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A new Oriental species of *Mesocyclops* (Copepoda: Cyclopidae)

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Abstract

Mesocyclops ferjemurami sp. nov. is described from Central Vietnam, North India and Sri Lanka. It differs from all congeners in having a unique spinule ornamentation on the caudal surface of the antennary basipodite: the '*leuckarti*-type' spinule pattern is supplemented with a group of spinules at the height of implantation of the medial setae, and proximal to this group a triangular spinule field occurs, the longest side of which runs more or less parallel to the oblique row of tiny spinules starting at distal half of the medial rim. It is suggested that *Mesocyclops ferjemurami* is closely related to *Mesocyclops pehpeiensis* Hu, 1943 and *Mesocyclops papuensis* Van de Velde, 1987.

Abbreviations: P4 – leg 4; enp – endopodite; exp – exopodite; CV – copepodid V; P4 enp3 – third segment of endopodite of fourth leg

The *Mesocyclops* fauna of Vietnam is one of the best known of south-eastern Asia (Hołyńska, 1998; Nam et al., in press). The new species described here was found during collections made under the auspices of a mosquito-control program, in Khanh Hoa Province (Central Vietnam), 1997. These well preserved recent specimens helped to identify an almost 100 year old *Mesocyclops* in the collection of Jenö Daday (Budapest) ('*Cyclops leuckarti*'), collected in northern India and Sri Lanka.

Material and methods

Material examined. – *Sri Lanka*: 5 ♀♀ and 1 copepodid V, dissected, Central (Madatugama or Kalawewa or River Mahaveli - see Daday (1898)), swamp, 07 Feb–08 Mar 1896, leg. J. Madarász, Collectio Dadayana (Budapest), vial no: III-253; other *Mesocyclops* species present in this same vial: *M. isabellae* Dussart & Fernando, 1988, *M. splendidus* Lindberg, 1943, *M. ogunnus* Onabamiro, 1957, and *M. parentium* Hołyńska, 1997. *India*: 1♀ dissected, Siliguri, 26° 44′ N–88° 28′ E, Collectio Dadayana (Budapest), vial no: III-257. *Vietnam:* 4♀♀ dissected, 1♀ undissected, Khanh Hoa Province, Nha Trang (Vinh Ngoc), 12° 10′ N–109° 10′ E, well, 05 Aug 1997, Museum and Institute of Zoology (Warsaw).

The observations and measurements were made on specimens in glycerine. Drawings were made using a camera lucida attached to an Olympus BX 50 microscope. Measurements were taken following the method of Koźmiński (1936), with the minor modification that length of pediger 4, a somite leaning over pediger 5, was measured as the distance between its anteriormost and posteriormost points. The length of pediger 5 itself was not added to either that of the body or urosome. The width of the third endopodal segment of leg 4, cephalothorax and genital double-somite was measured across their widest part. All linear dimensions, with the exception of the length of the body, urosome, and terminal caudal setae, where an accur-

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acy of 5 μm was used, were measured to the nearest 1 μm.

Mesocyclops ferjemurami *sp. nov.*

Types. Female holotype (dissected) Vietnam, Khanh Hoa Province, Nha Trang (Vinh Ngoc), 12° 10′ N–109° 10′ E, well, 05 Aug 1997. Three paratypes (two dissected, one undissected) from the same locality as the holotype. Dissected specimens mounted on two slides each. Types are deposited in the Museum and Institute of Zoology PAS, Warsaw (cat. no: 4614 (holotype), 4615–4617 (paratypes)).

Etymology. This species is dedicated to the husband of the senior author, Roman Hołyński. 'Férjem uram' is a respectful, old-fashioned Hungarian expression for a woman to refer to her husband.

Description of holotype

Length of body=1375 μm; prosome/urosome=1.83; cephalothorax length/width=0.98; cephalothorax width/genital double-somite width=3.25 (Figure 1A)

Pediger 5 (Figure 4A,B,G): No hairs on somite. On dorsal surface, two sensilla medially and other two laterally near distal rim. Dorsum covered with rod-like structures: their shape, the asymmetric appearance of the rod-field, and lack of such structures in one paratype and all specimens from Sri Lanka however suggest that these rods are not the specimen's own integumental structures (bacteria?).

Genital double-somite (Figure 4A,B): Length/width=1.12. Somite ornamented with rows of pits, but, with exception of six dorsal and two ventral hair-sensilla, no hairs. Lateral arms of seminal receptacle (Figure 4A) elongated, anterior margin of proximal part sinuate in the middle; one circular pore posterior to horseshoe-shaped copulatory pore; transverse ducts meet at deep acute angle anterior to copulatory pore (Figure 4C); copulatory duct slightly curved.

Abdominal somites: Abdominal somites 2 and 3 ornamented with pits on ventral surface and 2 and 0 dorsal sensilla, respectively. Anal somite (Figure 4E,F) with two sensilla anterior to arcuate anal operculum, and a pair of median pores near posterior rim on ventral surface; entire posterior rim with strong spinules.

Caudal rami (Figure 4E,F): Length/width=2.82. Tiny spinules spread over the whole surface (not shown in the figure), hairs absent. Spinules at implantation of antero- and postero-lateral caudal setae present. Anterolateral seta/length of caudal ramus=0.48. Dorsal seta/posterolateral seta=0.81. Length of terminal setae from terminal accessory (medialmost) to posterolateral (lateralmost): 320 μm, 670 μm, 450 μm, 115 μm. Inner terminal (longest) seta/length of urosome=1.38.

Antennula. (Figure 1B-E): 17-segmented, setation pattern like in *M. leuckarti*, type species of genus: 8, 4, 2, 6, 4, 1+1 spine, 2, 1, 1, 0, 1, 1+aesthetasc, 0, 1, 2, 2+aesthetasc, 7+aesthetasc. Last two segments with hyaline membrane. Hyaline membrane of segment 17, extending along almost entire length of the segment, with one large notch. Aesthetasc on segment 16 highly reduced (Figure 1C,E). Segments 1, 5, 7–13 ventrally adorned with spinules. Fourth antennulary segment adorned with single spinule on antennula of the right-hand side only. Dorsal surface of antennula , with exception of segment 6 and 17 ornamented with pits.

Antenna. Basipodite, and three-segmented endopodite with 3, 1, 7, 7 setae, respectively. Exopodite seta long, reaching beyond distal rim of third endopodal segment. Setae at mediodistal angle of basipodite, of equal size. Endopodal segments with shallow pits on frontal and medial surfaces.

Basipodite, caudal spinule ornamentation (Figure 2A): near base of the segment long spinules on lateral rim and very small ones on and next to medial rim; oblique row spinules (8) next to spinules on lateral rim; longitudinal row of spinules (12) along lateral rim; oblique row of tiny spinules starting at distal half of medial rim; field of spinules near the implantation of medial setae; between the two groups mentioned above a triangular spinule field, longest side of the triangle runs more or less parallel to oblique row of tiny spinules.

Basipodite, frontal spinule ornamentation (Figure 2B): longitudinal row of spinules (28) along lateral rim, two transverse rows of spinules near proximal rim.

Mouthparts. Labrum (Figure 2C) with 10 teeth on distal rim between lateral angles. Except two groups of long hairs no other hairs on ventral surface, epistoma and vertical cleft also naked. Mandibular palp (Fig-

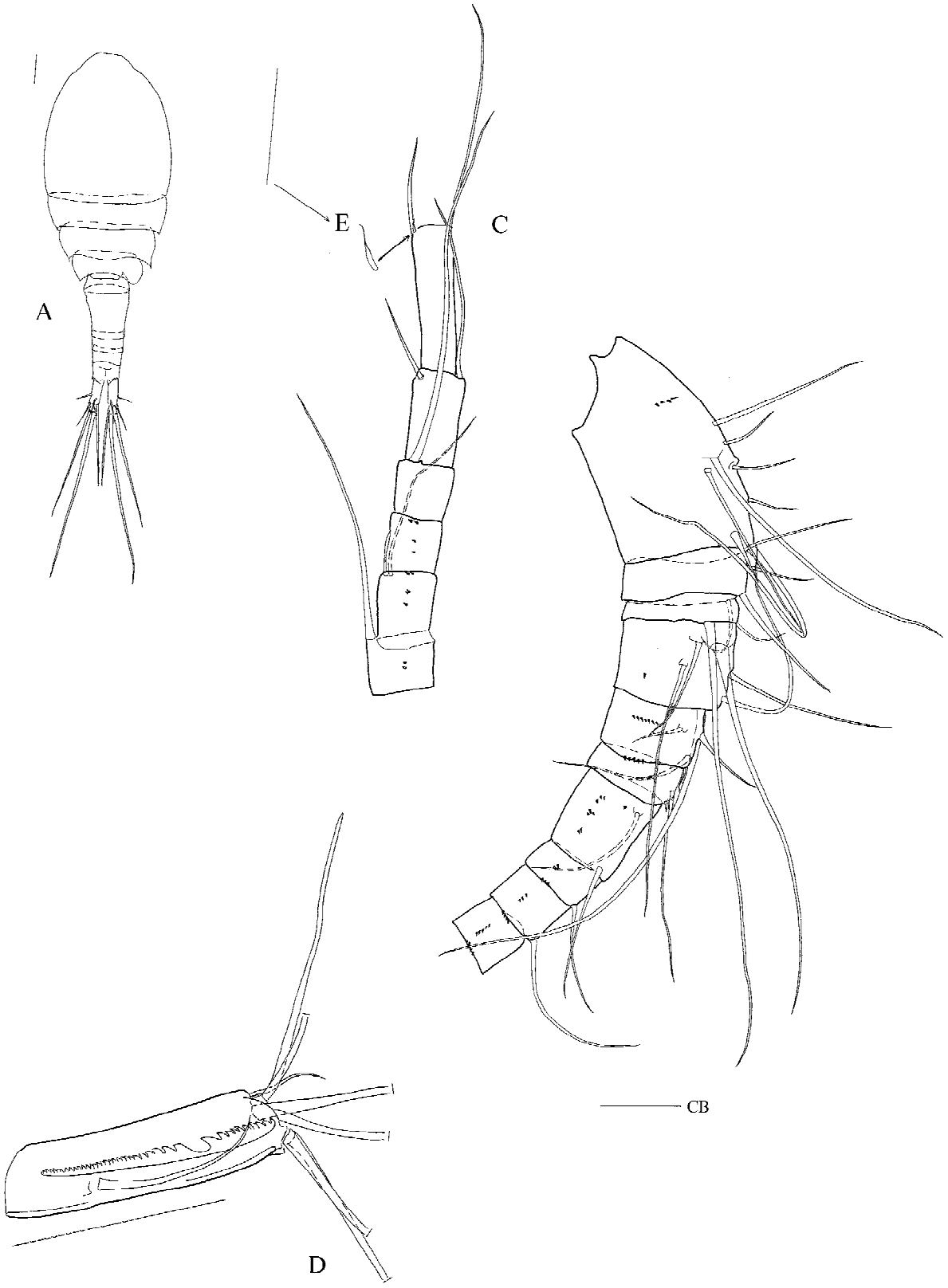

Figure 1. *Mesocyclops ferjemurami* sp. nov. (A) Habitus – paratype (no: 4617); (B–E) Antennula – holotype: (B) Segment 1–10; (C) Segment 11–16; (D) Segment 17; (E) Aesthetasc inserted on segment 16. Scales: 50 μm.

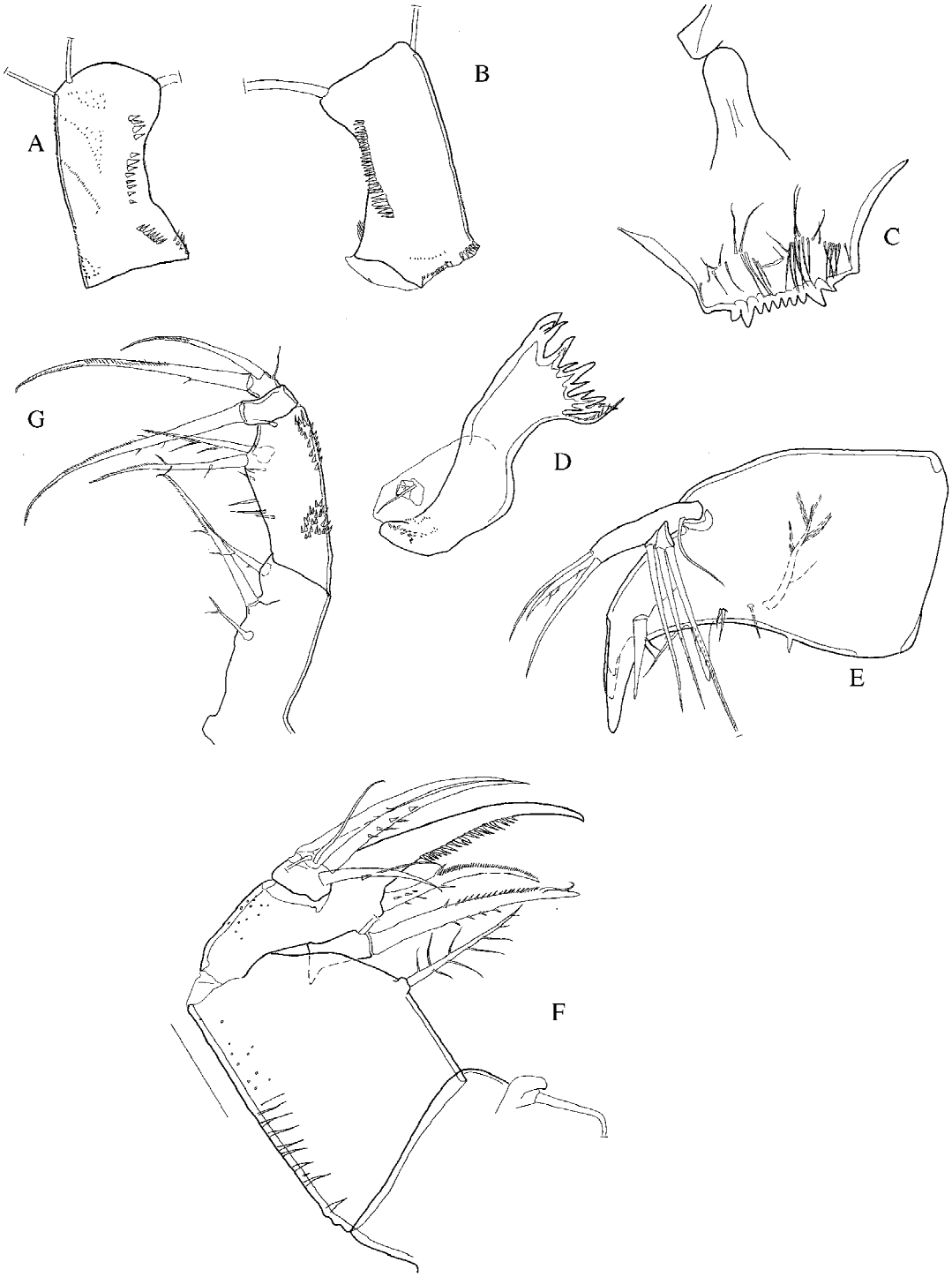

Figure 2. Mesocyclops ferjemurami sp. nov. (A) (B) Antennary basipodite – holotype: (A) caudal view; (B) frontal view; (C) Labrum, ventral view – paratype (no: 4616); (D) Mandibula, frontal view – holotype; (E) Maxillula, ventral view – holotype; (F) Maxilla, caudal view - holotype; (G) Maxilliped, caudal view – holotype. Scale: 50 μm.

ure 2D) with two long and one short setae. Near palp three groups of spinules. Segmentation and setation of maxillula (Figure 2E) like in *M. leuckarti* (Van de Velde, 1984). No spinules on palp, lateralmost (longest) seta of lateral lobe without long setules. Segmentation and setation of maxilla (Figure 2F) the same as in *M. leuckarti* (Van de Velde, 1984). Frontal surface of coxopodite without spinule ornamentation. Claw-like endite of basipodite armed with 20 strong teeth. Basal seta in front of claw-like endite with two longer setules inserted at proximal two-fifth, followed by fine teeth on posterior edge only. Segmentation and setation of maxilliped (Figure 2G) like in *M. leuckarti* (Van de Velde, 1984). Syncoxopodite with group of tiny spinules frontally near lateral rim. Scale-like spinules on caudal surface of basipodite arranged in two groups.

Leg 1–4: Setation the same as in M. leuckarti (Table 1).

Caudal spinule ornamentation on coxopodite with gradually increasing complexity from leg 1 to leg 4 (Figure 3A–F). Spinule ornamentation on leg 4 coxopodite (Figure 3E) consists of: intermittent or continuous row of spinules (4+3; 5) along distal rim; relatively thick and short spinules arranged in row at laterodistal angle; few spinules (8) of conspicuously different size along proximal rim; tiny spinules at lateroproximal angle; and row of hairs proximal to spinule group at laterodistal angle. Intercoxal sclerites of leg 1–4 without hairs on frontal and caudal surfaces. Leg 4 intercoxal sclerite with large ougrowths (ca. half of the height of medial expansion of basipodite), other legs with rounded marginal protrusions. Medial expansion of leg 1–4 basipodite with distal hairs. Semicircular group of spinules on frontal surface of leg 1 basipodite. Coxopodite seta of leg 4 1.76 times as long as height of medial expansion of basipodite. P4enp3 (Figure 4D) 2.9 times as long as wide, length of apical spines nearly the same (medial/lateral=0.99), longer apical spine 0.86 times as long as enp3 length. No teeth on lateral rim of medial apical spine.

Leg 5: Segmentation and setation typical of genus. Length of medial and apical setae on segment 2 and seta on segment 1: 124 μm, 155 μm, and 94 μm.

Leg 6: Ovoid plate with long seta (82 μm) and two short spines (8 μm, 5 μm) on latero-dorsal surface of genital double-somite.

Description of copepodid V (female)

(Because of contamination of the body surface, sensilla/hair ornamentations of the urosomites were not verifiable.)

Length of body=1075 μm; cephalothorax length/width=1.14; prosome/urosome=1.93; inner terminal (longest) caudal seta/urosome=1.7.

Entire posterior rim of anal somite with strong spinules. Caudal rami 2.48 times as long as wide, without hairs on medial rim. Spinules at implantation of antero- and posterolateral caudal setae present. Length of terminal caudal setae from medialmost to lateralmost: 185 μm, 650 μm, 395 μm, 65 μm.

Antennula: 11-segmented, with setation: 7, 4, 8, 4, 1+1spine, 2, 3, 2+aesthetasc, 2, 2+ae, 7+ae. Last two segments with hyaline membrane. Hyaline membrane of segment 11 extends little beyond implantation of medial seta.

Antenna: Basipodite, and three-segmented endopodite with 3, 1, 7, 7 setae, respectively. Caudal and frontal spinule ornamentation like in adult female, but number of spinules in particular groups reduced (e.g. there are 10 and 23 spinules in the longitudinal rows along lateral rim on caudal and frontal surfaces respectively).

Mouthparts: Segmentation and setation identical to adult female.

Leg 1–4: Armature see Table 1. Rami two-segmented, however spinule rows even though allocated on distal margin of mid segments appearing in adult stages only, recognizable with exception of leg 1 and leg 4 endopodites on all rami. Caudal spinule ornamentation on leg 4 coxopodite similar to that in adult female, but spinules (14) along proximal rim of about equal length. Intercoxal sclerites without hairs on frontal and caudal surfaces, in leg 4 with large outgrowths on distal rim. Medial expansion of basipodite with distal hairs in all legs. Of apical spines inserted on leg 4 endopodite, medial one 0.81 times as long as lateral one. Lateral rim of medial apical spine with 7/8 teeth.

Leg 5: Segmentation and setation as in adult female.

Leg 6: One long seta and two small spines inserted midlength of genital somite on laterodorsal surface. Male not found.

Table 1. Armature of leg 1–4 in *Mesocyclops ferjemurami* sp. nov. (Spines are denoted by Roman, setae by Arabic numerals. The armature on the outer margin of any segment is given first, followed by the elements on the apical and inner margins)

		Coxopodite	Basipodite	Exopodite	Endopodite
Leg 1	CV	0–1	1–0	I-1; II-II,1-3	0-1; 1-I,1-5
	adult	0–1	1–0	I-1; I-1; I-II,1-2	0-1; 0-2; 1-I,1-3
Leg 2	CV	0–1	1–0	I-1; II-II,1-4	0-1; 1-I,1-5
	adult	0–1	1–0	I-1; I-1; I-II,1-3	0-1; 0-2; 1-I,1-3
Leg 3	CV	0–1	1–0	I-1; II-II,1-4	0-1; 1-I,1-5
	adult	0–1	1–0	I-1; I-1; I-II,1-3	0-1; 0-2; 1-I,1-3
Leg 4	CV	0–1	1–0	I-1; II-II,1-4	0-1; 1-II-4
	adult	0–1	1–0	I-1; I-1; I-II,1-3	0-1; 0-2; 1-II-2

Variability

Variability of morphometric features in specimens collected in Sri Lanka, North India and Central Vietnam is presented in Table 2. Spinules usually present on antennulary segments 1, 4, 5, 7–13 are reduced on segment 4 in Vietnamese specimens and in one adult female from Sri Lanka. Distribution of dorsal pits on the antennula varies between the total lack of pits and their presence on all, except for segments 6 and 17. Spinule patterns on the antennary basipodite and leg 4 coxopodite consists of the same elements, only the number of spinules in particular groups changes: 10–16 and 28–33 spinules in the longitudinal rows along lateral rim on caudal and frontal surfaces of antennary basipodite; caudal spinules next to distal rim of antennary basipodite are present in two Vietnamese specimens; there are 5–9 spinules along distal rim, 7–15 spinules arranged in row or group at laterodistal angle and 6–12 spinules of conspicuously different size along proximal rim on caudal surface of leg 4 coxopodite. Medial expansion of leg 4 basipodite in the single specimen from Siliguri seems to be ornamented, in contrast to all other females, with short spinule-like hairs. Taking into consideration that the material collected in North India is nearly a century old, presence of spinule-like instead of normal hairs on the medial expansion of leg 4 basipodite can be explained by damage as well – apical parts of those hairs could be broken off. Lateral rim of medial apical spine of P4 enp3 with 0–2 teeth. Curvature of copulatory duct varies from slight to strong.

Diagnosis

Mesocyclops ferjemurami sp. nov. differs from all congeners in having a unique spinule ornamentation on the caudal surface of the antennary basipodite: the '*leuckarti*-type' spinule pattern (Van de Velde, 1984) is supplemented with a group of spinules at the height of implantation of the medial setae, and proximal to this group with a triangular spinule field, the longest side of which runs more or less parallel to the oblique row of tiny spinules starting at distal half of medial rim. Other features helping in identification: relatively large body (length: 1300–1500 μm); single deep notch on the hyaline membrane of last antennulary segment; no medial spine (seta) on leg 1 basipodite; distal margin of leg 4 intercoxal sclerite with large (ca. half of the height of medial expansion of basipodite) outgrowths; caudal spinule ornamentation of leg 4 coxopodite characterized by few spinules along distal rim, relatively short and thick spinules at laterodistal angle, row of spinules of unequal size along proximal rim, and reduced hairiness on lateral rim; distal hairs on medial expansion of leg 4 basipodite present; lateral rim of medial apical spine of leg 4 endopodite with few (0–2) teeth; pediger 5 and genital double-somite without hairs; transverse ducts (female genital structure) meet at deep acute angle anterior to copulatory pore; caudal rami short (length/width$<$3.20); entire posterior rim of anal somite with strong spinules; spinules at implantation of antero- and posterolateral caudal setae present.

Key to *Mesocyclops* species found in Vietnam

1. Leg 4 intercoxal sclerite with large (length/width$>$1) outgrowths ..... 2.
–. Leg 4 intercoxal sclerite with small (lengthwidth$\leq$ 1) outgrowths ..... 4.

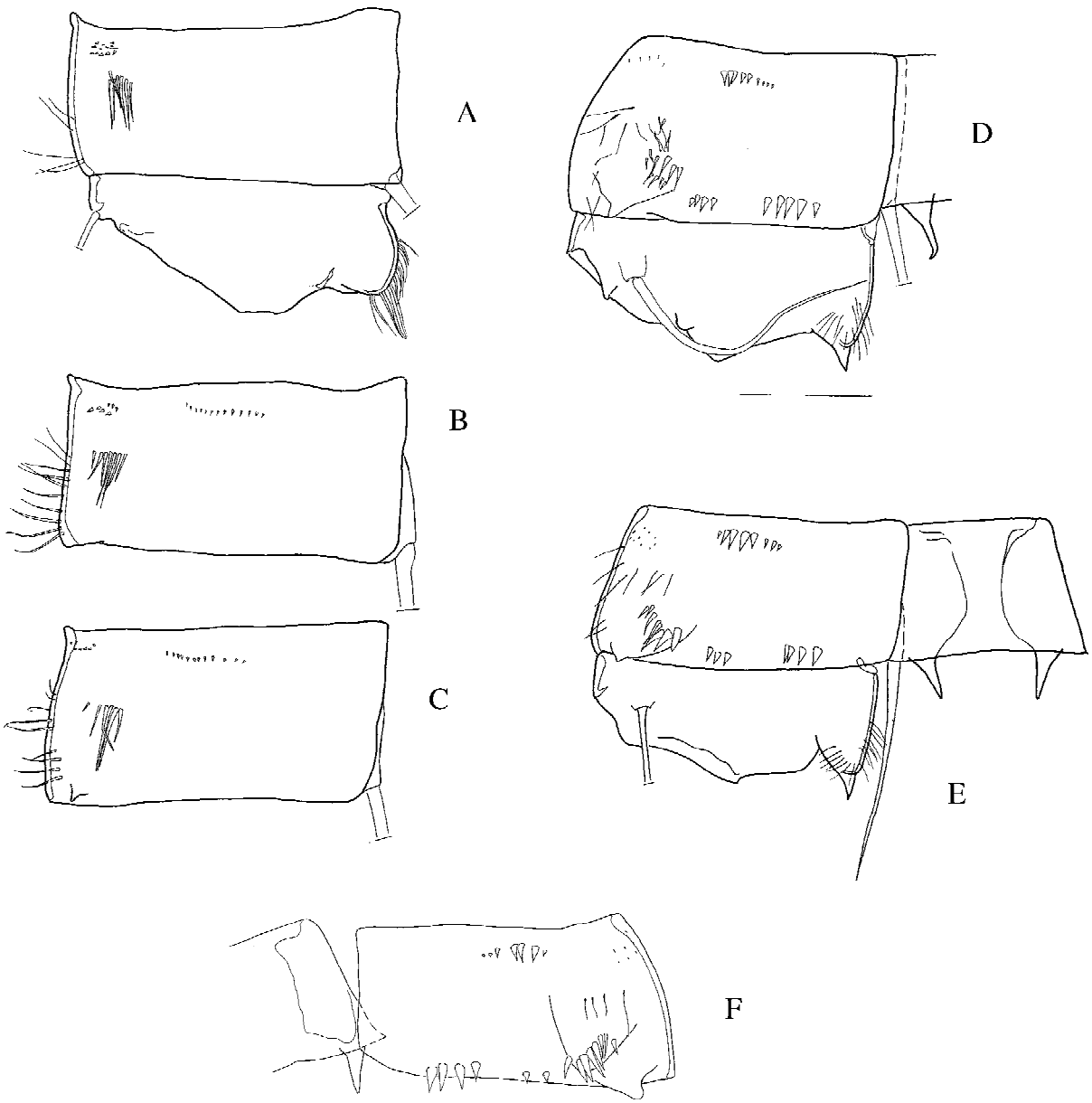

Figure 3. Mesocyclops ferjemurami sp. nov. (A–F) Caudal spinule ornamentation of coxopodite: (A) Leg 1 – paratype (no: 4616); (B) Leg 2 – holotype; (C) Leg 3 – holotype; (D) Leg 4, Sri Lanka; (E) Leg 4, Vietnam – holotype; (F) Leg 4, North India. Scale: 50 μm.

2. Terminal accessory (medialmost) caudal seta at most 1.5 times as long as posterolateral (lateralmost) caudal seta ..... *M. yenae* Hołyñska, 1998.
–. Terminal accessory caudal seta at least 2.5 times as long as the posterolateral caudal seta ..... 3.
3. Medial expansion of leg 4 basipodite with distal hairs; caudal surface of antennary basipodite ornamented with triangular field of spinules between the spinule group at height of medial setae and oblique row of tiny spinules starting at distal half of medial rim ..... *M. ferjemurami* sp. nov.
–. Medial expansion of leg 4 basipodite without hairs; between the spinule group at height of medial setae and oblique row of tiny spinules starting at distal half of medial rim, no other element on caudal surface of antennary basipodite .....*M. pehpeiensis* Hu, 1943 (syn. *M. ruttneri* Kiefer, 1981 (Guo, in press.))

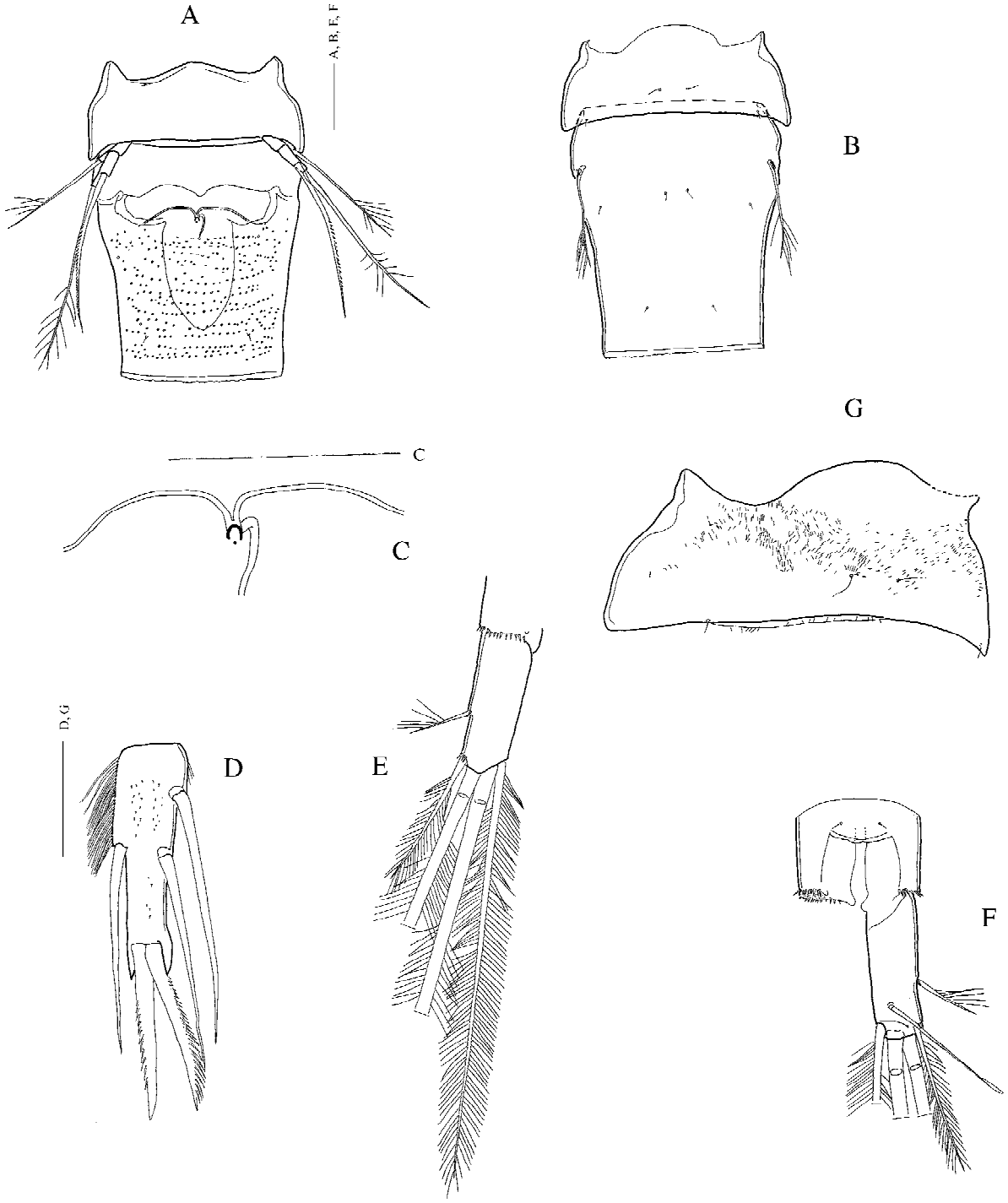

Figure 4. Mesocyclops ferjemurami sp. nov. (A) (B) Pediger 5 and genital double-somite: (A) Ventral view – holotype; (B) Dorsal view – paratype (no: 4615); (C) Transverse and copulatory ducts – holotype; (D) P4 enp3 – holotype; (E) Caudal ramus, ventral view – holotype; (F) Caudal ramus and anal somite, dorsal view - paratype (no: 4615); (G) Pediger 5 with rod-like elements, dorsal view – paratype (no: 4616). Scales: 50 μm.

Table 2. Morphometric variability of adult females of *Mesocyclops ferjemurami* sp. nov. (in parentheses the numbers of specimens measured)

	Sri Lanka Central	India Siliguri(1)	Vietnam Khanh Hoa
Total l (μm)	1300–1380(4)	1340	1360–1495(5)
Cephalothorax l/w	0.93–1.16(4)	1.06	0.98–1.15(5)
Prosome/urosome	1.58–1.93(4)	1.77	1.81–1.92(5)
Genital double-somite, l/w	1.15–1.39(4)	1.17	1.10–1.23(5)
Cephalothorax w/genital double-somite w	3.06–3.25(4)	3.31	3.00–3.35(5)
P4 enp3			
l/w	2.79–3.04(4)	3.10	2.64–3.00(5)
apical spines, medial/lateral	0.88–0.90(4)	0.99	0.97–1.03(5)
longer apical spine/enp3 l	0.95–1.02(4)	0.82	0.86–0.94(5)
P5 setae			
medial/apical	0.89–0.91(2)	0.72	0.80–0.84(4)
medial/basal	1.20–1.33(2)	–	1.18–1.32(4)
Caudal ramus l/w	2.63–3.00(4)	3.12	2.79–3.14(5)
Caudal setae			
terminal accessory (μm)	300–320(3)	–	320–330(5)
inner terminal (μm)	685–805(4)	–	630–680(5)
outer terminal (μm)	455–505(4)	–	450–475(5)
posterolateral (μm)	104–115(4)	–	105–115(5)
anterolateral/caudal ramus l	0.49–0.50(2)	–	0.47–0.49(4)
dorsal/posterolateral	0.79–0.96(3)	–	0.81–0.89(3)
terminal accessory/posterolateral	2.81–2.87(3)	–	2.78–3.05(5)
inner terminal/terminal accessory	2.15–2.49(3)	–	1.97–2.09(5)
inner terminal/urosome	1.33–1.66(4)	–	1.22–1.44(5)

Abbreviations: enp3 – third segment of endopodite; l – length; P4 – leg 4; P5 – leg 5; w – width.

4. Caudal rami medially pilose; caudal surface of antennary basipodite adorned with a spinule group between proximal oblique and longitudinal spinule rows ..... *M. aspericornis* (Daday, 1906).
–. Caudal rami medially naked; on caudal surface of antennary basipodite spinule group between proximal oblique and longitudinal spinule rows absent ..... 5.
5. Spinule row on maxillulary palp present .... *M. ogunnus* Onabamiro, 1957. –. Spinule row on maxillulary palp absent ..... 6.
6. Caudal surface of antennary basipodite adorned with group/row of large spinules at height of medial setae; pediger 5 and genital double-somite dorsally pilose ..... *M. thermocyclopoides* Harada, 1931.
–. Group/row of large spinules at height of medial setae on caudal surface of antennary basipodite absent; dorsum of pediger 5 and genital double-somite without hairs ..... 7.
7. Transverse ducts meet at obtuse angle (not 'V-shaped') anterior to copulatory pore; curvature of copulatory duct varies from straight to moderate ..... *M. affinis* Van de Velde, 1987.
–. Transverse ducts in most cases meet at acute angle ('V-shaped') anterior to copulatory pore and curvature of copulatory duct varies from moderate to strong; if transverse ducts meet at obtuse angle (not 'V-shaped'), and/or curvature of copulatory duct slight or nearly straight, spinules at implantation of antero- and posterolateral caudal setae absent ..... 8.
8. Spinules at implantation of antero- and posterolateral caudal setae present .. *M. dissimilis* Defaye et Kawabata, 1993.
–. Spinules at implantation of anterolateral caudal seta always absent, those at implantation of posterolateral caudal seta usually absent ..... *M. woutersi* Van de Velde, 1987.

Remarks

A close affinity between *Mesocyclops ferjemurami* sp. nov., *M. pehpeiensis* Hu, 1943 (*M. ruttneri* Kiefer, 1981 is considered here as synonym of *M. pehpeiensis* – Guo, in press) and *M. papuensis* Van de Velde, 1987 is suggested by several shared character: medial spine on leg 1 basipodite absent; antennula ventrally adorned with spinules on segment 1, 4, 5 and 7–13; hyaline membrane of the last antennulary segment with one large notch and extending conspicuously beyond the medial seta of segment 17; second endopodal segment of the antenna bearing seven setae; caudal spinule ornamentation of antennary basipodite more complex than in *M. leuckarti*; outgrowths on distal margin of leg 4 intercoxal sclerite large; pediger 5 and genital double-somite without hair ornamentation; seminal receptacle with wide and elongated lateral arms, transverse ducts meet at acute angle anterior to copulatory pore; entire posterior rim of anal somite with strong spinules; spinules at implantation of postero- and anterolateral caudal setae present.

The range of *Mesocyclops pehpeiensis* extends from Central Asia (South Kazakhstan, Uzbekistan) through India, Sri Lanka, South East Asia, China to the Japanese Islands (as far as Honshu), but it is probably an introduced element in the United States (for distributional data see Reid, 1994; Kawabata & Defaye, 1994; Mirabdullayev et al., 1995; Mirabdullayev, 1996; Ueda & Ishida, 1997; Ueda et al., 1997). *Mesocyclops papuensis* has so far been recorded from New Guinea and the Greater Sundas (Java, Borneo) (Van de Velde, 1987; Hołyńska, 2000). Records of *Mesocyclops ferjemurami* in Sri Lanka, North India and Central Vietnam suggest a wide, Oriental distribution of the species. Lim & Fernando (1985) described a *Mesocyclops* from Malaysia identified by them as *M. pehpeiensis* Hu, 1943, which, despite the great collecting efforts made in that country, was found only in few marshy areas in the northwest. This *Mesocyclops* having dense distal hairs on the medial expansion of leg 4 basipodite, large outgrowths on the distal margin of leg 4 intercoxal sclerite, and no teeth on the lateral rim of the medial apical spine of leg 4 endopodite, seems to match *M. ferjemurami* better than *M. pehpeiensis*. In *M. pehpeiensis* (redescription of the species from China provided by Guo (in press)), the medial expansion of leg 4 basipodite is naked, the lateral rim of the medial apical spine of leg 4 endopodite usually armed with several and only rarely with few teeth, and outgrowths on leg 4 intercoxal sclerite somewhat smaller, reaching about to one-third of the height of the medial expansion of the basipodite. In the illustration provided by Lim & Fernando (1985), the triangular spinule field on the caudal surface of the antennary basipodite, a diagnostic characteristic of *M. ferjemurami*, is missing, but this spinule group is easily overlooked. Taking into consideration other features, which *M. pehpeiensis* sensu Lim & Fernando (1985) and *M. ferjemurami* share, and the northern Malaysian occurence of the former *Mesocyclops*, we suspect that the two forms are conspecific.

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