body length and 3 times as wide as genital double-somite. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite with smooth fringe dorsally and ventrally.

Genital double-somite (Fig. 93b) 1.3 times as long as wide. Hyaline fringe of genital double-somite and subsequent somites smooth dorsally and serrulate ventrally. Copulatory pore oval, copulatory duct rigidly sclerotized. Seminal receptacle large, representing 70% of somite’s length, divided into proximal and distal parts; proximal part elongated into lateral arms and distal part sac-like. Ovipores situated dorso laterally, covered by reduced sixth legs. Anal somite with smooth, broad, concave anal operculum representing 48% of somites width, ornamented with 2 pairs of
cuticular pores and sensilla dorsally, and 1 row of spinules ventrally along posterior margin at base of caudal rami. Anal sinus widely open, and unornamented.

Caudal rami (Fig. 93c, d) parallel 3 times as long as wide, with little space between them. Lateral seta almost in the mid length of caudal ramus and slightly longer than ramus width. Dorsal seta 0.7 times as long as ramus, 1.2 times as long as outermost apical seta; inserted at 80% of ramus length and plumose distally. Outermost apical seta spiniform, 0.6 times as long as ramus. Innermost apical seta as long as or slightly longer than outermost apical seta. Principal apical setae without breaking planes, homogeneously ornamented, slightly bulged proximally; inner median apical seta 1.2 times as outer median apical seta.

Antennule (Fig. 94a) 11-segmented, reaching almost the anterior end of second pedigerous somite, 1 aesthetasc each on segments 8 and 11; setal formula as follows: 6.1.6.1.1+1spine.2.3.2+ae.2.2.7+ae. First segment ornamented with a row of spinules proximally, 1 seta on segment 5 spiniform, 1 seta on segment 11 articulating at base; second segment partly telescoping into first segment.

Antenna (Fig. 94b) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis 2.4 times as long as wide; ornamented on caudal surface with 2 short rows of small spinules medially, few spinules along outer proximal margin; armed with 2 smooth setae at distal inner corner; seta representing exopod pinnate, reaching the tip of the appendage. First endopodal segment 1.5 times as long as wide, armed with 1 smooth seta at middle, ornamented with 1 row of spinules along distal outer margin. Second endopodal segment 1.7 times as long as wide, also ornamented with 1 longitudinal row of spinules along outer margin and armed with 5 setae. Third endopodal segment 2.8 times as long as wide, ornamented with 1 longitudinal row of spinules and armed with 7 apical setae.
Labrum (Fig. 94c) almost trapezoidal, cutting edge straight, with 10 relatively strong teeth, between produced lateral rounded corners.

Mandible (Fig. 94d, e) with distinct palp, armed with 2 long plumed setae and 1 short smooth seta on distal end. Coxal gnathobase cutting edge with 7 strong teeth with an outermost bipinnate seta.

Maxillule (Fig. 95a, b) composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 4 strong apical spines, with a smooth seta at their base on ventral surface. Praecoxa armed with 6 armature elements along inner margin, the longest one plumose. Palp bearing 2 apical smooth setae and 1 robust bipinnate seta; endopod distinct, bearing 2 apical pinnate and 1 subapical smooth setae, exopodal seta smooth.

Maxilla (Fig. 95c) 5-segmented, with praecoxa, coxa, basis and 2-segmented endopod. Praecoxa unornamented, proximal endite of coxa elongate armed with 2 distally pinnate setae, distal endite small and unarmed. Proximal endite of coxa with 1 strong bipinnate seta, distal endite armed apically with 2 unequal bipinnate setae. Basis expanded into robust claw, ornamented with 1 longitudinal row of spinules along concave margin, armed with 2 setae; strong pinnate seta slightly shorter than claw, small seta at its base. Endopod 2-segmented, proximal segment armed with 1 robust and 1 slender setae; distal segment armed with 1 robust seta and 2 short subapical setae.

Maxilliped (Fig. 95d) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa without ornamentation, armed with 2 pinnate and 1 smooth seta; middle seta strongest and longest 1.7 times as long as proximal one and 1.8 times as long as distal seta. Basis longer than wide, ornamented with 1 longitudinal row of long spinules at outer and inner margins, 1 transverse row of
spinules at distal end; armed with 1 short bipinnate seta. First endopodal segment with few small spinules and armed with 1 strong seta. Second endopodal segment armed with 2 smooth and 1 bipinnate seta.

Legs 1–4 (Fig. 96 a–d) with 2-segmented exopod and endopod. Coxa of legs 1–4 except second leg ornamented with a transverse row of spinules near distal margin; armed with a long, plumose seta on distal inner corner. Intercoxal sclerites of legs 1–4 unornamented with rounded protrusions on both sides. Second exopodal segment spine formula 3.3.3.3 and setal formula 5.5.5.5. Spine inserted at inner corner of basis of leg 1 reaching 2/3 length of second endopodal segment, outer seta on basis of legs 1–2 longer than that of legs 3–4. Inner distal corner of basis of leg 4 ornamented with tiny spinules. All exopodal and endopodal setae slender and plumose; exopodal spines on leg 1 longer than those of other legs. Second endopodal segment of leg 4 (Fig. 96d) 2.1 times as long as wide; inner apical spine 3.2 times as long as outer one, and 1.8 times as long as segment. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th>Leg</th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Leg1</td>
<td>1-0</td>
<td>1-1</td>
<td>1-1</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg2</td>
<td>1-0</td>
<td>0-1</td>
<td>1-1</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg3</td>
<td>1-0</td>
<td>0-1</td>
<td>1-1</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg4</td>
<td>1-0</td>
<td>0-1</td>
<td>0-1</td>
<td>4, 1+I, II</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 93b) basal segment completely fused to somite; outer basal seta smooth and inserted dorsally. Distal segment 2.3 times as long as wide, armed with apical outer seta and a short sub apical inner spine. Apical seta 3 times as long as segment, 7 times as long as spine.
Leg 6 (not figured) in distinct, very small cuticular plate, armed with 2 almost unequal spines.

**Redescription of male.** Total body length excluding caudal setae 0.62 mm. Habitus (Fig. 97a) slenderer than female with prosome/urosome ratio 1.5 and greatest width at posterior end of cephalothorax. Body length/width ratio about 3.4. Cephalothorax 1.2 times as long as its greatest width, 3 times as wide as genital somite, representing 35% of total body length. Free pedigerous somites without lateral expansions.

Genital somite (Fig. 97b) 0.76 times as long as wide. Hyaline fringes of genital somite and subsequent urosomites smooth dorsally and serrulate ventrally. Anal somite with smooth, weakly concave anal operculum, ornamented with spinules along posterior margin ventrally. Anal sinus widely open and unornamented.

Caudal rami 3.1 times as long as wide, parallel, with little space between them. Armature and ornamentation as in female.

Antennule (Fig. 97c) 17-segmented, digeniculate with geniculations between 8 and 9, and 14 and 15 segments. First segment with 3 aesthetasc and 1 aesthetasc each on segments 4, 9, 13, and 17. Setal formula as follows: 7.4.1.2+ae.1.2.1.2.2+ae.2.2.2.2+ae.2.1.3.6+ae. Antenna, maxillule, maxilla, maxilliped and legs 1–5 as in female.

Leg 6 (Fig. 97b) large cuticular plates, armed with 2 pinnate setae, the inner one 1.2 times as long as outer seta.

**Distribution and ecology.** *Metacylops margarete* is an Asian species. In India, it has been reported from a rain-fed pond at Bassein near Bombay (now Mumbai), along with *Microcyclops indolusitanus* and *Mesocylops leuckarti* by Lindberg in 1938. In the material examined the species is available in surface water.
bodies of ponds, and was accompanied with abundant calanoids, few *Microcyclops varicans*, 2 harpacticoids, few Chaoborus larvae, a crab, 2 water mites, and 4 shrimp larvae.

**Discussion.** Lindberg (1961) established two main groups within the genus: (1) *minutus-planus* group with 1 spine on the second endopodal segment of leg 4, and (2) *gracilis-mendocinus* group with 2 such spines. Of the two Indian species described by Lindberg (1938), *M. margaretae* belongs to *gracilis-mendocinus* group. The taxonomic works of (Herbst, 1988; Reid, 1987, 1991; Fiers, 2001, Karanovic, 2004a, b) recognized four groups based on spine formula of exopod 2 of legs 1–4. The A group with 3.4.4.3 spine formula includes 52 of the 62 species of the genus. The B group with 3.4.4.2 contains but one species *M. mortoni* Pesce, Laurentiis & Humphreys, 1996a and C group with 3.4.3.3 also contains one species *M. cushae* Reid, 1991. The D group among the species of *Metacyclops* is the *trispinosus*-group with 3.3.3.3 spine formula (Karanovic, 2004a, 2004b). Until recently it contained 8 species but Karanovic et.al. (2011) reallocated 6 of them in the new genus *Pescecyclops* Karanovic, 2011. Thus only 2 species *Metacyclops trispinosus* (Dumont, 1981) and *M. margaretae* (Lindberg, 1938) are in the *trispinosus*-group.

*M. margaretae* has been considered a synonym of *M. gracilis* (Lilljeborg, 1853) by Dussart (1969), Dussart & Defaye (1985), and Monchenko (1974). However, Karanovic (2004) considered it a separate species, and also opined that a detailed taxonomic examination of *M. trispinosus* (Dumont, 1981) might reveal its synonymy with *M. margaretae*. In the cladistic analysis and taxonomic revision of the Australian *Metacyclops* and *Goniocyclops* Kiefer, 1955, Karanovic et al. (2011) pointed out that the Indian *M. margaretae* and the African *M. trispinosus* are morphologically quite similar because: the leg 4 second endopodal segment consists
of one large and one minute spine; leg 5 exopod has a minute inner spine; the outermost apical caudal seta only slightly shorter than innermost apical caudal seta. All this confusion is due to incomplete descriptions of the two species in question.

In the key given for *Metacyclops* by Karanovic (2004), *Metacyclops trispinosus* and *M. margaretae* were separated from each other by the absence of spinules on the rounded inner distal corner of basis of leg 4. Now that *M. margaretae* has been studied in detail based on the present material, it is now clear that the above-mentioned spinules are also present in this species. However, the earlier viewpoint of Karanovic (2004) that *M. trispinosus* could be a synonym of *M. margaretae* is correct. So, *M. trispinosus* should henceforth be treated as a junior synonym of *M. margaretae*. It is also concluded here that *M. gracilis* (Lilljeborg, 1853) is distinct from *M. margarete* by virtue of some decisive differences as outlined in Table 18.
Table 17. Morphometric data of *Metacyclops margaretae* (Lindberg, 1938)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>0.72</td>
<td>0.84</td>
<td>0.78</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.2</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>2.9</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>5.</td>
<td>Inner medial apical seta: outer median apical seta</td>
<td>1.20</td>
<td>1.30</td>
<td>1.25</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.0</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outermost apical seta</td>
<td>1.20</td>
<td>1.30</td>
<td>1.25</td>
</tr>
<tr>
<td>8.</td>
<td>Dorsal seta: caudal ramus</td>
<td>0.6</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, length: width</td>
<td>2.1</td>
<td>2.3</td>
<td>2.2</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>3.12</td>
<td>3.52</td>
<td>3.32</td>
</tr>
<tr>
<td>11.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>1.80</td>
<td>1.90</td>
<td>1.85</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th><em>M. margaretae</em></th>
<th><em>M. gracilis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Caudal ramus length: width</td>
<td>2.8–3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>2.</td>
<td>Caudal ramus position</td>
<td>Slightly divergent</td>
<td>Slightly divergent</td>
</tr>
<tr>
<td>3.</td>
<td>Shape of anal operculum</td>
<td>Not figured</td>
<td>Weakly convex</td>
</tr>
<tr>
<td>4.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>5.</td>
<td>Terminal median inner seta: Terminal median outer seta</td>
<td>1.15</td>
<td>1.20</td>
</tr>
<tr>
<td>6.</td>
<td>Shape of terminal median setae</td>
<td>Both setae bulbous at origin</td>
<td>Outer median seta bulbous at origin</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: caudal ramus</td>
<td>0.5</td>
<td>1.6</td>
</tr>
<tr>
<td>8.</td>
<td>Shape of seminal receptacle</td>
<td>Similar to <em>M. gracilis</em> but post. part slightly wider.</td>
<td>Post. Part sac like.</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Value</td>
<td>Value</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>9.</td>
<td>Genital double-somite length: width</td>
<td>1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>10.</td>
<td>No. of segments in antennule</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>11.</td>
<td>Position of lateral seta on caudal ramus</td>
<td>Middle</td>
<td>Slightly anterior to middle</td>
</tr>
<tr>
<td>12.</td>
<td>Leg 1 exopodal spines</td>
<td>Long</td>
<td>Long</td>
</tr>
<tr>
<td>13.</td>
<td>Leg 4 ep2, length: width</td>
<td>2.3–2.4</td>
<td>3.0</td>
</tr>
<tr>
<td>14.</td>
<td>Leg 4 ep2, inner apical spine : outer apical spine</td>
<td>4.75 (in description range is from 3.12 – 4.54)</td>
<td>5.3</td>
</tr>
<tr>
<td>15.</td>
<td>Leg 4 ep2, inner apical spine : segment</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>16.</td>
<td>Leg 4 coxa ornamentation</td>
<td>absent</td>
<td>absent</td>
</tr>
<tr>
<td>17.</td>
<td>Leg 4 basis ornamentation</td>
<td>absent</td>
<td>absent</td>
</tr>
<tr>
<td>18.</td>
<td>Exopodal spine formula</td>
<td>3.3.3.3</td>
<td>3.3.3.3</td>
</tr>
<tr>
<td>19.</td>
<td>Dorsal seta : outermost apical seta</td>
<td>1.2–1.5</td>
<td>2.4</td>
</tr>
<tr>
<td>20.</td>
<td>Leg 5 distal segment length: width</td>
<td>2.3</td>
<td>2.0</td>
</tr>
<tr>
<td>21.</td>
<td>Leg 5 apical seta: segment</td>
<td>3.2</td>
<td>4.0</td>
</tr>
<tr>
<td>22.</td>
<td>Male leg 6</td>
<td>2 unequal setae</td>
<td>2 almost equal setae</td>
</tr>
</tbody>
</table>
**Metacyclops paracushae n. sp.**
(Figs 98–101)

**Type locality.** Bore-well on Acharya Nagarjuna University campus, Nagarjuna Nagar (16°30'38"N, 80°43'05"E; elevation 30 m) in Guntur District, Andhra Pradesh, South India.

**Material examined.** Holotype female (MNHN-IU-2013-9840) dissected on 5 slides, 11 July 2005, Coll. V. Subhashini.

**Etymology.** The specific epithet is derived from the North American species, *cushae*, to which the Greek para, meaning “by the side of, near” is prefixed to refer to the close morphological affinity of the new species.

**Diagnosis.** Genital double-somite ornamented with several incomplete transverse rows of narrow pits dorsally and ventrally; somite length slightly less than width. Seminal receptacle relatively large divided into anterior and posterior expansions; transverse ducts almost horizontal. Anal somite with spinules along posterior margin dorsally and ventrally. Anal operculum smooth, bowl-shaped, reaching slightly beyond posterior margin of anal somite. Caudal ramus 2.6 times as long as wide; lateral seta inserted at 70% of ramus length. Innermost apical seta almost half as outermost apical seta. Antennule 11-segmented, slightly shorter than cephalothorax. Antennary exopod short and finely plumed; second endopodal segment with 5 setae. Claw of maxilla with 3 small and 2 strong spinules on its concave margin. Maxilliped with only 2 setae on syncoxa. Second exopodal segment spine formula 3.4.3.3 and setal formula 5.5.5.5. Intercoxal sclerites of legs 1–4 without ornamentation. Basis of leg 1 with lobed medial expansion; apical spine of second endopodal segment long, stout and claw-like. First endopodal segment of leg 4 with cuticular in folding along inner margin, second endopodal segment about 1.4
times as long as wide, length of single terminal spine slightly shorter than segment. Leg 5 basal segment completely fused and its seta long; free segment almost as long as wide with an apical outer seta and inner spine.

**Description of adult female (Holotype).** Total body length, excluding caudal setae 0.63 mm. Habitus (Fig. 98a) robust with prosome/urosome ratio 2 and greatest width near posterior end of cephalothorax. Body length/width ratio 3.1. Free pedigerous somites without pronounced lateral expansions. Cephalothorax 1.1 times as long as its greatest width, 2.4 times as wide as genital-double somite and representing 32% of total body length. Hyaline fringes of prosomites and fifth pedigerous somite narrow and smooth dorsally and ventrally.

Genital double-somite (Fig. 98b, c) 0.9 times as long as wide, ornamented with pits arranged in fixed pattern on the dorsal and ventral surfaces. Hyaline fringe of genital double-somite smooth dorsally and serrulate ventrally. Seminal receptacle relatively large, divided into anterior and posterior expansions and representing 63% of double-somite’s width. Copulatory pore oval; copulatory ducts sclerotized. Hyaline fringes of subsequent urosomites smooth dorsally and finely serrulate ventrally. Anal somite with smooth, bowl-shaped anal operculum, reaching slightly beyond posterior margin of somite and representing 43% of somite’s width; ornamented with a row of spinules dorsally and ventrally at base of caudal rami. Anal sinus widely open, without ornamentation.

Caudal rami (Fig. 98d, e) parallel, 2.6 times as long as wide. Dorsal seta 0.9 times as long as ramus, 1.1 times as outermost apical seta, inserted at 90% of ramus length, uniarticulate at base and plumose distally. Lateral seta situated dorsally at 70% of ramus length, unipinnate, ornamented with tiny spinules at base and 0.8 times of ramus width. Outermost apical seta stout, bipinnate, ornamented with spinules at base
dorsally and ventrally, and 0.85 times as long as ramus. Innermost apical seta, plumose, 0.52 times as long as outermost apical seta. Principal apical setae plumose, with breaking planes; inner median apical seta 1.3 times as long as outer median apical seta and 0.35 times as long as the body.

Antennule (Fig. 99a) slightly shorter than cephalothorax, 11-segmented, with 1 aesthetasc each on segments 8 and 11 and setal formula as follows: 7.3.5.2.1+1 spine.2.3.3+ae.2.3.7+ae. One seta on segment 3 and 2 setae on segment 11 with articulating bases; 1 seta on segment 5 spiniform.

Antenna (Fig. 99b) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis 1.8 times as long as wide, ornamented with 1 row of spinules proximally, 2 short rows medially on caudal surface close to outer edge; armed with 2 smooth setae at distal inner corner; seta representing exopod finely pinnate. First endopodal segment armed with 1 smooth seta, ornamented with 1 longitudinal row of spinules along outer margin. Second endopodal segment 2 times as long as wide, also ornamented with 1 longitudinal row of spinules along distal outer margin, armed with 5 setae. Third endopodal segment 2.4 times as long as wide, ornamented with 1 longitudinal row of spinules and armed with 7 apical setae.

Labrum (Fig. 100a) trapezoidal, without ornamentation, cutting edge almost straight, with 12 teeth between produced rounded lateral corners.

Mandible (Fig. 100b, c) palp distinct, armed with 2 long pinnate setae and 1 short, smooth seta. Coxal gnathobase with 5 strong teeth (first, second and third teeth complex) and 2 setae, outermost one bipinnate and inner one smooth.

Maxillule (Fig. 100d, e) composed of well-developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines, 1 seta at their base on ventral surface, ornamented with 2 spinules. Praecoxa armed with 7 armature
elements along inner margin, longest one plumose. Palp apically bearing 2 slender setae and 1 robust bipinnate spine; endopod distinct, with 2 apical and 1 subapical smooth setae; exopodal seta smooth.

Maxilla (Fig. 99c) 5-segmented, composing of praecoxa, coxa, basis and 2-segmented endopod. Praecoxa unornamented, proximal endite elongate, armed with 2 smooth slender setae; distal endite small and unarmed. Coxa unornamented, proximal endite with 1 smooth, short seta; distal endite bearing 1 proximal seta (with 1 spinule at base) and 1 distal bipinnate seta, slightly shorter than proximal seta. Basis expanded into robust claw, ornamented with 3–4 short spinules and 2 strong spinules proximally along concave margin, armed with 2 setae, strong seta slightly longer than claw and unipinnate distally; 1 short seta at its base. Endopod 2-segmented, proximal segment with 2 robust smooth setae; distal segment with 1 strong seta and 2 smooth setae.

Maxilliped (Fig. 99d) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa without ornamentation, armed with 2 smooth setae; distal seta 1.6 times as long as proximal seta. Basis twice as long as wide, ornamented with a transverse row of long spinules along inner margin and armed with 2 setae, proximal seta bipinnate, 2 times as long as distal smooth seta. First endopodal segment armed with 1 strong smooth seta; second endopodal segment armed with 3 smooth setae, innermost seta 1.1 times as middle seta and 1.24 times as outermost seta.

Legs 1–4 (Fig. 101a–d) with 2-segmented exopod and endopod. Coxa of all legs ornamented with 3 rows of spinules as figured, armed with 1 plumose seta, somewhat bulbous at base. Intercoxal sclerites of legs 1–4 without ornamentation. Second exopodal segment spine formula 3.4.3.3 and setal formula 5.5.5.5. Basis of
leg 1 less produced at inner distal corner than in other legs; that of leg 4 with relatively elongated medial expansion. Basis of legs 1–3, except leg 4 ornamented with hair like spinules at inner distal corner, armed with a plumose seta at outer corner. Spine inserted at inner corner of basis of leg 1 pinnate, reaching anterior 1/3 of second endopodal segment. Terminal spine on second endopodal segment of leg 1 long, stout and claw- like. Leg 4 first endopodal segment with cuticular in folding on inner margin; second endopodal segment 1.4 times as long as wide, with only 1 apical spine, slightly shorter than segment. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
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<tr>
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<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>1 – 0</td>
<td>1 – 1</td>
<td>1 - I</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>1 - I</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>1 - I</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>0 - I</td>
<td>4, 1+I, II</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 98b, c) with basal segment completely fused to somite; outer basal seta smooth and inserted dorsally. Distal free segment almost as long as wide, armed with bipinnate apical outer seta and smooth inner spine. Apical seta 7 times as long as segment and 5 times as long as spine and almost as long as distal seta.

Leg 6 (Fig. 101e) small cuticular plates, armed with 2 almost equal smooth spines, and 1 much elongate seta.

**Male.** Unknown

**Distribution and ecology.** The new species is known from its type locality only. In the material examined it was accompanied by some harpacticoid copepods, few *Rybocyclops nagarjuna* n. sp. specimens, 1 isopod and 4 water mites.
Discussion. *M. paracushae n. sp.* also belongs to the C group 3.4.3.3 (see above). Intriguingly, *M. paracushae n. sp.* has closest morphological similarity with the North American *M. cushae* Reid, 1991, which was originally collected from “temporarily water-filled depressions in greater New Orleans, Louisiana”, U.S.A., subsequently from Honduras, Brazil; natural and artificial fresh waters, wells, not only in having identical spine formula, but also in several other important features: i) genital double-somite pitted and slightly shorter than wide; ii) position of lateral seta on caudal ramus; iii) 11-segmented antennule; iv) short exopodal seta on coxobasis of antenna; v) syncoxa of maxilliped carrying only two setae; vi) leg 1 second endopodal segment with a long, sturdy claw-like terminal spine; vii) second endopodal segment of leg 4 armed with a single terminal spine, and its length relative to the segment; and viii) absence of ornamentation on the intercoxal sclerites of legs1–4.

*M. paracushae n. sp.*, however, differs from *M. cushae* in the following characters: i) seminal receptacle with slightly concave vs. convex anterior margin; ii) anal operculum bowl-shaped and barely reaching the posterior border of anal somite vs. semicircular and reaching beyond the posterior border of anal somite; iii) dorsal seta long vs. short; iv) presence vs. absence of aesthetasc on segment 8 of antennule; v) absence vs. presence of transverse grooves and sensory hair on segments 6, 7 and 9 of antennule; vi) labrum with 12 vs. 9 teeth; vii) claw of maxilla with vs. without 2 strong teeth in addition to other teeth; viii) medial expansion of leg 4 basis elongated vs. deeply sculptured; ix) coxal seta of legs 1–4 bulbous vs. normal at base; x) leg 5 distal segment as long as wide vs. wider than long. I am of the view that these differences warrant the establishment of the new species. Incidentally, the new species is only the second species of the genus with the spine formula 3.4.3.3.
**Metacyclops karanovici n. sp.**
(Figs 102–105)

**Type Locality.** Elephant Waterfalls at Shillong (25°53'78"N, 91°82'22"E; elevation 802 m) in the East Khasi Hills District, Meghalaya, North East India.

Elephant Falls is 12 km from Shillong city. It was originally called ‘Three Steps Waterfalls’ by the local people as it consists of three successive sections. It was renamed by the British as Elephant Falls as there used to be an elephant-shaped rock near the left side of the bottom falls, which was said to be destroyed in 1897 in an earth quake. The present sample was collected from a small, shallow pool formed of the stream course on the left-side of waterfalls. Water at the time of sampling was crystal clear, with some algal mass accumulated at the bottom and along the margins.

**Material examined.** Holotype female (MNHN-IU-2013-9841) dissected on 4 slides, 2 females in author’s personal collections, 8 May 2007, Coll. Y. Ranga Reddy.

**Etymology.** The new species is named for Dr. T. Karanovic, who has made significant contributions to subterranean groundwater fauna.

**Diagnosis.** Fifth pedigerous somite with 2 rows of spinules ventro-laterally. Genital double-somite almost as long as wide, slightly lobulated in the anterior half; seminal receptacle divided into anterior and posterior lobes. Copulatory pore oval, flanked on either side by long sclerotized crest, lying perpendicularly to the surface of the somite anteriorly and obliquely in the posterior half. Anal somite with smooth, broad, W-shaped anal operculum, slightly overreaching the posterior margin of the somite, ornamented with a pair of cuticular pores dorsally and ventrally. Caudal rami 2.7–3.2 times as long as wide, ornamented with 2 somewhat arched rows of spinules dorso-laterally and extending to the ventral surface and also 1 row of 5–6 ventral spinules above the point of insertion of dorsal seta. Antennule 11-segmented with 1
aesthetasc each on segments 8 and 11; second endopodal segment of antenna armed with 9 setae. Labrum with 12 sharp teeth and with very tiny ventral spinules arranged in 2 circles. Claw of maxilla ornamented with 4 strong teeth. Intercoxal sclerites of legs 1–4 ornamented with 4–6 tiny denticles on disto-lateral lobes. Leg 1 basis with 1 strong spine; apical spine on second endopodal segment strong and curved. Leg 4 first exopodal segment with a cuticular fold; second endopodal segment with only 1 apical spine. Second exopodal segment spine formula 3.4.4.3. and setal formula 5.5.5.5. Legs 1–4 second exopodal and endopodal segments ornamented with few fine spinules. Leg 5 distal segment almost as long as wide, ornamented with an apical pinnate seta and spine.

**Description of adult female (Holotype).** Habitus robust (Fig. 102a), total body length excluding caudal setae 0.46 mm, with prosome/urosome ratio 2, and greatest width near posterior end of cephalothorax. Body length/width ratio 2.7. Second prosomite with pronounced moderate lateral expansions. Rostrum well developed, membranous, broad and slightly lobed. Nauplius eye not visible. Cephalothorax 0.9 times as long as wide and representing 34% of total body length and 2.4 times as wide as genital double-somite. Fifth pedigerous somite with smooth dorsal fringe and ornamented with 2 rows of spinules on ventro-lateral side.

Genital double-somite (Fig. 102 b) 0.9 times as long as wide, lobulated in the anterior half; ornamented with 2 pairs of cuticular pores ventrally. Hyaline fringe of genital double-somite serrulate dorsally and ventrally. Seminal receptacle large, representing 50% of somite’s width; divided into anterior and posterior lobes; transverse ducts meeting at straight angle, fused near copulatory pore; copulatory duct short. Copulatory pore oval, flanked on either side by long sclerotized crest, lying perpendicularly to the surface of the somite anteriorly and obliquely in the posterior
half. Ovipores situated dorso-laterally covered by reduced sixth legs. Hyaline fringes of subsequent somites serrulate dorsally and ventrally. Anal somite with smooth, broad, W-shaped anal operculum, slightly overreaching the posterior margin of the somite, ornamented with a pair of cuticular pores dorsally and ventrally, and a transverse row of minute spinules at base of caudal rami dorsally and ventrally. Anal sinus widely open without ornamentation.

Caudal rami (Fig. 102c, d) slightly divergent, 2.7 times as long as wide, (range 2.7–3.2), ornamented with 2 somewhat arched rows of spinules dorso-laterally and extending to the ventral surface, and also 1 row of 5–6 ventral spinules above the point of insertion of dorsal seta. Dorsal seta 0.68 times as long as ramus, 0.8 times as outermost apical seta, inserted at 5/6 of ramus length, uniarticulate at base and plumose distally. Lateral seta arising at about 70% of ramus length, unipinnate, 0.9 times as ramus width. Outermost apical seta stout, spiniform, 0.65 times as ramus. Innermost apical seta plumose, 1.3 times longer than outermost apical seta. Principal median apical setae plumose with breaking planes and homogeneously ornamented; inner median apical seta 1.2 times as long as outer median apical seta and 0.28 times as long as body.

Antennule (Fig. 103a) 11-segmented, reaching the posterior margin of cephalothorax, with 1 aesthetasc each on segments 8 and 11 and setal formula as follows: 8.4.6.2.1+1spine.2.3.2+ae.2.3.7+ae. One seta on segment 5 spiniform and short. First segment ornamented with 1 arched row of spinules, other segments without ornamentation.

Antenna (Fig. 103b) 4-segmented, consisting of coxobasis and 3-segmented endopod, with setal formula 1, 9, 7. Coxobasis 2 times as long as wide, ornamented with transverse row of few spinules proximally along inner margin; 4 long spinules
along inner margin, and 1 short transverse row of long spinules along outer margin on caudal surface; armed with 2 setae (1 pinnate, 1 smooth), at distal inner corner; seta representing exopod pinnate, reaching the proximal part of third endopodal segment. First endopodal segment armed with 1 smooth seta, 1.5 times as long as wide, ornamented with a longitudinal row of spinules at distal outer corner. Second endopodal segment 1.5 times as long as wide, ornamented with 1 row of spinules along outer distal margin and armed with 9 setae. Third endopodal segment 2.1 times as long as wide, ornamented with spinules at outer margin and armed with 7 unequal setae.

Labrum (Fig. 103d) trapezoidal in outline; cutting edge straight, with 12 sharp teeth between produced rounded lateral corners; ventral ornamentation consisting of very tiny spinules arranged in 2 circles.

Mandible (Fig. 104a, b) with distinct palp, armed with 2 very long, finely plumed setae and 1 short smooth seta. Cutting edge with 12 strong teeth and 1 outermost unipinnate seta.

Maxillule (Fig. 104c, d) composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines, 1 smooth seta at their base on ventral surface. Praecoxa armed with 6 armature elements along inner margin, longest one plumose. Palp apically bearing 2 smooth setae and 1 robust, bipinnate spine; endopod distinct, bearing 2 apical and 1 subapical pinnate setae; exopodal seta pinnate.

Maxilla (Fig. 104e) 5-segmented, composed of praecoxa, coxa, basis and 2-segmented endopod. Praecoxa unornamented, proximal endite elongate armed with 2 long pinnate setae, distal endite small, unarmed. Proximal endite of coxa with 1 strong, smooth, short seta; distal endite highly mobile, elongate and armed apically
with 1, long unipinnate seta and 1 short, smooth seta. Basis expanded into robust claw, ornamented with 4 strong teeth like spinules along concave margin and armed with 2 setae, strong seta almost as long as claw, ornamented with tiny spinules along inner distal margin and with smooth short seta at its base. Endopod 2-segmented, proximal segment armed with 2 strong setae; distal segment with 1 robust apical seta and 2 slender subapical setae; all setae on endopod smooth.

Maxilliped (Fig. 103c) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa ornamented with 1 row of spinules on proximal part of outer margin, armed with 3 setae; middle seta unipinnate, strongest and longest, 1.5 times as long as proximal bipinnate seta and 1.3 times as distal smooth seta. Basis 1.7 times as long as wide, ornamented with a row of spinules on inner margin, 1 arched row of spinules along outer distal margin and armed with 2 pinnate setae. First endopodal segment without ornamentation and armed with 1 strong bipinnate seta, second endopodal segment unornamented, armed with 3 setae, innermost seta unipinnate and strongest, about 1.3 times as long as unipinnate middle seta and twice as long as outermost smooth seta.

Legs 1–4 (Fig. 105a–d) with 2-segmented exopod and endopod. Coxa of leg 1 ornamented with 2 short rows of spinules along proximal outer margin; legs 2 and 3 with an additional row of spinules along distal outer margin, that of leg 4 with only distal row of spinules along outer margin; all legs armed with a plumose seta on inner margin. Intercoxal sclerites of legs 1–4 ornamented with 4–6 tiny denticles on distolateral lobes. Exopodal segment spine formula 3.4.4.3 and setal formula 5.5.5.5. Inner margin of leg 1 basis lobed, those of others rounded and ornamented with hair-like spinules; armed with slender, plumose seta on outer margin. Spine inserted at inner corner of basis of leg 1 reaching beyond the mid length of second endopodal segment,
ornamented with few spinules at its base. All exopodal and endopodal setae ornamented with few spinules at base; all setae plumose except one seta on leg 1, plumose proximally and pinnate distally; second exopodal and endopodal segments of legs 1–4 ornamented with few spinules. Apical spine on the second endopodal segment of leg 1 strong and slightly curved. First exopodal segment of leg 4 with cuticular fold, second endopodal segment 1.6 times as long as wide, with only 1 apical spine, 0.8 times as long as the segment. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

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<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Leg 1</td>
<td>1 – 0</td>
<td>1 – 1</td>
<td>1 - I</td>
<td>4, 1+I, II</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>1 - I</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>1 - I</td>
<td>4, 1+I, III</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1 – 0</td>
<td>0 – 1</td>
<td>0 - I</td>
<td>4, 1+I, II</td>
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</tbody>
</table>

Leg 5 (Fig. 102b) with basal segment completely fused to somite, ornamented with 2 rows of spinules, outer pinnate basal seta inserted dorsally. Distal segment almost as long as wide, armed with 1 apical outer bipinnate seta and 1 inner pinnate spine; apical seta about 3.3 times as long as segment, 2.8 times as long as spine and 1.2 times as long as basal seta.

Leg 6 (Fig. 105e) distinct, composed of cuticular plate, armed with 2 unequal smooth spines and 1 long smooth seta.

**Male.** Unknown

**Discussion.** *Metacyclops karanovici n. sp.* has a unique combination of characters as mentioned under diagnosis. As already mentioned genus *Metacyclops* has four groups A, B, C, and D. *M. karanovici n. sp.* belongs to group A by possessing the spine formula of 3.4.4.3, which is identical to that of its Indian conger
Both these taxa are also very closely related to each other in the following characters: i) 11-segmented antennule; length/width ratios of: ii) genital double-somite, caudal rami, and inner median to outer median apical caudal setae, and iii) the presence of a single apical spine on the second endopodal segment of leg 4. The new species, however, differs from the latter: i) in the ornamentation of the fifth pedigerous somite, ii) caudal rami and iii) intercoxal sclerite of leg 4 (legs 1–3 not depicted for *M. communis* and no comparison of these appendages is possible), iv) shape of seminal receptacle, v) presence of sclerotized crest lying perpendicular to the surface of genital double-somite vi) position of the lateral seta, vii) shape of anal operculum, viii) length/width ratios of outermost to innermost apical caudal setae, and ix) length/width ratios of leg 4 endopod and its apical spine.

Of the total 62 nominal species of the genus *Metacyclops*, only four taxa have so far been reported with ornamentation on fifth pedigerous somite (Karanovic, 2004): *M. mendocinus* (Wierzejskl, 1892) s. str., from Cuba and Puerto Rico (see Smith & Fernando, 1978; Pesce, 1985); *M. leptopus mucubajiensis* Kiefer, 1956, from South America (Kiefer, 1956; Dussart, 1984; Reid, 1985); *M. problematicus* Dumont, 1973 from Europe (Dumont, 1973); and *M. superincidentis* Karanovic, 2004 from Australia. Of the four species mentioned, the first three species have a 12-segmented antennule, whereas *M. superincidentis* Karanovic, 2004 and *Metacyclops karanovici n. sp.* have 11-segmented antennule as also ornamentation on fifth pedigerous somite. In other respects, *M. karanovici n. sp.* distinctly differs from *M. superincidentis*: i) the shape of seminal receptacle, ii) presence vs. absence of cuticular plates near the copulatory pore; iii) caudal rami ornamented with two rows of arched spinules vs. unornamented; iv) anal operculum 48% vs. 66% of somite’s width; v) second
endopodal segment of antenna with nine setae vs. six setae; vi) second endopodal segment of leg 4 with 1 spine vs. 2 spines; and vii) spine on leg 5 pinnate vs. smooth.

**Key to the identification of Indian species of genus *Metacyclops* Kiefer, 1927**

1. Leg 4 second endopodal segment with 1 apical spine……………………………………2
   Leg 4 second endopodal segment with 2 apical spines……………………………………4

2. Second exopodal segment spine formula 3.4.3.3………………. *M. paracushae* n. sp.
   Second exopodal segment spine formula 3.4.4.3………………………………………..3

3. Caudal ramus and fifth pedigerous somite unornamented; innermost apical seta shorter than outermost apical seta…………………. *M. communis* Lindberg, 1938
   The same ornamented with spinules; innermost apical seta longer than outermost apical seta…………………………………………………………………….*M. karanovici* n. sp.

5. Second exopodal segment spine formula 3.3.3.3.; leg 4 enp 2 inner spine 3–4.5 times as long as outer spine ...................... *M. margaretae* Lindberg, 1938
Genus *Thermocyclops* Kiefer, 1927

**Generic diagnosis.** Mirabdullayev, Reid & Ueda (2003) provided the following generic diagnosis: body slender, medium-sized cyclopoids. Seminal receptacle hammer-shaped. Caudal rami less than 4 times as long as wide. Inner median apical caudal setae, sometimes with ventrally curved tips. Antennule 17-segmented. Antenna armed with 3 setae on coxobasis and 1, 5–9, 7 setae on 1–3 endopodal segments. Legs 1–4 with 3-segmented rami. Leg 1 basis with a spine-like seta near its inner angle. Leg 5, 2-segmented, terminal segment bearing 1 apical seta and 1 subapical long spine, the later inserted apically or sub apically.

Up till now, this genus is represented by 55 nominal species and subspecies, according to the World Directory of Crustacean Copepoda of Inland waters II (see Dussart & Defaye 2006). Of these, the following 8 taxa are already known from India:

1. *Thermocyclops Crassus* (Fischer, 1853)
2. *Thermocyclops decipiens* (Kiefer, 1929)
3. *Thermocyclops rylovi* (Smirnov, 1929)
5. *Thermocyclops rectus* (Lindberg, 1937)
6. *Thermocyclops maheensis* (Lindberg, 1941)
7. *Thermocyclops conspicuous* (Lindberg, 1947)

Besides the above mentioned species, *Thermocyclops oblongatus oblongatus* (G. O. Sars, 1927) is a doubtful record from India (Dussart & Defaye 2006). Only 3 species, viz. *Thermocyclops crassus, Thermocyclops decipiens,* and *Thermocyclops rylovi* have been met in this study.
*Thermocyclops crassus* (Fischer, 1853)
(Figs 107–111)

**Synonymy**

*Cylcops crassus* Fischer, 1853: 92–93, Pl.111, Fig. 29.


*Mesocyclops (Thermocyclops) crassus*, Rylov, 1948: 305–306, Fig. 77.


**Locality.** Pond at Inkollo (15°49′48″N, 80°12′00″E; elevation 10 m), Prakasam District, Andhra Pradesh, South India.

**Material examined.** 4 voucher specimens: 1 female (MNHN-IU-2013-9842) and 1 male (MNHN-IU-2013-9844) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9843) dissected on 9 slides and 1 male (MNHN-IU-2013-9845) dissected on 2 slides; 10 females and 6 males in author’s personal collections; 11 June, 2005, Coll. V. Subhashini.

**Other material examined.** Bollapalli Pond, Tativaripalem village (15°58′00″N, 80°03′00″E; elevation 69 m), Prakasam District, Andhra Pradesh, South India, 9 March 2005: 6 females and 3 males, Coll. V. Subhashini.
River Moosi, 18 km from Podili (15°36′14″N, 79°36′29″E; elevation 154 m) Prakasam District, Andhra Pradesh, South India, 16 July, 2005: 16 females and 6 males, Coll. D. Ambedkar.

Rain-fed pond, Velupucherla, near Nuzivid, (16°46′48″N, 80°51′00″E; elevation 16 m), Krishna District, Andhra Pradesh, South India, 19 May 2005: 12 females and 8 males, Coll. V Subhashini.

Cumbum Cheruvu, 5Km from Cumbum (15°34′0.12″N, 79°09′0.12″E; elevation 184 m), Prakasam District, Andhra Pradesh, South India, 28 July 2005: 10 females and 4 males, Coll. D. Ambedkar.

Kundyangulam Kollam tank, Thrissur, (10°31′12″N, 76°12′36″E; elevation 2.83 m) Thrissur District, Kerala, South India, 26 December 2005: 11 females and 4 males, Coll. Y. Ranga Reddy and D. Ambedkar.

Large pond, Bhadrakali Kshetram (10°31′12″N, 76°12′36″E; elevation 2.83 m), Thrissur District, Kerala, South India, 26 December 2005: 14 females and 6 males, Coll. Y. Ranga Reddy and D. Ambedkar.

Pulvetti Tank, Agricultural pond at Sempatti village (10°21′00″N, 77°57′00″E; elevation 268m), Dindigul District, Tamil Nadu, South India, 31 December 2005: 6 females and 2 males, Coll. Y. Ranga Reddy and D. Ambedkar.

Swathantra Fish pond, Vuyyuru (16°22′04″N, 80°50′84″E; elevation 11 m), Krishna District, Andhra Pradesh, South India, 12 September 2006: 12 females and 8 males, Coll. V. Subhashini.

**Redescription of adult female.** Habitus robust (Fig. 107a), total body length, excluding caudal setae 0.8 mm. Prosome/urosome ratio 1.8 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.9. Free pedigerous somites without pronounced lateral expansions. Rostrum well developed, membranous and
broadly rounded. Cephalothorax 1.1 times as long as wide, representing 37% of total body length and 3.3 times as wide as genital double-somite. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite with smooth fringe dorsally and ventrally, and ornamented with hair-like spinules on ventrolateral sides.

Genital double-somite (Fig. 107b) 1.4 times as long as wide (range 1.2–1.4). Hyaline fringes of genital double-somite and subsequent somites smooth dorsally and serrulate ventrally. Copulatory pore round and copulatory ducts rigidly sclerotized. Seminal receptacle large, representing 73% of double somites length, divided into proximal and distal parts. Proximal part formed into short, wide lateral arms perpendicular to body axis; distal part elongated. Ovipores situated dorso-laterally covered by reduced sixth legs. Anal somite with smooth, broad concave and operculum, representing 58% of somite’s width, ornamented with few spinules at base of caudal rami dorsally and ventrally (Fig. 107c, d). Anal sinus widely open without visible ornamentation.

Caudal rami (Fig. 107c, d) divergent, 2.6 times as long as wide, (range 2.2–2.8) with smooth medial surface; implantations of lateral and outermost apical seta without spinules. Dorsal seta 1.4 times as long as ramus and 1.6 times as outermost apical seta, uniarticulate at base and plumose distally. Lateral seta inserted at 70% of ramus length and bipinnate. Outermost apical seta spiniform, 0.8 times as long as ramus. Innermost apical seta 3.2 times as long as outermost apical seta; 2.8 times as caudal ramus. Principal apical setae with breaking planes and homogeneously ornamented; inner median apical seta 1.4 times as long as outer median apical seta, tips strongly curved ventrally.

Antennule (Fig. 108a) 17-segmented, reaching the posterior margin of second pedigerous somite, with 1 aesthetasc each on segments 12, 16 and 17; and setal
formula as follows: 8.4.2.6.4.1.2.1.1.0.1.1+ae.0.1.2.2+ae.7+ae. Hyaline membrane of last antennulary segment not extending beyond insertion of medial seta, and without notch.

Antenna (Fig. 108 b, c) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis 2.3 times as long as wide; ornamented with 2 rows of spinules proximally along outer margin on frontal surface; 2 longitudinal rows of spinules near outer margin on caudal surface; armed with 2 smooth setae at distal inner corner; seta representing exopod pinnate. First endopodal segment 1.8 times as long as wide with 1 smooth seta in the middle, ornamented with a row of spinules along outer margin. Second endopodal segment 2.3 times as long as wide, also ornamented with a longitudinal row of spinules along outer margin and armed with 9 setae. Third endopodal segment 3.3 times as long as wide, ornamented with 1 longitudinal row of spinules and armed with 7 apical setae.

Labrum (Fig. 108d) unornamented, cutting edge straight with 11 teeth between produced, elongated lateral corners.

Mandible (Fig. 109a, b) with distinct palp, armed with 2 long finely plumed setae and 1 short smooth seta. Cutting edge with 10 teeth and 1 outermost unipinnate seta.

Maxillule (Fig. 109c) composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines and 1 smooth seta at their base on ventral surface. Praecoxa armed with 6 armature elements along inner margin, longest one plumose. Palp apically bearing 2 slender smooth setae and 1 robust unipinnate spine; endopod distinct bearing 2 apical and 1 subapical pinnate setae, exopodal seta smooth.
Maxilla (Fig. 109d) unornamented, 5-segmented with praecoxa, coxa, basis and 2-segmented endopod. Proximal endite of praecoxa, elongate, armed with 2 pinnate setae; distal endite small and unarmed. Proximal endite of coxa with 1 strong bipinnate seta, distal endite elongate, armed apically with 1 proximal strong, bipinnate seta and 1 distal smooth, slender seta. Basis expanded into a robust claw, ornamented with longitudinal row of spinules along concave margin; armed with 2 setae, strong seta bipinnate proximally, unipinnate distally almost as long as claw; small seta at its base. Endopod 2-segmented, proximal segment armed with 2 strong bipinnate setae, distal segment with 1 strong, robust apical seta and 2 slender smooth subapical setae.

Maxilliped (Fig. 109e) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa unornamented, armed with 3 pinnate setae; middle seta strongest, bipinnate 1.1 times as long as distal seta and 1.4 times as long as proximal seta. Basis 2 times as long as wide; ornamented with 1 longitudinal row of long spinules, 1 irregular row of short spinules; along inner margin; 2 short rows of spinules along outer margin; armed with 1 pinnate and 1 smooth seta; proximal seta 1.3 times as long as distal one. First endopodal segment armed with 1 strong seta, bipinnate proximally and unipinnate distally. Second endopodal segment unornamented and armed with 2 smooth and 1 bipinnate setae.

Legs 1–4 (Fig. 110 a–d) with 3-segmented exopod and endopod. Coxa of legs 1–3 ornamented with a row of spinules along outer margin; that of leg 4 without lateral spinules; legs 1–4 armed with a plumose seta at distal inner corner. Intercoxal sclerites of legs 1 and 3 without ornamentation, that of leg 2 with 1 row of spinules, and leg 4 with 2 rows of spinules medially on caudal surface; rounded prominences of legs 1–4 with 2–4 spinules at distal margin. Third exopodal segment spine formula 2.3.3.3 and setal formula 4.4.4.4. Spine inserted at inner corner of basis of leg 1.
reaching the anterior end of third endopodal segment (Fig. 110a). Leg 4 third endopodal segment, 3.6 times as long as wide; inner apical spine with hair like spinules along inner distal margin and short spinules on outer distal margin and 2.3 times as long as outer apical spine and 0.84 times as segment. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>1–0</td>
<td>1–1</td>
<td>1–I</td>
<td>3, 1+I, I</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1–0</td>
<td>0–1</td>
<td>1–1</td>
<td>3, 1+I, II</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1–0</td>
<td>0–1</td>
<td>1–1</td>
<td>3, 1+I, II</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1–0</td>
<td>0–1</td>
<td>1–1</td>
<td>3, 1+I, II</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 107b) 2-segmented; basal segment about 1.8 times as long as wide; armed with 1 lateral smooth seta. Distal segment 1.7 times as long as wide, armed apically with inner unipinnate spine and outer plumose seta; inner spine 1.2 times as seta, 5.4 times as long as segment and 2.5 times as long as lateral seta.

Leg 6 (Fig. 110e) distinct, cuticular plates, armed with 2 almost equal smooth spines and 1 long bipinnate seta.

**Description of male.** Total body length excluding caudal setae 0.66mm. Habitus (Fig. 111a) slenderer than female with prosome/urosome ratio 1.6 and greatest width near posterior end of cephalothorax. Body length/width ratio about 1.6. Cephalothorax about 2.8 times as wide as genital somite. Free pedigerous somites without pronounced lateral expansions. Cephalothorax 1.3 times as long as its greatest width; representing 41% of total body length. Hyaline fringes of prosomites, fifth pedigerous somite and genital somite smooth dorsally. Genital somite almost as long as wide. Anal somite with smooth, broad, concave anal operculum representing 50%
of somites width, ornamented with few spinules at base of caudal rami dorsally and ventrally. Anal sinus widely open without visible ornamentation.

Caudal rami (Fig. 111a) parallel, 2.4 times as long as wide, armature and ornamentation as in female. Implantations of lateral and outermost apical seta not provided with spinules.

Antennule (Fig. 111c) 16-segmented, digeniculate with geniculations between segments 8 and 9, and 14 and 15. First segment with 3 aesthetasc, segments 4 and 16 one each and setal formula as follows: 8+3ae.3.4.2+ae.2.2.1.0.0.2.1.0.0.0.2.9+ae. Antenna, labrum, mandible, maxillule, maxilla, maxilliped and legs 1–5 similar to female.

Leg 6 (Fig. 111b) triangular plate, armed with 3 setae; outer seta 1.5 times as long as inner one.

**Distribution and Ecology.** *Thermocyclops crassus* (Fischer, 1853) was widely distributed in India (see Kiefer 1978). Ranga Reddy (1977) also recorded it from different localities of Andhra Pradesh like Guntur and its environs, Giddalur, Nallamalai forests, Guntakal, Hyderabad, Warangal, and Vishakhapatnam. In the present study *T. crassus* is reported from the states of Andhra Pradesh, Kerala and Tamilnadu. In the material examined by me, it was accompanied by several unidentified rotifers, a few calanoids, and strays of ergasilids.

**Remarks.** The present material perfectly agrees with the brief description of this species already available in the literature (see Mirabdullayev et al., 2003, and others). Here, a detailed redesription of all the appendages and their micro-characters of this species are given. Of the known Indian species, *T. crassus* and *T. maheesensis* have ventrally curved terminal median apical seta, but both of them differ in shape of seminal receptacle and its curvature of lateral arms; ornamentation of caudal rami,
length/width ratios of genital double somite; leg 4 basis medial expansion; its intercoxal sclerite and number of spinules on the rounded prominences of the sclerites. There are 12 other species from different countries with ventrally curved terminal median apical seta. The Indian specimens of *T. Crassus* agree with the spinule pattern of antennal coxobasis and pilose inner margins of basis of legs 1–4 with the Cambodian specimens (Chaicharoen et al., 2011) but differ from the European and Australian females (Mirabdullayev et al., 2003; Holyńska, 2006).

**Table. 19. Morphometric data of *Thermocyclops crassus* (Fischer, 1853)**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm.</td>
<td>0.8</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>1.6</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>1.3</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>2.8</td>
<td>3.4</td>
<td>3.1</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>2.8</td>
<td>3.4</td>
<td>3.1</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outermost apical seta</td>
<td>1.4</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>8.</td>
<td>Dorsal seta: caudal ramus</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, length: width</td>
<td>3.2</td>
<td>3.8</td>
<td>3.5</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>1.9</td>
<td>2.4</td>
<td>2.15</td>
</tr>
<tr>
<td>11.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>0.8</td>
<td>1.0</td>
<td>0.9</td>
</tr>
</tbody>
</table>
Thermocyclops decipiens (Kiefer, 1929)
(Figs 112–116)

Synonymy

Mesocyclops (Thermocyclops) decipiens Kiefer, 1929: 99–110.
Mesocyclops (Thermocyclops) decipiens, Kiefer, 1929c: 305–309; 1933: 121–142;
Thermocyclops decipiens, Einsle, 1970: 13–38; Dussart, 1977: 821–840; Kiefer,
180; Defaye et al., 1987: 3144–3153; Reid 1989: 149–174; Mirabdullayev, Reid &
Ueda in Ueda & Reid, 2003: 259. Fig. 121A – F; Holyńska, 2006: 345–346, Figs. 21, 22.

Locality. Pond at Pedakakani village (16º20'44"N, 80º29'17"E; elevation 29 m),
Prakasam District, Andhra Pradesh, South India.

Material examined. 4 voucher specimens: 1 female (MNHN-IU-2013-9846) and 1
male (MNHN-IU-2013-9848) whole-mounted on 1 slide each; 1 female (MNHN-IU-
2013-9847) dissected on 10 slides and 1 male (MNHN-IU-2013-9849) dissected on 2
slides; 12 females and 4 males in authors personal collections; 27 July 2004, Coll. V.
Subhashini.

Other material examined. Temple pond, Tadikonda (16º20'10"N, 80º27'06"E;
elevation 37 m), Guntur District, Andhra Pradesh, South India, 6 June 2005: 6
females and 2 males. Coll. V. Subhashini.
Timma Reddi Cheruvu, Kandukuru (15º12′36′′N, 79º54′32′′E; elevation 632 m)
Prakasam District, Andhra Pradesh, South India, 09 January 2005: 6 females and 3
males. Coll. V. Subhashini.
Bucking Ham Canal, Vallabhapuram (16°20′50″N, 80°43′14″E; elevation 11 m), Krishna District, Andhra Pradesh, South India, 07 May 2005: 10 females and 4 males. Coll. D. Ambedkar.

Kotula Tank, Tiruvuru (17°06′47″N, 80°36′38″E; elevation 73 m), Krishna District, Andhra Pradesh, South India, 14 July 2005: 14 females and 6 males. Coll. D. Ambedkar.

Ayyanthol Kollam Corporation pond, Thrissur (10°30′54″N, 76°12′29″ E; elevation 5 m), Thrissur District, Kerala, South India, 26 December 2005: 10 females and 4 males. Coll. Y. Ranga Reddy & D. Ambedkar.

Road side open well, Mullorkara village (10°42′15″N, 76°16′19″E; elevation 5 m), Thrissur District, Kerala, South India, 28 December 2005: 4 females and 1 male, Coll. Y. Ranga Reddy & D. Ambedkar.

Pond at Paravai village, 10 km from Madurai (09°58′36″N, 78°03′13″E; elevation 98 m), Madurai District, Tamil Nadu, South India, 31 December 2005: 10 females and 8 males, Coll. Y. Ranga Reddy & D. Ambedkar.

Pond at Saroor Nagar, Hyderabad (17°21′21″N, 78°31′38″E; elevation 487 m) Hyderabad District, Andhra Pradesh, South India, 9 October 2005: 6 females and 4 males. Coll. D. Ambedkar.

Rain fed Tank, University Campus, Midnapore (22°05′26″N, 86°19′08″E; elevation 29 m), Paschim Midnapore District, West Bengal, 20 October 2005: 6 females and 4 males. Coll. Y. Ranga Reddy.

**Redescription of female.** Total body length, excluding caudal setae 1.1 mm. Habitus robust (Fig. 112a) with prosome/urosome ratio 1.7 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.8. Free pedigerous somites without pronounced lateral expansions. Rostrum well developed, membranous and
broadly rounded. Cephalothorax 0.9 times as long as wide, 2.8 times as wide as genital double-somite and representing 34% of total body length. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite with smooth fringe dorsally and ventrally, ornamented with hair-like spinules on ventro-lateral side.

Genital double-somite (Fig. 112b) 1.4 times as long as wide. Hyaline fringes of genital double-somite and subsequent somites smooth dorsally and serrulate ventrally. Copulatory pore round, copulatory duct rigidly sclerotized. Seminal receptacle relatively large representing 65% of somite’s length, divided into proximal and distal parts. Proximal part formed into short, thick lateral arms slightly curved posteriorly; distal part elongated and sac-like. Ovipores situated dorso-laterally covered by reduced sixth legs. Anal somite with smooth, broad, concave anal operculum, representing 46% of somite’s width ornamented with few spinules at base of caudal rami dorsally and ventrally (Fig. 112c, d). Anal sinus widely open, without visible ornamentation.

Caudal rami (Fig. 112c, d) divergent, 2.3 times as long as wide with smooth medial surface. Implantations of lateral and outermost apical setae without spinules. Dorsal seta 1.3 times as long as ramus, 1.4 times as outermost apical seta, uniarticulate at base and plumose distally. Lateral seta inserted at 67% of ramus length, bipinnate. Outermost apical seta, spiniform, almost as long as ramus, bipinnate. Innermost apical seta 3 times as long as outermost apical seta and caudal ramus. Principal apical setae with breaking planes, straight tips, homogeneously ornamented; inner median apical seta 1.2 times as long as terminal median outer seta.

Antennule (Fig. 113a) 17-segmented, reaching almost the posterior margin of second pedigerous somite, with 1 aesthetasc each on segments 12 and 17 and setal
formula as follows: 8.4.2.6.4.1+1sp.2.1.1.0.1.1+ae.0.1.2.1.7+ae. One seta on segment 6 spiniform and 1 seta on segment 17 articulating at base.

Antenna (Fig. 113b, c) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis 2.6 times as long as wide; ornamented with 1 proximal row of spinules on frontal surface; 4–5 long spinules proximally, 1 curved row of spinules proceeding towards distal end, and 1 short row of spinules along inner proximal margin on caudal surface; armed with 1 pinnate and 1 smooth seta at distal inner corner; seta representing exopod pinnate overreaching the third endopodal segment. First endopodal segment 1.7 times as long as wide, with 1 smooth seta at mid-length of the segment, ornamented with a row of spinules along outer margin. Second endopodal segment 2.2 times as long as wide, ornamented with 1 longitudinal row of spinules along outer margin and armed with 9 setae. Third endopodal segment 3.2 times as long as wide, ornamented with 1 longitudinal row of spinules and armed with 7 apical setae.

Labrum (Fig. 113d) trapezoidal, unornamented; cutting edge straight with 11 teeth between produced rounded lateral corners.

Mandible (Fig. 114a) with distinct palp, armed with 2 long finely plumed setae and 1 short, smooth seta at distal end.

Maxillule (Fig. 114b) composed of well-developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines, and 1 bipinnate seta at their base on ventral surface. Praecoxa armed with 7 armature elements along inner margin, the longest one plumose. Palp apically bearing 2 slender smooth setae and 1 robust unipinnate spine; endopod distinct, with 2 apical and 1 subapical smooth setae; exopodal seta smooth.
Maxilla (Fig. 114c) unornamented, 5-segmented with praecoxa, coxa, basis and 2- segmented endopod. Proximal endite of praecoxa elongate, robust, armed with 2 pinnate setae, distal endite small and unarmed. Proximal endite of coxa with 1 strong bipinnate seta, distal endite, elongate, armed apically with 1 strong, bipinnate seta and 1 smooth slender seta. Basis expanded into robust claw, ornamented with longitudinal row of spinules along concave margin, armed with 2 setae; strong bipinnate seta longer than claw, small seta at its base. Endopod 2-segmented, proximal segment armed with 2 robust pinnate setae; distal segment with 1 robust pinnate apical seta and 2 slender smooth subapical setae.

Maxilliped (Fig. 114d) 4-segmented, composed of syncoxa, basis and 2- segmented endopod. Syncoxa unornamented, armed with 3-pinnate setae; middle seta strongest, bipinnate, 1.4 times as long as distal seta and 1.2 times as long as proximal seta. Basis 2 times as long as wide; ornamented with 1 row of longitudinal spinules along inner margin; 2 rows of spinules along outer margin; (1 arched proximal row, 1 longitudinal distal row) and a few spinules on medial surface; armed with 2 pinnate setae, proximal seta 1.3 times as long as distal one. First endopodal segment armed with 1 strong bipinnate seta. Second endopodal segment unornamented and armed with 2 smooth and 1 bipinnate setae.

Legs 1–4 (Fig. 115a–d) with 3-segmented exopod and endopod. Coxa of leg 1 ornamented with a row of short spinules at distal edge; legs 2 and 3 without ornamentation; leg 4 ornamented with 3 rows of spinules and all legs armed with 1 plumose seta at distal inner corner. Intercoxal sclerite of leg 1 unornamented; legs 2 and 3 with 2 rows of small spinules and that of leg 4 with 2 rows of hair like spinules medially on caudal surface. Legs 1–3 with 2 spinules and leg 4 with 3–4 spinules on disto-lateral protuberances. Third exopodal segment spine formula 2.3.3.3 and setal
formula 4.4.4.4. Spine inserted at inner corner of basis of leg 1 reaching 2/3 of second endopodal segment (Fig. 115a). Legs 1–3 basis medial margins bearing hairs, that of leg 4 with small spinules (Fig. 115d). Exopodal and endopodal setae slender and plumose; spines on exopodal segments of leg 1 longer than others. Third endopodal segment of leg 4, 2.5 times as long as wide; inner apical spine 2.8 times as long as outer apical spine and almost as long as the segment. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>1–0</td>
<td>1–1</td>
<td>1-I</td>
<td>1-I</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1–0</td>
<td>0–1</td>
<td>1-I</td>
<td>1-I</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1–0</td>
<td>0–1</td>
<td>1-I</td>
<td>1-I</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1–0</td>
<td>0–1</td>
<td>1-I</td>
<td>1-I</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 112b) 2-segmented; basal segment about 0.7 times as long as wide; armed with lateral bipinnate seta. Distal segment narrower, 2.8 times as long as wide, armed apically with inner spine and outer unipinnate seta; inner spine 1.3 times as long as seta and 3.3 times as long as segment.

Leg 6 (Fig. 115e) distinct, cuticular plate, armed with 2 tiny spines and 1 bipinnate longer seta.

**Redescription of male.** Total body length excluding caudal setae 0.72 mm. Habitus (Fig. 116a) slenderer than female with prosome/urosome ratio about 2 and greatest width at posterior end of cephalothorax. Body length/width ratio about 3.0; cephalothorax about 3.8 times as wide as genital somite. Free pedigerous somites without pronounced lateral expansions. Cephalothorax 1.1 times as long as its greatest width; representing 36% of total body length. Hyaline fringes of prosomites, fifth pedigerous somite and genital somite smooth dorsally. Genital somite almost as long as wide. Anal somite with smooth, broad, concave anal operculum representing 42%
of somite’s width and ornamented with spinules along base of caudal rami dorsally and ventrally.

Caudal rami (Fig. 116a) parallel, 3 times as long as wide, armature and ornamentation similar as in female. Implantations of lateral and outermost apical setae not provided with spinules.

Antennule (Fig. 116c) 16-segmented, digeniculate with geniculations between segments 7 and 8, 14 and 15. First segment with 3 aesthetascs; 1 aesthetasc each on segments 4 and 16. Setal formula as follows: 8+3ae.3.4.2.2.1.1+1spine.2.0.2.1.0.1.0.2.8+ae. Antenna, labrum, mandible, maxillule maxilla, maxilliped, legs 1–5 similar as in female.

Leg 6 (Fig. 116b) triangular plate, armed with 1 spine and 2 pinnate setae. Outer seta 1.8 times as long as middle seta and 3.5 times as long as spine.

**Distribution and ecology.** *Thermocyclops decipiens* is pantropical in distribution, having been reported from Africa, Central and South America, India, Sri Lanka, Vietnam, Indonesia, and Australia (Mirabdullayev et al., 2003). It is indeed the most common member of the genus *Thermocyclops* in the plankton community of lentic habitats such as pools, ponds, reservoirs, and lakes, and rarely in streams and canals in India. In the material examined it was associated with some calanoids, cladocerans, rotifers (*Brachionus* species) and very few oligochaetes.

**Remarks.** The specimens under study almost perfectly agree with the previous descriptions by Kiefer (1978), Mirabdullayev et al. (2003), Chaicharoen et al. (2011) and others. The range of inter-population variation observed in conventionally important characters are as outlined in Table 20.
Table 20. Morphometric data of *Thermocyclops decipiens* (Kiefer, 1929)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>0.8</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome/urosome</td>
<td>1.4</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.1</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>2.2</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.18</td>
<td>1.30</td>
<td>1.24</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>2.60</td>
<td>3.50</td>
<td>3.05</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outermost apical seta</td>
<td>1.30</td>
<td>1.45</td>
<td>1.38</td>
</tr>
<tr>
<td>8.</td>
<td>Dorsal seta: caudal ramus</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, length: width</td>
<td>2.4</td>
<td>3.0</td>
<td>2.7</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>2.4</td>
<td>2.8</td>
<td>2.6</td>
</tr>
<tr>
<td>11.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>0.9</td>
<td>1.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Thermocyclops rylovi (Smirnov, 1929)
(Figs 117–121)

Synonymy


Mesocyclops (Thermocyclops) rylovi, Sewell, 1934: 45–121; Lindberg, 1942b: 146,147, Figs 5–6; Rylov, 1948: 1–318.


Thermocyclops rylovi, Kiefer, 1978: 213–214, Fig. 92A; Defaye et al., 1987: 239–271, Fig. 127; Holyńska, 2006: 342–344, Figs 15–18.

Locality. Pond at Varatar village, Theni (09°55′11″N, 78°07′10″E; elevation 100 m), Theni district, Tamil Nadu, South India.

Material examined. 4 voucher specimens: 1 female (MNHN-IU-2013-9850) and 1 male (MNHN-IU-2013-9852) whole-mounted on 1 slide each; 1 female (MNHN-IU-2013-9851) dissected on 6 slides and 1 male (MNHN-IU-2013-9853) dissected on 2 slides; 6 females and 2 males in authors personal collections; 31 December 2005, Coll. Y. Ranga Reddy & D. Ambedkar.

Other material examined. Road-side tank near Theni Collector’s Office, Kari Velanaya Kanpatti village (10°00′32″N, 77°28′12″E; elevation 100 m ), Theni District, Tamil Nadu, South India, 31 December 2005: 12 females and 6 males, Coll. Y. Ranga Reddy & D. Ambedkar.

Road-side agricultural tank, Lakshmipuram village (09°55′11″N, 78°07′00″E; elevation 296 m), Theni District, Tamil Nadu, South India, 31 December 2005: 6 females and 2 males, Coll. Y. Ranga Reddy & D. Ambedkar.

Redescription of female. Total body length excluding caudal setae 0.9 mm. Habitus robust (Fig. 117a) with prosome/urosome ratio 1.7 and greatest width near
posterior end of cephalothorax. Body length/width ratio 2.6. Free pedigerous somites without pronounced lateral expansions. Cephalothorax almost as long as wide, 2.6 times as wide as genital double-somite and representing 37% of total body length. Fifth pedigerous somite with smooth fringe dorsally and ventrally, ornamented with few ventro-lateral hairs.

Genital double-somite (Fig. 117 b) with transverse rows of pits ventrally, 1.1 times as long as wide and hyaline fringe serrulate ventrally. Seminal receptacle large, representing 70% of somite’s length; divided into anterior and posterior parts. Lateral arms of seminal receptacle slightly curved posteriorly. Oviducts rigidly sclerotized and ovi pores situated dorso-laterally covered by reduced sixth legs. Anal somite with smooth, concave anal operculum, representing 56% of somite’s width, and ornamented with a pair of cuticular pits dorsally and bearing 2 groups of 7–9 spinules at the base of caudal rami ventrally. Anal sinus widely open, without visible ornamentation.

Caudal rami (Fig. 117c, d) slightly divergent, 3.4 times as long as wide with smooth medial surface. Implantations of lateral and outermost apical setae without spinules. Lateral seta unipinnate arising at 70% length of caudal ramus. Dorsal seta 1.4 times as long as ramus, uniarticulate at base and plumose distally. Outermost apical seta stout, spiniform 0.7 times as long as ramus. Innermost apical seta plumose, 2.3 times as long as outermost apical seta and caudal ramus. Principal apical setae plumose with breaking planes; inner median apical seta 1.2 times as long as outer median apical seta.

Antennule (Fig. 118a) reaching the middle of second pedigerous somite, 17-segmented with 1 slender aesthetasc each on segments 12, 16 and 17 and setal formula as follows: 8.4.2.6.4.2.2.1.1.0.1.1+ae.0.1.2.2+ae.7+ae. First segment
ornamented with elongated pits and 1 proximal arched row of spinules. Hyaline membrane on last antennulary segment without notch.

Antenna (Fig. 118b, c) 4-segmented. Coxobasis twice as long as wide, armed with 2 smooth setae at distal inner corner and 1 pinnate seta representing exopod, reaching beyond tip of appendage. Coxobasis ornamented on caudal surface with 4–6 somewhat strong spinules in oblique row, 7-8 spinules in longitudinal row near outer margin, group of tiny spinules between oblique and longitudinal rows; a field of small spinules present on inner middle region; a few tiny spinules arranged in oblique row near mid-length; frontal surface of coxobasis with few spinules in longitudinal row on proximal half of segment near lateral margin. First endopodal segment armed with 1 smooth seta, ornamented with a longitudinal row of spinules along outer margin. Second endopodal segment twice as long as wide, ornamented with 1 longitudinal row of spinules and armed with 9 setae. Third endopodal segment thrice as long as wide, ornamented with 1 longitudinal row of spinules and armed with 7 apical setae.

Labrum (Fig. 118d) unornamented, cutting edge straight with 12 teeth between rounded, protruded corners.

Mandible (not figured), consisting of well-developed gnathobase and 1-segmented palp, armed with 2 long pinnate seta and 1 short smooth seta.

Maxillule composed of well-developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines; praecoxa armed with 6 armature elements along inner margin, longest one plumose. Palp (Fig. 119a) apically bearing 2 slender (1 pinnate and 1 smooth setae) and 1 robust unipinnate spine; endopod distinct, bearing 2 apical and 1 subapical pinnate setae; exopodal seta smooth.

Maxilla (Fig. 119b) 5-segmented composed of praecoxa, coxa, basis and 2-segmented endopod. Praecoxa unornamented, with elongated proximal endite, armed
with 2 long bipinnate setae; distal endite small and unarmed. Coxa unornamented, proximal endite with 1 strong, long, bipinnate seta; distal endite elongate and armed apically with 1 strong, pinnate seta and 1 smooth, slender, short seta. Basis expanded into robust claw, ornamented with longitudinal row of spinules along concave margin and armed with 2 setae, strong seta longer than claw, unipinnate at distal end, and short seta at its base. First endopodal segment armed with 1 bipinnate seta and 1 smooth seta; second endopodal segment with 1 strong, distally unipinnate seta, and 2 smooth setae.

Maxilliped (Fig. 119c) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa armed with 3 strong setae; middle seta bipinnate proximally, unipinnate distally, strongest and longest, 1.5 times as long as unipinnate proximal seta and 1.3 times as long as bipinnate distal seta. Basis 1.6 times as long as wide, ornamented with a row of spinules proximally, 2 rows of spinules distally at outer margin along with 1 longitudinal row; 1 row of 5–6 spinules on inner margin, 1 group of spinules above long spinules and armed with 2 pinnate setae; proximal seta 1.8 times as long as distal one. First endopodal segment ornamented with a curved row of spinules, armed with 1 strong seta, bipinnate proximally and unipinnate distally. Second endopodal segment small, unornamented, armed with 3 setae, innermost seta strongest, bipinnate proximally, unipinnate distally, about twice as long as middle smooth seta and 2.2 times as long as outermost smooth seta.

Legs 1–4 (Fig. 120a–d) with 3-segmented exopod and endopod. Coxa of legs 1–4 ornamented with long spinules along outer margin; 2 rows of spinules at distal outer and median margins; that of leg 4 with an additional row of 6 long spinules at distal outer corner; armed with a plumose seta at inner margin. Intercoxal sclerite of leg 4 with 2 rows of spinules medially on posterior surface. Legs 1–4 with 4–7
spinules on disto-lateral protuberances. Third exopodal segment spine formula 2.3.3.3 and setal formula 4.4.4.4. Legs 1–3 medial margins of basis bearing hairs; that of leg 4 without hairs. Spine inserted at distal inner corner of basis of leg 1 pinnate, reaching anterior one-third of third endopodal segment. Exopodal and endopodal setae slender and plumose. Third endopodal segment of leg 4, 2.6 times as long as wide; inner apical spine ornamented with small spinules on outer edge and hairs on inner edge; 2.5 times as outer apical spine and almost as long as the segment. Legs 1–4 armature formula as follows (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Leg 1</td>
<td>1</td>
<td>0</td>
<td>1 - I</td>
<td>1 - I</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1</td>
<td>0</td>
<td>0 - I</td>
<td>1 - I</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1</td>
<td>0</td>
<td>0 - I</td>
<td>1 - I</td>
</tr>
<tr>
<td>Leg 4</td>
<td>1</td>
<td>0</td>
<td>0 - I</td>
<td>1 - I</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 117b) 2-segmented, basal segment twice as long as wide, armed with a smooth seta. Distal segment twice as long as wide, unornamented, armed with outer apical seta and inner spine; apical seta plumose 0.53 times as long as inner spine and 1.4 times as long as smooth seta.

Leg 6 (Fig. 121 d) distinct cuticular plate, armed with 2 unequal smooth spines and 1 long pinnate seta.

**Redescription of male.** Total body length excluding caudal setae 0.6 mm. Habitus (Fig. 121a) relatively slenderer with prosome/urosome ratio 1.5 and greatest width near posterior end of cephalothorax. Body length/width ratio about 1.8. Cephalothorax 2.7 times as wide as genital somite, almost as long as its greatest width, representing 34% of body length. Hyaline fringes of prosomites and fifth pedigerous somite smooth dorsally and ventrally. Genital somite (Fig. 121b) 0.9 times
as long as wide, with serrulate hyaline fringe ventrally. Anal somite with smooth, narrow, slightly concave anal operculum representing 54% of somites width. Anal sinus widely open without ornamentation.

Caudal rami (Fig. 121a) 2.5 times as long as wide, parallel with little space between them and without hairs on inner margin. Implantations of lateral and outermost apical seta not provided with spinules. Tips of inner median apical seta slightly curved.

Antennule (Fig. 121c) 16-segmented, first segment with 3 aesthetasc, 1 aesthetasc each on segments 4 and 16. Setal formula as follows: 8+3ae.4.3.2+ae.1.2.1.1.2.1.1.0.1.1.9+ae. Labrum, mandible, maxillule, maxilliped, and legs 1–5 as in female.

Leg 6 (Fig. 121b) distinct large plate, armed with 1 spine and 2 pinnate setae; the outermost seta 2.7 times as long as middle seta and 1.3 times as inner spine.

**Distribution and Ecology.** *Thermocyclops rylovi* (Smirnov, 1929) was first described from Caucasus, Subsequently, it was also reported from Central Asia (Uzbekistan) (Mirabdullayev and Kumetov, 1997), Iran (Lindberg, 1936, 1942), Afghanistan (Lindberg, 1959), Pakistan (Defaye et al. 1987), India (Lindberg, 1935, Defaye et al., 1987), Australia (Holyńska, 2006), and Cambodia (Holyńska et. al., 2011). In India, it was previously reported by Lindberg (1935) from a municipal reservoir at Pandharpour. In the present study, this species was found to be common in Tamilnadu State of peninsular India. In the material examined the species is accompanied by several calanoids, few cladocerans and rotifers of *Brachionus* species.

**Remarks.** *Thermocyclops rylovi* can be easily recognized by the presence of transverse rows of pits on the ventral surface of the genital double-somite. The only
other Indian species that has similar pits is *T. conspicuus* Lindberg, 1947. *T. rylovi*, however, differs from *T. conspicuus* in having short caudal rami (2.9–3.5) vs. long caudal rami (3.67–3.86); leg 4 intercoxal sclerite with 2 rows of hair-like spinules vs. short spinules; rounded prominences of intercoxal sclerites with 5–6 spinules vs. many spinules. Further, the two species differ from each other in length/width ratios of third endopodal segment of leg 4 as well as the length ratio of inner apical spine to outer apical spine of leg 4.

**Table 21. Morphometric data of Thermocylops rylovi (Smirnov, 1929)**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Total body length in mm</td>
<td>0.8</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome/urosome</td>
<td>1.6</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>0.90</td>
<td>1.20</td>
<td>1.05</td>
</tr>
<tr>
<td>4.</td>
<td>Caudal ramus length: width</td>
<td>2.9</td>
<td>3.6</td>
<td>2.5</td>
</tr>
<tr>
<td>5.</td>
<td>Inner median apical seta: outer median apical seta</td>
<td>1.0</td>
<td>1.30</td>
<td>1.15</td>
</tr>
<tr>
<td>6.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>2.2</td>
<td>2.4</td>
<td>2.3</td>
</tr>
<tr>
<td>7.</td>
<td>Dorsal seta: outermost apical seta</td>
<td>1.6</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>8.</td>
<td>Dorsal seta: caudal ramus</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>9.</td>
<td>Leg 4 enp 3, length: width</td>
<td>2.4</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>10.</td>
<td>Leg 4 enp 3, inner apical spine: outer apical spine</td>
<td>2.4</td>
<td>2.6</td>
<td>2.5</td>
</tr>
<tr>
<td>11.</td>
<td>Leg 4 enp 3, length of segment: inner apical spine</td>
<td>0.9</td>
<td>1.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Key to the identification of Indian species of genus Thermocyclops Kiefer, 1927

1. Tips of terminal median apical setae straight ........................................2
   Tips of terminal median apical setae curved ventrally ..........................6

2. Genital double-somite without ornamentation/pits .................................................3
   Genital double-somite with ornamentation/pits .................................................5

3. Leg 4 endopod 3, inner apical spine less than 2 times as long as outer apical spine,
   leg 4 basis inner margin without spinules .........................................................4
   Leg 4 endopod 3, inner apical spine more than 2 times as long as outer apical spine,
   leg 4 basis inner margin with spinules ......................................................... T. decipiens Kiefer, 1929

4. Leg 4 endopod 3, more than 3 times as long as wide; intercoxal sclerite rounded
   prominences with 3–4 spinules .......................................................... T. vermifer vermifer (Lindberg, 1935)
   Leg 4 endopod 3, less than 3 times as long as wide; intercoxal sclerite rounded
   prominences without spinules .......................................................... T. marmagoensis Sewell, 1957

5. Fifth pedigerous somite with hair like spinules; leg 4 endopod 3, inner apical spine
   more than 1.5 times as long as outer apical spine .................................. T. rylovi (Smirnov, 1929)
   The same with hair like spinules; leg 4 endopod 3, inner apical spine less than 1.5
   times as long as outer apical spine ......................................................... T. conspicuus Lindberg, 1950

6. Lateral arms of seminal receptacle T-shaped ......................................................7
   Lateral arms of seminal receptacle curved posteriorly ...................................... T. maheensis Lindberg, 1941

7. Leg 4 intercoxal sclerite ornamented with 2 rows of hair like spinules ..............
   ............................................................................................................. T. crassus (Fischer, 1853)
   Leg 4 intercoxal sclerite unornamented ....................................................... T. rectus Lindberg, 1937
Genus *Rybocyclops* Dussart, 1982

**Generic diagnosis.** The amended generic diagnosis is provided by Ranga Reddy & Defaye (2008) as follows: small-sized cyclopoids. Body robust with a pseudosomite present between prosome and genital double-somite. Genital double-somite enlarged and anal operculum greatly produced as in *Bryocyclops*. Caudal rami short, antennule 11-segmented. Coxa of leg 1 without a seta at inner margin. Second exopodal segment of legs 1–4 with spine formula 2.2.2.2 and setal formula either 5.4.4.3 or 5.5.5.4; leg 4 with 2-segmented rami in male and 1 or 2-segmented endopod in female. Sexual dimorphism in the armature of second endopodal segment of leg 3 or leg 4. Intercoxal sclerites of legs 1–4 with rounded prominences. Leg 5 reduced to 1 seta inserted on the edge of fifth thoracic segment and 2 others inserted on a very small plate. Leg 6 of male reduced to 2 setae.

*Rybocyclops nagarjuna* n. sp.  
(Figs 123–127)

**Type locality.** Bore well on Acharya Nagarjuna University campus (16°30'38"N, 80°43'05"E; elevation 30 m) Guntur District, Andhra Pradesh, South India. The type locality accesses a groundwater aquifer developed in garnet-sillimanite gneiss (“Khondalite”) bed rock, belonging to the Eastern Ghats group, which is approximately 3,000 M. Y. old.

**Material examined.** Holotype female (MNHN-IU-2013-9854) and allotype male (MNHN-IU-2013-9856) whole-mounted on 1 slide each; paratype female (MNHN-IU-2013-9855) dissected on 8 slides and paratype male (MNHN-IU-2013-9857) dissected on 3 slides; 4 females and 2 males in author’s personal collections; 23 July, 2005; Coll. V. Subhashini.
**Etymology.** The specific epithet alludes to Nagarjuna, a great Buddhist philosopher, after whom the Acharya Nagarjuna University is named; proposed as a noun in the nominative singular standing in apposition to the generic name.

**Diagnosis.** Genital double-somite 0.76 to 0.8 times as long as wide; seminal receptacle with anterior and posterior expansions. Pseudosomite present between prosome and genital double-somite. Anal somite with broad anal operculum, extending up to the posterior end of the somite. Caudal rami 1.5–2.2 times as long as wide. Dorsal seta 2.6–3.2 times as long as caudal ramus. Innermost apical seta 0.5 times as outermost apical seta and inner median apical seta 3.8 times as long as outer median apical seta. Antennule 11-segmented; antennal endopod setal formula 1, 5, 7. Coxa of legs 1 and 4 without inner seta, that of 2 and 3 with plumose seta; basis of leg 1 without spine at inner distal corner. Leg 4 coxa and intercoxal sclerite with ornamentation. Second endopodal segment of leg 4, 1.8 times as long as wide, with 1 apical spine and 2 setae; apical spine 0.7 times as long as segment. Exopodal segment spine formula 2.2.2.2 and setal formula 5.5.5.4. Leg 5 represented by 3 slender setae.

**Description of adult female (Holotype).** Total body length excluding caudal setae 0.45 mm; paratypes 0.41–0.48 mm. Habitus robust (Fig. 123a) dorso-ventrally compressed with prosome/urosome ratio 1.8 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.7. Free pedigerous somites without pronounced lateral expansions. Rostrum developed, membranous and broadly rounded. Cephalothorax 1.2 times as long as wide, representing 40% of total body length and 2.2 times as wide as genital double-somite. Pseudosomite present between prosome and genital double-somite but discernible more clearly in ventral view. Fifth pedigerous somite with smooth fringe dorsally and ventrally.
Genital double-somite (Fig. 123b) 0.8 times as long as wide. Hyaline fringe of genital double-somite and next 2 somites smooth dorsally and ventrally. Seminal receptacle large, clearly divided into anterior and posterior expansions representing 44% of double-somites length. Copulatory pore oval, copulatory duct rigidly sclerotized. Anal somite (Fig. 123c, d) with smooth broad, bowl-shaped anal operculum extending posteriorly, representing 60% of somites width, ornamented with a row of spinules at the base of caudal rami on posterior margin ventrally. Anal sinus widely open without any ornamentation.

Caudal rami (Fig. 123c, d) parallel, close to each other; 1.5 times as long as wide. Dorsal seta 3.2 times as long as caudal ramus, inserted at 5/6 of ramus length, uniarticulate at base and plumose distally. Lateral seta arising on dorsal surface situated at 40% length of caudal ramus and 0.5 times as long as ramus width. Outermost apical seta 0.6 times as long as ramus and spiniform. Innermost apical seta small, slender, plumose 0.4 times as long as outermost apical seta. Principal apical setae plumose without breaking planes; inner median apical seta 3.8 times as long as outer median apical seta and 0.4 times as long as the body. Implantations of lateral and outermost apical seta not provided with spinules.

Antennule (Fig. 124a) reaching middle of cephalothorax, 11-segmented with 1 slender aesthetasc each on segments 8 and 11 and setal formula as follows: 7.2.5.1.1.3.3.2+ae.2.2.7+ae. First segment with an arched row of spinules.

Antenna (Fig. 124b) 4-segmented, consisting of coxobasis and 3-segmented endopod. Coxobasis 2.7 times as long as wide, ornamented with a row of spinules along outer and inner margins proximally, an arched row of spinules medially on caudal surface; armed with 1 smooth seta at distal inner corner, exopod absent. First endopodal segment 1.6 times as long as wide, armed with 1 smooth seta on inner
margin and ornamented with 1 row of spinules on outer margin; second endopodal segment 2.1 times as long as wide, ornamented with 1 row of spinules along outer margin and armed with 5 setae; third endopodal segment 2.5 times as long as wide armed with 7 apical setae and ornamented with 1 row of spinules along outer margin.

Labrum (Fig. 124c) trapezoidal, anterior edge nearly straight with 17 small teeth, between produced rounded lateral corners, ornamented with 2 groups of 4 hair-like spinules.

Mandible (Fig. 125d) without ornamentation, consisting of gnathobase and a small palp. Cutting edge with 9 teeth and 1 outermost unipinnate seta; palp unornamented, armed with 2 long and 1 short smooth setae.

Maxillule (Fig. 125a, b) composed of well-developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines, 1 smooth seta at their base on ventral surface. Praecoxa with 6 armature elements along inner margin, longest one plumose. Palp apically bearing 2 slender setae and 1 robust unipinnate spine; endopod distinct, bearing 2 apical and 1 subapical setae; exopodal seta smooth.

Maxilla (Fig. 125c) longer, 5-segmented, composing of praecoxa, coxa, basis and 2 segmented endopod. Praecoxa unornamented, with elongated proximal endite, armed with 2 long pinnate setae, distal endite small, unarmed. Proximal endite of coxa with 1 short smooth seta, distal endite elongate and armed apically with 2 unequal smooth setae. Basis expanded into robust claw, ornamented with longitudinal row of spinules along inner margin and armed with 2 setae; strong seta slightly shorter than claw, short seta at its base. Endopod 2-segmented, proximal segment armed with 1 unipinnate and 1 smooth seta, distal segment with 1 robust unipinnate apical seta and 2 slender, smooth subapical setae.
Maxilliped (Fig. 124d) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa unornamented, 2.6 times as long as wide, armed with 2 pinnate setae, distal seta stronger and about 1.5 times as long as proximal one. Basis 1.8 times as long as wide, ornamented with 4 to 5 long spinules along middle inner margin, a few spinules on distal outer corner, armed with 2 setae, distal seta 1.5 times as long as proximal seta. First endopodal segment ornamented with few spinules at outer margin, armed with 1 strong bipinnate seta. Second endopodal segment small, unornamented, with 2 pinnate setae, inner seta about 1.1 times as long as outer seta.

Legs 1–4 (Fig. 126a–d) with 2-segmented exopod and endopod. Coxa of legs 1–3 unornamented, that of leg 4 with 2 rows of spinules at medial distal inner corner, and an oblique row of spinules at proximal outer corner. Coxa of legs 1 and 4 without seta, but legs 2 and 3 with plumose seta along inner corner. Intercoxal sclerites of legs 1–4 ornamented with 2 groups of hair-like spinules distally, and that of leg 4 with few median spinules on posterior surface. Second exopodal segment spine formula 2.2.2.2 and setal formula 5.5.5.4. Basis of legs 1–4 with rounded inner corner ornamented with group of hairs and armed with an outer plumose seta. Exopodal and endopodal setae slender and plumose. Second endopodal segment of leg 4, 1.8 times as long as wide, with 1 apical spine and 2 setae; apical spine 0.7 times as long as segment, 1 more inner seta not present. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>0-0</td>
<td>0-1</td>
<td>0-1</td>
<td>4, 1+I, 1</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1-0</td>
<td>0-1</td>
<td>0-1</td>
<td>4, 1+I, 1</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1-0</td>
<td>0-1</td>
<td>0-1</td>
<td>4, 1+I, 1</td>
</tr>
<tr>
<td>Leg 4</td>
<td>0-0</td>
<td>0-1</td>
<td>0-1</td>
<td>3, 1+I, 1</td>
</tr>
</tbody>
</table>

186
Leg 5 (Fig. 123b) completely fused to somite and represented by 3 slender setae; basal seta on small protuberance; 2 other setae representing ancestral distal segment almost equal in length, but shorter than basal seta.

Leg 6 composed of small plate bearing 2 tiny spinules.

**Description of adult male (Allotype).** Total body length excluding caudal setae 0.4mm. Habitus (Fig. 127a) slenderer, with prosome/urosome ratio 1.8 and greatest width at posterior end of cephalothorax. Body length/width ratio about 3. Cephalothorax 2 times as wide as genital somite, 1.1 times as long as its greatest width, representing 38% of body length. Hyaline fringe of fifth pedigerous somite smooth and next 3 urosomites smooth dorsally and ventrally.

Genital somite (Fig. 127 b) 0.7 times as long as wide. Anal somite with smooth, broad, bowl-shaped anal operculum, reaching the posterior end of somite, with transverse rows of spinules on posterior margin ventrally. Caudal rami parallel 1.8 times as long as wide. Armature and ornamentation as in female.

Antennule (Fig. 127c) 15-segmented, with 2 aesthetascs on segment 1 and 1 each on segments 9 and 15. Armature formula as follows: 8+2ae.3.2.1.3.3.1.1.1+ae.3.1.1.1.3.7+ae. Antenna, labrum, mandible, maxilla and maxilliped and legs 1–3 similar as in female.

Leg 4 second endopodal segment 1.7 times as long as wide and with 1 additional seta on inner margin as compared with the condition in the female. Leg 5 as in female.

Leg 6 (Fig. 127 b) with flat flaps armed with 2 spines, inner spine 1.6 times as long as outer.
Distribution and Ecology. As of now, this stygobiotic new species is not known outside its type locality. At the type locality, it was accompanied by strays of *Paracyclops fimbriatus* (Fischer, 1853) and some unidentified water mites.

Discussion. The genus *Rybocyclops* was established as a subgenus of the *Bryocyclops* Kiefer, 1927. Lindberg (1956) defined the V group (out of six groups) to elucidate the status of the genus *Bryocyclops* on the basis of the Madagascan *Bryocyclops pauliani* (Lindberg, 1954). Subsequently Dussart (1982) described it as *R. pauliani* and listed this species as such in the World Directory of Dussart & Defaye (2006). Prior to this, Dussart & Defaye (2001) elevated the subgenus *Rybocyclops* Dussart, 1982 to the generic status.

The closely allied genera, viz. *Bryocyclops* Kiefer, 1927, *Palaeocyclops* Monchenko, 1972, *Haplocyclops* (Kiefercyclops) Karanovic & Ranga Reddy, 2005, and *Speocyclops* Kiefer, 1937 share the following characters: 11 segmented antennule; legs 1–4 with bi-segmented rami; and leg 5 bearing 3 setae, the inner two inserted on a small protuberance. Above all, *Haplocyclops* and *Rybocyclops* are more closely related to each other than to any other genus (Fiers, 2002; see Ranga Reddy & Defaye, 2008).

Leg 5 is represented by only 3 setae, one of which is basal and the remaining two setae located on a small protuberance which is not distinct at base, perhaps a synapomorphy of the closely allied *Bryocyclops* Kiefer, 1927; *Stolonicyclops* Reid & Spooner, 1998, and *Haplocyclops* Kiefer, 1952.

The second species added to this genus is *Rybocyclops dusartti* Ranga Reddy & Defaye, 2008 was reported from a roadside agricultural bore well, 1 km from Chollaveedu village, Prakasam district, Andhra Pradesh, South India. Subsequently,
no other species have been added to the genus. *Rybocyclops nagarjuna n. sp.* is thus the third species of the genus, which is also from a bore-well in Andhra Pradesh.

The new species is assigned to the genus *Rybocyclops* as it fulfills all the generic criteria as defined and amended by Ranga Reddy & Defaye (2008). Compared with its two known congeners, the new species has closest affinity with its Indian *R. dussarti* as evident from the following characters: i) sexual dimorphism on leg 4 second endopodal segment; ii) length/width proportion of the female genital double-somite; iii) extended anal operculum; iv) dorsal seta longer than outer median seta; v) lateral seta short and dorsal in position; vi) principal apical setae without breaking planes. *Rybocyclops nagarjuna n. sp.* however, is distinctly different from *R. dussarti* in length/width ratios of: i) caudal ramus, genital double-somite, innermost caudal seta to outermost caudal seta; terminal median inner seta to terminal median outer seta; ii) armature formula of antennule, iii) presence vs. absence of mandibular palp, iv) presence vs. absence of spinules on leg 4 coxa; and v) strong spine on second endopodal segment of leg 1 vs. normal spine.

*R. nagarjuna n. sp.* differs from the type species, *R. pauliani* Dussarti, 1982, in the following salient features: i) complete vs. incomplete septum between first and second endopodal segments of leg 4; ii) length/width ratios of: caudal rami, dorsal seta to caudal ramus, and terminal median inner seta to terminal median outer seta; iii) shape of seminal receptacle and anal operculum; iv) exopodal setal formula 5.5.5.4 vs.5.4.4.3.
**Rybcyclops sagileru n. sp.**
(Figs 128–132)

**Type locality.** River Sagileru, Uyyalawada village (16º22'34"N, 80º31'34"E; elevation c.37 m) in Kurnool district, Andhra Pradesh. Sagileru is a small river, a tributary of the Penna River in southern India, originating in the Nallamalai hills, and flowing in the north-south direction. The river basin has red, black and loamy soils.


**Other localities.** None.

**Etymology.** The specific name, alluding to the River Sagileru, the habitat of occurrence of the new species, is proposed as a noun in apposition to the generic name; the name is in singular masculine genitive.

**Diagnosis.** Genital double-somite 0.9 times as long as wide; seminal receptacle with small anterior and large posterior expansions. Anal somite with smooth, broad, bowl-shaped anal operculum extending posteriorly beyond somites length. Caudal rami 1.6 times as long as wide. Dorsal seta thrice as long as caudal ramus. Lateral seta dorsal in position, situated at 42% of the length of caudal ramus. Innermost apical seta 0.7 times as outermost apical seta; inner median apical seta 2.8 times as long as outer median apical seta. Antennule 11-segmented, with aesthetascs; setal formula of endopod of antenna 1, 5, 7. Coxa of legs 1 and 4 without inner seta, that of 2 and 3 with plumose seta; basis of leg 1 without spine at inner distal corner; endopodal spine longer and stouter. No ornamentation on the intercoxal sclerites of legs 1–4. Second endopodal segment of leg 4, 1.8 times as long as wide, with 1 apical spine and 2 setae; apical spine almost as long as segment. Sexual dimorphism in the
armature of second endopodal segment of leg 4; females 1 apical spine and 2 setae, (inner seta absent) in males 1 apical spine and 3 setae. Second exopodal segment spine formula 2.2.2.2 and setal formula 5.5.5.4. Leg 5 represented by 3 slender setae.

**Description of adult female (Holotype).** Total body length excluding caudal setae 0.38mm. Habitus somewhat robust (Fig. 128a) dorso-ventrally compressed with prosome/urosome ratio 1.7 and greatest width near posterior end of cephalothorax. Body length/width ratio 3.1. Free pedigerous somites without pronounced lateral expansions. Rostrum membranous and broadly rounded. Cephalothorax 1.2 times as long as wide representing 37% of total body length and 1.7 times as wide as genital double-somite. Fifth pedigerous somite with smooth fringe dorsally and ventrally.

Genital double-somite (Fig. 128b) 0.9 times as long as wide. Hyaline fringe of genital double-somite and succeeding 2 somites smooth dorsally and ventrally. Seminal receptacle large, clearly divided into small anterior and large posterior expansions representing 30% of double somite’s length. Copulatory pore round, copulatory duct sclerotized. Anal somite (Fig. 128c, d) with smooth, bowl-shaped anal operculum, extending posteriorly beyond the somites length representing 67% of somites width, ornamented with 1 row of spinules at the base of caudal rami on posterior margin ventrally. Anal sinus widely open without any ornamentation.

Caudal rami (Fig. 128c, d) parallel, close to each other 1.6 times as long as wide. Dorsal seta 3 times as long as caudal ramus, inserted at 5/6 of ramus length, uniarticulate at base and plumose distally. Lateral seta arising on dorsal surface, situated at 42% of the length of caudal ramus, 0.5 times as long as ramus width. Outermost apical seta 0.8 times as long as ramus and spiniform. Innermost apical seta, small slender, plumose 0.7 times as outermost apical seta. Principal apical setae plumose without breaking planes; inner median apical seta 2.8 times as long as outer
median apical seta and 0.5 times as long as the body. Implantations of lateral and outermost apical seta not provided with spinules.

Antennule (Fig. 129a) reaching 2/3 of cephalothorax, 11-segmented with 1 slender aesthetasc each on segments 9 and 11 and setal formula as follows. 7.3.5.2.1.2.3.2+ae.2.2.7+ae. First segment with an arched row of spinules.

Antenna (Fig. 129b) 4-segmented, consisting of coxobasis and 3-segmented endopod. Coxobasis 1.7 times as long as wide, unornamented, armed with 1 smooth seta at distal inner corner, exopod absent. First endopodal segment 1.2 times as long as wide, armed with 1 smooth seta on inner margin and ornamented with 1 row of spinules on outer margin; second endopodal segment 1.8 times as long as wide, armed with 5 setae; third endopodal segment 2.1 times as long as wide, armed with 7 apical setae and ornamented with a row of spinules along outer margin.

Labrum (Fig. 129c) trapezoidal, unornamented, anterior edge nearly straight with 17 small teeth between produced rounded lateral corners.

Mandible (Fig. 130a) without ornamentation consisting of small palp. Cutting edge with 7 teeth, 1 outermost unipinnate seta; palp armed with 2 long smooth setae, small seta not visible.

Maxillule composed of well developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines, one smooth seta at their base on ventral surface, 6 armature elements along inner margin, longest one plumose. Palp (Fig. 130b) apically bearing 2 slender setae and 1 robust bipinnate spine; endopod distinct, bearing 2 apical and 1 subapical setae; exopodal seta smooth.

Maxilla (Fig. 130c) 5-segmented, praecoxa unornamented with elongated proximal endite, armed with 2 long pinnate setae, distal endite small, unarmed. Proximal endite of coxa with 1 short smooth seta, distal endite elongate and armed
apically with 2 unequal smooth setae. Basis expanded into a robust claw, ornamented with a longitudinal row of spinules along inner margin and armed with 2 setae; strong seta almost as long as claw, unornamented, short seta at its base. Endopod 2-segmented, proximal segment armed with 1 unipinnate and 1 smooth seta, distal segment armed with 1 unipinnate apical seta and 2 slender smooth subapical setae.

Maxilliped (Fig. 130d) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa unornamented 2.2 times as long as wide, armed with 2 short pinnate setae, distal seta 1.4 times as long as proximal one. Basis 1.5 times as long as wide, ornamented with 4 long spinules along middle inner margin, armed with 2 setae, distal seta 1.4 times as long as proximal seta. First endopodal segment unornamented and armed with 1 strong bipinnate seta. Second endopodal segment small, unornamented, armed with 1 strong bipinnate seta. Third endopodal segment small, unornamented armed with 2 pinnate setae, inner seta 1.3 times as long as outer seta.

Legs 1–4 (Fig. 131a–d) with 2-segmented exopod and endopod. Coxa of legs 1–3 unornamented, that of leg 4 ornamented with a few spinules at inner median distal corner and 1 arched row at outer proximal region; coxa of legs 1 and 4 without inner seta; legs 2 and 3 with plumose seta along inner edge. Intercoxal sclerites of legs 1–4 unornamented with rounded prominences. Second exopodal segment spine formula 2.2.2.2 and setal formula 5.5.5.4. Basis of legs 1–4 with rounded inner corners ornamented with group of hairs and armed with an outer plumose seta. Exopodal and endopodal setae slender and plumose. Leg 1 second endopodal segment apical spine somewhat longer and stouter than the remaining legs. Second endopodal segment of leg 4 almost as long as wide, with 1 apical spine and 2 setae; apical spine almost as long as segment; 1 more inner seta absent. Legs 1–4 armature formula as follows: (legend:
inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):

<table>
<thead>
<tr>
<th></th>
<th>Coxa</th>
<th>Basis</th>
<th>Exopod</th>
<th>Endopod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg 1</td>
<td>0-0</td>
<td>0-1</td>
<td>1</td>
<td>4, 1+I, I</td>
</tr>
<tr>
<td>Leg 2</td>
<td>1-0</td>
<td>0-1</td>
<td>1</td>
<td>4, 1+I, I</td>
</tr>
<tr>
<td>Leg 3</td>
<td>1-0</td>
<td>0-1</td>
<td>1</td>
<td>4, 1+I, I</td>
</tr>
<tr>
<td>Leg 4</td>
<td>0-0</td>
<td>0-1</td>
<td>3</td>
<td>1+I, I</td>
</tr>
</tbody>
</table>

Leg 5 (Fig. 128b) completely fused to somite and represented by 3 slender setae; basal seta on small protuberance; 2 other setae representing ancestral distal segment, almost equal in length, but shorter than basal seta.

Leg 6 composed of small plate bearing 2 tiny spinules.

**Description of adult male (Allotype).** Total body length excluding caudal setae 0.34mm. Habitus (Fig. 132a) slenderer than in female with prosome/urosome ratio 1.8 and greatest width at posterior end of cephalothorax. Body length/width ratio about 3.1. Cephalothorax twice as wide as genital somite and 1.2 times as long as its greatest width, representing 38% of body length. Hyaline fringe of fifth pedigerous somite and succeeding urosomites smooth dorsally and ventrally.

Genital somite (Fig. 132b) 1.4 times as long as wide. Anal somite with smooth, broad bowl-shaped anal operculum, reaching the posterior end of somite, with transverse row of spinules on posterior margin ventrally. Caudal rami parallel, 1.5 times as long as wide. Armature and ornamentation similar as in female.

Antennule (Fig. 132c) 15-segmented, with 2 aesthetascs on segment 1 and 1 each on segments 9 and 15; armature formula as follows: 8+2ae.4.2.1.2.2.1.0.2+ae.1.1.2.1.3.7+ae. Antenna, labrum, mandible, maxilla and maxilliped and legs 1–3 as in female.
Leg 4 second endopodal segment 1.6 times as long as wide, apical spine 0.8 times as segment; with 1 additional seta on inner margin than that of female; leg 5 similar to female.

Leg 6 (Fig. 136b) with cuticular plate armed with 2 spines; inner spine 1.5 times as long as outer.

**Distribution and ecology.** The new species has not been recorded from any other locality than its type locality. It is collected from a hyporheic, interstitial zone.

**Discussion.** *R. sagileru n. sp.* has closest affinity with *R. nagarjuna n. sp.* as borne out by the following characters: i) sexual dimorphism on leg 4 second endopodal segment; ii) length/width proportion of: a) female genital double-somite, b) caudal rami, and c) dorsal seta to caudal ramus; iii) shape and extension of anal operculum; iv) lateral seta short and dorsal in position; and v) principal apical setae without breaking planes.

*R. sagileru n. sp.*, however, is distinctly different from *R. nagarjuna n. sp.* in certain subtle characters as follows: i) length/width ratios of: a) innermost apical seta to outermost apical seta, b) inner median apical seta to outer median apical seta, and c) leg 4 second endopodal segment apical spine to length of the segment; ii) armature formula of antennule; iii) leg 1 second endopodal segment armed with strong vs. normal apical spine.

*R. sagileru n. sp.* differs from the type species, *R. pauliani* Dussarti, 1982, in the following salient features: i) complete vs. incomplete septum between first and second endopodal segments of leg 4; ii) length/width ratios of: a) caudal rami, b) dorsal seta to caudal ramus; and c) inner median apical seta to outer median apical seta; iii) shape of seminal receptacle and anal operculum; iv) exopodal setal formula 5.5.5.4 vs. 5.4.4.3. In *R. pauliani*, whether sexual dimorphism in the armature
elements of the second endopodal segment of leg 4 exists or not is unknown because of its incomplete description.

*Rybocyclops gunturensis* n. sp.
(Figs 133–137)

**Type Locality.** Domestic bore-well in Guntur town (16°18'51"N, 80°26'06"E; elevation 33 m) Guntur District, Andhra Pradesh, South India.

**Material Examined.** Holotype female (MNHN-IU-2013-9860) and allotype male (MNHN-IU-2013-9862) whole-mounted on 1 slide each; paratype female (MNHN-IU-2013-9861) dissected on 10 slides and paratype male (MNHN-IU-2013-9863) dissected on 3 slides; 2 females and 1 male in author’s personal collections; 05 September 2005: Coll. Y. Ranga Reddy.

**Etymology.** The specific name is derived from the place of occurrence of the new species, viz. Guntur town; the name is an adjective for place, made with the Latin suffix “-ensis”.

**Diagnosis.** Genital double-somite 0.9 times as long as wide. Seminal receptacle with small anterior and large posterior expansions. Pseudosomite present between prosome and urosome. Anal somite with smooth, broad, elongated anal operculum, extending beyond the somites length. Caudal rami 1.4–2.0 times as long as wide. Dorsal seta twice as long as caudal ramus. Lateral seta dorsal in position situated at 40% of the length of caudal ramus. Innermost apical seta 0.6 times as outermost apical seta; inner median apical seta 2.5 times as long as outer median apical seta. Antennule 11-segmented, without aesthetascs; setal formula of endopod of antenna 1, 5, 7. Coxa of legs 1 and 4 without inner seta, that of 2 and 3 with plumose seta; basis of leg 1 without spine at inner distal corner. Coxa of leg 4 ornamented with a few spinules that of remaining legs without ornamentation. Intercoxal sclerites of
legs 1–4 without ornamentation. Second endopodal segment of leg 4, 1.4 times as long as wide, with 1 apical spine and 3 setae; apical spine 0.8 times as long as segment. Armature formula of leg 4 is similar in both males and females; sexual dimorphism not observed.

**Description of adult female (Holotype).** Total body length excluding caudal setae 0.39 mm. Habitus somewhat robust (Fig. 133a) dorso-ventrally compressed with prosome/urosome ratio 1.7 and greatest width near posterior end of cephalothorax. Body length/width ratio 2.7. Free pedigerous somites without pronounced lateral expansions. Rostrum well developed, membranous and broadly rounded. Cephalothorax almost as long as wide, representing 38% of total body length and 1.8 times as wide as genital double-somite. Pseudosomite present between prosome and genital double-somite, but discernible more clearly in ventral view. Fifth pedigerous somite with smooth fringe dorsally and ventrally.

Genital double-somite (Fig. 133b) 0.9 times as long as wide. Hyaline fringe of genital double-somite and succeeding 2 somites smooth dorsally and ventrally. Seminal receptacle large, clearly divided into anterior and posterior expansions representing 24% of double-somites length. Copulatory pore oval in shape, copulatory duct rigidly sclerotized. Anal somite with much elongated anal operculum, extending posteriorly beyond the somites length, representing 56% of somites width, ornamented with spinules at base of caudal rami ventrally. Anal sinus widely open without any ornamentation.

Caudal rami (Fig. 133c, d) parallel, 1.6 times as long as wide. Dorsal seta 2.1 times as long as caudal ramus, inserted at 5/6 of ramus length and plumose distally. Lateral seta dorsal in position, situated at 40% length of caudal ramus, 0.5 times as long as ramus width. Outermost apical seta 0.7 times as long as ramus and spiniform.
Innermost apical seta, small, slender, 0.6 times as long as outermost apical seta. Principal apical setae plumose without breaking planes; inner median apical seta 2.5 times as long as outer median apical seta and 0.5 times as long as the body. Implantations of lateral and outermost apical setae not provided with spinules.

Antennule (Fig. 134a) reaching two thirds of cephalothorax, 11-segmented, without aesthetases and setal formula as follows: 6.2.4.1.1.3.2.2.3.7.

Antenna (Fig. 134b) 4-segmented, consisting of coxobasis and 3-segmented endopod. Coxobasis 2.4 times as long as wide, unornamented, armed with a smooth seta at distal inner corner; exopod absent. First endopodal segment 1.7 times as long as wide, armed with a smooth seta on inner margin and ornamented with 1 row of spinules on outer margin; second endopodal segment 1.7 times as long as wide, also ornamented with 1 row of spinules along outer margin and armed with 5 setae; third endopodal segment 2.3 times as long as wide, armed with 7 apical setae and ornamented with a row of spinules along outer margin.

Labrum (Fig. 134c) anterior edge nearly straight with 18 small teeth, between produced rounded lateral corners, unornamented.

Mandible (Fig. 135a) without ornamentation and palp. Cutting edge with 9 teeth and 1 outermost unipinnate seta.

Maxillule (Fig. 135b) composed of well-developed praecoxa and 2-segmented palp. Arthrite of praecoxa with 3 strong apical spines, and 6 armature elements along inner margin, longest one plumose. Palp with 2 slender setae and 1 robust unipinnate spine; endopod distinct, bearing 2 apical and 1 subapical smooth seta; exopodal seta smooth.

Maxilla (Fig. 135c) 5-segmented, with elongate proximal endite, armed with 2 long pinnate setae, distal endite small, unarmed. Proximal endite of coxa with 1 short
smooth seta, distal endite elongate and armed apically with 2 unequal smooth setae. Basis expanded into claw, ornamented with longitudinal row of spinules along inner margin and armed with a smooth seta, longer than claw. Endopod 2-segmented, proximal segment armed with 2 smooth setae, distal segment armed with 1 robust unipinnate apical seta and 2 slender, smooth subapical setae.

Maxilliped (Fig. 135d) 4-segmented, composed of syncoxa, basis and 2-segmented endopod. Syncoxa unornamented, 1.5 times as long as wide, armed with 2 pinnate setae, distal seta stronger and longer, about 1.4 times as long as proximal one. Basis 1.4 times as long as wide, unornamented, armed with 2 setae, distal seta 1.5 times as long as proximal seta. First endopodal segment unornamented, armed with 1 strong bipinnate seta. Second endopodal segment small, unornamented, armed with 2 pinnate setae, inner seta about 1.3 times as long as outer seta.

Legs 1–4 (Fig. 136a–d) with 2-segmented exopod and endopod. Coxa of legs 1–3 unornamented, that of leg 4 with few spinules at inner median distal corner; coxa of legs 1 and 4 without inner seta, legs 2 and 3 with plumose seta along inner corner. Intercoxal sclerites of legs 1–4 unornamented with rounded prominences. Second exopodal segment spine formula 2.2.2.2 and setal formula 5.5.5.4. Basis of legs 1–4 with rounded inner margin ornamented with group of hairs and armed with outer plumose seta. Exopodal and endopodal setae slender and plumose; exopodal spines relatively small. Second endopodal segment of leg 4, 1.4 times as long as wide, with 1 apical spine and 3 setae; apical spine 0.8 times as long as segment. Legs 1–4 armature formula as follows: (legend: inner/outer spine or seta; inner/terminal/outer); (Roman numerals = spines; Arabic numerals = setae):
Leg 5 (Fig. 133b) completely fused to somite, represented by 3 slender setae; basal seta on small protuberance; 2 other setae representing ancestral distal segment, almost equal in length, but shorter than basal seta.

Leg 6 composed of small plate bearing 2 tiny spinules.

**Description of adult male (Allotype).** Total body length excluding caudal setae 0.29mm Habitus (Fig. 137a) slenderer than in female with prosome/urosome ratio 1.5 and greatest width at posterior end of cephalothorax. Body length/width ratio about 3. Cephalothorax 1.8 times as wide as genital somite. Cephalothorax 1.8 times as long as its greatest width, representing 39% of body length. Hyaline fringe of fifth pedigerous somite and succeeding urosomites smooth dorsally and ventrally.

Genital somite (Fig. 137b) 0.7 times as long as wide. Anal somite with smooth, broad, much elongated anal operculum, extending posteriorly beyond somites length, with a transverse row of spinules at base of caudal rami on posterior margin ventrally. Caudal rami parallel, 1.6 times as long as wide. Armature and ornamentation as in female.

Antennule (Fig. 137c) 15-segmented, unornamented, aesthetascs not visible and armature formula as follows: 8.2.1.0.1.2.0.1.0.1.1.0.0.7. Antenna, labrum, mandible, maxilla and maxilliped and legs 1–4 similar to female. (Fig. 137d). Sexual dimorphism not observed in the legs of female and male. Leg 5 similar to female.

Leg 6 (Fig. 137b) with 2 spines, inner spine 1.2 times as long as outer spine.

**Distribution and ecology.** As of now, the new species is known only from the phreatic waters of its type locality. It was accompanied by strays of unidentified
species of the genus *Parastenocaris* (Copepoda, Harpacticoids) and water mites (Acari).

**Discussion.** Compared with its congeners, *Rybecyclops gunturensis* n. sp. is close to *Rybecyclops nagarjuna* n. sp. in the body being robust, almost similar in: i) length/width ratios of: a) the female genital double-somite, b) the caudal rami, c) the innermost apical seta to outermost apical seta, and ii) the unmodified spine on the leg 1 second endopodal segment. The new species also has closest affinity with its Indian congener *R. dussarti* as evident from the following characters: i) length/width proportion of the female genital double-somite; ii) extended anal operculum; iii) dorsal seta longer than outer median seta; iv) lateral seta short and dorsal in position; v) principal apical setae without breaking planes. However, it differs from it in the absence of sexual dimorphism. The various details in which this species is distinct from all its congeners are outlined in Table. 22.
Table. 22. Comparison of morpho-taxonomic characters of *Rybocyclops* species

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Character</th>
<th><em>R. nagarjuna</em> n. sp.</th>
<th><em>R. sagileru</em> n. sp.</th>
<th><em>R. gunturensis</em> n. sp.</th>
<th><em>R. dussarti</em></th>
<th><em>R. pauliani</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Body length in mm</td>
<td>0.40 – 0.50</td>
<td>0.38</td>
<td>0.35–0.40</td>
<td>0.38</td>
<td>0.42–0.44</td>
</tr>
<tr>
<td>2.</td>
<td>Prosome: urosome</td>
<td>2.7</td>
<td>3.1</td>
<td>2.7</td>
<td>2.8</td>
<td>-----------</td>
</tr>
<tr>
<td>3.</td>
<td>Genital double-somite length: width</td>
<td>1.80</td>
<td>1.70</td>
<td>1.40</td>
<td>1.80</td>
<td>0.85</td>
</tr>
<tr>
<td>4.</td>
<td>Cephalothorax length: width</td>
<td>1.1</td>
<td>1.2</td>
<td>1.0</td>
<td>1.2</td>
<td>-----------</td>
</tr>
<tr>
<td>5.</td>
<td>Genital somite length: width</td>
<td>0.8</td>
<td>0.9</td>
<td>0.9</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>6.</td>
<td>Caudal ramus length: width</td>
<td>1.5 – 2.2</td>
<td>1.6</td>
<td>1.6</td>
<td>2</td>
<td>2.0–2.5</td>
</tr>
<tr>
<td>7.</td>
<td>Anal operculum</td>
<td>bowl-shaped</td>
<td>bowl-shaped</td>
<td>elongated</td>
<td>bowl-shaped</td>
<td>bifurcate at post. end</td>
</tr>
<tr>
<td>8.</td>
<td>Dorsal seta: caudal ramus</td>
<td>3.1</td>
<td>3</td>
<td>2.1</td>
<td>3</td>
<td>equal</td>
</tr>
<tr>
<td>9.</td>
<td>Position of lateral seta</td>
<td>40% of caudal ramus length</td>
<td>42% of caudal ramus length</td>
<td>40% of caudal ramus length</td>
<td>42% of caudal ramus length</td>
<td>50% of caudal ramus length</td>
</tr>
<tr>
<td>10.</td>
<td>Innermost apical seta: outermost apical seta</td>
<td>0.44</td>
<td>0.66</td>
<td>0.52</td>
<td>0.66</td>
<td>0.42</td>
</tr>
<tr>
<td>11.</td>
<td>Outermost apical seta: caudal rami</td>
<td>0.60 - 0.80</td>
<td>0.85</td>
<td>0.80</td>
<td>0.80</td>
<td>0.63</td>
</tr>
<tr>
<td>12.</td>
<td>Innermost apical seta: caudal rami</td>
<td>0.28 – 0.37</td>
<td>0.60</td>
<td>0.35– 0.56</td>
<td>0.42</td>
<td>0.36</td>
</tr>
<tr>
<td>13.</td>
<td>Inner median apical seta: outer median seta</td>
<td>3.8</td>
<td>2.8</td>
<td>2.5</td>
<td>4.5</td>
<td>1.8</td>
</tr>
<tr>
<td>14.</td>
<td>Antennule armature formula</td>
<td>7.2.5.1.1.3.2.2+ae.2.2.7</td>
<td>6.3.4.2.12.3.2+ae.2.2.7</td>
<td>6.2.4.1.1.13.2.2.3.7</td>
<td>6.3.4.1.1.13.2.2.7</td>
<td>-----------</td>
</tr>
<tr>
<td>15.</td>
<td>Aesthetascs</td>
<td>present</td>
<td>present</td>
<td>absent</td>
<td>absent</td>
<td>-----------</td>
</tr>
<tr>
<td>16.</td>
<td>Armature on coxobasis of antenna</td>
<td>present</td>
<td>absent</td>
<td>absent</td>
<td>absent</td>
<td>-----------</td>
</tr>
<tr>
<td>17.</td>
<td>Spine on second endopodal segment of leg 1</td>
<td>normal</td>
<td>large</td>
<td>normal</td>
<td>normal</td>
<td>large</td>
</tr>
<tr>
<td></td>
<td>Leg 4 enp 2 length: width</td>
<td>Leg 4, apical spine: length of segment</td>
<td>Leg 4 enp 2, number of spines and setae</td>
<td>Sexual dimorphism of leg 4</td>
<td>Ornamentation on coxa and intercoxal sclerite of leg 4</td>
<td>Exopodal setal formula</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
<td>--------------------------</td>
<td>-----------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>20.</td>
<td>1.8</td>
<td>1.8</td>
<td>1.35</td>
<td>2.5</td>
<td>single segment</td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>0.66</td>
<td>1.0</td>
<td>0.84</td>
<td>1.0</td>
<td>2.5 (single segment)</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>1: 2</td>
<td>1: 2</td>
<td>1: 3</td>
<td>1: 2</td>
<td>1: 3 (Single segment)</td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>present</td>
<td>present</td>
<td>absent</td>
<td>present</td>
<td>not known</td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>present</td>
<td>present only on coxa</td>
<td>present only on coxa</td>
<td>absent</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>5.5.5.4</td>
<td>5.5.5.4</td>
<td>5.5.5.4</td>
<td>5.5.5.4</td>
<td>5.4.4.3</td>
<td></td>
</tr>
</tbody>
</table>

**Key to the identification of the Indian species of genus *Rybocyclops* Dussart, 1982**

1. Sexual dimorphism in leg 4; anal operculum bowl shaped …………………… …………………… ……………………2

   The same absent in leg 4; anal operculum elongated…………………… *Rybocyclops gunturensis* n. sp.

2. Inner median apical seta less than 4 times as long as outer median apical seta………3

   The same more than 4 times as long as outer seta……………… *Rybocyclops dussarti*    Ranga Reddy & Defaye, 2008

3. Terminal spine on leg 1 enp 2 normal ………………… *Rybocyclops nagarjuna* n. sp.

   Terminal spine on leg 1 enp 2 normal ………………… *Rybocyclops sagileru* n. sp.
EVALUATION OF MORPHO-TAXONOMIC CHARACTERS AND THEIR STATES

Analysis of morphological characters forms the basis of taxonomical categorization. Attention is given to morphological characters in cyclopoids for identification of a species, discriminating between closely related species or for suggesting relationships. If a given species is likely to be a new one, its general position is determined by observing as many characters as possible and by comparing them with those of the nearest known relatives, usually with reference to the type material. On the basis of the present study, an attempt is made to evaluate the taxonomic/ecologic significance of the whole gamut of the morphological characters and their diverse states within the Indian cyclopoid taxa. Such an appraisal becomes all the more important, given the fact that at least some of the morphologic characters, especially micro-characters which are generally ignored while characterizing new species, are now found to be useful in discriminating the species.

**Body size.** Among cyclopoids females are always more robust than males. A look at the body size spectrum of Indian cyclopoids shows that *Cyclops, Mesocyclops* and *Megacyclops* are the largest species, the body length of females in these species reaching a maximum of 1.8–2.0 mm. *Thermocyclops* comes next with a mean length of 1.2–1.4 mm. followed by *Metacyclops, Paracyclops* and *Eucyclops* reaching a maximum, of 0.8–1.2 mm. All other taxa are less than 0.8 mm; the minimum body size was observed in *Rybocyclops* spp., measuring about 0.3 mm.

Body size is an important regulator of the interactions between consumers and their resources in aquatic ecosystems (Paine 1976, Yodzis and Innes 1992). It is particularly important because there is a regular and progressively increasing size spectrum in pelagic food webs (Sheldon et.al 1972). Both temperature and food may play a role in this seasonal variation, though individual growth rates may be
constrained independently of external environmental factors (Thorp et al., 2009; Lin et. al., 2012).

Body size in cyclopoids reveals sexual dimorphism, which is more pronounced than in diaptomids or harpacticoids. Cyclopoids have a mean female: male body length ratio of 1.4 while for diaptomids the ratio is 1.3 (Thorp et al. 2009). According to Marten & Reid (2007), only the larger copepod species with a body length of more than 1.4 mm are of practical use for mosquito control. The most effective species have the capacity to kill more than 40 *Aedes* larvae/copepods/day.

**Ornamentation of cuticle.** Topography and number of integumental pores across the body (pore signature) supplemented by routine morphological characters were studied in the females of different species of *Thermocyclops* by Baribwegure & Dumont (1999 & 2003), Baribwegure et. al. (2001) and Baribwegure & Mirabdullayev (2003). Although the function of integumental pores is not well known, these structures are rich in information (Galassi et.al., 1998). Fleminger (1973) and others used pore signature, as an approach to the taxonomy of calanoids, and concluded that integumental perforations are typically bilaterally symmetrical and species-specific. This technique has not been widely used in cyclopoids, although Rocha (1994) included urosome pores to describe *Metacyclops cushae*. According to Baribwegure & Dumont (2003) pore signature mapping provides a suite of characters from which inferences about phylogenetic relationships between copepods can be derived and separate a new species from its congeners recognized. Other such patterns that can be used in taxonomic differentiation of cyclopoids are sensilla, hairs, and cuticular windows.

**Prosome.** In cyclopoids, prosome comprises the cephalothotax and thoracic somites. The major body articulation is present between the fourth and fifth
pedigerous somites. The shape of the rostrum and number of sensillae on the rostrum are significant in different species. Length/width ratios of cephalothorax, prosome and urosome are of taxonomic importance in cyclopoids. The lateral prolongations of pro somites discriminate the species of genus *Cyclops*. The fourth pedigerous somite of *Cyclops vicinus* is produced postero-laterally into wide wings, which are species-specific and separates it from its Indian congener *Cyclops ladakanus*. Similarly fifth pedigerous somite is broadly pointed outward in *Cyclops vicinus* and not so in *Cyclops ladakanus*. In *Tropocyclops multicolor*, a dark band at the posterior end of cephalothorax is consistently seen in different populations. The fifth pedigerous somite with lateral group of short setules in *Eucyclops*, hair-like setules in *Tropocyclops* and fringe-like elongate setules at postero-lateral angles in *Paracyclops* discriminate the respective genera from others. The dorsal, lateral and ventral hairs/spinules on fifth pedigerous somite are species-specific and important in separating the females of *Mesocyclops*, *Thermocyclops* and *Metacyclops*. (*T. crassus* and *T. decipiens* have short lateral hairs or spinules on fifth pedigerous somite). As already mentioned Rocha (1998) reported that border ornamentation of prosomal somites is useful in taxonomy and separated five species of *Microcyclops* form Brazil, namely *M. alius*, *M. anceps anceps*, *M. ceibaensis*, *M. finitimus* and *M. mediasetosus*. In the present study, three Indian species of *Microcyclops*, viz. *M. varicans*, *M. rechtyae* and *M. karvei*, are distinguished from one another by using the same character.

**Female urosome.** Urosome comprises the genital double-somite, 2 post-genital somites and anal somite ending in caudal rami with caudal setae. The morphological differentiation and ornamentation of the female genital double-somite is of immense taxonomic value but only for species-level decisions. This somite
varies widely in its size and shape. The proximal part is generally dilated and distal part narrow. In the genus *Halicyclops*, genital double-somite generally carries spiniform, angular/obtuse or small protuberances laterally. The exact location, size and shape of these processes often help in distinguishing the closely allied congeners.

In some species, the double-somite is ornamented with pits arranged in a definite pattern as in *Metacyclops cushae*, *Metacyclops communis* and *Thermocyclops rylovi*. The somite is ornamented with hairs in genus *Mesocyclops*; anterior dorsal half pilose in *M. dadayi* and *M. isabellae*, entire dorsum pilose in the Indian *M. ornatus n. sp.* and a West African species *M. dussarti*. In the genus *Rybocyclops* the width of genital double-somite is more than length. The ornamentation of anal somite, shape and size of anal operculum are useful in taxonomy. In general the anal somite has two cuticular pores with sensilla antero-laterally. In certain species of *Halicyclops*, *Paracyclops* and *Eucyclops* (*E. semidenticulatus*) anal operculum extends right up to the anterior margin of anal somite; in *Rybocyclops* and *Metacyclops* species it extends beyond the anal somite. The shape of the anal operculum is usually convex or concave, but in *Rybocyclops* it may be broad, bowl- or boat-shaped, or semicircular, w-shaped in *Metacyclops karanovici n. sp.* The ornamentation of anal operculum and anal sinus differs in different species of *Halicyclops*, *Paracyclops* and *Microcyclops*.

The presence/absence of spinules on the distal edge of anal somite dorsally, ventrally and laterally is taxonomically important.

**Caudal rami.** The caudal rami are generally longer than wide, ranging from 1.1–1.2 as in *Halicyclops* to about 7–8 times as in *Cyclops* species. The length/width ratios of caudal rami are important in discriminating the species. The ornamentation consists of dorsal ridges as in *Cyclops vicinus*, hairs on inner margins as in *Mesocyclops aspericornis*, *M. ornatus n. sp.*, etc; spinules or denticles on outer
margins as in *Eucyclops* species; spinules in transverse or oblique rows as in *Paracyclops, Metacyclops* and *Ectocyclops* species, which are of taxonomic importance.

**Caudal setae.** The length/width ratios of caudal setae and their ornamentation receive much attention in cyclopoid taxonomy and they are useful at species-level determinations. The length/width ratios of outermost and innermost caudal setae, principal apical setae, dorsal seta and caudal ramus, and position of lateral seta are significant in cyclopoid taxonomy. Homogenous/heterogeneous ornamentation on principal apical setae, presence/absence of breaking planes on them, presence or absence of spinules at the insertions of lateral, dorsal and outermost apical setae differentiate the cyclopoids from their closest congeners. The position of lateral seta is important in discriminating the species of various genera. Bulged principal apical setae in *Metacyclops margaretae* and ventrally curved setae in *Thermocyclops crassus* differentiate them from their congeners. Details in the ornamentation of principal apical setae are used by Rocha (1998) in identifying five species of *Microcyclops* form Brazil and the same micro-character states are used in the present study to separate four Indian species, viz. *M. varicans, M. rubellus, M. rechtyae* and *M. karvei*.

**Antennule.** The comparative study of female antennules by Karaytug et. al. (2004) shows that the strict application of homology of antennulary segments is essential in order to resolve phylogenetic relationships between the genera of Cyclopidae. The strict application of homology in inferring the copepod phylogeny by Huys & Boxshall (1991) has been a revolution in systematic studies on copepods. Boxshall & Huys (1992) strongly stressed that the identification of homologous characters and character states is a priority for phylogenetic analysis, and the most difficult task in any phylogenetic study is correctly identifying homologous shared

The antennules of cyclopoids are uniramous, basically cylindrical and comprise up to 17 segments. The female antennules are straight, whereas those of males are geniculate (mono- or digeniculate). The examination of the female antennules for the number of segments, their setation, ornamentation, presence or absence of aesthetascs, modified setae, hyaline membrane with notches provides significant information for the systematics of the family Cyclopidae. The segments ornamented with pits, hyaline fringes with notches provide information for the separation of species in *Mesocyclops* and *Thermocyclops*. In *Mesocyclops aspericornis* 1, 4–5, 7–13 segments are ornamented with pits and 1, 4–5, 7–14 in *M. isabellae*. Holyńska et.al., (2011) used the character states of hyaline membrane of antennule, its presence and position on the last three segments in describing different species of *Thermocyclops*. Altaff et. al. (2002) described the antennule of *M. aspericornis* in detail, with due attention to the number and size of plumose and non-plumose setae. Thus complete description of antennule is significant in species-level taxonomy. In the present study, an attempt is made to describe the antennule of all the species so that it is comparable with other species.

**Antenna.** In Cyclopoida, the number of antennal segments was used for subdivision at the family level, and the structural details of the antenna were never fully investigated. The careful examination and study of 45 species and subspecies belonging to 14 cyclopoid genera and subgenera by Fiers & Van De Velde (1984)
clearly showed the taxonomic importance of the antennal coxobasis ornamentation at the species level.

The antenna is composed of four segments except in the Halicyclopinae, which has three segments only. The length, number and arrangement of the spinules on the frontal and caudal sides of coxobasis of antenna are characteristic of the various genera, and the patterns contain important taxonomic information. Males exhibit almost the same pattern as females, but the size of spinules is usually smaller in males. In the present study, comparison is made between four species of *Microcyclops*, which revealed that the distinct patterns found on the coxobasis of antenna do have taxonomic value. The number of setae on second endopodal segment of antenna is of taxonomic importance.

**Oral parts.** The morphology of the oral appendages was used by Thorell (1859) to propose a classification of Copepoda in three series. All free-living copepods were put in the Gnathostoma group, while many marine free-living copepods were assigned to the Poecilostoma group, characterized by reduced oral appendages, or to the Siphonostoma group in which the oral appendages are modified into sucking organs. Labrum is externally smooth, ornamented with setae and bordered by teeth, which are important from taxonomic viewpoint. In cyclopoids the endopod of the mandible exists only as a palp. The ornamentation on the palp, number of teeth on the coxal gnathobase also receives attention in the taxonomy of cyclopoids. The setal ornamentation of the maxillulary palp is used as a specific criterion in the cyclopoid genus *Mesocyclops* by Van De Velde, 1984 while revising the African species of the genus *Mesocyclops* Sars, 1914. Within the genus *Mesocyclops* the *thermocyclopoides*-group is defined on the basis of the presence of spiniform armature on the maxillary coxa by Holyńska & Fiers, (1994). Their results
proved that coxal armature on the maxilla are the best single character for defining the *thermocyclopoides*-group and clarification of species. In the present study, comparison of ornamentation of claw and strong seta of maxillary basis of four *Microcyclops* species is done. Ornamentation on the basis and endopodal segments of maxilliped help in the identification of species. The present study includes the complete description of all the oral parts, which help separate the species.

The morphology of cephalothoracic appendages is compared between 12 taxa of *Cyclops* O. F. Müller by Holyńska et al. (2004). The criteria considered were: relative lengths of aesthetascs on the ancestral XXI antennular segment; spinule ornamentation on the caudal surface of antennal coxobasis; maxillulary palp; frontal surface of syncoxopod of the maxilliped; setulation of the maxillulary palp setae; and setulation of the medial spine and spinule ornamentation on the frontal surface of leg 1 basis.

**Natatory legs 1–4.** The descriptions of legs 1–4 throw useful taxonomic clues. The shape of the terminal spine of the second endopodal segment, the presence and number of integumental pores on the anterior surface of the terminal endopodal segment especially in *Microcyclops* species (Rocha, 1997); presence, length and ornamentation of spine on the basis of leg 1 in all other genera also help in discriminating the taxa (species). The third or second exopodal spine and setal formulae are important in differentiating the species of *Halicyclops, Metacyclops*, etc. Legs 2–4 have more or less similar structure, but differences in setation (spine and setal formulae) are important to differentiate species (Sewell, 1949). As for the genus *Cyclops*, Einsle (1993) stated that the setae and spine ornamentation present on both surfaces of coxa and intercoxal plate are of taxonomic interest, and the differences between the presence or absence of some rows of spinules and their location are used
to identify the species. The ornamentation of intercoxal sclerites is one of the conventional characters used to separate the species of some genera in cyclopoids. Species of *Rybocyclops* show sexual dimorphism in the number of setae on the second endopodal segment of leg 3 and 4. The armature of connecting lamella, coxa and basis of leg 4, armature of apical spines of leg 4 third endopodal segment are used as diagnostic characters by Van de Velde (1984) in revising the African species of genus *Mesocyclops* Sars, 1914.

**Leg 5.** In cyclopoids, leg 5 is similar in both sexes. It is considerably reduced in some cases like *Rybocyclops* and represented by 2 or 3 setae. The diversity of the structure of leg 5 forms the basis of the genera in cyclopoids.

**Leg 6.** In cyclopoids, the genital double-somite generally bears a rudimentary leg-like structure, i.e. leg 6. The female leg 6 is represented by two small spines and a seta, attached more or less dorso-laterally to the genital double-somite. These appendages border a cuticular thickening, which is a vestigial suture between the two somites of the genital complex. In males, leg 6 is better developed, consisting of two setae and one spine, which are useful in separating species (genus *Paracyclops*).
BIOGEOGRAPHY OF INDIAN CYCLOPOID COPEPODS

The land area of India (20°00'N, 70°00'E) is about 3,287,263 km², which is 2.4% of the total surface of the world, has three biodiversity hotspots, viz. Western Ghats, Eastern Himalayas, and India-Myanmar border (hilly ranges). The evolution of any group of biota is always intricately linked to the geomorphologic evolution of the area. Hence, a proper comprehension of the salient features of the historical biogeography of India is essential for analyzing the origin, evolution, and species richness of the cyclopoids.

Tectonic evolution of the Indian Plate and its aftermath

Current plate tectonic theory postulates that India was nestled in the supercontinent Pangaea at high southerly latitudes between Late Paleozoic and Early Permian ca. 255 Ma (Chatterjee & Scotese, 1999). The Pangaea was intact during the Late Triassic and Early Jurassic periods, but the first stage of its rifting took place in the Middle Jurassic period ca. 180 Ma. Before its journey into northern latitudes, the Indian plate rifted from other Gondwanan landmasses at different times in the geological past—from Africa along with Madagascar ca. 180-170 Ma, from Antarctica-Australia ca. 130 Ma, and from Madagascar ca. 90 Ma. Eventually, the docking against Asia began ca. 55-65 Ma.

Apart from serving as Noah’s Ark to transport a variety of animals from Africa to Asia (Briggs, 1995), the Indian plate had apparently experienced extensive exchange between peninsular autochthonous and Asian Tertiary biota (Briggs, 1989, 2003; Mani, 1974; Ali & Aitchison, 2008). Out-of-India dispersal consequent upon India-Asia collision is evidenced by the fossil records of diverse taxa such as freshwater ostracods, ranid frogs, agamid lizards, grasses, diatoms and whales (Bajpai & Gingerich, 1998; Thewissen et al., 2007). It must also be noted that the dramatic
latitudinal and climatic changes that affected the peninsular India during its northward drift caused substantial extinction in its original biota (Mani, 1974; Raven & Axelrod, 1974). Moreover, the massive Deccan Traps volcanism had a devastating impact on peninsular India biota, including the extinction of dinosaurs at Cretaceous-Tertiary boundary (Bajpai, 2009). On the whole, the researches carried out in stratigraphy, palaeomagnetics, and paleontology provide a substantial body of knowledge about India’s past (Briggs, 2003).

**Current scenario of biogeography in India**

Though nearly half of the country lies outside tropics, in the middle latitudes and within the temperate zone, it is customary to describe India as tropical, mainly because it is shielded off by the Himalaya in the north from the rest of Asia and has nearly uniform tropical monsoon climate. Nevertheless, the variety in elevation and the local climate is extremely remarkable and includes transitions from the nearly rainless Thar Desert in Rajasthan to the rainiest place on earth, i.e. Mawsynram in the East Khasi Hills district of Meghalaya state in north-eastern region (annual rainfall 11,872 mm), from Sriganganagar in Rajasthan, one of the hottest places on earth (54°C) to alpine and arctic conditions on the Himalaya, and from the geologically stable and ancient areas of the Peninsula with senile topography to geologically unstable and recent areas of youthful topography on the Himalaya. Except for the high-altitude, Himalayan habitats, which are characteristically temperature-dominated, vast areas of monsoon-mediated ecology support tropical flora and fauna, but contain also numerous remarkable pockets of temperate biota. The uplift of the Himalayan Mountains exercised far-reaching influence on the climate and the composition of the flora and fauna of the whole of India. In one word, the Himalaya presides over the ecology and biogeography of India.
As a result of the spectacular tectonic and historical biogeographic upheavals outlined above, the modern terrestrial and freshwater biota of India is overwhelmingly Oriental although it does harbor but a few living relicts that might date back to the pre-drift period, e.g., the bivalve mollusk *Mullaria*, two genera of land snails, an earthworm species of the family Pheodrilidae, and some millipedes of the family Sphaerotheriidae, etc. (Briggs, 2003; Mani, 1974). And in zoogeographic approaches, India is generally placed in the Oriental Realm of Wallacea (1876). According to Mani (1974), however, parts of the Punjab and the higher Himalaya should be included within the Palearctic, and also the western parts of the Indo-Gangetic Plains of north India are related more to the Ethiopian-Mediterranean than to the Malayan area. It cannot be overemphasized that the peninsular India is quite distinct geomorphologically and biogeographically from the rest of India and its primary faunistic affinities are to be traced back more to the Madagascan Region than to the Oriental or even the Malayan area. Thus, while “the Peninsula *per se* is biogeographically *India vera*, the largest and the oldest region of differentiation of the original floras and faunas of India, the Himalaya and the other Extra-Peninsular parts are merely biogeographical appendages of secondary importance” (Mani, 1974). It was further emphasized by Mani (1974) that the greatest bulk of the true Indian flora and fauna had differentiated and evolved in the Peninsula, throughout the Paleozoic, Mesozoic and Tertiary, right nearly up to Pleistocene times, and spread extensively into the Extra-Peninsular areas during the late Tertiary. The fauna and flora that had differentiated in the Peninsula should be regarded as the original flora and fauna of India. However, as mentioned above, for the sake of biogeographical convenience, the peninsular part and the Eastern Borderlands of India, despite their fundamental
Biogeographic evolution of Indian cyclopoids

The order Cyclopoida comprises a total of 66 genera and 1008 valid species (Dussart & Defaye 2006). It is one of the most conspicuous and diverse groups of freshwater copepods (Boxshall & Jaume, 2000). The concept of cosmopolitan distribution of the freshwater Cyclopoida is not as common as a few decades ago (Reid, 1998). Cyclopoid copepods of continental waters are represented by four families of which the family Cyclopidae Rafinesque, 1815 comprises 58 genera and 986 species and subspecies (Dussart & Defaye 2006). The Indian tally till date is 92 valid species and subspecies (inclusive of six new species and one new subspecies described herein) in 25 genera of 4 families of the order Cyclopoida. Of these 43 species are endemic to India (see Table 23) and of the remaining 49 species 14 species are Oriental in distribution, 3 species show Gondwanan affinity and the rest are widely distributed (see Table 24).

A perusal of the existing literature shows that there is no clear and distinct information regarding the biogeographic distribution of Indian cyclopoids except for World Directory of Crustacean Copepoda of Inland waters II–Cyclopiformes by Dussart & Defaye (2006). Ranga Reddy (2011) has dealt with the definitive Gondwanan affinities of all Indian bathynellaceans and some cyclopoid and harpacticoids species. Here, an attempt is made to give a brief account of biogeography of Indian cyclopoids.

The family Oithonidae G. O. Dana, 1853 with 5 species (in 2 genera Oithona Baird, 1843 and Dioithona Kiefer, 1935); family Cyclopinidae G. O. Sars, 1913 with 2 species ( in 2 genera Allocyclopina Kiefer, 1954, Arenocyclopina Krishnaswamy,
The family Cyclopidae is divided into 4 subfamilies (Monchenko, 1974) of which the first subfamily Euryteinae comprising only 2 genera (all of which are marine) is not represented in India till now. It has to be mentioned at this juncture that all the species belonging to family Cyclopidae do not follow the same distribution pattern, as some of them are widely distributed, some confined to Oriental region, some ar endemic, few are Gondwanan derivates, and some confined only to certain localities in a country.

The second subfamily Halicyclopinae Kiefer, 1927 comprises of 5 genera of which 2 genera, viz. *Halicyclops* Norman, 1903 and *Neocyclops* Gurney, 1927, have representatives in India. Of the six species of *Halicyclops* reported from India, barring *Halicyclops (H.) spinifer*, the remaining five species are endemic to India and are distributed mainly in brackish waters. The genus *Neocyclops* represented by a single species, *Neocyclops salinarum* (Gurney, 1927), is widely distributed, but it did not appear in the present survey. The third subfamily Eucyclopinae Kiefer 1927, comprising of ten genera has representatives of six genera in India, viz. *Eucyclops* Claus, 1893, (11 species), *Macrocyclops* Claus, 1893, (3 species), *Paracyclops* Claus, 1893 (3 species), *Ectocyclops* Brady, 1904 (3 species), *Afrocyclops* G.O. Sars, 1927 (1 species), and *Tropocyclops* Kiefer, 1927 (5 species). This subfamily Eucyclopinae has Oriental elements, Indian endemics, widely distributed taxa, and Gondwanan derivatives, as listed in Table 24.

The fourth subfamily Cyclopinae Kiefer, 1927 comprises 42 genera of which 12 genera have representatives in India. They are *Cyclops* O.F Müller, 1776 (3 species), *Microcyclops* Claus, 1893 (10 species), *Mesocyclops* G. O. Sars, 1914 (10 species), *Paracyclopina* Smirnov, 1935) is represented in India.
species), *Bryocyclops* Kiefer, 1927 (2 species), *Cryptocyclops* G.O. Sars, 1927 (2 species), *Diacyclops* Kiefer, 1927 (1 species), *Megacyclops* Kiefer, 1927 (1 species), *Metacyclops* Kiefer, 1927 (4 species), *Thermocyclops* Kiefer, 1927 (8 species), *Apocylops* Lindberg 1942 (3 species), *Haplocyclops* Kiefer, 1952 (1 species), and *Rybocyclops* Dussart, 1982 (4 species). The fourth subfamily Cyclopinae also has widely distributed taxa, Gondwanan derivatives, Oriental elements and Indian endemics. The genus *Cyclops* is recorded only in Kashmir lakes at an altitude of 1,580–4,686 m. and none of the *Cyclops* spp. is known from the peninsular India including the elevated localities such as Nilgiris with an altitude 2,637 m. Hence *Cyclops* species are strictly confined to Himalayan amphitheatre, which has climatic conditions closely resembling the temperate belt. Similarly *Thermocyclops rylovi* is restricted to certain localities in Peninsular India especially, Tamilnadu State.

In the present study, certain species like *Microcyclops karvei, Microcyclops rechtyae, Tropocyclops multicolor* and *Mesocyclops ornatus n. sp.* are recorded from caves. Some of the previously recorded species like *Eucyclops speratus, E. serrulatus, Microcyclops varicans subequalis* and *Microcyclops moghulensis* are also recorded from Ajanta and Ellora caves. Similarly certain species of *Rybocyclops, Metacyclops* and *Paracyclops* are reported from bore wells. The species that are prevalent in surface waters are also occasionally found as stygoxenes in cave pools. Strangely, the interstitial samples collected during the present study from the Himalayan Rivers from Badrinath to Haridwar did not contain any cyclopoid species but yielded only two Harpacticoids in one sample. This is perhaps due to the remarkably reduced sediment grain size to fine silt, which might interfere with the feeding process of the hyporheic fauna.
Given India’s tectonic history and its physical and biotic links with Asia following its break-up from the Gondwanan Supercontinent, one would expect the Indian cyclopidae to present a mix of phylogenetic (Gondwanan) and geographical (Asiatic) elements, the latter greatly outnumbering the former, as in other groups of Indian biota (see Mani, 1974). Endemic taxa are represented by large numbers. Indeed, the Indian cyclopoid genera represent five distinct biogeographic groups:

1. The Indian endemics: These include species from different genera as in Table 23. The closely related species of the genus live in the neighboring Sri Lanka, which has land connections with Peninsular India and is indeed a “detached portion of the Peninsula”.

2. Widely distributed taxa: These are distributed mainly in the continents of Africa, America, Australia, Europe and Asia.

3. Gondwanan derivatives: These represent the oldest component-elements (phylogenetic relicts) of the character fauna of the Peninsula (see Table 24).

4. Oriental elements: These are largely isolates and outliers of the Tertiary Asiatic forms of the Indo-Chinese and Malayan sub regions. The species represented by these genera are the dominant geographical relicts in the Peninsula and characterized by more or less pronounced discontinuity in their distribution.

5. The Pleistocene relicts (Palaearctic elements): These are represented by *Cyclops* species and which are restricted to the Himalayan Amphitheatre. Most probably these lineages radiated into India from the northwestern rather than the northeastern corridor.
Table: 23. The Indian endemic species of Cyclopoida

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the Species</th>
<th>Locality: habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Oithona dissimilis</em> Lindberg, 1940</td>
<td>Pondicherry: Coastal waters</td>
</tr>
<tr>
<td>2</td>
<td><em>Dioithona horai</em> (Sewell, 1934)</td>
<td>Kolkata: Salt lakes</td>
</tr>
<tr>
<td>3</td>
<td><em>Dioithona indogallica</em> Lindberg, 1940</td>
<td>Oupalom (Suburb of Pondicherry); and Coramandal Coast: Coastal waters</td>
</tr>
<tr>
<td>4</td>
<td><em>Allocyclopina inopinata</em> Defaye &amp; Ranga Reddy, 2008</td>
<td>Kotipalli: River Godavari</td>
</tr>
<tr>
<td>5</td>
<td><em>Paracyclopina orientalis</em> Lindberg, 1941</td>
<td>Pondicherry: Coastal waters; Mahim &amp; Angara: Salt marshes</td>
</tr>
<tr>
<td>6</td>
<td><em>Paracyclopina intermedia</em> (Sewell, 1924)</td>
<td>Kolkata: Salt lakes; Chilka Lake: brackish waters; Manguluru and Kolletikota: Lake Kolleru, fresh waters</td>
</tr>
<tr>
<td>7</td>
<td><em>Paracyclopina longifurca</em> (Sewell, 1924)</td>
<td>Chilka Lake and Tuticorin: brackish waters; Kolletikota: Lake Kolleru, fresh waters.</td>
</tr>
<tr>
<td>8</td>
<td><em>Arenocyclopina biarticulata</em> (Krishnaswamy, 1957)</td>
<td>Chennai Coast: Coastal waters</td>
</tr>
<tr>
<td>9</td>
<td><em>Halicyclops (H.)tenuispina</em> Sewell, 1924</td>
<td>Chilka Lake: brackish waters</td>
</tr>
<tr>
<td>10</td>
<td><em>Halicyclops (H.) canui</em> Lindberg, 1941</td>
<td>Mumbai: Bandra coast, brackish waters</td>
</tr>
<tr>
<td>11</td>
<td><em>Halicyclops (H.)electus</em> Lindberg, 1943</td>
<td>Mumbai: Mahim, brackish waters</td>
</tr>
<tr>
<td>12</td>
<td><em>Halicyclops (H.)konkanensis</em> Lindberg, 1949</td>
<td>Konkan Coast: brackish waters</td>
</tr>
<tr>
<td>13</td>
<td><em>Halicyclops (H.) pilifer</em> Lindberg, 1949</td>
<td>Thane (Mumbai): brackish waters</td>
</tr>
<tr>
<td>14</td>
<td><em>Eucyclops (E.) indicus</em> (Kiefer, 1927)</td>
<td>Darjiling: pond waters</td>
</tr>
<tr>
<td>15</td>
<td><em>Eucyclops (Eucyclops) productus</em> Kiefer, 1936</td>
<td>Kashmir: lake waters</td>
</tr>
<tr>
<td>16</td>
<td><em>Eucyclops (Eucyclops) serrulatus defecta</em> Lindberg, 1937</td>
<td>“Patch-Mahri” (Provinces Centrales): pond waters</td>
</tr>
<tr>
<td>No.</td>
<td>Species</td>
<td>Location</td>
</tr>
<tr>
<td>-----</td>
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</tr>
<tr>
<td>17</td>
<td><em>Eucyclops</em> (<em>Eucyclops</em>) microdenticulatus Lindberg, 1940</td>
<td>Kodaikanal, Palni Hills, Ooty, Nilgiris, Nadiad, Ajanta, Aurangabad: pond waters and river basins</td>
</tr>
<tr>
<td>18</td>
<td><em>Eucyclops</em> (<em>Eucyclops</em>) semidenticulatus Lindberg, 1940</td>
<td>Salsette Island (Mumbai), Nilgiris, Gharipouri near Barsi, Deccan plateau, Kotagiri, Phandharpur: ponds, lakes, reservoirs and rivers</td>
</tr>
<tr>
<td>19</td>
<td><em>Eucyclops</em> (<em>Eucyclops</em>) bryophilus Lindberg, 1950</td>
<td>Shillong (Meghalaya): waterfalls</td>
</tr>
<tr>
<td>20</td>
<td><em>Eucyclops</em> (<em>Eucyclops</em>) bryophilus mahanandiensis n.ssp.</td>
<td>Mahanandi: Koneru (man made concrete basin filled with ground water)</td>
</tr>
<tr>
<td>21</td>
<td><em>Tropocyclops prasinus palniensis</em> Lindberg, 1946</td>
<td>Palni Hills: ponds and lakes</td>
</tr>
<tr>
<td>23</td>
<td><em>Cyclops hutchinsoni</em> Kiefer, 1936</td>
<td>Kashmir: Lakes</td>
</tr>
<tr>
<td>24</td>
<td><em>Microcyclops</em> (<em>Microcyclops</em>) diminutus (Lindberg, 1937)</td>
<td>Goa, Dandi, Lake Povai: lakes and rivers</td>
</tr>
<tr>
<td>25</td>
<td><em>Microcyclops</em> (<em>Microcyclops</em>) indolusitanus (Lindberg, 1938)</td>
<td>Bassein near Mumbai: rain fed pools</td>
</tr>
<tr>
<td>26</td>
<td><em>Mesocyclops dadayi</em> Holyńska, 1997</td>
<td>Kolkata: ponds, pools and lakes</td>
</tr>
<tr>
<td>27</td>
<td><em>Mesocyclops ornatus</em> n. sp.</td>
<td>Kolimigundla, Nelabelum Caves: cave pool</td>
</tr>
<tr>
<td>28</td>
<td><em>Bryocyclops</em> (<em>Bryocyclops</em>) constrictus Lindberg, 1947</td>
<td>Annamalai Hills: ponds and lakes</td>
</tr>
<tr>
<td>29</td>
<td><em>Bryocyclops</em> (<em>Bryocyclops</em>) travancoricus Lindberg, 1947</td>
<td>Mountain Travancore: ponds and lakes</td>
</tr>
<tr>
<td>30</td>
<td><em>Metacyclops communis</em> (Lindberg, 1938)</td>
<td>Deccan Plateau, Pandharpour: pools of rain water</td>
</tr>
<tr>
<td>31</td>
<td><em>Metacyclops margaretae</em> (Lindberg, 1938)</td>
<td>Mumbai, Akaveedu, Bandarlapalle, Alurukona, Vegendla: Ponds and rain fed pools</td>
</tr>
<tr>
<td>32</td>
<td><em>Metacyclops paracushae</em> <strong>n. sp.</strong></td>
<td>Acharya Nagarjuna University campus, Nagarjuna Nagar, near Guntur: bore well</td>
</tr>
<tr>
<td>33</td>
<td><em>Metacyclops karanovici</em> <strong>n. sp.</strong></td>
<td>Shillong (Meghalaya): Elephant Falls</td>
</tr>
<tr>
<td>34</td>
<td><em>Thermocyclops rectus</em> (Lindberg, 1937)</td>
<td>Patch mahri, Central Province: ponds</td>
</tr>
<tr>
<td>35</td>
<td><em>Thermocyclops maheensis</em> (Lindberg, 1941)</td>
<td>Mahe: cement basin filled with rain water</td>
</tr>
<tr>
<td>36</td>
<td><em>Thermocyclops conspicuus</em> (Lindberg, 1947)</td>
<td>Annamalai Hills, Western Ghats, Tamil Nadu: lentic water bodies</td>
</tr>
<tr>
<td>37</td>
<td><em>Thermocyclops marmagoensis</em> (Sewell, 1960)</td>
<td>Marmagoa, (Goa): ponds</td>
</tr>
<tr>
<td>38</td>
<td><em>Apocylops dengizicus elamicus</em> (Lindberg, 1940)</td>
<td>Mumbai: ponds and pools</td>
</tr>
<tr>
<td>39</td>
<td><em>Haplocyclops (Kiefercyclops) fiersi</em> Karanovic &amp; Ranga Reddy, 2005</td>
<td>Acharya Nagarjuna University campus, Nagarjuna Nagar, near Guntur: bore-well</td>
</tr>
<tr>
<td>40</td>
<td><em>Rybocyclops dussarti</em> Ranga Reddy &amp; Defaye, 2008</td>
<td>Chollaveedu village, near Racherla: bore-well</td>
</tr>
<tr>
<td>41</td>
<td><em>Rybocyclops nagarjuna</em> <strong>n. sp.</strong></td>
<td>Acharya Nagarjuna University campus, Nagarjuna Nagar, near Guntur: bore-well</td>
</tr>
<tr>
<td>42</td>
<td><em>Rybocyclops sagileru</em> <strong>n. sp.</strong></td>
<td>Uyyalawada village near Kurnool: hyporheic zone of R. Sagileru</td>
</tr>
<tr>
<td>43</td>
<td><em>Rybocyclops gunturensis</em> <strong>n. sp.</strong></td>
<td>Guntur: bore-well</td>
</tr>
</tbody>
</table>
Table: 24. List of cyclopoid species common to India and other parts of the world

<table>
<thead>
<tr>
<th>S. No</th>
<th>Name of the species</th>
<th>Known distribution</th>
<th>Biogeographic group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Oithona brevicornis</em> Giesbrecht, 1891</td>
<td>Africa; Asia: India (River Hooghly, Salt lakes of Kolkata, Chilka Lake, Chennai Coast, Malabar, Cochin Backwaters, Lake Kolleru).</td>
<td>Gondwanan</td>
</tr>
<tr>
<td>2</td>
<td><em>Oithona hebes</em> Giesbrecht, 1891</td>
<td>Central and South America; Asia: India (Chennai Coast, Cochin Backwaters, Lake Kolleru).</td>
<td>Gondwanan</td>
</tr>
<tr>
<td>3</td>
<td><em>Halicyclops (H.) spinifer</em> Kiefer, 1935</td>
<td>South America; Western Australia; Asia: Iran, Tonga, India (Bandra near Mumbai, Lake Kolleru).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>4</td>
<td><em>Neocyclops (Neocyclops) salinarum</em> (Gurney, 1927)</td>
<td>Africa; Europe; Asia: India (Andaman Islands).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>5</td>
<td><em>Eucyclops (Eucyclops) serrulatus</em> Fischer, 1851</td>
<td>Africa; Europe; America; Australia; Asia: China, Israel, Iran, Japan, Malaysia, Sri Lanka, Tibet, India (Nadiad, Mumbai, Salsette Island, Ajanta, Ellora, Hyderabad, Ramaling near Barsi, Gharipouri, Kurduvadi, Phandharpur, Belgaum, Kotagiri, River Krishna Vijayawada, Lake Kolleru, Acharya Nagarjuna University).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>6</td>
<td><em>Eucyclops (Eucyclops) speratus</em> Kiefer, 1929</td>
<td>Europe; North America; Asia: China, Iran, Turkey, India (Ajanta Caves, Ludhiana, Manakwal village).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>7</td>
<td><em>Eucyclops (E.) agiloides</em> (G. O. Sars, 1909)</td>
<td>Africa; Asia: China, Indonesia, India (common in Peninsular India).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>8</td>
<td><em>Eucyclops (Eucyclops) permixtus</em> Kiefer, 1928</td>
<td>Asia: Afghanistan, Java, India (Punjab, Mt. Khasi, Assam, Eastern Himalayas).</td>
<td>Oriental</td>
</tr>
<tr>
<td>9</td>
<td><em>Macrocyclops albidus</em> (Jurine, 1820)</td>
<td>Africa; North America, South America; Europe; Tasmania; Asia: China, Indonesia, Iran, Israel, Japan, Malaysia, Turkey, India.</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>10</td>
<td><em>Macrocyclops distinctus</em> (Richard, 1887)</td>
<td>Europe; New Zealand; Asia: China, Israel, Japan, Malaysia, Nepal, Sri Lanka, Thailand, Uzbekistan, India (Phandarpour, Mumbai, Secunderabad, Kondaveedu, Lake Kolleru).</td>
<td>Widely Distributed</td>
</tr>
<tr>
<td>11</td>
<td><em>Macrocyclops neuter</em> Kiefer, 1931</td>
<td>Asia: Burma, Sri Lanka, Java, Malaysia, India (Mts Khasi, Assam).</td>
<td>Oriental</td>
</tr>
<tr>
<td>12</td>
<td><em>Paracyclops fimbriatus</em> (Fischer, 1853)</td>
<td>Europe; Asia: China, Japan, Mongolia, Turkey, Palestine, Kazakhstan, Uzbekistan, India (Karli, Phandharpur, R. Bhima, R. Sina, Ellora, Nilgiris).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>No.</td>
<td>Species</td>
<td>Distribution</td>
<td>Status</td>
</tr>
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<tr>
<td>13</td>
<td><em>Paracyclops affinis</em> (G. O. Sars, 1863)</td>
<td>Africa; Europe; Asia: China, Indonesia, Isreal, Japan, Malaysia, Nepal, Singapore, Taiwán, India (River Krishna, R. Sina, Hyderabad, Aurangabad, Ellora, Coonoor, Nilgiris, Lake Kolleru).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>14</td>
<td><em>Paracyclops poppei</em> (Rehberg, 1880)</td>
<td>North America; Europe; Asia: Isreal, Japan, India (Ludhiana).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>15</td>
<td><em>Ectocyclops phaleratus phaleratus</em> (Koch, 1838)</td>
<td>Africa; North America; South America; Europe; Asia: China, Irán, Israel, Japan, Malaysia, Mongolia, Philippines, Sri Lanka, Thailand, India (Punjab).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>16</td>
<td><em>Ectocyclops rubescens</em> Brady, 1904</td>
<td>Africa; North America; South America; Australia; Asia: Irán, Malaysia, South Yemen, Sri Lanka, Thailand, India (Lake Kolleru).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>17</td>
<td><em>Ectocyclops phaleratus medius</em> Kiefer, 1930</td>
<td>Africa; East Indies; Asia: India (Pandharpour, Miraj, Hyderabad, Aurangabad, Ellora, Ajanta, Nadiad, Ooty, Vengalayapalem pond near Guntur, Visakhapatnam).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>18</td>
<td><em>Afrocyclops gibsoni</em> (Brady, 1904)</td>
<td>Africa, Asia: Israel, India (Mysore).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>19</td>
<td><em>Tropocyclops prasinus prasinus</em> (Fischer, 1860)</td>
<td>Africa; North America; South America; Europe; Asia: China, Japan, Israel, Malaysia, Sri Lanka, Thailand, Iran, Turkey, Philippines, India.</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>20</td>
<td><em>Tropocyclops confinis confinis</em> (Kiefer, 1930)</td>
<td>Africa; South America; Asia: China, Iran, Israel, India (Kotagiri, Pandarpour, River Bhima, Coonoor).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>21</td>
<td><em>Tropocyclops confinis frequens</em> (Kiefer, 1931)</td>
<td>Africa; Asia: China, India (Salsette near Bombay, Pandharpour, Kotagiri).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>22</td>
<td><em>Cyclops vicinus</em> Uljanin, 1875</td>
<td>North America; Europe; Asia: China, Afganistán, Irán, Iraq, Israel, Japan, India (Kashmir).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>23</td>
<td><em>Cyclops ladakanus</em> Kiefer, 1936</td>
<td>Asia: China, Iran, India (Ladakh, Kashmir).</td>
<td>Oriental</td>
</tr>
<tr>
<td>24</td>
<td><em>Microcyclops</em>(<em>Microcyclops</em>) varicans varicans (G. O. Sars, 1863)</td>
<td>Africa; North America; Central America; South America; Europe; Asia: China, Irán, Israel, Japan, Malaysia, Nepal, Philippines, Sri Lanka, Thailand, India (Nagpur, Chandrapur, Central Provinces, Nadiad, Ellora, Aurangabad, Hyderabad, Elephant caves Mumbai, Lake Povai, Salsette Island, Ghatkopar, Gharipouri, Pandharpour, River Takli, Goa, Pondicherry, Ooty, Kodaikanal).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td></td>
<td>Species</td>
<td>Distribution</td>
<td>Record</td>
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</tr>
<tr>
<td>25</td>
<td><em>Microcyclops</em> (Microcyclops) varicans subequalis (Kiefer, 1928)</td>
<td>Africa; South America; Asia: China, Indonesia, India (Ellora, Pandharppour, Ramaling, River Takli).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>26</td>
<td><em>Microcyclops</em> (Microcyclops) rubellus Lilljeborg, 1905</td>
<td>Africa; North America, Central America; Europe; Asia: China, Israel, Japan, India (Hyderabad).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>27</td>
<td><em>Microcyclops</em> (Microcyclops) karvei (Kiefer &amp; Moorthy, 1935)</td>
<td>Asia: Cambodia, Iran, Tajikistan, Uzbekistan, India (Mysore, Ongole, Banganapalli, Nelabhelum caves).</td>
<td>Oriental</td>
</tr>
<tr>
<td>28</td>
<td><em>Microcyclops pachympina</em> (Lindberg, 1937)</td>
<td>Asia: Yemen, India (Pondicherry, Pandharppour).</td>
<td>Oriental</td>
</tr>
<tr>
<td>29</td>
<td><em>Microcyclops moghulensis</em> (Lindberg, 1939)</td>
<td>Asia: Sri Lanka, India (Ellora, Hyderabad).</td>
<td>Oriental</td>
</tr>
<tr>
<td>30</td>
<td><em>Microcyclops</em> (Microcyclops) rechtyae Lindberg, 1960</td>
<td>Asia: Afghanistan, Uzbekistan, India (Nelabhelum Caves, Banganapalli, Kurnool District).</td>
<td>Oriental</td>
</tr>
<tr>
<td>31</td>
<td><em>Microcyclops davidi</em> var. <em>subtropicus</em> (Lindberg, 1937)</td>
<td>Africa; Asia: Yemen (Socotra island), Sri Lanka, India (Salsette, Mumbai, Kodaikanal, Palni, Lake Povai, Lake Vehar, Ghatkopar).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>32</td>
<td><em>Mesocyclops aspericornis</em> (Daday, 1906)</td>
<td>Africa; North America; Australia; Asia: China, Burma, Thailand, Malay Peninsula, Sumatra, Taiwan, Uzbekistan, Vietnam, Yemen, India (Chennai, Vuyyuru, Draksaramam, Kandukuru, Tripurantakam, Tenali, Kerala).</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>33</td>
<td><em>Mesocyclops annae</em> Kiefer, 1930</td>
<td>Africa; Madagascar; Asia: Sri Lanka, India (Eastern Coasts India).</td>
<td>Gondwanan</td>
</tr>
<tr>
<td>34</td>
<td><em>Mesocyclops pehpeiensis</em> Hu, 1943</td>
<td>North America; Asia: Burma, Japan, Kazakhstan, Southern China, South Korea, Uzbekistan, India.</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>35</td>
<td><em>Mesocyclops splendidus</em> Lindberg, 1943</td>
<td>Asia: Bangladesh, Sri Lanka, Thailand, India (Mahe, Union Territory of Pondicherry).</td>
<td>Oriental</td>
</tr>
<tr>
<td>36</td>
<td><em>Mesocyclops granulatus</em> Dussart &amp; Fernando, 1988</td>
<td>Asia: Bangladesh, Burma, Pakistan, Yemen India (Tamil Nadu).</td>
<td>Oriental</td>
</tr>
<tr>
<td>38</td>
<td><em>Mesocyclops parentium</em> Holyńska, 1997</td>
<td>Asia: Sri Lanka, India (Chalakudy, Kerala, South Indian swamps).</td>
<td>Oriental</td>
</tr>
<tr>
<td>39</td>
<td><em>Mesocyclops ferjemurami</em> Holyńska, &amp; Nam, 2000</td>
<td>Asia: Vietnam, Sri Lanka, India (Siliguri, West Bengal).</td>
<td>Oriental</td>
</tr>
<tr>
<td>40</td>
<td><em>Cryptocyclops linjanticus linjanticus</em> (Kiefer, 1928)</td>
<td>Africa; Europe; Asia: Iran, Nepal, Taiwan, Fiji Islands, India</td>
<td>Widely distributed</td>
</tr>
<tr>
<td>41</td>
<td><em>Cryptocyclops tricolor</em> (Lindberg, 1937)</td>
<td>Asia: China, India (Nadiad, Salsette, Lake Povai, Elephanta Caves)</td>
<td>Oriental</td>
</tr>
</tbody>
</table>
| 42 | *Diacyclops alticola*  
(Kiefer, 1935) | Asia: China, Tibet, India (Kashmir, Ladakh, Lake Tsar, Lake Panggong) | Oriental |
| 43 | *Megacyclops viridis viridis*  
(Jurine, 1820) | Africa; America; Europe; Asia: China, Indonesia, Irán, Israel, Japan, India. | Widely distributed |
| 44 | *Thermocyclops crassus*  
(Fischer, 1853) | Africa; Europe; Australia; North America, South America; Asia: China, Iran, Japan, Mongolia, Sri Lanka, Thailand, Turkey, Uzbekistan, Indonesia, India (States of Andhra Pradesh, Kerala, Tamilnadu, Karnataka). | Widely distributed |
| 45 | *Thermocyclops decipiens*  
(Kiefer, 1929) | Africa; Central America, South America, Australia; Asia: Indonesia, Philippines, Sri Lanka, India (States of Andhra Pradesh, Kerala, Tamilnadu, Karnataka). | Widely distributed |
| 46 | *Thermocyclops rylovi*  
(Smirov, 1929) | Africa; Asia: Irán, Tajikistan, Pakistan, Kazakhstan, Thailand, Malaysia, Uzbekistán, India (Coimbatore, Tamil Nadu). | Widely distributed |
| 47 | *Thermocyclops vermifer vermifer*  
(Lindberg, 1935) | Asia: China, India, Iran, Tajikistan, Uzbekistan, Kazakhstan, Pakistan, Turkmenistán, India (Mysore, Kuruduvadi, Goa, Pandharpour, Dhalgaon, Latour, Ajanta). | Oriental |
| 48 | *Apocyclus dengizicus dengizicus*  
(Lepechkine, 1900) | Africa; America; Australia; Asia: Israel, Irán, Iraq, Malaysia, Sri Lanka, India. | Widely distributed |
| 49 | *Apocyclus royi*  
(Lindberg, 1940) | Africa; Asia: China, Taiwan, India (Mumbai). | Widely distributed |