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A new representative of *Mesocyclops thermocyclopoides*-circle (Copepoda: Cyclopoida) from India

by
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Abstract: A new *Mesocyclops* species, *M. dadayi*, has been described from India (Calcutta). *M. dadayi* sp. n. has all the characteristics of *Thermocyclopoides*-circle and can be distinguished from other representatives of the circle by hairy intercoxal sclerite of leg 4. Character analysis suggests West-African *M. dussarti* Van de Velde, 1984 to be the closest relative of *M. dadayi*. Key to fourteen Afro-Asian representatives of the *Thermocyclopoides*-circle is added.
Key words: taxonomy, Copepoda, Cyclopidae, *Mesocyclops*, Oriental region.

Introduction

The genus *Mesocyclops* Sars, 1918 has diversified to a great extent in the Palaeotropis, harbouring seventy percent (ca. 40 species) of the total world fauna as recently known. These predacious cyclopids have radiated to extremely different habitats, living in all kinds of waterbodies from the deep and long-lived ancient lakes to the ephemeral pools.

From the Indian subcontinent and Sri Lanka fourteen taxa (Table 1) have been recorded until now. Yet three *(M. leuckarti deccanensis, M. forbesi, M. cokeri)* of them should be considered as nomina dubia, and strong doubts are raised, suggested by the recent taxonomical and distributional knowledge (Kiefer 1981, Van de Velde 1984, Holyński 1994) against the occurrence of other three species (*M. annae, M. leuckarti* and *M. thermocyclopoides*) in this region.

Table 1. *Mesocyclops* species recorded from the Indian subcontinent and Sri Lanka. (In parentheses are sources of information. Species names with asterisk are considered as nomina dubia)

	Indian subcont.	Sri Lanka
M. annae Kiefer, 1930	–	+[1]
M. aspericornis (Daday, 1906)	+[2]	+[3]
M. cokeri Nisa *et al.* 1987*	+[4]	–
M. forbesi Nisa *et al.* 1987*	+[4]	–
M. granulatus Dussart & Fernando, 1988	+[5]	–
M. isabellae Dussart & Fernando, 1988	+[5]	+[6]
M. kieferi Van de Velde, 1984	–	+[5]
M. leuckarti (Claus, 1857)	+[7,8,9]	–

M. leuckarti deccanensis Lindberg, 1935*	+[10]	–
M. ogunnus Onabamiro, 1957	+[5,11]	+[6]
M. cf. *pehpeinestis* (Hu, 1943)	+[6]	+[3,5]
M. ruttneri Kiefer, 1981	+[6]	+[3,5]
M. splendidus Lindberg, 1943	+[5,12]	+[3,5]
M. thermocyclopoides Harada, 1931	+[2]	–

Legend: 1 = Dussart & Fernando (1986); 2 = Kiefer (1981); 3 = Dussart & Fernando (1985); 4 = Nisa *et al.* (1987); 5 = Dussart & Fernando (1988); 6 = the author's unpublished results on Daday collection - Budapest, Hungarian Natural History Museum; 7 = Vass & Zutshi (1983); 8 = Sharma & Pant (1985); 9 = Vass *et al.* (1988); 10 = Lindberg (1935); 11 = Dussart & Sarnita (1987); 12 = Lindberg (1943)

In two vials of the Daday collection (Forró & Dussart 1985), labelled as "*Mesocyclops leuckarti*", I found a new *Mesocyclops* species belonging to the *Thermocyclopoides*-circle (Holyński & Fiers 1994).

Material and methods

Material examined: Type material - holotype: female (ex. vial no: III-265; India, Calcutta); paratypes: eleven females (ex vials no: III-263, 265; India, Calcutta), dissected in glycerin and mounted in two Cobb-slides each - the first contains A1-P4, the second P5-abdomen; non-type material - 194 undissected females (ex vial no: III-265). Male was not found. Both vials were deposited in "Collectio Dadayana", Department of Zoology, Hungarian Natural History Museum.

Measurements were made on the twelve dissected specimens in glycerin. I made the drawings by means of Wild M 20 microscope fitted with drawing tube. In three paratype specimens the light microscope studies of the urosome were supplemented by scanning electron microscopic examinations. In the nearly hundred years old *Mesocyclops* material I could not find any specimen without injuries, therefore the characterization of armatures of the antennulae, mouth organs and legs, is a compilation based on all the dissected specimens.

The holotype, seven paratypes and 174 undissected non-type specimens are deposited in the Department of Zoology, Hungarian Natural History Museum, Budapest, four paratypes and 20 undissected females in the Museum and Institute of Zoology, Warsaw.

I used the terminology of the furcal setae and female genital system according to Huys & Boxshall (1991).

Abbreviation used in the text, and figures are: A1 = antennula, P4 = leg 4, P5 = leg 5, enp = endopod, exp = exopod, s = seta, sp = spine, ae = aesthetasc.

Results

Mesocyclops dadayi sp. n.

Type locality: India, Calcutta

Etymology: The species is named after Jenő Daday Deés, renowned Hungarian student of microcrustacea, whose collection this species is described from.

Description of the holotype (female)

Length of the body (excluding furcal seta) = 1060 μm; prosome/urosome = 1.62; cephalothorax length/width = 1.15

Antennula. (Fig. 1B) 17-segmented, last two segments with finely serrate hyaline membrane. Hyaline membrane of segment 17 with one strikingly large notch (Fig. 1C). Anterior surface of articles 1, 4, 5, 7-14(!) adorned with spinule rows. The armature formula as in *M. leuckarti*, and *M. thermocyclopoides*: 8s, 4s, 2s, 6s, 4s, 1s+1sp, 2s, 1s, 1s, 0, 1s, 1s+1ae, 0, 1s, 2s, 3s, 7s+ae (Fig. 1D). Some of the setae on the holotype were broken off, therefore the real armature had to be reconstructed by the use of other specimens as well.

Antenna. (Fig. 1G) Coxa, basis, and three-segmented endopod with 0, 3, 1, 7, 7 setae respectively.

Basis, caudal spinule pattern (Fig. 1E, I): near base long spinules on outer rim, very small ones on inner rim; next to spinules on outer rim oblique row of spinules; longitudinal row of 14 distally growing spinules along the outer rim; oblique row of very fine spinules, starting from ca. half of inner rim; group of small spinules next to implantation of inner setae; tiny spinules next to the distal rim of basis in one of two antennae.

Basis, frontal spinule pattern (Fig. 1F): longitudinal row of 22 spinules on outer rim; no spinule group next to implantation of exopod seta; transverse row of tiny spinules near base of segment.

Labrum. (Fig. 1J) Distal margin toothed. On external (ventral) surface two longitudinal ridges, each bearing one transversal row of long hairs.

Paragnath. (Fig. 1K) Ventral armature: medialmost lappet with spinules; longitudinal row of teeth in distal third of inner rim; two longitudinal rows of setules, external ones longer and proximally shifted; on inner side of paragnath large serrate teeth, perpendicular to its axis.

Mandibula. (Fig. 2D) Gnathobase with strongly chitinized teeth. One segmented palp with two long and one short setae. Near the palp three groups of spinules on frontal surface. Spinule-like structures on praecoxa.

Maxillula. (Fig. 2B) Praecoxal arthrite with three claws distally, at their base one spiniform seta on ventral surface. The largest, setulose seta on the inner rim is broken off in the holotype. Two medium-sized and three small spiniform setae on inner rim, and small spine at base of praecoxal arthrite. Palp (Fig. 1H) with one spine and two setae apically, one external seta proximally, and three seta on external lobe. No spinules on palp.

Maxilla. (Fig. 2A) Syncoxa, basis, and one-segmented endopod. Praecoxa bears one endite with two setae, coxa has one endite with one seta (broken off in the holotype) in distal two thirds, and one distal endite bearing one spiniform apical seta, and one ca. half as long, slender subapical seta. Basis with two setae, shorter seta placed caudally, the longer one inserted in front of the claw-like basal endite armed with strong teeth. One-segmented endopod with five setae. Two small setae of endopod inserted on caudal surface of external spiniform setae, near its articulation on endopod. Coxa with longitudinal spinule rows on frontal surface.

Maxilliped (Fig. 2C) Syncoxa, basis and two-segmented endopod. Coxa with three inner setae. Basis with one inner (broken off in the holotype) seta at distal third, and one spiniform seta shifted to frontal surface. Caudally two groups of spinules near outer margin. Long spinules on inner margin and frontal surface below the insertion of basal setae. Enp1 with one stout seta and few spinules on frontal surface. Enp2 with three setae of increasing length from outermost to innermost.

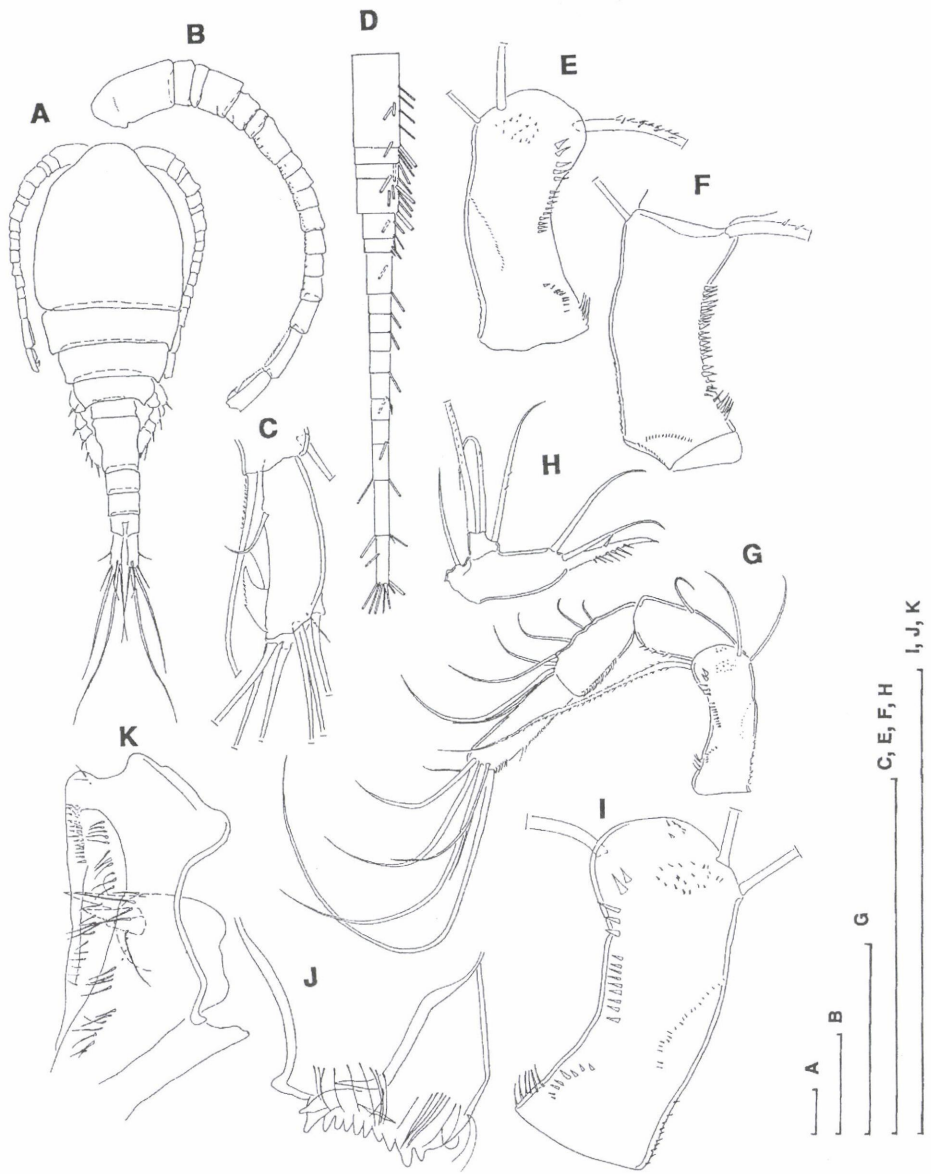

Fig. 1. *Mesocyclops dadayi* sp. n. female; A = habitus; B = antennula (anterior): C = last segment of the antennula; D = antennula armature (schematic representation); E = antennary basis (caudal); F = antennary basis (frontal); G = antenna (caudal); H = maxillulary palp (frontal); I = antennary basis (caudal); J = labrum (ventral); K = paragnath (ventral) Except the figures A (paratype) and D (compilation based on all the dissected specimens), all the pictures show the holotype. Scales: 100 μm.

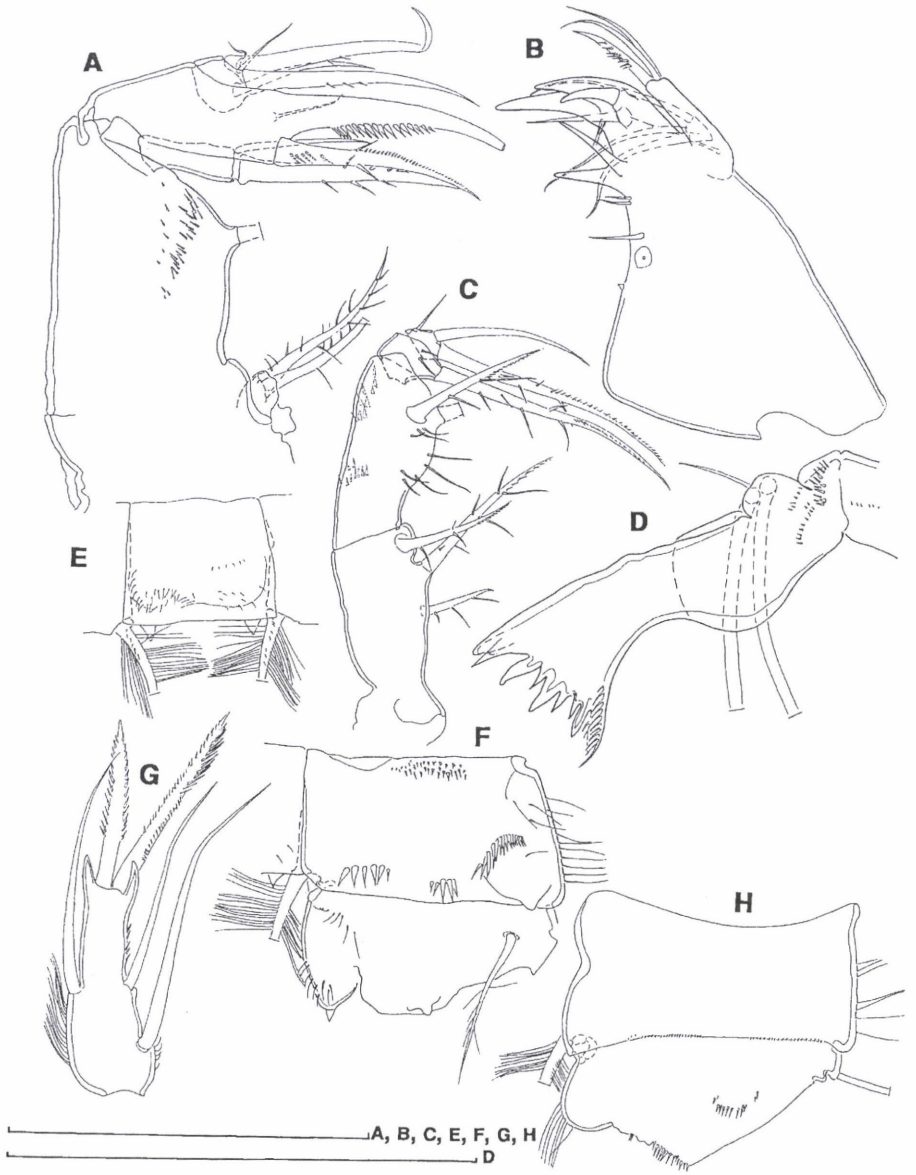

Fig. 2. *Mesocyclops dadayi* sp n. female, holotype; A = maxilla (frontal); B = maxillula (dorsal); C = maxilliped (frontal); D = mandibula (frontal); E = leg 4 intercoxal sclerite (caudal); F = leg 4 coxa, basis (caudal): G = leg 4 end3 (caudal); H = leg 1 basis, coxa (frontal). Scales: 100 μm.

Leg 1-4. Spine and seta formula as in *M. leuckarti* and *M. thermocyclopoides* (Table 2).

Group of small spinules in semicircular arch on frontal surface of leg 1 basis (Fig. 2H). Lateral rim of leg 1-4 coxa with hairs. Apical part of medial expansion of leg 1-4 basis bearing hairs. On medial expansion of leg 4, proximal group of few long hairs caudally also present. Intercoxal sclerite of leg 4 haired on caudal surface (Fig. 2E), naked frontally. No hairs either frontally or caudally on intercoxal sclerite of leg 1-3. Two small acute outgrowths on intercoxal sclerite of leg 4.

Caudal armature of leg 4 coxa (Fig. 2F): intermittent group of large spinules (6+5) near distal rim; oblique, oblique row of long spinules inserted side by side on outer distal corner; long hairs next to and on lateral rim; many small spinules in 2 or 3 rows near proximal rim.

Leg 4 enp3 (Fig. 2G): length/width = 2.55; inner apical sp/outer apical sp = 1.22; inner apical sp/enp3 length = 1.0; outer edge of inner apical spine, except the proximal third, with teeth at full length .

Table 2. Armature of leg 1-4 of *Mesocyclops dadayi* sp. n. (Spines are denoted by Roman-, setae by Arabic numerals. The armature on theouter margin of any segment is given first, it is followed by the elements on the apical and inner margins)

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-0	I-1; I-1; I-II,1-2	0-1; 0-2; 1-I,1-3
Leg 2	0-1	1-0	I-1; I-1; I-II,1-3	0-1; 0-2; 1-I,1-3
Leg 3	0-1	1-0	I-1; I-1; I-II,1-3	0-1; 0-2; 1-I,1-3
Leg 4	0-1	1-0	I-1; I-1; I-II,1-3	0-1; 0-2; 1-II-2

Leg 5 (Fig. 3A) Segmentation and armature as typical of the genus. Spiniform (inner) seta of exopod/seta of baseoendopod = 0.74. Apical exopod seta ca. half as long as the genital double somite.

Leg 6. Long medial seta and two short spines of about equal length.

Pediger 5 (Fig. 3B) Laterally and dorsally haired.

Genital double somite. (Fig. 3A, B) Dorsal surface densely haired in proximal half .

Receptaculum seminis. (Fig. 3A) Lateral arms short, weakly curved posteriorly; anterior margin of proximal part strongly concave in the middle; horseshoe-shaped copulatory pore moved upward to the level of the transverse ducts (posterior margin of proximal part); transverse ducts do not form acute angle ("V-shaped") before their connection with copulatory duct (pore canal); part of copulatory duct connecting copulatory pore and transverse ducts is not recognizable; two hardly discernible - light microscope observations leave some doubt about their presences - circular pores posterior to copulatory pore; copulatory duct curved, with ring-like structures at full length (Fig. 3C).

Anal segment. (Fig. 3D, E) Distal margin with several well-developed spinules ventrally, and only few small medially shifted ones on dorsal surface.

Furca. (Fig. 3D, E) Length/width = 3.40; dorsal s/posterolateral s = 1.33; length of apical setae from innermost to outermost: 195 (m, 380 (m, 265 (m, 70 (m; longest furcal s/urosome length = 0.94. Spinules at base of insertion of posterolateral furcal setae only. Hairy medial and ventral surface.

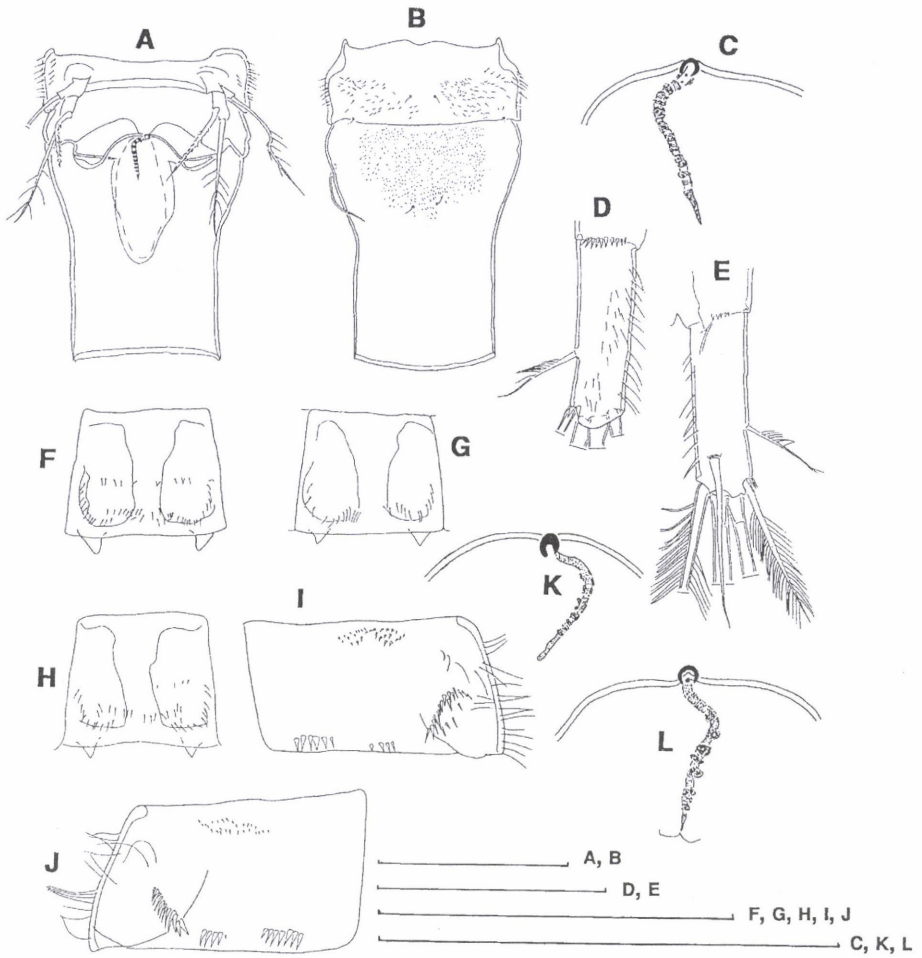

Fig. 3. A. *Mesocyclops dadayi* sp. n. female; A = pediger 5 and genital double somite (ventral); B = pediger 5 and genital double somite (dorsal); C = copulatory pore, copulatory and transverse ducts; D = furcal ramus (ventral); E = furcal ramus (dorsal); F-H = variable hairiness on the leg 4 intercoxal sclerite (caudal); I.-J = variability in armature of the leg 4 coxa; K-L = variable banding of the copulatory duct .Except the figures F-L made from paratypes, all the drawings show the holotype.
Scales: 100 μm.

Variability

Variability of body length and ratios is shown in Table 3.

Table 3. Morphometrical variability of *Mesocyclops dadayi* sp. n. (in parentheses the numbers of specimens measured).

	Range	Average
Total length (12):	940-1060 µm	982 µm
Cephthx l/w (9):	1.05-1.16	1.12
Gen dos l/w (10):	1.05-1.41	1.27
Pros/Uros (10):	1.49-1.78	1.59
P4 enp3		
l/w (12):	2.39-2.76	2.60
ap sp, in/out (12):	1.10-1.31	1.22
in ap sp/ enp3 l (12):	0.90-1.03	0.97
P5		
in exp s/basend s (4):	0.74-1,35	1.14
Furca		
l/w (10):	3.16-3.61	3.35
Furcal s		
ter acces (5):	175-195 µm	187 µm
in ter (5):	365-380 µm	375 µm
out ter (5):	255-270 µm	263 µm
post lat (5):	65-70 µm	69 µm
Ant lat s/furca l (7):	0.38-0.49	0.43
Dors s/post lat s (6):	1.24-1.72	1.43
In ter s/Uros (5):	0.94-1.03	1.00

Abbreviations: cephthx = cephalothorax, l = length, w = width, gen dos = genital double somite, pros = prosome, uros = urosome, P4 = leg 4, enp3 = third segment of endopod, ap = apical, sp = spine, in = inner, out = outer, P5 = leg 5, exp = exopod, s = seta, basend = baseoendopod, ter = terminal, acces = accessory, post = postero-, lat = lateral, ant = antero-, dors = dorsal

Retaining the basic pattern of the spinule ornamentation of the antennary basis, the number of spinules changes in certain groups (e. g. 10-17 and 20-26 spinules in the longitudinal rows on the caudal and frontal surface respectively). Caudal group of tiny spinules next to distal rim (Fig. 1I) is absent in 3 of 12 specimens on both antennary basis. Variability in the armature of P4 intercoxal sclerite and coxa, the curvature and banding of the copulatory duct see in Fig. 3F-L. The light microscope observations suggest that the number of circular pores posterior to the copulatory pore also changes from 0 to 2 (Fig. 3C, K, L).

Diagnosis

Mesocyclops dadayi sp. n. differs from other members of the *Thermocyclopoides*-circle by the following combination of the characters: caudal spinule ornamentation of the antennary

basis; intercoxal sclerite of P4 with hair rows on the caudal surface; dorsum of genital double somite densely haired in proximal half only; armature of P4 coxa; copulatory duct with ring-like structures; furca with hairs on medial and ventral surface; pediger 5 laterally and dorsally haired; position and connection of copulatory pore with transverse ducts. The first six characters distinguish *M. dadayi* from its supposedly closest relative, *M. dussarti* Van de Velde, 1984.

Discussion

One of the characteristics of the Asian *Mesocyclops* fauna is the domination of the speciose and widely distributed *Thermocyclopoides*-circle. The species belonging to this complex share a polythetic character assemblage (small outgrowths on the intercoxal sclerite of leg 4; medial expansion of the leg 4 basis proximally and distally pilose; pediger 5 laterally pilose; receptaculum seminis with short and wide, not strongly curved lateral arms; no spine on the medial expansion of leg 1 basis; no spinule group proximal to the insertion of the exopod seta on the frontal surface of the antennary basis), and distinct rows of spinules on the frontal surface of the maxilla, a feature with relatively strong diagnostic value in itself (Holyñski & Fiers 1994). It seems rather obvious, that the polythetic character-set is a mixture of features evolved at different times, partly perhaps even before the appearance of the direct ancestor of the *Thermocyclopoides*-circle. Within the Palaeotropical *Mesocyclops* the spiny armature on the maxillary coxa is present, with one exception, only in those species, where the above mentioned polythetic character set also appears, supporting the naturalness of the polythetically defined *Thermocyclopoides*-circle. The exception is *M. ruttneri* Kiefer,1981: the specimens from South India - referred to in our previous paper (Holyñski & Fiers 1994) as *M. cf. papuensis* - North Vietnam, and United States display great variability (no spinules, few small spinules, distinct rows of medium sized spinules) in this character. Phylogenetic relationships between *M. ruttneri* Kiefer, 1981 and *Thermocyclopoides*-circle, as in the genus *Mesocyclops* on the whole, are still unclear. Here I prefer the term "circle" (Holyñski 1992) over "group", the latter is too neutral, not necessarily implying any phylogenetic relations among its members, and on the other hand the term "clade", which refers to strictly monophyletic (holophyletic) taxa. "Circle" can be applied to both holophyletic and paraphyletic groups.

Besides those species mentioned before (Holyñski & Fiers 1994), my later examinations have revealed *M. granulatus* Dussart & Fernando, 1988, *M. isabellae* Dussart & Fernando, 1988, *M. tobae* Kiefer, 1934, *M. microlasius* Kiefer, 1981, *M. dissimilis* Defaye & Kawabata, 1993, and *M. dadayi* sp. n. to be members of the circle. Although I did not observe original material of *M. arcanus* Defaye, 1995, *M. notius,* Kiefer, 1981, and *M. australiensis* (Sars, 1908), the published descriptions suggest that they belong to the complex as well.

Structure of the *Thermocyclopoides*-circle is not known yet, therefore my hypotheses on the polarities have been based upon the character distribution in - and even outside - the whole *Thermocyclopoides*-circle rather than on one or two arbitrarily chosen "outgroup"-species.

Among the 14 described species of the *Thermocyclopoides*-circle, the irregular hairiness on dorsum of the pediger 5 and presence of hairs on proximal half of genital double somite

unite *M. thermocyclopoides* Harada, 1931, *M. isabellae* Dussart & Fernando, 1988, *M. dussarti* Van de Velde, 1984 and *M. dadayi* sp. n. in a subgroup [I have no information of these features in *M. arcanus* Defaye, 1995, *M. notius* Kiefer, 1981, and *M. australiensis* (Sars, 1908)]. Among the Old-World *Mesocyclops* not belonging to the *Thermocyclopoides*-circle and known to me (*M. ruttneri* Kiefer, 1981, *M. papuensis* Van de Velde, 1987, *M. splendidus* Lindberg, 1943, *M. pseudoannae* Van de Velde, 1987, *M. pehpeiensis* (Hu, 1943), *M. leuckarti* (Claus, 1857), *M. salinus* Onabamiro, 1957, *M. paludosus* Lindberg, 1956, *M. rarus* Kiefer, 1981, *M. spinosus* Van de Velde, 1984, *M. darwini* Dussart & Fernando, 1988, *M. brevisetosus* Dussart & Sarnita, 1987, and *M. major* Sars, 1927), the only species having hairy pediger 5 and genital double somite is the African *M. major* Sars, 1927, but there these features very probably are homoplasies. These observations suggest, that the characters in question appeared in the common ancestor of *M. thermocyclopoides* Harada, 1931, *M. isabellae* Dussart & Fernando, 1988, *M. dussarti* Van de Velde, 1984 and *M. dadayi* sp. n.

Within the quartette, *M. isabellae* Dussart & Fernando, 1988, *M. dussarti* Van de Velde, 1984, and *M. dadayi* sp. n. are connected by a less spectacular feature: transversal rows of spinules, occurring in all the other species of the *Thermocyclopoides*-circle on the 1. 4-5. 7-13. antennular segments only, are present in these three species on the 14. antennular segment also. To be sure, I could also observe spinules on the 14. antennular segment in some specimens of *M. woutersi* Van de Velde, 1987 (Papua New Guinea: Madang Pr.) *M. dissimilis* Defaye & Kawabata, 1993 (Japan: Lake Biwa and Lake Kitaura) and *M. aequatorialis similis* Van de Velde, 1984 (Ethiopia: Lake Awassa), but in fixed state this character is exlusively confined to *M. isabellae* Dussart & Fernando, 1988, *M. dussarti* Van de Velde, 1984, and *M. dadayi* sp. n. In those Palaeotropical *Mesocyclops* species, which do not belong to the *Thermocyclopoides*-circle, this feature in fixed state is never present.

To resolve the relations within this triad, the autapomorph characters and their alternates as synplesiomorphies had to be exluded from the analysis. The banded pore canal in *M. dadayi* sp. n. is a unique feature I have not seen in other Old-World *Mesocyclops*. Features, which are unique within the *Thermocyclopoides*-circle, as hairs on the caudal surface of leg 4 intercoxal sclerite in *M. dadayi* sp. n., and caudal hairs near medial rim of leg 4 coxa in *M. dussarti* Van de Velde, 1984 also appear in outside of the circle - the former feature in *M. major* Sars, 1927, *M. salinus* Onabamiro, 1957 and *M. tenuisaccus* (Sars, 1927), the latter one in *M. major* Sars, 1927 and *M. tenuisaccus* (Sars, 1927) - , therefore I reckon the presence of these characters among homoplasies, and their absence among symplesiomorphies in the group studied. Although hairs on medial surface of the furca are present in two other representatives of the *Thermocyclopoides*-circle [*M. aspericornis* (Daday, 1906)- at full length; *M. microlasius* Kiefer, 1981- in the proximal half], I think it is more likely that they are non-homologous features evolved independently in the three species: differences in the position of the copulatory pore and its connection with transverse ducts (female genital system), hair ornamentation on dorsum of the pediger 5 and genital double somite, and in the spinule ornamentation of 14. antennular segment suggest that those species can not be united with *M. dadayi* sp. n. in a monophyletic group. I consider the completely haired dorsum of the genital double somite of *M. dussarti* Van de Velde, 1984 *vs.* the partly (in the proximal half) haired genital double somite of *M. dadayi, M. isabellae* Dussart & Fernando, 1988 and *M. thermocyclopoides* Harada, 1931 as autapomorphy, too. The genital double somite, fused from 7. thoracic (genital) and 1. abdominal segment, is entirely naked in other representatives of the *Thermocyclopoides*-circle, and only in *M. major* Sars, 1927 - a species outside the circle - it is at full length hairy. It seems likely, that the hairiness of the genital dou-

ble somite - representing in fact two independent characters - was expressed on one (the proximal) half of the somite in the ancestor of the *isabellae-dadayi-dussarti-thermocyclopoides* group, this feature has been conserved in *isabellae-dadayi-thermocyclopoides* trio, while in *M. dussarti* Van de Velde, 1984 the distal half has become also hairy. The caudal spinule ornamentation of the antennary basis is represented by specific pattern in all the three species in question, that makes any phylogenetic interpretation here rather difficult.

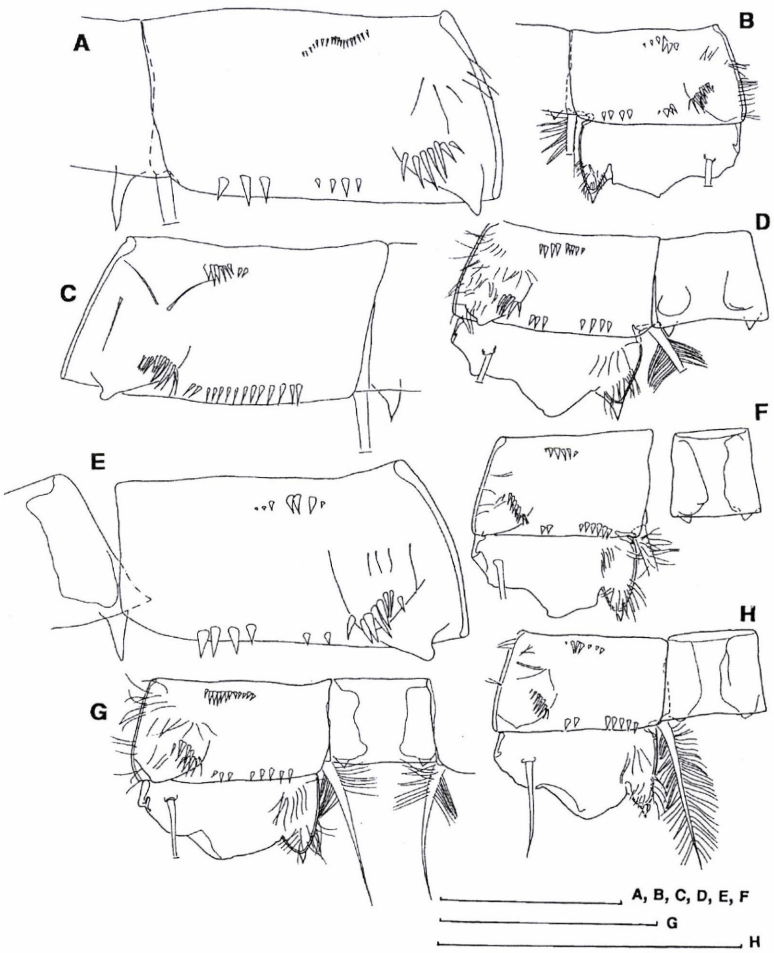

Fig.4. Ornamentation of the leg 4 coxa in *Mesocyclops* species recorded from the Indian subcontinent and Sri Lanka; A = *M. ruttneri* (South-India, Ernakulam); B = *M. granulatus* (Bangladesh, Mymensingh); C = *M. splendidus* (South India, Trichur); D = *M. aspericornis* (Indonesia, Celebes, Salua); E = *M.* cf. *pehpeiensis* (North-India, Siligure); F = *M. isabellae* (Central-India, Jabalpur); G = *M. ogunnus* (South-India, Chalakudy); H = *M. thermocyclopoides* (Taiwan, Sun Moon Lake).
Scales: 100 μm.

Nevertheless, the similarities in the spinule armature of the furcal rami and the caudal surface of leg 4 coxa (spinules at implantation of the posterolateral furcal setae; several spinules in more than one row near the proximal rim, and also relatively many spinules near the distal rim of leg 4 coxa) suggest *M. dussarti* Van de Velde, 1984 to be the closest relative of *M. dadayi* sp. n. *M. isabellae* Dussart & Fernando, 1988 and *M. thermocyclopoides* Harada, 1931 have no teeth at base of the posterolateral furcal setae, the caudal surface of leg 4 coxa bears one spinule row near the proximal rim and few spinules along distal rim (Fig. 4F, H). Alternates of the three above mentioned characters occur both in, and outside of the *Thermocyclopoides*-circle, which does not support in their case unambiguous polarizations.The character distribution within the species quartette and proposed scheme of the phylogenetic relationships are shown in Table 4 and Fig. 5.

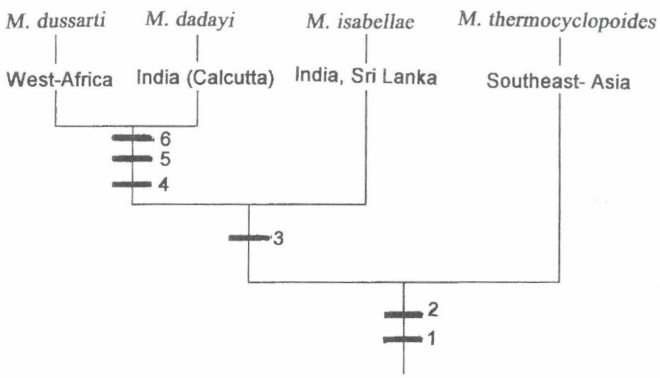

Fig. 5. Hypothetic phylogenetic relationships of *M. dadayi* sp. n., and distribution of the closely related species. (Characters used in the phylogenetic reconstruction see in Table 4.)

Table 4. Distribution of characters choosed to resolve phylogenetic relationships of *M. dadayi* sp. n.

	1	**2**	**3**	**4**	**5**	**6**
M. dadayi sp. n.	+	+	+	+	+	+
M. dussarti Van de Velde, 1984	+	+	+	+	±	+
M. isabellae Dussart et Fernando, 1988	+	+	+	–	–	–
M. thermocyclopoides Harada, 1931	+	+	–	–	–	–

1 = Irregular hairs on dorsum of pediger 5
2 = Dorsal hairs on proximal half of the genital double somite
3 = Spinule rows on 14. antennular segment
4 = Spinules at implantation of posterolateral furcal setae
5 = Many (>9) spinules near distal rim on caudal surface of the leg 4 coxa.
6 = More than one spinule row near proximal rim on caudal surface of the leg 4 coxa.
\+ = presence [**1-4**]; many spinules [**5**]; more than one row [**6**]
– = absence [**3,4**]; few (at most 9) spinules[**5**]; one spinule row [**6**]
± = many, or few spinules

The form of leg 4 endopod in the females of the cyclopids and the form and setation of the female caudal rami in Baikalian harpacticoid copepods (*Moraria*) are suspected by Boxshall & Evstigneeva (1994) to be significant tactile part of the specific mate recognition system (SMRS). Gophen's observations (1979) on the mating process of "*M. leuckarti*" [it was later identified by Van de Velde as *M. ogunnus* Onabamiro, 1957 (Defaye 1995)] from Lake Kinneret show, that the male usually grasps with its geniculate antennulae the female at her furcal setae close to the rami at first, later his hold moves toward the genital segment, and finally he attaches to the fourth leg of the female. On the other hand, *Mesocyclops* species often show sexual dimorphism in both the caudal armature of the leg 4 coxa and the spinulation at the insertion of furcal setae. Sexual dimorphism of these features has also been observed in *M. dussarti* Van de Velde, 1984 and *M. thermocyclopoides* Harada, 1931 (Van de Velde 1984, Holyñski 1994). Males of *M. isabellae* Dussart & Fernando, 1988 and *M. dadayi* sp. n. are still unknown. I suspect, that the spinule armature of the furcal rami and the spinule pattern on the leg 4 coxa of *Mesocyclops* female can also serve as tactile signals in the SMRS. If it is so, we should expect these characters to be similar (or identical) in the very closely related allopatric forms, but differentiated in the sympatric ones. *M. dussarti* Van de Velde, 1984 is a West African (Sahel) species with pluvial relict populations in Tassili-n-Ajjer, and a southern record from Lualaba - upper reach of R. Zaire - (Van de Velde 1984); *M. dadayi* sp. n. is known only from its Indian type locality; the area of *M. isabellae* Dussart & Fernando, 1988 includes the Indian subcontinent (Dussart & Fernando, 1988) and Sri Lanka (my unpublished data); there are uncertainties about the distribution of the genuine *M. thermocyclopoides* Harada, 1931 - I identified this species from Malaysia, Vietnam, Burma and Taiwan. The zoogeographical and morphological characteristics in this case just fit in the predicted way. To confirm the hypothesis about the function of these characters, it would be necessary to analyze the ornamentation of the leg 4 coxa and the furcal rami in other, supposedly closely related allopatric species-pairs. Of course, several other morphological structures on the furca, abdominal segments, and leg 4, can also play a more or less significant role in the SMRS, modifying the importance of any single feature in itself.

Key to the Afro-Asian *Mesocyclops* belonging to the *Thermocyclopoides*-circle.

(*M. arcanus* - supposed also to belong to the *Thermocyclopoides*-circle, but unknown to me in nature - is not included in this key. Another, not yet described species from South-India and Sri Lanka, closely related to *M. woutersi* and *M. dissimilis,* has been omitted as well.)

1. Pediger 5 laterally naked 2
– Pediger 5 laterally pilose 3

2. Medial expansion of leg 4 basis distally with minute spinules on caudal surface; dorsal furcal seta shorter or only a little longer than posterolateral one
..... *M. kieferi* Van de Velde, 1984
Transverse ducts of female genital system ("posterior margin of the proximal part of the receptaculum seminis") directed at acute angle ("V-shaped") to one another before the connection with copulatory duct; copulatory duct curved like a comma; caudal surface of the antennary basis with simple ("leuckarti-type") spinule ornamentation: abdominal segments dorsally and ventrally adorned with rows of spinules. Distribution: sub-Saharan Africa, Yemen, Israel, Sri Lanka, Brazil? (probably recently introduced).
– Medial expansion of leg 4 basis distally with hairs; dorsal furcal seta at least twice longer than posterolateral one ..... *M. tobae* Kiefer, 1934

Transverse ducts of the female genital system not V-shaped (make straight angle with one another) before their connection with the copulatory duct; copulatory duct straight or very slightly curved; caudal surface of the antennary basis with but a reduced pattern of extremely small spinules. Distribution: Lake Toba (Sumatra)

3. Furcal rami medially pilose 4
– Furcal rami medially naked 6

4. Furcal rami medially pilose in the proximal half only ..... *M. microlasius* Kiefer, 1981
A field of small spinules in addition to the "leuckarti-type" pattern on the caudal surface of antennary basis, next to implantation of the inner setae; transverse ducts of the female genital system V-shaped before their connection with the copulatory duct; the part of the copulatory duct connecting the copulatory pore and transverse duct, well visible. Distribution: Philippines (Luzon)
– Medial surface of furcal rami pilose at full length 5

5. Dorsum of genital double somite naked ..... *M. aspericornis* (Daday, 1906)
Caudal surface of antennary basis, in addition to the "leuckarti-type" pattern, with a group of small spinules between the proximal oblique and longitudinal spinule rows, and a field (very often of rectangular shape) of small spinules next to implantation of the inner setae (few spinules near the distal margin of the segment present in specimens from West-Africa); transverse ducts of the female genital system V-shaped before connection with the copulatory duct; distal margin of anal segment ventrally and dorsally fringed with well developed spinules; spinules at implantation of both the antero-and posterolateral furcal setae; no hairs on the caudal surface of the intercoxal sclerite of leg 4 . Distribution: Pantropical.
– Dorsum of genital double somite pilose ..... *M. dadayi* sp. n.
On the caudal surface of the antennary basis, in addition to the pattern of "leuckarti-type", a field of small spinules next to implantation of the inner setae always present, spinules next to distal rim of the segment frequently absent; transverse ducts not "V-shaped" before their connection with copulatory duct; copulatory duct with ring-like structures all along; distal margin of anal segment fringed with strong spinules ventrally, and only few small spinules on the dorsal surface; spinules at implantation of only the posterolateral furcal setae; intercoxal sclerite of leg 4 hairy on the caudal surface. Distribution: Known only from its type locality, Calcutta (India).

6. Spinule row on the maxillulary palp present ..... *M. ogunnus* Onabamiro, 1957
Caudal surface of the antennary basis, besides the "leuckarti-type" spinule pattern, shows a group of large spinules next to implantation of the inner setae; transverse ducts of female genital system often directed to one another at very obtuse angle before their connection with copulatory duct; pediger 5 bears hair rows on the dorsum; distal rim of the anal segment both ventrally and dorsally fringed with large spinules; spinules at implantation of the anterolateral furcal setae often present, but sometimes strongly reduced in size or absent; spinules at implantation of posterolateral furcal setae always present. Distribution: Tropical Asia (northernmost record from Uzbekistan), Africa, Brazil (probably recently introduced).
– Spinule row on the maxillulary palp absent 7

7. Group of large spinules on the caudal surface of antennary basis, next to implantation of inner setae, present 8
– Group of large spinules on the caudal surface of antennary basis, next to implantation of inner setae, absent 9

8. Caudal hairs next to medial rim of the leg 4 coxa present
..... *M. dussarti* Van de Velde, 1984
Dorsum of genital double somite hairy at full length; spinules at implantation of only the posterolateral furcal setae; transverse rows of spinules on the 1., 4-5., and 7-14. antennular segments. Distribution: West-Africa

– No caudal hairs next to medial rim of the leg 4 coxa
..... *M. thermocyclopoides* Harada, 1931
Dorsum of genital double somite hairy on the proximal half only; no spinules at implantation of either the posterolateral, or anterolateral furcal setae; transverse rows of spinules on the 1., 4-5. and 7-13. segments. Distribution: Malay Peninsula, Indochina and Taiwan.

9. Group of small spinules between the proximal oblique and longitudinal spinule rows on caudal surface of the antennary basis present
..... *M. isabellae* Dussart & Fernando, 1988
Pediger 5 pilose dorsally; dorsum of genital double somite hairy in the proximal half only; no spinules at implantation of the antero- and posterolateral furcal setae; distal rim of anal segment dorsally fringed with but few minute spinules; transverse rows of spinules on the 1., 4-5., 7-14. antennular segments. Distribution: India, Nepal, Sri Lanka.
- Group of small spinules between the proximal oblique and longitudinal spinule rows on caudal surface of the antennary basis absent 10

10. Caudal surface of medial expansion of the leg 4 basis pilose only distally
..... *M. granulatus* Dussart & Fernando, 1988
Granules along the copulatory duct; transverse ducts of the female genital system "V-shaped" before the connection with copulatory duct; pediger 5 dorsally with hair rows; no spinules at implantation of the antero- and posterolateral furcal setae; distal rim of the anal segment dorsally fringed only with minute spinules; caudal spinule pattern of the antennary basis of "leuckarti-type". Distribution: Indian subcontinent.
– Caudal surface of medial expansion of the leg 4 basis both proximally and distally pilose
..... 11

11. Transverse ducts not directed to one another at acute angle ("V-shaped") before the connection with copulatory duct, and curvature of copulatory duct varies from straight to moderate
..... 12
– Transverse ducts in most cases"V-shaped" before the connection with copulatory duct , and curvature of copulatory duct varies from moderate to strong; if transverse ducts directed to one another obtuse angle (not V-shaped) and/or curvature of copulatory duct slight, or near straight, spinules at implantation of antero- and posterolateral furcal setae absent 13

12. Transverse ducts strongly chitinized; the part of the copulatory duct, connecting copulatory pore and transverse ducts, well visible ..... *M. aequatorialis* Kiefer, 1929
The "leuckarti-type" spinule pattern on caudal surface of the antennary basis is often supplemented with a group of relatively large spinules next to exopod seta, and/or fields of spinules next to implantation of inner setae and the distal rim of the segment; spinules at implantation of both antero- and posterolateral furcal setae present Distribution: Africa, Israel, Uzbekistan.
- Transverse ducts not strongly chitinized; the part of the copulatory duct, connecting copulatory pore and transverse ducts, not visible ..... *M. affinis* Van de Velde, 1987
"Leuckarti-type" spinule pattern on the caudal surface of antennary basis supplemented with a field of spinules next to implantation of inner setae, group of relatively large spinules next to exopod seta and few spinules near the distal rim of the segment - the latter two elements can be absent; spinules at implantation of posterolateral furcal setae present; spinules at implantation of anterolateral furcal setae can be present or absent. Distribution: New Guinea, Malay Archipelago and Indochina.

13. Spinules at implantation of both the antero- and posterolateral furcal setae present
..... *M. dissimilis* Defaye & Kawabata, 1993
The "leuckarti-type" spinule pattern on the caudal surface of antennary basis supplemented with a field of spinules near the implantation of inner setae, and rarely a group of spinules near distal rim of the

segment; inner exopod seta of the leg 5 often shorter, in some cases as long as, or longer, than the baseoendopod seta of the leg 5; dorsal furcal seta often conspicuously longer (>1.2x) than the posterolateral one. Distribution: Japan

– Spinules at implantation of the anterolateral furcal seta always absent, those next to insertion of the posterolateral furcal seta usually absent ..... *M. woutersi* Van de Velde, 1987
The "leuckarti-type" spinule pattern on the caudal surface of antennary basis supplemented with a field of spinules near the implantation of inner setae, and sometimes a group of spinules near distal rim of the segment; inner exopod seta of the leg 5 longer than the leg 5 baseoendopod seta; dorsal furcal seta shorter or slightly, but never conspicuously longer (max. ca.1.1x) than the posterolateral one. Distribution: New Guinea, Indochina, China and Japan.

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