THREE NEW SPECIES OF *MESOCYCLOPS* G. O. SARS, 1914 (COPEPODA, CYCLOPOIDA) FROM AUSTRALIA AND BURMA, WITH COMMENTS ON THE *MESOCYCLOPS* FAUNA OF AUSTRALIA

BY

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ABSTRACT

Three new species of *Mesocyclops* G. O. Sars, 1914 are described: *M. acanthoramus* sp. nov. and *M. pubiventris* sp. nov. from northern Queensland, and *M. kayi* sp. nov. from northern Burma.

Mesocyclops papuensis Van de Velde, 1987 and *M. woutersi* Van de Velde, 1987 are reported from Australia for the first time. Other Australian records include: *M. aspericornis* (Daday, 1906) from Queensland; *M. brooksi* Pesce, De Laurentiis & Humphreys, 1996 from Queensland and Western Australia; *M. darwini* Dussart & Fernando, 1988 from Queensland and Western Australia; and *M. notius* Kiefer, 1981 from Queensland and Western Australia. A key to all Australian species of *Mesocyclops*, as well as a short discussion on the composition and distribution of the Australian fauna, are provided.

RÉSUMÉ

Trois espèces nouvelles de *Mesocyclops* G. O. Sars sont décrites: *M. acanthoramus* sp. nov. et *M. pubiventris* sp. nov. du nord de Queensland, et *M. kayi* sp. nov. du nord de la Birmanie.

Mesocyclops papuensis Van de Velde, 1987 et *M. woutersi* Van de Velde, 1987 ont été trouvées en Australie pour la première fois. D'autres observations pour l'Australie incluent: *M. aspericornis* (Daday, 1906) du Queensland, *M. brooksi* Pesce, De Laurentiis & Humphreys, 1996 du Queensland et d'Australie Occidentale, et *M. notius* Kiefer, 1981 du Queensland et d'Australie Occidentale. Une clé des espèces australiennes de *Mesocyclops*, ainsi qu'une courte discussion sur la composition et la répartition géographique de la faune australienne, sont fournies.

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INTRODUCTION

Recent epidemiological studies in SE Asia and Australia put special emphasis on the inventarization of the local *Mesocyclops* fauna, in order to choose the species best adapted for the biological control of disease vector mosquitoes (*Anopheles*, *Aedes*, and *Ochlerotatus* spp.). This approach provided valuable data on the habitat preferences, the geographical distribution, and also on the taxonomy of the genus *Mesocyclops* (cf. Hołyńska, 1998; Vu et al., 2000; Hołyńska & Vu, 2000). A team under the leadership of Dr. B. H. Kay has been conducting investigations on the use of these predator copepods in the northern Queensland subterranean urban environment (service manholes, pits) for several years, i.e., where mosquito larvae may find refuge in cool and dry periods (Kay et al., 2000, 2002). The two new species here described from Queensland were found during a survey of the local copepod fauna living in subterranean sites in northern Queensland, and *Mesocyclops* inoculation experiments in Townsville, Hughenden, and Richmond (northern Queensland). A new species was also found during the collections made to evaluate the potential for 'dengue' and its control by copepods in northern Burma (Myanmar).

So far, eight species of *Mesocyclops* have been reported from Australia: *M. annae* Kiefer, 1930, *M. aspericornis* (Daday, 1906), *M. australiensis* (G. O. Sars, 1908), *M. brooksi* Pesce, De Laurentiis & Humphreys, 1996, *M. cuttacuttae* Dumont & Maas, 1985, *M. darwini* Dussart & Fernando, 1988, *M. notius* Kiefer, 1981, and *M. pehpeiensis* Hu, 1943. Yet, records of *Mesocyclops annae* (cf. Tait et al., 1984; Dussart & Fernando, 1986) and *M. pehpeiensis* (cf. Dussart & Fernando, 1986) are presumably referable to their close Australasian relatives, *M. pseudoannae* Van de Velde, 1987 and *M. papuensis* Van de Velde, 1987, respectively, and *M. annae* and *M. pehpeiensis* probably do not occur on the Australian continent (Hołyńska, 2000). Very little is known about the freshwater cyclopids of Burma (Lindberg, 1949; Dussart & Fernando, 1985). Altogether, six *Mesocyclops* species are known from the country: *M. aspericornis*, *M. granulatus* Dussart & Fernando, 1988, *M. ogunnus* Onabamiro, 1957, *M. pehpeiensis*, *M. restrictus* Dussart & Fernando, 1985, and *M. thermocyclopoides* Harada, 1931 (cf. Dussart & Fernando, 1985; Kay et al., in press a). However, being in the contact zone of the Indian and Southeast Asian faunae, the real species diversity is supposedly significantly higher (27 *Mesocyclops* spp. have been recorded already from tropical Asia!).

MATERIAL AND METHODS

From northern Queensland 151 samples, collected from service manholes and pits in 9 tropical and drier inland towns, were examined. Locality data are given

at the descriptions and records of the particular species. A large part of the material came from the inoculation experiments conducted in Townsville (109 samples), Richmond (2 samples), and Hughenden (2 samples). In Townsville, *M. acanthoramus* sp. nov., originally collected from a manhole in Ingham (96 km NW of Townsville), was inoculated to a manhole (by Morey and Hubert Streets) in June 1997. Before the inoculation some *Mesocyclops* spp. were detected in the Townsville manholes, but no data on the specific identity of these taxa are known to us. In May 1999, *M. aspericornis* and *M. darwini* (cf. Kay et al., 2002) of unknown origin were inoculated to a few pits in Hughenden and Richmond, where previously no *Mesocyclops* had been found. All the other Queensland records refer to urban (manholes, pits) but non-manipulated (no inoculation) habitats. The faunistic data from Queensland are supplemented with the identification of *Mesocyclops* that were collected by Dr. S. Halse in Western Australia, and sent to us for verification. Since the species reported have already been described in detail in other publications (Hołyńska, 2000; Hołyńska et al., in press), information on these taxa is here restricted to the collecting sites and morphological data provided in the identification key. Illustrations of the diagnostic characters used in the key can be also found in the afore-mentioned papers.

Observations and measurements were made on specimens in glycerin. Drawings were made using a camera lucida attached to an Olympus BX 50 compound microscope. Telescoping body segments were measured separately. The length of pediger 4, a somite leaning over pediger 5, was measured as the distance between its anteriormost and posteriormost points, therefore 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, the genital double-somite, and the cephalothorax were measured across their widest parts.

Abbreviations: P1-P4, natatory leg 1 to leg 4; exp, exopodite; enp, endopodite; exp1-3, first to third segment of exopodite; enp1-3, first to third segment of endopodite.

TAXONOMY

Mesocyclops acanthoramus sp. nov. (figs. 1-4)

"*Mesocyclops acanthoramus* Brown & Morton, 1995" (unpublished name in Brown, 1995: 42-44, figs. 3.1-3.2.).

Types. — Holotype (♀) from Townsville (19°16′S 146°47′E, Queensland, Australia), T-135, 93 Railway Avenue, 2 Dec. 1998, service manhole. The holotype and 6 paratypes (2 ♂♂ and 2 ♀♀ from Townsville, 2 ♀♀ from Cairns) are deposited in the Queensland Museum, Brisbane. The 2 paratypes (♀♀) from Cairns are placed at the Museum and Institute of Zoology PAS (Polish Academy of Sciences), Warsaw. All specimens are dissected, females are mounted on two slides, males are mounted on one slide each.

Other material examined. — Queensland: Culture, manhole from **Ingham** (18°39′S 146°09′E), 8 Mar. 1999, 2 ♂♂ and 1 CV copepodid mounted, 1 ♂, 1 CIV, and 1 CIII copepodid in alcohol. **Cairns** (16°55′S 145°45′E): **C6**, 26 Aug. 1988, 2 ♀♀, mounted; **C17**, 25 Aug. 1998, in hole, 1 ♀ and 1 CV copepodid, mounted; **C18**, Mayer/Woodward, pillar, 25 Aug. 1998, 2 CV copepodids, mounted. **Mossman** (16°27′S 145°22′E), service manholes: **MM-15**, Front/Bow St., 4 Mar. 1999, 3 ♀♀ in alcohol; **MM-22**, Sawmill Rd./Cook Hwy, 4 Mar. 1999, 2 ♀♀ mounted, 3 ♀♀ in alcohol. **Port Douglas** (16°29′S 145°27′E), service manholes: **PD-5**, Blake/Davidson, 2 Mar. 1999, 4 ♀♀, 1 CV copepodid in alcohol; **PD-5**, Carrick/Macrossan, 3 Mar. 1999, 2 ♀♀ in alcohol; **PD-6**, Crimmins/Davidson, 3 Feb. 1999, 1 ♀ in alcohol; **PD-12**, Langley/Port Douglas Rd., 3 Mar. 1999, 2 ♀♀ in alcohol; **PD-23**, Cook Hwy beside creek, 4 Mar. 1999, 1 ♀ mounted, 3 ♀♀ and 1 CV copepodid in alcohol; **PD-23**, Grant/Macrossan, 3 Mar. 1999, 4 ♀♀ and 1 CV copepodid in alcohol; **PD-27**, Grant/Warner St., 3 Mar. 1999, 5 ♀♀ in alcohol. **Townsville**, service manholes: Abbott St. 38, 2 Feb. 1999, 1 ♀ mounted, 4 ♀♀ in alcohol; Auction Centre, Railway Ave., 2 Dec. 1998, 5 ♀♀ in alcohol; Cnt 9th St./10th Ave., 9 Dec. 1998, 4 ♀♀ in alcohol; **T-1**, Morey/Hubert, 25 Jan. 1999, 1 ♀ mounted, 3 ♀♀ in alcohol; **T-2**, Boundary/Seventh Ave.: 26 Jan. 1999, 6 ♀♀ in alcohol; 21 Feb. 2000, 3 ♀♀ in alcohol; 17 May 2000, 1 ♀ mounted, 2 ♀♀ in alcohol; **T-2**, Morey/Hubert, 9 Feb. 2000, 1 ♀ in alcohol; **T-4**, Morey/Nelson: 25 Jan. 1999, 3 ♀♀ in alcohol; 21 Feb. 2000, 1 ♀ and 1 CV copepodid in alcohol; 16 May 2000, 4 ♀♀ in alcohol; **T-6**, 69 Morey St.: 25 Jan. 1999, 9 ♀♀ in alcohol; 16 May 2000, 3 ♀♀ in alcohol; **T-7**, Morey/Bell, 25 Jan. 1999, 1 CV copepodid mounted, 3 ♀♀ in alcohol; **T-11**, Morey/Perkins: 25 Jan. 1999, 2 CV copepodids mounted, 1 ♀ in alcohol; 16 May 2000, 3 ♀♀ in alcohol; **T-12**, 44 Tully St.: 26 Jan. 1999, mud sample, 1 ♀ mounted, 1 ♀ in alcohol; 10 Feb. 2000, 1 ♀ in alcohol; May 2000, 6 ♀♀ in alcohol; **T-15**, 20 Allen St.: 9 Feb. 2000, 1 ♀ in alcohol; 14 May 2000, mud sample, 2 ♀♀ in alcohol; **T-17**, Davidson/Allen: 10 Feb. 2000, 4 ♀♀ in alcohol; 16 Aug. 2000, 3 ♀♀ in alcohol; **T-18**, Allen/Perkins, 18 May 2000, mud sample, 2 ♀♀ in alcohol; **T-29**, Clifton/Gregory, 27 Jan. 1999, 1 ♀ in alcohol; **T-36**, Hooper/Bishop, 28 Jan. 1999, 2 ♀♀ mounted, 3 ♀♀ in alcohol; **T-37**, Albany/Haigh 82, 28 Jan. 1999, 1 ♀ mounted, 8 ♀♀ in alcohol; **T-39**, Kings/Albany, 28 Jan. 1999, 1 ♀ mounted; **T-43**, Marks/Carr., 22 Jan. 1999, 1 ♀ mounted, 2 ♀♀ in alcohol; **T-44**, 38 Railway Ave., 22 Jan. 1998, 2 ♀♀ mounted, 2 ♀♀ in alcohol; **T-96**, Morey/Tully, 25 Jan. 1999, 1 ♀ mounted; 9 Feb. 2000, 1 ♀ in alcohol; 16 May 2000, 3 ♀♀ in alcohol; **T-99**, 32 Doorey/Tenth Ave., 4 Dec. 1998, 4 ♀♀ in alcohol; **T-100**, Morey/Perkins St.: 27 Jan. 1999, 2 ♀♀ mounted, 3 ♀♀ in alcohol; 21 Feb. 2000, 3 ♀♀ in alcohol; **T-101**, Morey/Davidson, 18 May 2000, 2 ♀♀ in alcohol; **T-102**, Cannan/Davidson: 27 Jan. 1999, 10 ♀♀ in alcohol; 21 Feb. 2000, 3 ♀♀ in alcohol; **T-110**, Bell St. (Rugby Club): 11 Feb. 2000, 1 CV copepodid mounted, 2 ♀♀ in alcohol; 16 May 2000, 6 ♀♀ in alcohol; **T-112**, Barlow Morey: 27 Jan. 1999, 2 ♀♀ mounted, 3 ♀♀ in alcohol; 21 Feb. 2000, 1 ♀ in alcohol; 17 May 2000, 3 ♀♀ in alcohol; **T-113**, 226 Boundary St., 17 May 2000, 3 ♀♀ in alcohol; **T-116**, Morehead St.: 27 Jan. 1999, 3 ♀♀ mounted, 3 ♀♀ in alcohol; 11 Feb. 2000, 2 ♀♀ in alcohol; 16 May 2000, 6 ♀♀ in alcohol; **T-117**, Morehead/Morey: 27 Jan. 1999, 6 ♀♀ in alcohol; 11 Feb. 2000, 3 ♀♀ in alcohol; 16 May 2000, 1 ♀ mounted, 4 ♀♀ in alcohol; **T-118**, Morehead/Morey (Bus wash), 21 Feb. 2000, 3 ♀♀ in alcohol; **T-119**, Griffith/Dean St.: 21 Feb. 2000, 1 ♀ in alcohol; May 2000, 2 ♀♀ in alcohol; **T-123**, Griffith/Plume, 21 Feb. 2000, 1 ♀ and 1 CV copepodid mounted, 1 ♀ in alcohol; **T-125**, Allen/Perkins: 26 Jan. 1999, 3 ♀♀ in alcohol; 9 Feb. 2000, 1 ♀ mounted, 2 ♀♀ in alcohol; 16 May 2000, 6 ♀♀ and 1 CIV copepodid in alcohol; **T-126**, Allen/Morehead, 21 Feb. 2000, 1 ♀ mounted, 3 ♀♀ in alcohol; **T-132**, 79 Railway Ave., 2 Dec. 1998, copepods from substrate, 2 ♀♀ in alcohol, 1 CV copepodid mounted; **T-141**, Railway/Putt, 22 Jan. 1999, 1 ♀, 1 ♂, and 1 CV copepodid mounted, 1 ♀ in alcohol.

Etymology. — The specific name is derived from the Greek “acanthos” for spine and Latin “ramus” for branch, alluding to the presence of spinules at the implantation of the lateral caudal and lateralmost terminal caudal setae. The species name is a noun in apposition to the generic name.

Description of female (unless otherwise stated, data refer to the holotype). — Body length 1165 μm; prosome/urosome: 1.8; cephalothorax length/width: 1.1; cephalothorax width/genital double-somite width: 2.9.

Pediger 5 (fig. 1A) with lateral hairs, dorsal surface, except for two medial and two laterodistal hair-sensilla, without ornament. Genital double-somite (fig. 1A) 1.1 times as long as wide, bare, with rows of shallow round pits on ventral and dorsal surfaces. Pits present also on succeeding urosomite. Posteriorly to P6, six pores present in group on laterodorsal surface of somite (verified on 1 female from Cairns). Seminal receptacle (fig. 1A) with wide lateral arms, distal part of seminal receptacle large, reaching level of distal sensilla, anterior margin of proximal part sinuate in middle. Transverse ducts (fig. 1B) forming V-shape meet strongly curved copulatory duct very near horseshoe-shaped copulatory pore; section of copulatory duct connecting copulatory pore and transverse ducts not discernible. One circular pore present posteriorly to copulatory pore. Posterior margin of anal somite with continuous row of spinules (fig. 1C). Caudal ramus (fig. 1D, E) 3.2 times as long as wide, set with tiny spinules arranged in strips on ventral surface, but showing patchy ornamentation on dorsal surface; no medial hairs. Larger spinules present at implantation of lateral caudal, and lateralmost terminal caudal setae. Dorsal caudal seta 0.85 times as long as lateralmost terminal caudal seta. Relative length of terminal caudal setae from medialmost to lateralmost: 2.7, 5.2, 3.9, 1,0. Longest terminal caudal seta 1.3 times as long as urosome.

Antennule 17-segmented, armature formula as common in genus: 8, 4, 2, 6, 4, 1+spine, 2, 1, 1, 0, 1, 1+aesthetasc, 0, 1, 2, 2+aesthetasc, 7+aesthetasc. Aesthetasc on segment 12 (fig. 1F) hardly reaching distal margin of segment 13, aesthetasc on segment 16 (fig. 1G) strongly reduced, ca. 1/3 length of segment 17. Ventral spinules present on segments 1, 4-5, 7-13, dorsal surface adorned with rows of shallow pits on segments 1 and 4. Last two antennular segments with hyaline membrane (fig. 1G). Serrate hyaline membrane on last antennular segment, extending proximally beyond implantation of medial seta, with one large notch.

Antenna armed with 3 setae on basipodite and 1, 7, 7 setae on endopodal segments 1-3, respectively. Spinule ornamentation on caudal surface of antennal basipodite (fig. 1H) composed of: long spinules on lateral rim near base; oblique row next to former group; longitudinal row along lateral rim, spinules distally slightly increasing; field of tiny spinules near implantation of mediodistal setae; oblique row of fine spinules starting approximately at half of medial rim; tiny spinules in proximal 2/5 of medial rim. Spinule pattern on frontal surface of antennal basipodite (fig. 1I): longitudinal row along lateral rim and short transverse row near base; no spinules next to implantation of exopodite (lateral) seta. Exopodite seta long, reaching beyond distal margin of terminal segment.

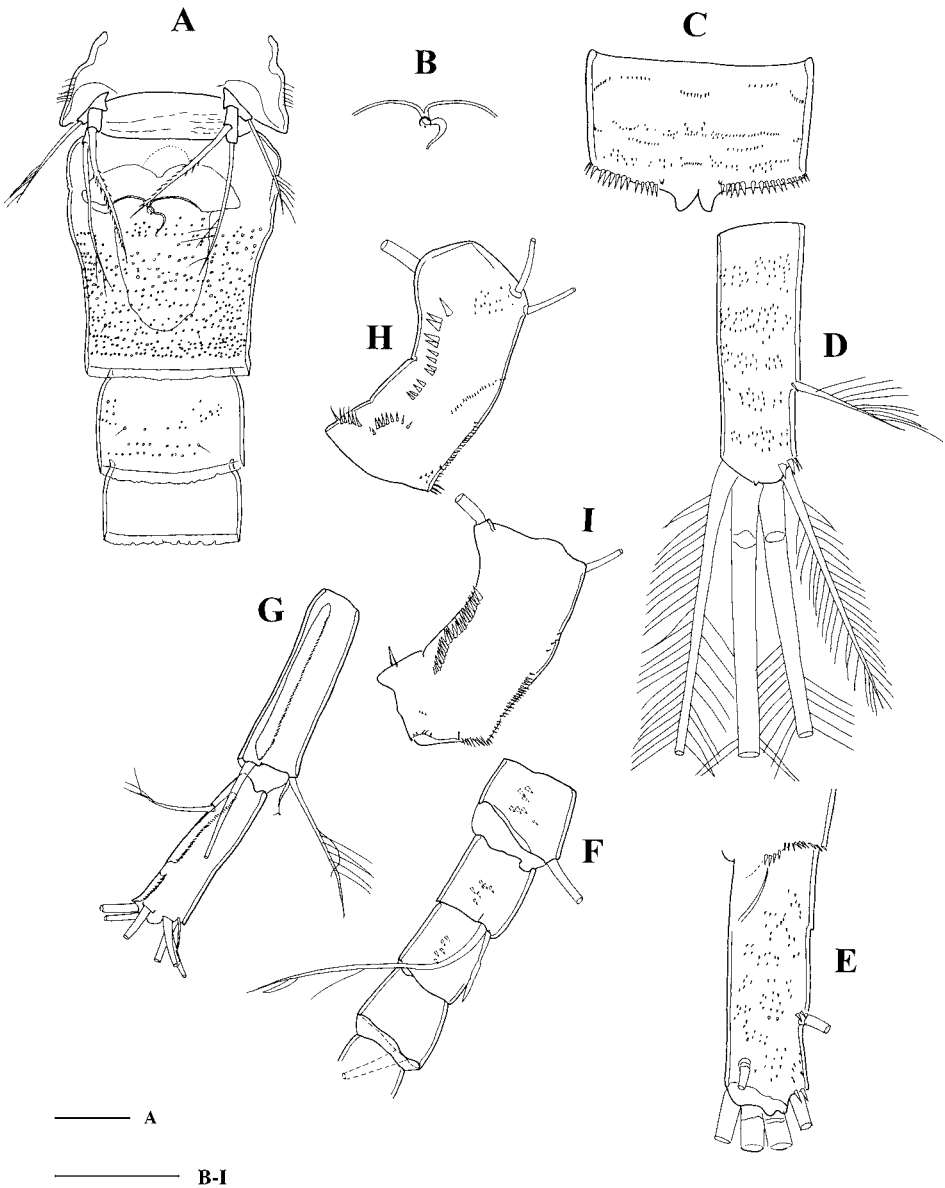


Fig. 1. *Mesocyclops acanthoramus* sp. nov. Holotype (female). A, urosomites 1-4, ventral (asymmetric position of the hair-sensilla on urosomite 3 is an aberration); B, copulatory pore and duct, and transverse ducts; C, anal somite, ventral; D-E, caudal ramus: D, ventral; E, dorsal; F-G, antennule: F, segments 11-14; G, segments 16-17; H-I, antennal basipodite: H, caudal; I, frontal. Scales: 50 μm.

With the exception of usual distal fringe hairs, no ornamentation on ventral surface of labrum, epistoma also bare (fig. 2A). Mandible (fig. 2B) with palp bearing two long and one short setae. Spinules near palp arranged in three groups,

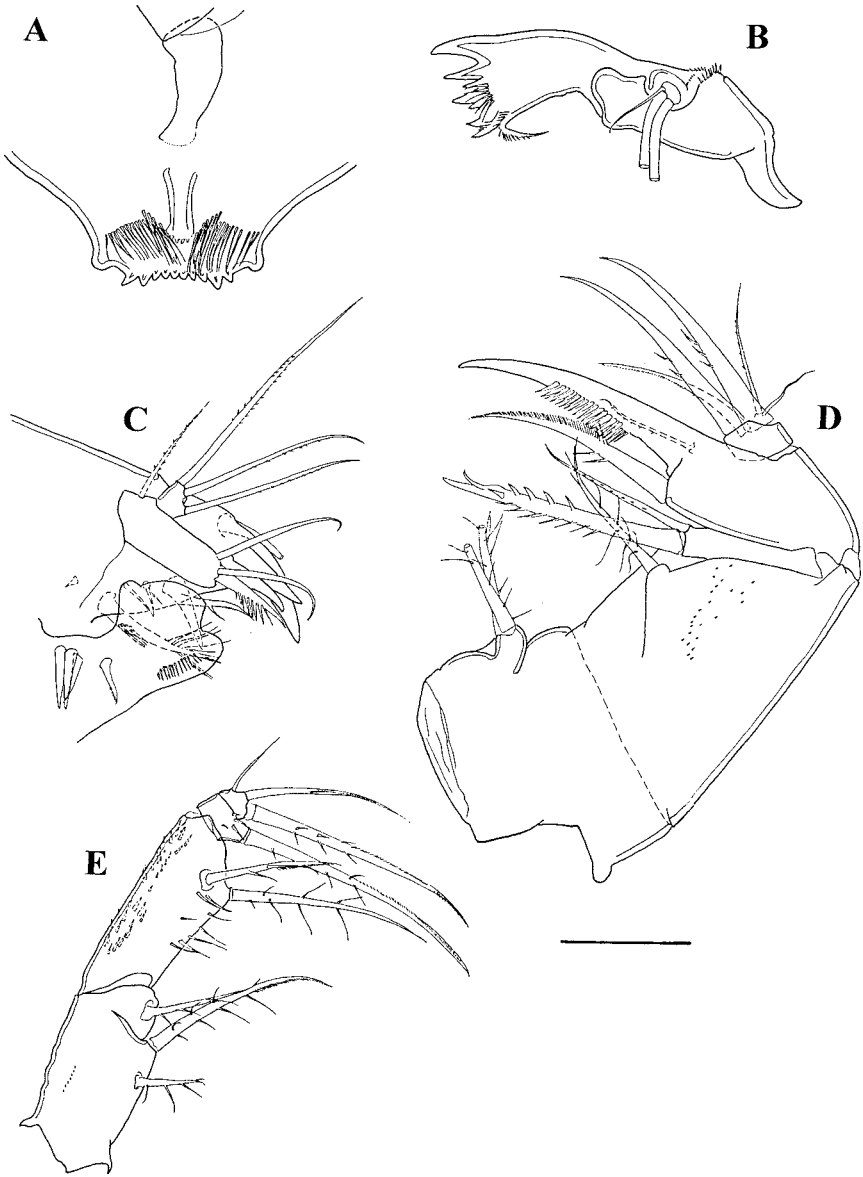


Fig. 2. *Mesocyclops acanthoramus* sp. nov. (female). A, labrum, ventral; B, mandible; C, maxillule and paragnath; D, maxilla, frontal; E, maxilliped, frontal. A-B show a paratype from Townsville (T-43), and C-E show the holotype. Scale: 50 μm.

those forming transverse row conspicuously larger than others; no ornamentation proximally to former groups. Maxillule (fig. 2C) with armature as common in genus: arthrite with three distal claws, one ventral seta at their base; four paired setae (one pair large and robust, and one pair small and slender), one

small and bare, and one long feathered seta on medial margin, spinous element lateroproximally to feathered seta. Maxillular palp bare, with articulating lateral lobe. Three setae of lateral lobe and proximalmost seta of palp with denticles, no long setules. Maxilla (fig. 2D) with syncoxa, basipodite, and one-segmented exopodite, armature formula: 5, 2, 5, respectively. Two short setae of exopodite implanted on caudal surface of lateralmost spiniform seta, near its articulation with free exopodal segment. Long basipodite seta in front of claw-like endite with caudal spinules near base, and 3 long setules at proximal 2/5 of its length, which are followed by teeth on posterior edge only. Small spinules present on frontal surface of syncoxopodite. Maxilliped (fig. 2E) with syncoxopodite, basipodite, and two-segmented endopodite, armature formula 3, 2, 1, 3, respectively. Syncoxopodite frontally adorned with hardly visible longitudinal row of tiny spinules; spinules arranged in two groups on lateral rim and caudal surface of basipodite. Lateralmost seta of enp2 relatively long, ca. 1/2 length of median seta of segment.

Armature of P1-P4 as in table I. P1 (fig. 3B) basipodite lacking medial spine; basipodite frontally adorned with spinules arranged in semicircular arch between implantations of exo- and endopodite, and row of hair-like spinules near lateral rim of segment. Middle element on distal margin of P1exp3 with long setules medially and with denticles laterally. Exopodite spines with thread-like tips. Couplers of P1-P4 bare on caudal and frontal surfaces. P4 (fig. 3A) coupler bearing two large and acute prominences on distal margin. Spinule ornamentation (fig. 3A) on caudal surface P4 coxopodite composed of: 11 spinules in intermittent, or continuous row along distal rim, relatively short spinules (in comparison to those in the same position in its congeners) arranged in row or group at laterodistal angle; many (17) spinules of equal length in one row near proximal rim; dense hairs near and on lateral rim. Medial expansion of P1 basipodite with distal and medial hairs, those of P2-P3 bearing distal hairs only. Distal hairs on medial expansion of P4 basipodite supplemented with oblique row of long hairs on caudal surface (fig. 3A). P4 coxopodite seta ca. 1.4 times as long as height of medial expansion of basipodite. Caudal ornamentation of P4 rami (fig. 3A): exp1-3 and enp3 with hair-like and

TABLE I

Armature of leg 1-4 in *Mesocyclops acanthoramus* sp. nov. Spines are denoted by Roman, setae by Arabic numerals. The armature on the lateral margin of any segment is given first, followed by the elements on the apical and medial margins

	Coxa	Basis	Exopodite	Endopodite
Leg 1	0-1	1-0	I-1; I-1; I-I,2-2	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

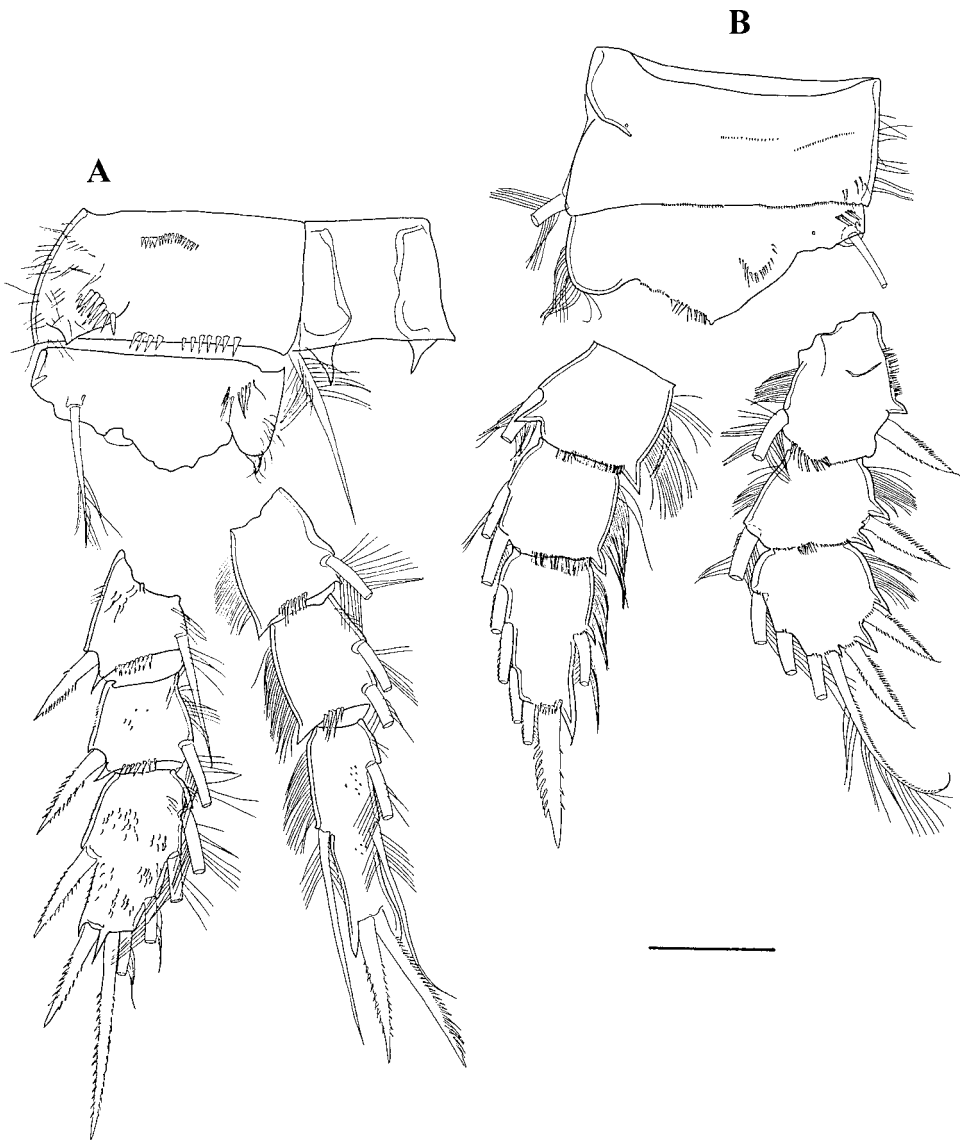
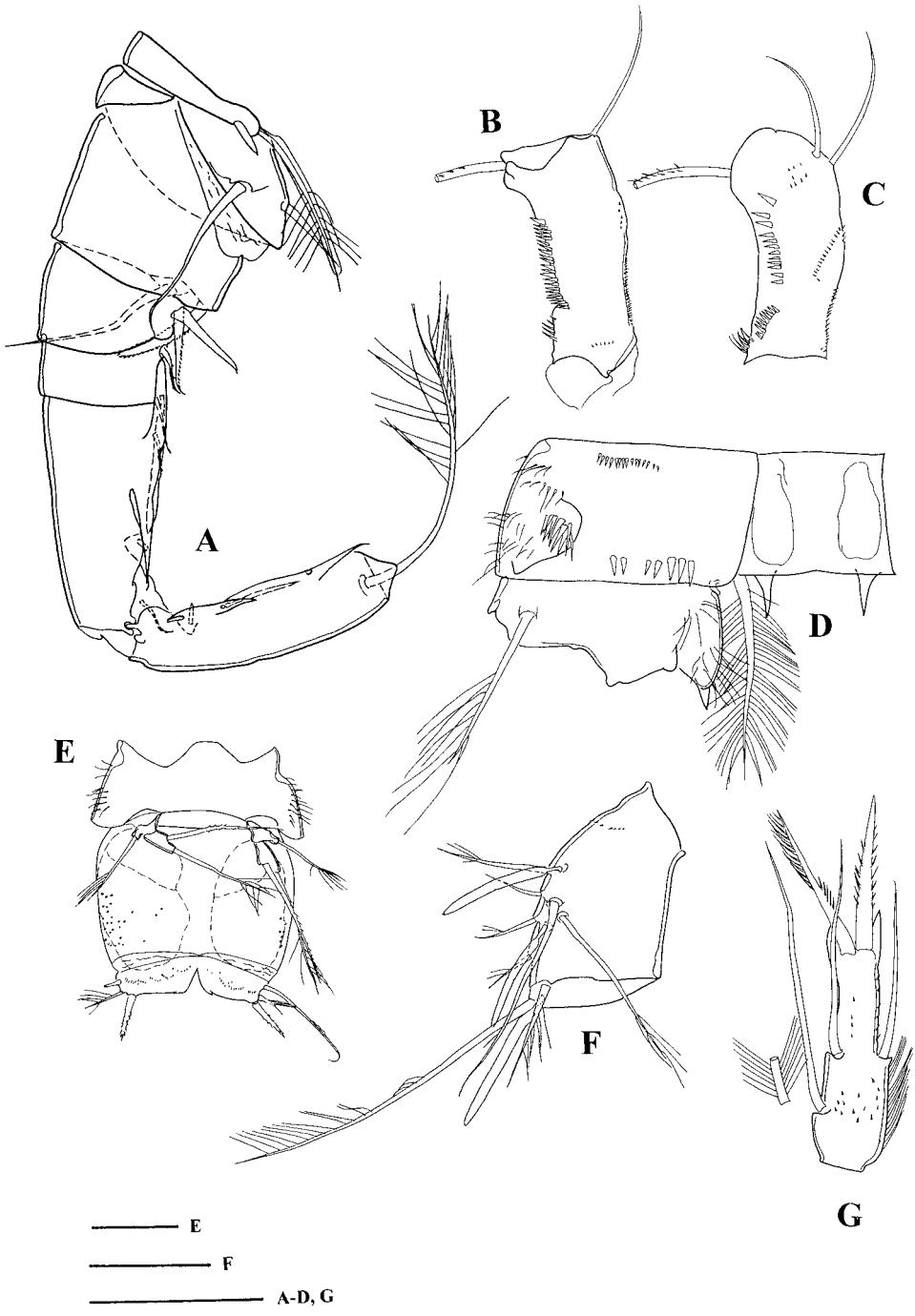


Fig. 3. *Mesocyclops acanthoramus* sp. nov. Holotype (female). A, P4, caudal; B, P1 frontal. Scale: 50 μm.

short spinules, respectively; enp1-2 bare. P4 enp3 2.8 times as long as wide; of apical spines, medial spine 1.2 times as long as lateral spine, and 0.91 times as long as segment; no teeth on lateral edge of medial apical spine. P5 (fig. 1A) two-segmented, lateral seta 0.7 times as long, apical seta as long as spiniform medial seta.


A
B
C
D
E
F
G
E
F
A-D, G

Male. — Description based on 2 ♂♂ from culture (Ingham) and 3 ♂♂ from Townsville (T-99, T-112, T-141).

Body length 825-885 μm; prosome/urosome: 1.5-1.9; cephalothorax length/width: 1.1-1.2. Pediger 5 (fig. 4E) with lateral hairs, dorsal surface bare. Posterior margin of anal somite with continuous row of spinules, spinules also present at implantation of lateral and lateralmost terminal caudal setae. Caudal ramus 2.9-3.7 times as long as wide, without medial hairs. Short, transverse lateral row of spinules present or absent at anterior third of ramus. Dorsal and lateralmost terminal caudal setae subequal. Relative length of terminal caudal setae from medialmost to lateralmost: 3.0-3.3, 6.2-6.4, 4.6-4.8, 1.0. Longest terminal caudal seta 1.1-1.2 times as long as urosome.

Antennule 16-segmented, with incomplete subdivision of compound apical segment, armature formula as common in genus: 8+3 aesthetascs, 4, 2, 2+aesthetasc, 2, 2, 2, 2, 1+spine+aesthetasc, 2, 2, 2, 2+aesthetasc, 2, 1+aesthetasc, [5, 7+aesthetasc] (fig. 4A, F). More medial seta on segment 11 and both setae on segment 12 spiniform (fig. 4A). Plate-like structures (1 large on segment 14 and 2 smaller ones on segment 15) and short conical elements (one on segment 14 and 15 each) at distal geniculation (fig. 4A). Ventral spinules present only on segment 1. Second endopodal segment of antenna bearing 6 (Townsville, T-112) or 7 (culture, Ingham) setae, armature formula otherwise as in female. Spinule pattern on caudal and frontal surfaces of antennal basipodite like in female, only number of spinules in particular groups less (fig. 4B, C). Armature and spinule ornamentation of mouthparts as in female.

Armature of P1-P4 as in female. P1 basipodite frontally adorned with spinules arranged in semicircular arch and long hair-like spinules near lateral rim. Couplers of P1-P4 bare on frontal and caudal surfaces, P4 coupler (fig. 4D) with 2 large acute prominences on distal margin. Ornamentation on caudal surface of P4 coxopodite like in female, only number of spinules in particular groups less, and lateral hairs sometimes reduced (fig. 4D). Medial expansion of P4 basipodite bearing long hairs distally, and oblique row of hairs on caudal surface. P4 coxopodite seta 1.5-1.7 times as long as height of medial expansion of basipodite. P4 rami with short spinules on caudal surface. P4 enp3 (fig. 4G) 2.8-2.9 times as long as wide; of the apical spines, medial spine 1.0-1.2 times as long as lateral spine, and 0.7-0.9 times as long as segment; 6-8 teeth on lateral edge of medial apical spine. P5 (fig. 4E):

Fig. 4. *Mesocyclops acanthoramus* sp. nov. (male). A, distal geniculation of the antennule, segments 9-15 [Townsville, T-141]; B-C, antennal basipodite [Culture, Ingham]: B, frontal; C, caudal; D, P4 protopodite and coupler, caudal [Culture, Ingham]; E, pediger 5 and genital somite, ventral [Culture, Ingham]; F, first antennular segment [Townsville, T-99]; G, P4 enp3 [Culture, Ingham]. Scales: 50 μm.

TABLE II

Morphometric variability of the adult females of *Mesocyclops acanthoramus* sp. nov. Figures give the range, **mean**, and standard deviation, those in parentheses refer to the number of specimens measured

	Townsville	Cairns	Darnley I.*
Body length (μm):	1080-1220, **1154**, 53(11)	1060-1210, **1174**, 58(7)	1040-1130
Cephthx l/w:	1.1-1.2, **1.17**, 0.05(10)	1.0-1.2, **1.11**, 0.05(6)	
Gen dos l/w:	1.1-1.2, **1.16**, 0.05(12)	1.1-1,2, **1.16**, 0.05(7)	>1.0
Pros/Uros:	1.7-2.1, **1.84**, 0.10(11)	1.6-1.9, **1.75**, 0.10(7)	
Cephthx w/gen dos w:	2.7-3.2, **3.0**, 0.16(9)	2.8-3.0, **2.93**, 0.08(6)	
P4 enp3			
l/w:	2.4-3.0, **2.69**, 0.16(18)	2.6-2.9, **2.74**, 0.11(7)	2.1-2.6
ap sp med/lat:	0.9-1.2, **1.07**, 0.08(19)	1.1-1.3, **1.17**, 0.10(7)	1.07-1.21
ap sp/enp3 l:	0.74-0.95, **0.86**, 0.05(17)	0.79-0.96, **0.86**, 0.06(7)	0.83-0.90
coxa s/basis h	1.4-1.7, **1.55**, 0.10(10)	1.4-1.7, **1.58**, 0.12(6)	
P5			
ap s/med sp:	0.8-1.1, **0.97**, 0.09(11)	0.8-1.0, **0.90**, 0.08(5)	
lat s/med sp:	0.5-0.7, **0.66**, 0.07(13)	0.5-0.7, **0.57**, 0.06(3)	
Caudal ramus, l/w:	2.8-3.6, **3.3**, 0.22(20)	3.1-3.5, **3.3**, 0.16(7)	2.6-3.0
Caudal setae			
term s_1/s_4	2.5-3.1, **2.80**, 0.22(13)	2.7-3.2, **2.89**, 0.22(7)	2.5-2.8
term s_2/s_4	5.0-7.1, **5.87**, 0.66(12)	5.5-6.5, **5.90**, 0.35(6)	
term s_3/s_4	3.5-4.9, **4.23**, 0.42(13)	3.9-4.5, **4.19**, 0.20(7)	
dors s/s_4	0.8-0.9, **0.88**, 0.06(5)	0.88-0.97, **0.93**, 0.04(4)	
term s_2/Uros	1.1-1.4, **1.25**, 0.07(12)	1.2-1.3, **1.22**, 0.04(6)	

Abbreviations: Cephthx l/w, cephalothorax, length/width; Cephthx w/gen dos w, cephalothorax width/genital double-somite width; Gen dos l/w, genital double-somite, length/width; Pros/Uros, prosome length/urosome length; P4, coxa s/basis h, leg 4, length of coxopodite seta/height of medial expansion of basipodite; P4 enp3, ap sp med/lat, third segment of P4 endopodite, length ratio of medial and lateral apical spines; P4 enp3, ap sp/enp3 l, longer apical spine on third segment of P4 endopodite/length of P4 enp3; P5 ap s/med sp, leg 5, apical seta/medial spine; P5, lat s/med sp, leg 5, lateral seta/medial spine; term s_1, term s_2, term s_3, term s_4, caudal terminal setae from medialmost to lateralmost; dors s/s_4, length ratio of dorsal and lateralmost terminal caudal setae; term s_2/Uros, longest terminal caudal seta/length of urosome.

* Data from Brown (1995).

apical seta 0.9-1.0 times as long, lateral seta 0.6-0.7 times as long as spiniform medial seta. P6 (fig. 4E): flaps with tiny spinules arranged in medially ascendant line, and small teeth at mediodistal angle; armature composed of medial spine, subequal middle seta, and lateral seta 2 times as long as medial spine.

Variability (females). — Next to the morphometric features (table II), individual differences were found in some qualitative or meristic characters, too:

Seminal receptacle: section of the copulatory duct connecting the copulatory pore with transverse ducts is usually not, but sometimes well discernible. Spinules at the implantation of the lateral caudal setae can be very tiny. The number of setae

on the second endopodal (third) segment of the antenna varies between 7 and 8 in Townsville population, 7-9 in Cairns; a 9 setae-state was reported in the specimens from Darnley Island. Antennal basipodite, spinule pattern: there are usually several small spinules in a large field near the implantation of the mediodistal setae, sometimes, however, this is reduced to one row with a few (3-7) spinules only; number of spinules in the longitudinal rows along the lateral rim on the caudal and frontal surfaces 11-18, and 18-31, respectively. Maxilla: spinules on the frontal surface of the syncoxopodite can be very tiny or absent; there are two sometimes three (holotype) long setules at the proximal 2/5 of the basipodite seta inserted in front of claw-like endite. Caudal spinule ornamentation of P4 coxopodite: number of spinules along distal rim and near proximal rim, 6-12, and 13-21, respectively.

Aberrations in females. — This qualification is inferred from an extremely rare, and usually asymmetrical occurrence (just on one side of the two appendages) of the character states as such.

Two aesthetascs appear on the first segment of the antennule, and an additional oblique row of hairs is present on the caudal surface of the medial expansion of P3 basipodite in one specimen (T-116). Another female (T-43) has several anomalous features: an additional triangular field of spinules is present on the caudal surface of the antennal basipodite, between the spinule field near the implantation of the mediodistal setae, and an oblique row of fine spinules starting at middle of the medial rim; the lateral and caudal spinules are absent on the basipodite of the maxilliped or represented by just one group (distal); the medial expansion of the P4 basipodite bare, or only the distal group of hairs appears; the ventral spinules on the posterior margin of the anal somite are missing; spinules are also absent at the implantations of the lateral caudal, and lateralmost terminal caudal setae. In one female (T-100) the proximal hairs are missing on the caudal surface of the medial expansion of P4 basipodite.

Diagnosis (female). — *Mesocyclops acanthoramus* can be distinguished from its congeners by the following combination of characters. Medium-sized, 1.0-1.2 mm. Pediger 5 with lateral hairs. Genital double-somite and succeeding urosomites without hairs. Seminal receptacle with wide lateral arms, anterior margin of proximal part sinuate in middle, distal part of seminal receptacle large, transverse ducts forming V-shape near copulatory pore. Posterior margin of anal somite with continuous row of spinules. Caudal ramus relatively short, 2.6-3.6 times as long as wide, without medial hairs. Spinules present at implantation of lateral caudal and lateralmost terminal caudal setae. Dorsal caudal seta shorter or nearly as long as lateralmost terminal caudal seta, longest terminal caudal seta 1.1-1.4 times as long as urosome. Antennule with ventral spinules on segments 1, 4-5, 7-13. Hyaline membrane on last antennular segment extending proximally beyond

implantation of medial seta, with one large notch. Antenna enp2 with 7-9 setae. Group of tiny spinules present near implantation of mediodistal setae on caudal surface of antennal basipodite, spinules absent next to implantation of exopodite (lateral) seta on frontal surface of basipodite. Mandible with three groups of spinules near palp. Maxillular palp bare, palp setae without long setules. Maxilla with one-segmented exopodite, field of small or medium-sized spinules usually present on frontal surface of syncoxopodite. Spinules arranged in two groups on lateral rim and caudal surface of basipodite of maxilliped. P1 basipodite lacking medial spine. Couplers of P1-P4 bare on caudal and frontal surfaces. P4 coupler bearing two large and acute prominences. Medial expansion of P4 basipodite with group of distal hairs and oblique row of hairs on caudal surface. P4 coxopodite seta conspicuously longer than height of medial expansion of basipodite. Apical spines on P4 endopodite subequal, no or few teeth present on lateral edge of medial spine.

Mesocyclops pubiventris sp. nov. (figs. 5-7)

Types. — Holotype (♀) from Cloncurry (20°42′S 140°30′E, Queensland, Australia), CL-78, Bowls Club, 23 Feb. 1999, service manhole. Holotype and 2 paratypes (♀♀, Cloncurry) are deposited at Queensland Museum, Brisbane. Two paratypes (♀♀, Cloncurry) are deposited at Museum and Institute of Zoology PAS, Warsaw. All specimens are dissected, and mounted on two slides each.

Other material examined. — Cloncurry, Queensland, service manholes, geographic coordinates as above: **CL-9**, Sheaffe/Daintree St., 23 Feb. 1999, 3 ♀♀ mounted, 6 ♀♀ in alcohol; **CL-11**, Daintree/Sheaffe, 24 Feb. 1999, 1 ♀ mounted, 5 ♀♀ in alcohol; **CL-15**, Sheaffe/Scarr St., 23 Feb. 1999, 1 ♀ mounted, 3 ♀♀ in alcohol; **CL-18**, Sheaffe/Flinders Hwy, 23 Feb. 1999, 7 ♀♀ in alcohol; **CL-78**, Bowls Club, 23 Feb. 1999, 2 ♀♀ in alcohol.

Etymology. — The specific name is derived from the Latin words, "pubes" for hair and "venter" for belly, referring to the pilose ornamentation of the ventral surface of the urosome. The specific name is an adjective agreeing in gender with the (masculine) generic name.

Description of female (holotype). — Body length 1150 μm; prosome/urosome: 1.9; cephalothorax length/width: 1.2; cephalothorax width/genital double-somite width: 3.1.

Pediger 5 (fig. 5A, D) laterally and dorsally pilose; two medial, and two laterodistal hair-sensilla present on dorsal surface. Genital double-somite (fig. 5A, D) 1.2 times as long as wide, ventrally and dorsally pilose; 2 and 6 hair-sensilla present on ventral and dorsal surfaces, respectively; posteriorly to P6, six pores present in group on laterodorsal surface of somite (verified on 2 females). Succeeding two urosomites with distinct rows of hairs ventrally (fig. 5B). Dorsal surface ornamentation could not be verified in the holotype, but dorsal pilosity extends to urosomite 3 in other females. Seminal receptacle (fig. 5A) with wide lateral arms, distal part of seminal receptacle large, anterior margin of proximal part sinuate in

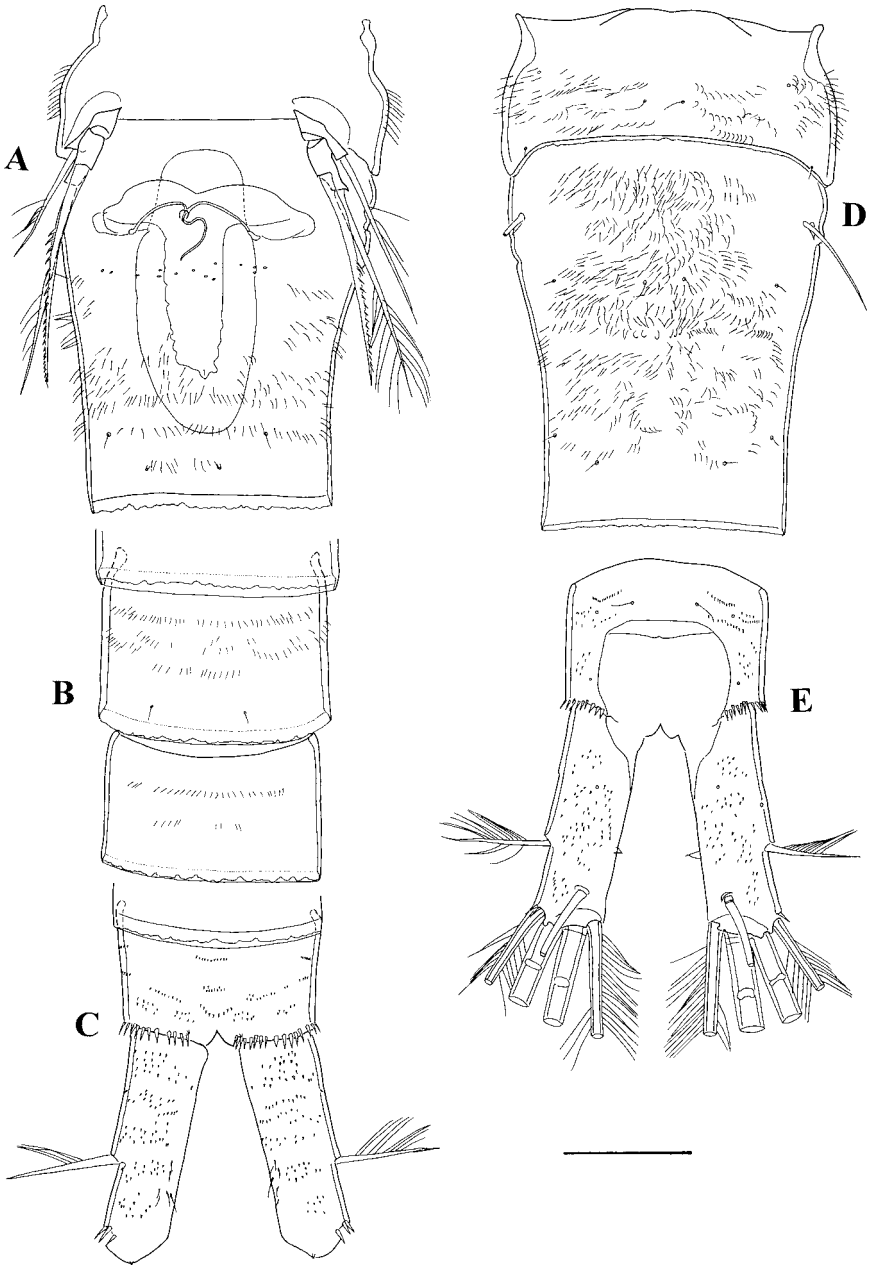


Fig. 5. *Mesocyclops pubiventris* sp. nov. Holotype (female). A, pediger 5 and genital double-somite, ventral; B, urosomites 3-4, ventral; C, anal somite, and caudal rami, ventral; D, pediger 5 and genital double-somite, dorsal; E, anal somite and caudal rami, dorsal. Scale: 50 μm.

middle. Transverse ducts meet approximately at right angle near copulatory pore; copulatory duct strongly curved, one circular pore present posteriorly to horseshoe-shaped copulatory pore. Posterior margin of anal somite with continuous row of spinules (fig. 5C, E). Caudal ramus (fig. 5C, E) 3.2 times as long as wide; except few hair-like spinules on posterior half, no hairs on medial rim. Ventral surface (fig. 5C) adorned with tiny spinules arranged in strips, patchy ornamentation on dorsal surface (fig. 5E). Larger spinules present at implantation of lateralmost terminal caudal seta, but spinules absent at implantation of lateral caudal seta (fig. 5C, E). Dorsal caudal seta 0.91 times as long as lateralmost terminal caudal seta. Relative length of terminal caudal setae from medialmost to lateralmost, 2.5, 5.3, 3.7, 1.0. Longest terminal caudal seta 1.2 times as long as urosome.

Antennule 17-segmented, armature formula as in *M. acanthoramus*, common in genus. Aesthetasc on segment 12 (fig. 6A) not reaching distal margin of segment 13; aesthetasc on segment 16 (fig. 6B) short, ca. 1/3 length of segment 17. Ventral spinules present on segments 1, 4-5, and 7-13, shallow round pits on dorsal surface. Last two antennular segments with hyaline membrane. Serrate hyaline membrane on last antennular segment, extending proximally beyond implantation of medial seta, with one notch.

Antenna armed with 3 setae on basipodite, and 1, 9, and 7 setae on endopodal segments 1-3, respectively. Spinule ornamentation on caudal surface of antennal basipodite (fig. 6F): long spinules on lateral rim near base; oblique row of 9 robust spinules next to former group; longitudinal row of tiny spinules along medial rim, intermittent ca. in middle of segment; longitudinal row of 11 robust spinules along lateral rim; group of small spinules near implantation of mediodistal setae; and oblique row of fine spinules starting in distal half of medial rim. Frontal ornamentation (fig. 6G) of antennal basipodite: longitudinal row of 26 spinules along lateral rim, and transverse row of fine spinules distally to elongate spinules on proximal margin. Exopodite seta (lateral seta on basipodite) reaching distal margin of enp3.

With the exception of long distal hairs, no other ornamentation on ventral surface of labrum, but epistoma pilose, and transverse lateral rows of long hairs present at heights of proximal and distal ends of epistoma (fig. 6C). Mandibular palp with two long and one short setae, 3 groups of spinules present near palp, no ornamentation proximally to trio (fig. 6D). Setation of maxillule (fig. 6H) as in *M. acanthoramus*; palp bare, 3 setae on lateral lobe, and proximalmost seta of palp with denticles, no long setules. Lateral lobe of maxillular palp incompletely articulated, separation visible in ventral view only. Maxilla (fig. 7A) with same structure as in *M. acanthoramus*; oblique row of long hair-like spinules present on frontal surface of syncoxopodite. Maxilliped (fig. 7B) with syncoxopodite, basipodite,

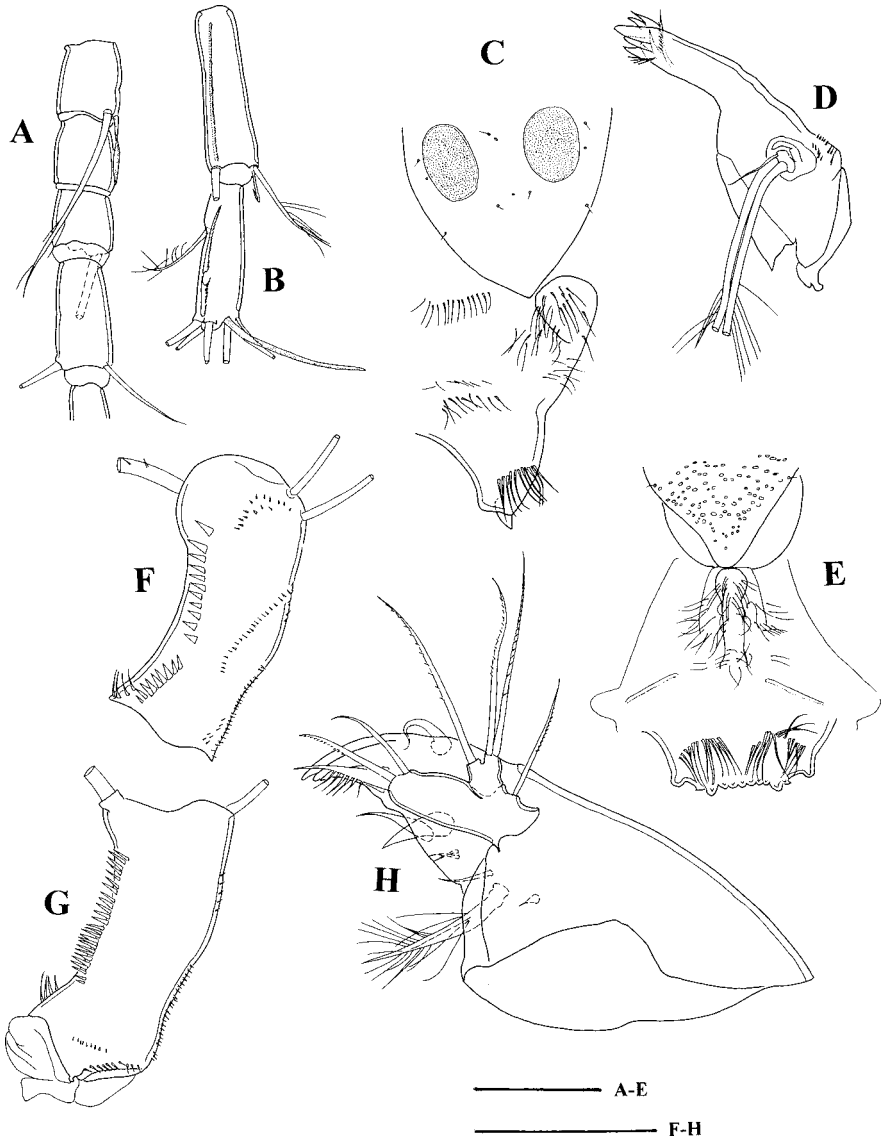


Fig. 6. *Mesocyclops pubiventris* sp. nov. (female). A-B, antennule: A, segments 12-15; B, segments 16-17; C, labrum, epistoma, and rostrum; D, mandible; E, labrum, epistoma, and rostrum; F-G, antennal basipodite: F, caudal; G, frontal; H, maxillule. A-D and F-G show the holotype, E and H show a paratype [Cloncurry, (Cl-9)]. Scales: 50 μm.

and two-segmented endopodite, armature formula 3, 2, 1, 3, respectively. Syncoxopodite frontally with double rows of tiny spinules; spinules arranged in two groups on caudal surface and lateral rim of basipodite.

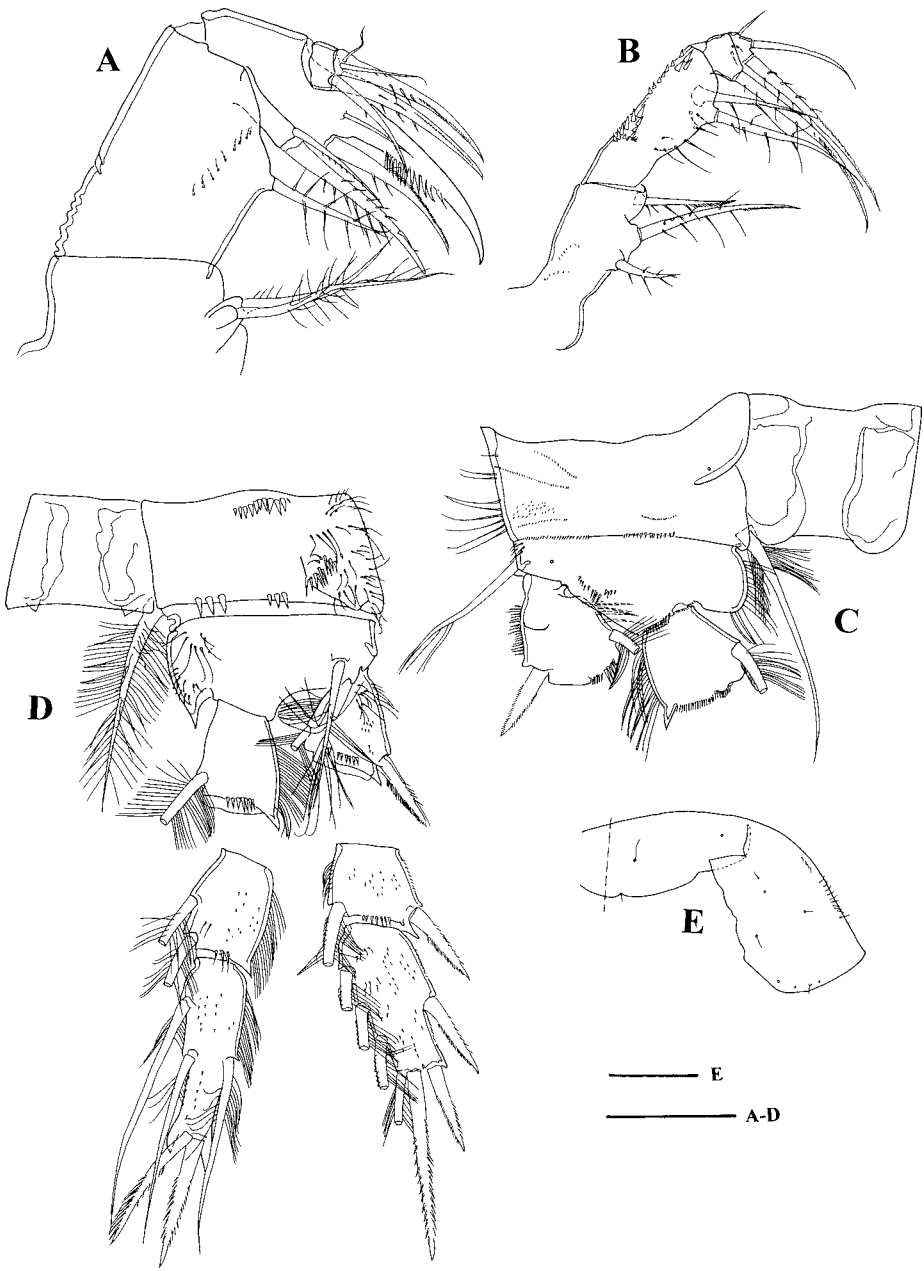


Fig. 7. *Mesocyclops pubiventris* sp. nov. Holotype (female). A, maxilla, caudal; B, maxilliped, caudal; C, P1 protopodite, exp1, and enp1, frontal; D, P4, caudal; E, P4 coupler (only half of the somite is shown). Scales: 50 μm.

Armature formula of P1-P4 as in *M. acanthoramus* (table I). P1 basipodite (fig. 7C) lacking medial spine; basipodite frontally with spinules arranged in arch between implantations of exo- and endopodite, and few hair-like spinules next to lateral rim. Middle element on distal margin of P1 exp3 with long setules medially and with denticles laterally. Couplers of P1-P4 bare on frontal and caudal surfaces. Pediger 3 with spinules, pediger 4 (fig. 7E) with short hairs on lateral surface. P4 (fig. 7D) coupler bearing two small and acute prominences on distal margin. Ornamentation on caudal surface P4 coxopodite (fig. 7D) composed of: 6 large spinules in intermittent row along distal rim; relatively small spinules (in comparison to those in the same position in the congeners) arranged in group at laterodistal angle; 11 spinules in one row near proximal rim; and dense lateral hairs. Coxopodite seta 1.9 times as long as height of medial expansion of P4 basipodite. Medial expansion of P1 basipodite bearing hairs distally and medially (fig. 7C), P2 and P3 with distal hairs only, on medial expansion of P4 basipodite (fig. 7D) short distal hairs supplemented with long hairs on caudal surface. P4 rami (with the exception of enp1, which is bare) caudally adorned with small spinules (fig. 7D). P4 enp3 2.8 times as long as wide; apical spines of equal length, and 0.71 times as long as segment; 6 fine teeth on lateral edge of medial apical spine. P5 (fig. 5A) two-segmented, lateral seta 0.8 times as long, apical seta 0.93 times as long as spiniform medial seta.

Male. — No male found.

Variability. — Variances of the morphometric features are given in table III. Individual differences were found in the following meristic and qualitative characters. Ventral pilosity of the urosome extends as far as urosomite 4, sometimes it is restricted to the genital double-somite and urosomite 3. Dorsal pilosity of urosome usually extends to urosomite 3, sometimes it is reduced to pediger 5 and the genital double-somite. Transverse ducts meet near copulatory pore at acute, or obtuse, or even at straight angle. Notch on the hyaline membrane of the last antennular segment is usually small, but sometimes big. Antennal basipodite: number of spinules in the longitudinal rows along the lateral rim on the caudal and frontal surfaces, are 10-15, and 23-29, respectively; the small spinules at height of the mediodistal setae on the caudal surface of the basipodite are arranged in 1 or 2 rows usually, but sometimes reduced to a few spinules only. The number of setae on the second endopodal segment of the antenna: 9 setae-state in 11 of 20, 8 setae-state in 8 of 20, 7 setae-state in 1 of 20 antennae (10 specimens examined). The ornamentation of the labrum and epistoma: the distal fringe hairs on the ventral surface of the labrum are always present, and the epistoma is pilose in all the specimens examined, yet the transverse lateral rows of hairs at heights of the proximal and distal ends of the epistoma are sometimes absent (fig. 6E). Caudal ornamentation of P4 coxopodite: number of spinules along distal and proximal rims are, 5-8, and 8-12, respectively;

TABLE III

Morphometric variability of the adult females of *Mesocyclops pubiventris* sp. nov. Figures give the range, **mean**, and standard deviation, those in parentheses refer to the number of specimens measured (see explanation to the abbreviations in table II)

	Cloncurry (Queensland)
Body length (μm):	980-1160, **1057**, 67(8)
Cephthx l/w:	1.1-1.2, **1.15**, 0.05(8)
Gen dos l/w:	1.2-1.3, **1.24**, 0.05(8)
Pros/Uros:	1.6-1.9, **1.75**, 0.11(8)
Cephthx w/gen dos w:	2.7-3.5, **3.09**, 0.25(7)
P4 enp3	
l/w:	2.6-3.1, **2.84**, 0.14(10)
ap sp med/lat:	0.9-1.1, **0.99**, 0.06(10)
ap sp/enp3 l:	0.71-0.81, **0.75**, 0.03(10)
coxa s/basis h	1.6-1.9, **1.77**, 0.12(9)
P5	
ap s/med sp:	0.93-1.3, **1.07**, 0.14(6)
lat s/med sp:	0.69-1.1, **0.85**, 0.15(6)
Caudal ramus, l/w:	3.0-3.5, **3.25**, 0.15(10)
Caudal setae	
term s_1/s_4	2.4-3.0, **2.64**, 0.22(8)
term s_2/s_4	5.0-6.7, **5.86**, 0.54(9)
term s_3/s_4	3.4-4.7, **4.1**, 0.43(10)
dors s/s_4	0.83-1.3, **1.0**, 0.15(8)
term s_2/Uros	0.96-1.33, **1.15**, 0.12(8)

spinules at the laterodistal angle are arranged in a group or 1 oblique row. Prominences on the distal margin of P4 coupler are acute or obtuse. Distal hairs on the medial expansion of P4 basipodite are relatively short and thick, or long and fine. There are usually many and fine, or sometimes few and robust spines on the lateral edge of the medial apical spine of P4 enp3.

Diagnosis (female). — *Mesocyclops pubiventris* can be distinguished from its congeners by the following combination of characters. Medium-sized, 1.0-1.2 mm. Pediger 5 with lateral and dorsal hairs. Genital double-somite and succeeding one or two urosomites pilose. Seminal receptacle with wide lateral arms, anterior margin of proximal part sinuate in middle, distal part of seminal receptacle large. Posterior margin of anal somite with continuous row of spinules. Caudal ramus 3.0-3.5 times as long as wide, without hairs along medial margin. Spinules absent at implantation of lateral caudal seta, but present at implantation of lateralmost terminal caudal seta. Dorsal caudal seta slightly shorter or longer than lateralmost terminal caudal seta, longest terminal caudal seta 1.0-1.3 times as long as urosome. Antennule with ventral spinules on segments 1, 4-5, 7-13. Hyaline membrane on last antennular segment, extending proximally beyond implantation of medial seta,

usually with one small notch. Antenna enp2 with 8 or 9 (sometimes 7) setae. Group of small spinules present near implantation of mediodistal setae on caudal surface of antennal basipodite, long longitudinal row of tiny spinules on medial rim of basipodite intermittent in middle of segment, spinules absent next to implantation of exopodite (lateral) seta on frontal surface of antennal basipodite. Mandible with three groups of spinules near palp, no ornamentation proximally to former groups. Maxillular palp bare, palp setae without long setules. Maxilla with one-segmented exopodite, row of hair-like spinules present on frontal surface of syncoxopodite. Spinules arranged in two groups on lateral rim and caudal surface of basipodite of maxilliped. P1 basipodite lacking medial spine. Couplers of P1-P4 bare on caudal and frontal surfaces. P4 coupler bearing two small, and acute or obtuse prominences. Medial expansion of P4 basipodite with short or long distal hairs, and group of long hairs on caudal surface. P4 coxopodite seta conspicuously longer than height of medial expansion of basipodite. Many (sometimes few) teeth on lateral edge of medial apical spine of P4 enp3.

Mesocyclops kayi sp. nov. (figs. 8-11)

Types. — Holotype (♀) and two paratypes (♀♀) from Minetown, 81 km W Monywa 22°05′N 95°12′E, Burma, copper mine, old fish pond, leg. B. Kay, 07 Mar. 2000. Types are dissected and mounted on two slides each, and deposited at Museum and Institute of Zoology PAS, Warsaw.

Other material examined. — Two ♀♀ from the same locality as the types, in alcohol.

Etymology. — The species is named in honour of the Australian arbovirologist, Dr. Brian Kay, who as one of the firsts used copepods in the biological control of disease vector mosquitoes, and collected the species here described. Hence, the specific epithet is a noun in the genitive singular.

Description of female (holotype and two paratypes). — Body length 1260-1365 μm (holotype 1365 μm); prosome/urosome: 1.6-1.7; cephalothorax length/width: 1.1-1.2; cephalothorax width/genital double-somite width: 2.5-2.8 (holotype, 2.7).

Pediger 5 (figs. 8A, 9A) laterally and dorsally pilose, two medial, and two laterodistal hair-sensilla present on dorsal surface. Genital double-somite and succeeding two urosomites with transverse ridges on dorsal and ventral surfaces (figs. 8A, 9A). Hyaline frills on urosomites wide, with deep indentations. Genital double-somite 1.0-1.1 times as long as wide, posteriorly to P6, six pores present in group on laterodorsal surface of somite, but no spinules near P6 (holotype). Seminal receptacle (fig. 8A) with wide and elongate lateral arms; anterior margin of proximal part very slightly sinuate or arcuate; distal part large; transverse ducts (fig. 8B) forming straight angle meet conspicuously broad copulatory duct anteriorly to copulatory pore. Row of spinules along posterior margin of anal

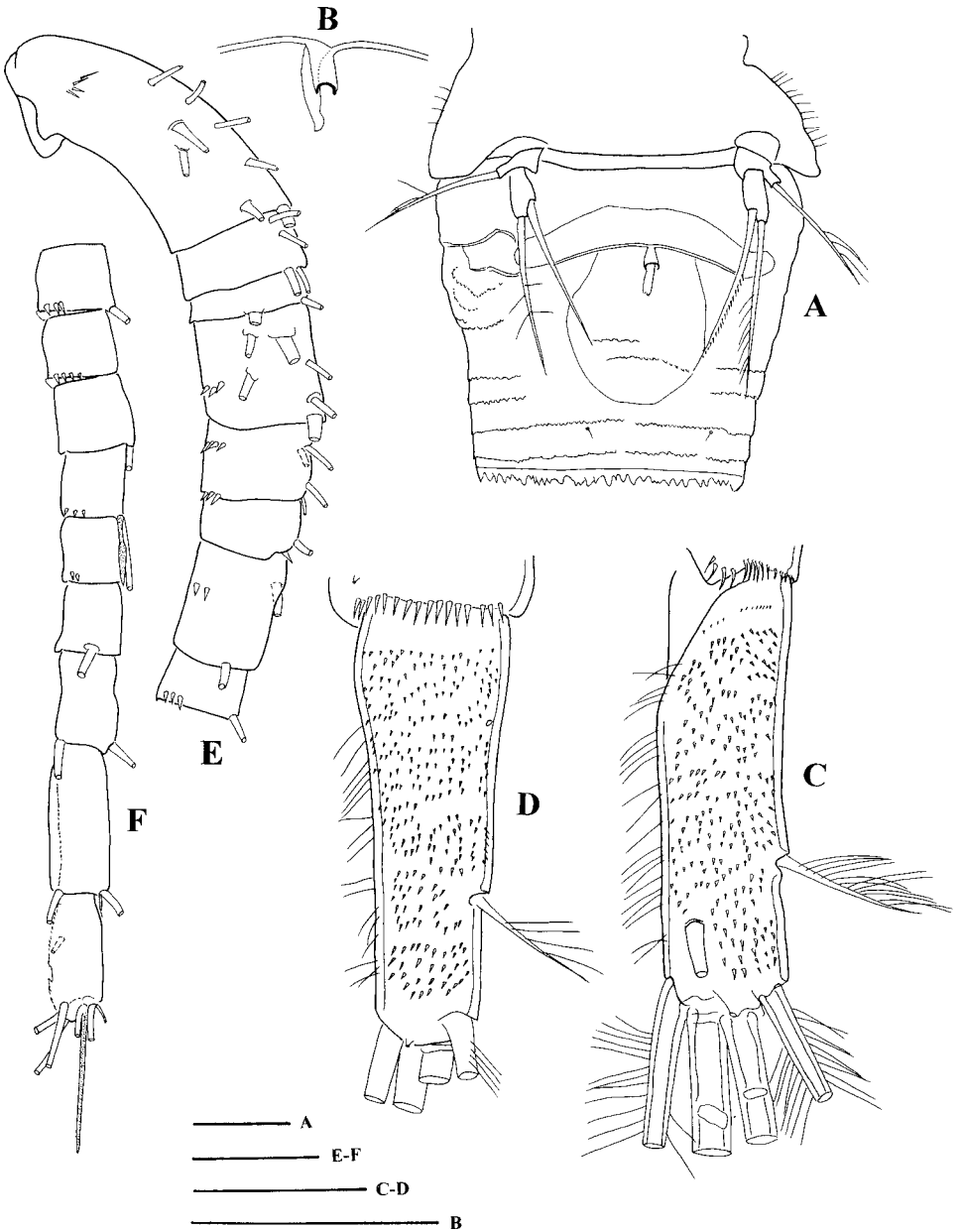


Fig. 8. *Mesocyclops kayi* sp. nov. (female). A, pediger 5 and genital double-somite, ventral; B, copulatory pore and duct, and transverse ducts; C-D, caudal ramus: C, dorsal; D, ventral; E-F, antennule: E, segments 1-8; F, segments 9-17. B shows a paratype, all the other figures show the holotype. Scales: 50 μm.

somite continuous (paratypes), or laterally intermittent (holotype) (fig. 8C, D). Caudal ramus (fig. 8C, D) 3.6-3.8 times as long as wide, with long medial hairs; small spinules approximately evenly distributed on dorsal surface (fig. 8C), ventral spinules (fig. 8D) arranged in patchy pattern on distal half of ramus (holotype). Spinules absent at implantations of lateral caudal and lateralmost terminal caudal setae. Dorsal caudal seta 0.5-0.8 (holotype, 0.8) times as long as lateralmost terminal caudal seta. Relative length of terminal caudal setae from medialmost to lateralmost: 2.2-2.4, 4.4-4.7, 3.3-3.5, 1.0. Longest terminal caudal seta 1.1 times as long as urosome.

Antennule (fig. 8E, F) 17-segmented, armature formula as in *M. acanthoramus*, common in genus. Aesthetasc on segment 12 reaching distal margin of segment 13; aesthetasc on segment 16 highly reduced (fig. 9C). Ventral spinules (fig. 8E, F) present on segments 1, 4-5, 7-10, and 12-13, shallow round pits appear on dorsal surface. Last two antennular segments with hyaline membrane. Serrate hyaline membrane on last antennular segment, extending proximally beyond implantation of medial seta, with one large notch (fig. 9C).

Antenna (fig. 9B) armed with 3 setae on basipodite, exopodite (lateral) seta reaching beyond distal margin of enp3. Endopodite 1-3 bearing 1, 8 or 9, and 7 setae, respectively. Spinule ornamentation on caudal surface of basipodite (fig. 9D) composed of: long spinules on lateral margin near base; oblique row of large spinules (8-10) next to former group; longitudinal row of 11-12 long slender spinules along lateral rim; row of large spinules near implantation of mediodistal setae; broad oblique field of small spinules starting approximately in middle of medial rim; spinules on medial rim reaching distal 1/3-1/4 of segment. Spinule ornamentation on frontal surface of antennal basipodite (fig. 9E): longitudinal row of spinules (17, 18) along lateral rim; and few spinules near base, distally to spinules along proximal margin.

Long distal hairs present on ventral surface of labrum; epistoma pilose, distinct rows of spinules present in vertical cleft (fig. 10A). Mandibular palp with two long and one short setae. Setation of maxillule as in *M. acanthoramus*; palp (fig. 11E) bare, 3 setae on lateral lobe and proximalmost seta of palp with denticles, no long setules; lateral lobe articulated. Maxilla (fig. 10B) with same structure as in *M. acanthoramus*; longitudinal field of tiny spinules present on frontal surface of syncoxopodite. Maxilliped (fig. 11D) with syncoxopodite, basipodite, and two-segmented endopodite, armature formula 3, 2, 1, 3, respectively. Tiny spinules present on frontal surface of syncoxopodite; large spinules arranged in two groups on caudal surface and lateral rim of basipodite.

Armature formula of P1-P4 as in table I. P1 basipodite (fig. 10C) lacking medial spine, frontal surface of segment adorned with large spinules arranged in arch between implantations of exopodite and endopodite, long spinules near lateral rim,

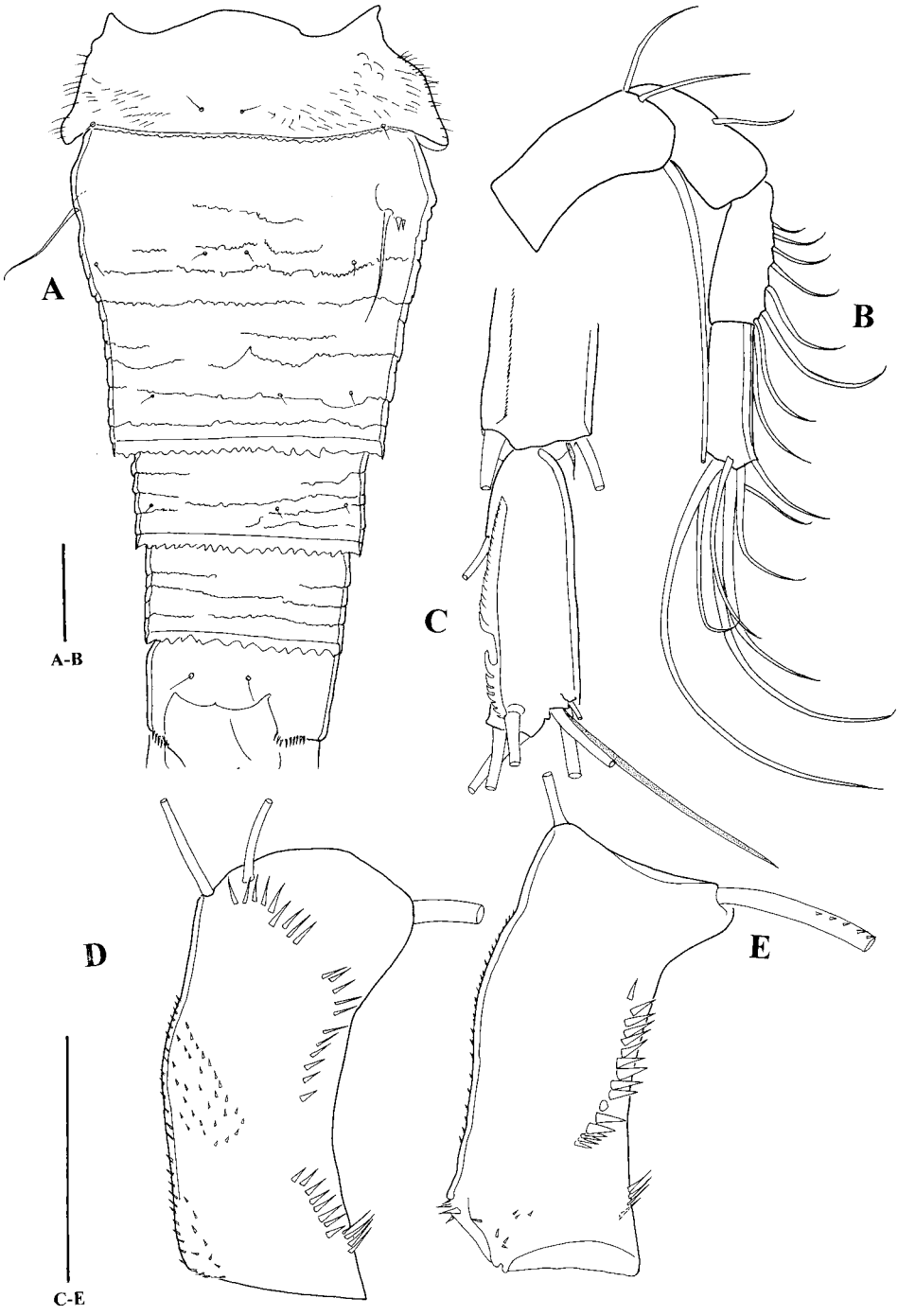


Fig. 9. *Mesocyclops kayi* sp. nov. (female). A, urosome, dorsal; B, antenna; C, last antennular segment; D-E, antennal basipodite: D, caudal; E, frontal. C and E show a paratype, all the other figures show the holotype. Scales: 50 μm.

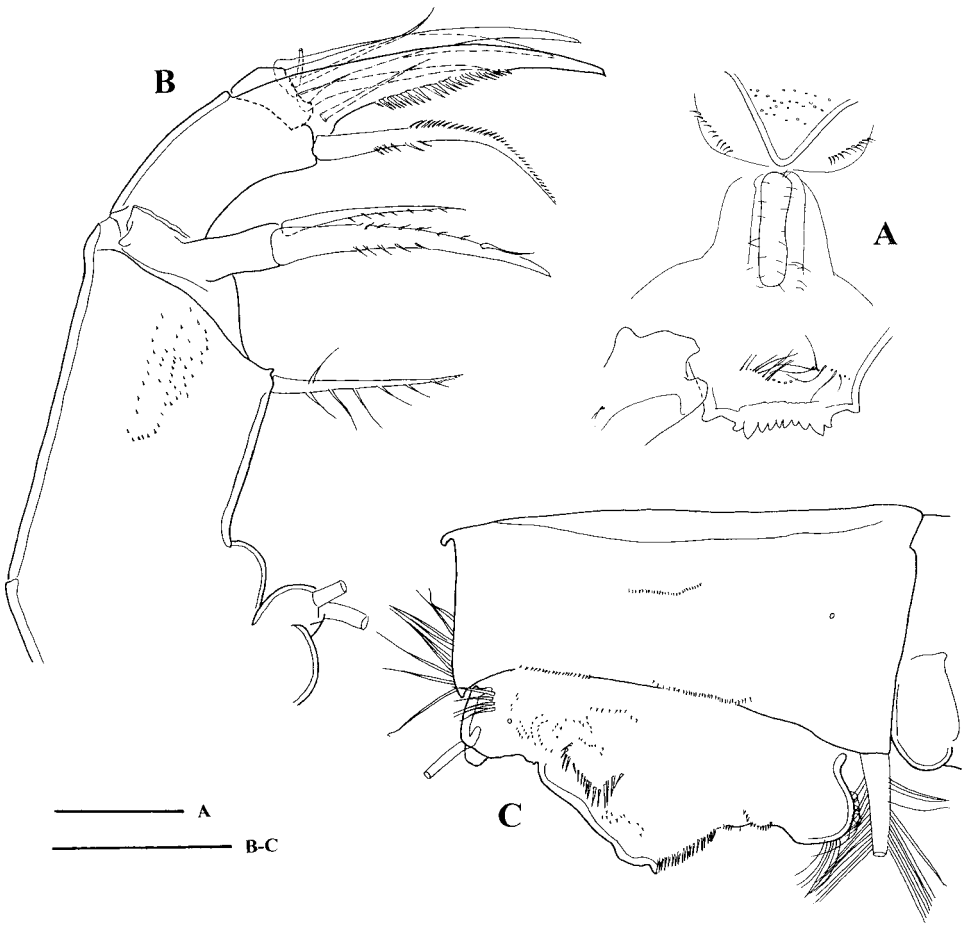


Fig. 10. *Mesocyclops kayi* sp. nov. (female). A, labrum epistoma, and vertical cleft; B, maxilla, frontal; C, P1 protopodite, frontal. A shows a paratype, B-C show the holotype. Scales: 50 μm.

and very tiny spinules dispersed in lateral half. Middle element on distal margin of P1 exp3 with long setules medially and with denticles laterally. Couplers of P1-P4 bare on caudal and frontal surfaces. P4 coupler (fig. 11A) bearing two large and acute prominences on distal margin. Pedigers 3 and 4 pilose. Ornamentation on caudal surface of P4 coxopodite (fig. 11A) composed of: few (3-5) spinules near distal rim; elongate spinules at laterodistal angle arranged in one or two oblique rows; few large spinules near middle of proximal rim, and lateral hairs. P4 coxopodite seta 1.4-1.6 times as long as medial expansion of basipodite. Medial expansion of P4 basipodite (fig. 11A) bearing distal hairs only. Caudal surface of P4 rami (fig. 11B, C, F) adorned with hair-like spinules on exopodite, and, with the exception of two groups of elongate spinules on endopodite 2, with short spinules on endopodite. P4 enp3 (fig. 11F) squat, 2.2-2.4 times as long as wide; medial

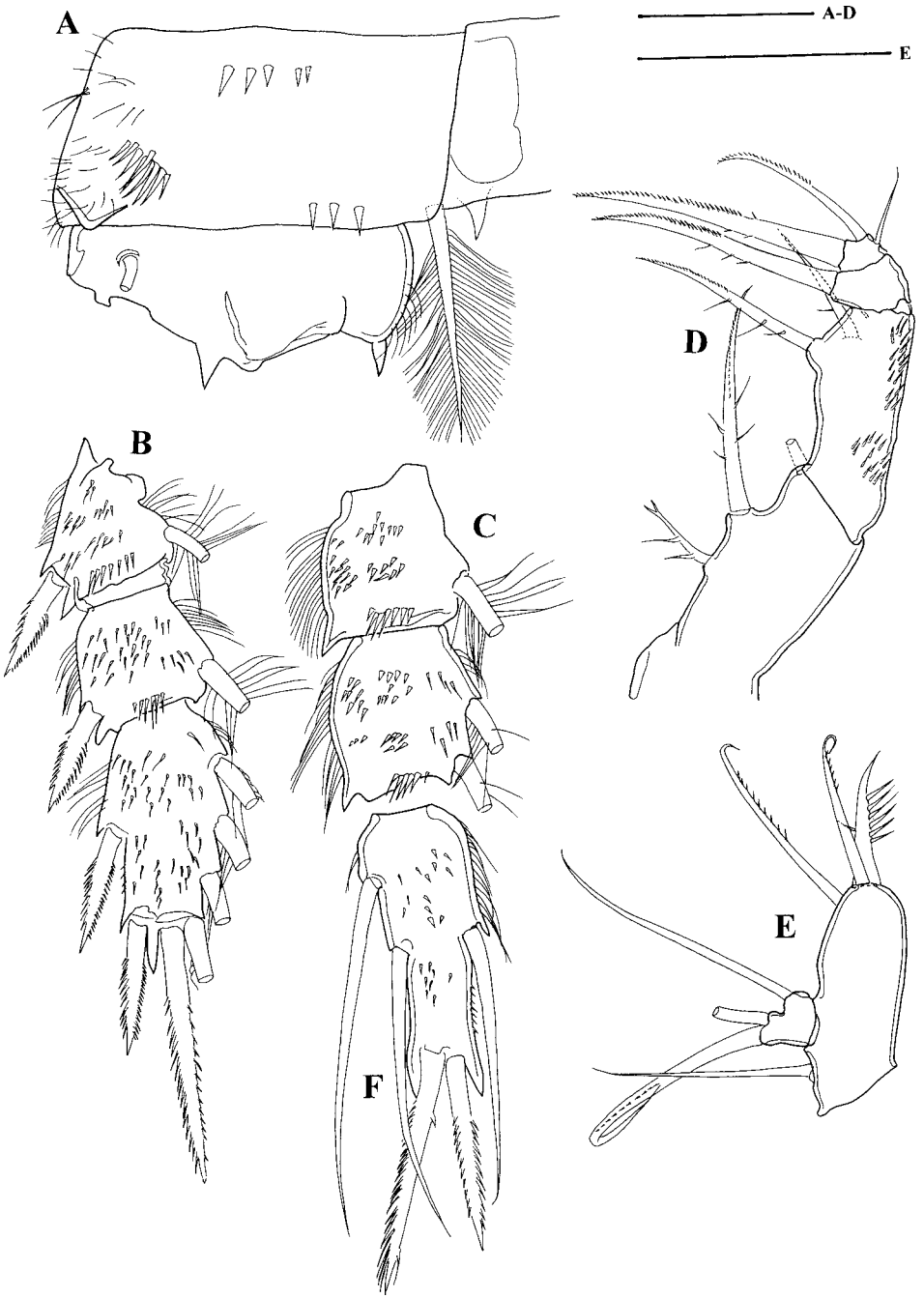


Fig. 11. *Mesocyclops kayi* sp. nov. (female). A, P4 protopodite, caudal; B, P4 exopodite, caudal; C, P4 enp1-2, caudal; D, maxilliped, caudal; E, maxillular palp; F, P4 enp3, caudal. A-C show the holotype, D-F show paratypes. Scales: 50 μm.

apical spine 1.2-1.3 times as long as lateral apical spine; longer (medial) apical spine slightly shorter, or as long as segment; no or few teeth present on lateral edge of medial apical spine. P5 (fig. 8A) two-segmented, lateral seta 0.8-0.9 times as long, apical seta 0.9-1.0 times as long as spiniform medial seta.

Male. — No male found.

Diagnosis (female). — *Mesocyclops kayi* can be distinguished from its congeners by the following combination of characters. Body length 1.2-1.4 mm. Pediger 5 laterally and dorsally pilose. Genital double-somite and succeeding two urosomites with transverse ridges. Seminal receptacle with wide and elongate lateral arms, anterior margin of proximal part arcuate, or very slightly sinuate, distal part of seminal receptacle large. Transverse ducts forming straight angle meet broad copulatory duct anteriorly to copulatory pore. Caudal ramus with long medial hairs, no spinules at implantations of lateral caudal and lateralmost terminal caudal setae. Longest terminal caudal seta only slightly longer (1.1×) than urosome. Antennule with ventral spinules on segments 1, 4-5, 7-10, and 12-13. Hyaline membrane of last antennular segment with one large notch. Antenna enp2 with 8 or 9 setae. Antennal basipodite caudally adorned with row of large spinules near implantations of mediodistal setae, and broad oblique field of small spinules starting approximately in middle of medial rim. Maxillular palp bare. Longitudinal field of tiny spinules present on frontal surface of syncoxopodite of maxilla. Large spinules arranged in two groups on caudal surface and lateral rim of basipodite of maxilliped. P1 basipodite without medial spine. Couplers of P1-P4 bare on caudal and frontal surfaces. P4 coupler with two large and acute prominences. Few large spinules present near proximal and distal rims, on caudal surface of P4 coxopodite. P4 coxopodite seta conspicuously longer than height of medial expansion of P4 basipodite. Medial expansion of P4 basipodite with distal hairs only. Of the apical spines of P4 enp3, medial spine longer than lateral spine, no or few teeth on lateral edge of medial apical spine.

NEW AUSTRALIAN RECORDS OF *MESOCYCLOPS*

Mesocyclops aspericornis (Daday, 1906)

QUEENSLAND: Charters Towers, 20°05′S 146°16′E: 03 Feb. 1999; 04 Feb. 1999; 07 Feb. 1999. Hughenden, 20°51′S 144°12′E: 13 Mar. 2000; 14 Mar. 2000. Mt. Isa, 20°43′S 139°29′E: 02 Aug. 1998; 24 Feb. 1999. Port Douglas, 16°29′S 145°27′E: 03 Feb. 1999; 02 Mar. 1999; 03 Mar. 1999. Richmond, 20°44′S 143°08′E: 13 Mar. 2000. Townsville, 19°16′S 146°47′E: 21 Jan. 1998; 22 Jan. 1998; 02 Dec. 1998; 09 Dec. 1998; 21 Jan. 1999; 22 Jan. 1999; 27 Jan. 1999; 28 Jan. 1999; 2 Feb. 1999; 04 Feb. 2000; 17 Feb. 2000; 18 Feb. 2000; 02 Mar. 2000; 12 May 2000; 16 May 2000.

Distribution. — Pantropical.

Mesocyclops brooksi Pesce, De Laurentiis & Humphreys, 1996

QUEENSLAND: Townsville, 19°16′S 146°47′E: 12 May 2000.

WESTERN AUSTRALIA: Pilbara region: Fortesque Marsh, Moonjari well, 22°29′55″S 119°31′08″E, 3 Jun. 2000, salinity 1.5 ppt. Southwest: Lake Cronin, 32°23′30″S 119°45′55″E, 25 Sep. 1997, salinity 0.22 ppt. Darkin swamp, 32°06′47″S 116°30′47″E, 03 Oct. 1997, salinity 0.22 ppt. Ellen Brook, 31°38′00″S 116°00′30″E, 07 Nov. 1991, fresh. Girraween Yate Swamp, 33°38′08″S 119°21′10″E, 26 Aug. 1998, salinity 0.35 ppt. Hotham River, 32°38′35″S 116°58′29″E, 29 Oct. 1997, salinity 10.89 ppt. Pindicup Lake, 34°24′26″S 116°42′47″E, 21 Oct. 1998, salinity 3.6 ppt. Poorginup Lake, 34°32′56″S 116°44′29″E, 02 Oct. 1998, salinity 0.21 ppt.

Endemic to Australia.

Mesocyclops darwini Dussart & Fernando, 1988

QUEENSLAND: Charters Towers, 20°05′S 146°16′E: 04 Feb. 1999; 07 Feb. 1999.

WESTERN AUSTRALIA: Pilbara region: Fortesque Marsh, Moonjari well, 22°29′55″S 119°31′08″E, 3 Jun. 2000, salinity 1.5 ppt.

Distribution. — New Guinea and Australia.

Mesocyclops notius Kiefer, 1981

QUEENSLAND: Mt. Isa, 20°43′S 139°29′E: 02 Aug. 1998. Townsville, 19°16′S 146°47′E: 22 Jan. 1999.

WESTERN AUSTRALIA: Kimberley region: Lake Gregory, 20°12′04″S 127°29′04″E, 01 Jun. 1991, fresh. Pilbara region: Fortesque Marsh, 22°29′55″S 119°31′08″E, 3 Jun. 2000, salinity 1.5 ppt.

Distribution. — Australia and New Guinea (?).

Mesocyclops papuensis Van de Velde, 1987

QUEENSLAND: Port Douglas, 16°29′S 145°27′E: 3 Mar. 1999. Townsville, 19°16′S 146°47′E: 04 Dec. 1998; 09 Dec. 1998; 02 Mar. 2000.

WESTERN AUSTRALIA: Kimberley region: Long Spring Rainforest, 14°54′00″S 128°45′00″E, 18 Nov. 1993, swamp, fresh. Mt. Elizabeth, 16°18′04″S 126°07′59″E, 14 Sep. 1999, fresh.

Distribution. — Borneo, Java, New Guinea, and Australia.

Mesocyclops woutersi Van de Velde, 1987

QUEENSLAND: Mt. Isa, 20°43′S 139°29′E: 01 Aug. 1998; 24 Feb. 1999. Townsville, 19°16′S 146°47′E: 21 Jan. 1998; 09 Feb. 1998; 04 Dec. 1998; 09 Dec. 1998; 21 Jan. 1999; 22 Jan. 1999.

WESTERN AUSTRALIA: Kimberley region: Big Spring, 16°59′03″S 123°57′21″E, 07 Sep. 1999, fresh seep on tidal flat.

Distribution. — Japan [the Ryukyus, possibly Honshu], South China, Vietnam, New Guinea, and Australia.

KEY TO THE IDENTIFICATION OF THE AUSTRALIAN SPECIES OF *MESOCYCLOPS* (FEMALE)
(The key also includes those species, the occurrence of which in Australia is expected.)

1. P1 basipodite with medial spine; frontal surface of antennal basipodite with group of spinules near implantation of exopodite (lateral) seta 2
– P1 basipodite without medial spine; frontal surface of antennal basipodite without group of spinules near implantation of exopodite seta 3
2. Lateral arms of seminal receptacle wide; pediger 5 not bending over genital double-somite . . . . . *M. pseudoannae* Van de Velde, 1987
– Lateral arms of seminal receptacle narrow; pediger 5 bending over genital double-somite . . . . . *M. darwini* Dussart & Fernando, 1988
3. P4 coupler with large (1 ≪ length/width) prominences 4
– P4 coupler with small (1 > or = length/width) prominences. 7
4. Medialmost terminal caudal seta maximally 1.5 times longer than lateralmost terminal caudal seta; caudal ramus with transverse row of spinules at about proximal 1/3 of lateral margin . . . 5
– Medialmost terminal caudal seta minimally 2 times longer than lateralmost terminal caudal seta; caudal ramus without transverse row of spinules at proximal 1/3 of lateral margin 6
5. Dorsally open pseudosomite between pediger 5 and genital double-somite absent; transverse ducts forming "V" near copulatory pore; medial expansion of P4 basipodite with distal hairs; antennule ventrally with spinules on segments 1, 4-13 . . . . . *M. brevisetosus* Dussart & Fernando, 1988
– Dorsally open pseudosomite between pediger 5 and genital double-somite present; transverse ducts meeting straight copulatory duct at right angle; medial expansion of P4 basipodite without distal hairs; antennule ventrally with spinules on segments 1, 4-5, 7-10, and 12-13 . . . . . *M. yenae* Hołyńska, 1998
6. Pediger 5 without hairs; medial expansion of P4 basipodite bare . . . . . *M. papuensis* Van de Velde, 1987
– Pediger 5 with lateral hairs; medial expansion of P4 basipodite bearing distal hairs, and oblique row of hairs on caudal surface . . . . . *M. acanthoramus* sp. nov.
7. Serrate hyaline membrane of last antennular segment, extending proximally only to implantation of medial seta of segment, without notch . . . . . *M. cuttacuttae* Dumont & Maas, 1985
– Serrate hyaline membrane of last antennular segment, extending proximally well beyond implantation of medial seta of segment, with one or more notches 8
8. Caudal ramus with medial hairs; antennal basipodite caudally with group of small spinules between proximal oblique and longitudinal spinule rows . . . . . *M. aspericornis* (Daday, 1906)
– Caudal ramus without medial hairs; antennal basipodite caudally without group of small spinules between proximal oblique and longitudinal spinule rows 9
9. Ventral surface of genital double-somite and succeeding one or two urosomites pilose . . . . . *M. pubiventris* sp. nov.
– Genital double-somite and succeeding urosomites ventrally bare 10
10. Genital double-somite dorsally bare; serrate hyaline membrane of last antennular segment with one large notch; caudal surface of P4 coxopodite with fine hairs proximally to group of spinules at laterodistal angle 11
– Genital double-somite pilose on dorsal surface; serrate hyaline membrane of last antennular segment with one or more notches; caudal surface of P4 coxopodite with fine or stout hairs or elongate spinules, proximally to group of spinules at laterodistal angle 12
11. Spinules present at implantation of lateralmost terminal caudal seta; transverse ducts forming straight angle near copulatory pore, curvature of copulatory duct varies from straight to moderate; caudal ornamentation of antennal basipodite: group of spinules usually present at laterodistal angle, spinules in longitudinal row along lateral rim of similar size . . . . . *M. affinis* Van de Velde, 1987

– Spinules absent at implantation of lateralmost terminal caudal seta; transverse ducts forming usually acute angle near copulatory pore; curvature of copulatory duct varies from moderate to strong (very rarely slight); caudal ornamentation of antennal basipodite: spinules absent at laterodistal angle, spinules in longitudinal row along lateral rim of conspicuously different size ..... *M. woutersi* Van de Velde, 1987

12. Genital double-somite only with few rows of hairs on dorsal surface; if dorsal surface of genital double-somite bare, serrate hyaline membrane of last antennular segment usually with more than one small notch, and caudal surface of P4 coxopodite with stout hairs or elongate spinules, proximally to group of spinules at laterodistal angle ..... *M. brooksi* Pesce, De Laurentiis & Humphreys, 1996

– Except anteriormost and posteriormost parts, genital double-somite with dense hairs on dorsal surface 13

13. Transverse ducts forming acute angle near copulatory pore; serrate hyaline membrane of last antennular segment usually with 2 or more notches; antennal basipodite caudally with row of large spinules near implantation of mediodistal setae ..... *M. notius* Kiefer, 1981

– Transverse ducts forming straight (sometimes obtuse) angle near copulatory pore; serrate hyaline membrane of last antennular segment with 1 large notch; antennal basipodite caudally with oval field of small spinules near implantation of mediodistal setae ..... *M. australiensis* (G. O. Sars, 1908)

COMMENTS ON THE AUSTRALIAN *MESOCYCLOPS*

Ten species of *Mesocyclops*, including the new taxa here described, have been reported from Australia so far. Nevertheless, it is highly probable that *M. pseudoannae* and *M. affinis*, species known from New Guinea, also occur on the tropical northern part of the continent. The identification of one more taxa, *M.* cf. *brevisetosus* from Queensland (unpubl. results of M. Brown), need further verification. Of 10 (13) species, five (*M. acanthoramus*, *M. cuttacuttae*, *M. pubiventris*, *M. brooksi* and *M. australiensis*) are known only from Australia. Dussart & Sarnita (1987) reported on the Indonesian occurrence of *M. notius*, but unfortunately the authors neither provide any morphological data that would allow the identification of the species, nor specify the region from where it was collected. If we add those taxa, i.e., *M. darwini*, *M. pseudoannae*, and *M. notius* (?), which outside Australia occur in New Guinea only, and, if *M.* cf. *brevisetosus* is not a still undescribed, endemic representative of the genus, the rate of endemism is 61% (8/13). In comparison, this value is 82% (18/22) for Central and South America combined (if '*M. thermocyclopoides*' recorded from Central America represents a new species, then the rate of endemism is 86%), 77% (10/13) for Africa and the Arab Peninsula, and 68% (19/28) for tropical Asia (distributional data in Hołyńska, 2000; and Hołyńska et al., in press). In contrast with the Oriental and northern temperate regions, a higher fraction of endemism has been found in insect genera of the Neotropics, Africa, and Australia (Handlirsch, 1913, cited in Udvardy, 1983), which can be a result of their stronger isolation from other biota.

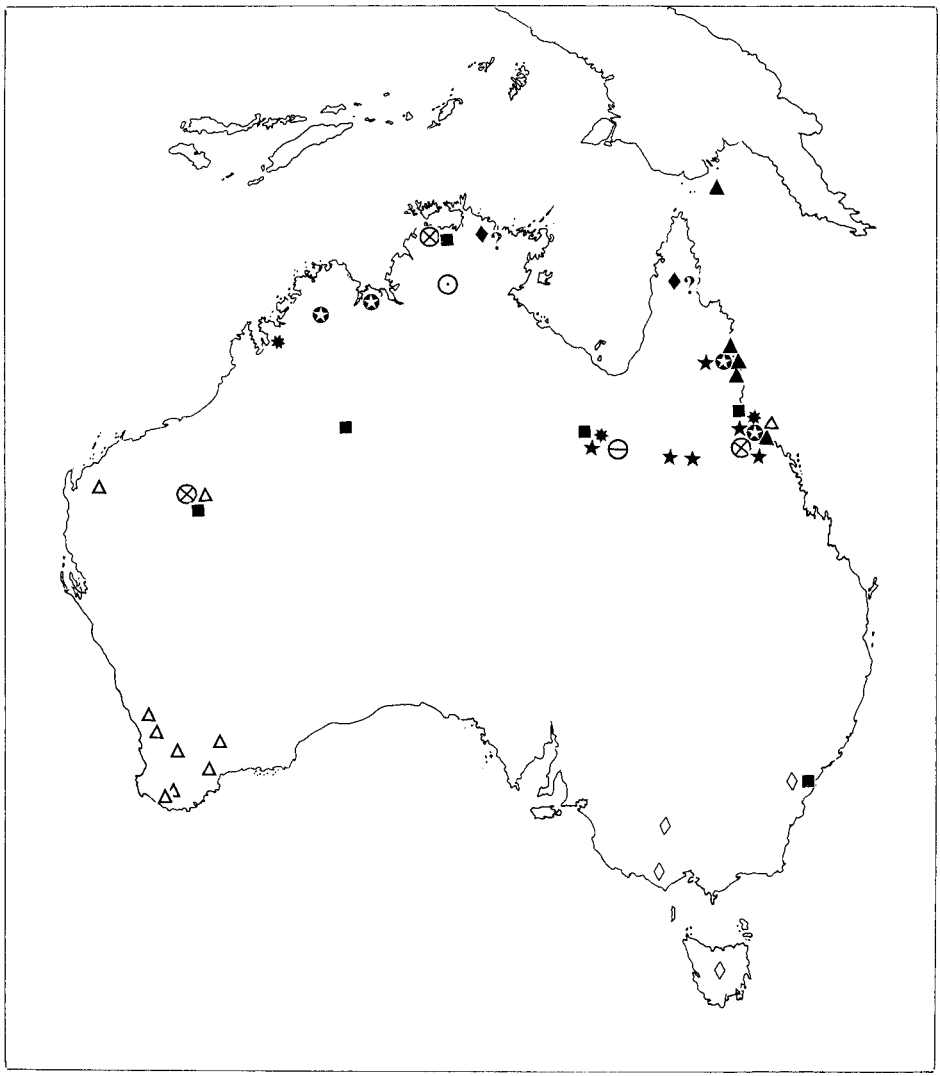


Fig. 12. Distribution of the verified records of *Mesocyclops* in Australia. ▲, *M. acanthoramus* sp. nov.; ★, *M. aspericornis* (Daday, 1906); ◇, *M. australiensis* (G. O. Sars, 1908); △, *M. brooksi* Pesce, De Laurentiis & Humphreys, 1996; ⊙, *M. cuttacuttae* Dumont & Maas, 1985; ⊗, *M. darwini* Dussart & Fernando, 1988; ■, *M. notius* Kiefer, 1981; ✪, *M. papuensis* Van de Velde, 1987; ♦?, *M. pseudoannae* Van de Velde, 1987; ⊖, *M. pubiventris* sp. nov.; ✳, *M. woutersi* Van de Velde, 1987.

An explanation for the lower rate of endemism observed here for *Mesocyclops*, a tropical genus, in Australia might be the species flux from Southeast Asia, but we should keep in mind that this value can be biased by the still fragmentary knowledge of the Australian fauna. After the papers of Morton (1985, 1990), recent taxonomic and faunistic investigations (Pesce et al., 1996a, b; Pesce & De

Laurentiis, 1996; Bayly, 1997; De Laurentiis et al., 1997, 1999, 2001; Fiers, 2001) concentrated on the western and southern parts, while the northern and eastern tropical regions have received less attention (Dumont & Maas, 1985; Dussart & Fernando, 1988; Timms & Morton, 1988). This is all the more regrettable, since distribution of the verified records (fig. 12) indicates a higher diversity of *Mesocyclops* in tropical than in temperate Australia. While 9 species (12 if *M.* cf. *brevisetosus*, *M. affinis*, and *M. pseudoannae* are also included here) occur in the north, only three taxa, *M. notius*, *M. australiensis*, and *M. brooksi*, inhabit the temperate southern part. We have some doubt as to the record of *M. australiensis* from SW Western Australia (Bayly, 1997), because this species was not encountered in the samples collected by S. Halse in this same region that were subsequently placed at our disposal. Instead, we identified *M. brooksi*, which can easily be confounded with *M. australiensis*. The northern Australian occurrence (Alligator Rivers region) of *M. australiensis* (cf. Tait et al., 1984) also remains to be verified. Taking into consideration that the genus radiated mainly in the tropics, we expect that the tendency of the north-south pauperization of the *Mesocyclops* fauna will hold firm, even though more intensive studies on the copepods of temperate Australia may bring new finds. Concerning the origin of Australian *Mesocyclops*, morphological data suggest strong connections with the Asian, to a lesser degree with African, and no or very weak relationships with the Neotropical fauna. However, a meaningful hypothesis can be proposed only when the phylogenetic relationships in the genus as a whole will have been analysed.

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