Copepods from ground waters of Western Australia, I. The genera Metacyclops, Mesocyclops, Microcyclops and Apocyclops (Crustacea: Copepoda: Cyclopidae)

G.L. Pesce1, P. De Laurentiis1 and W.F. Humphreys2
1 Dipartimento di Scienze Ambientali, University of L’Aquila,Via Vetoio, 1-i67100 L’Aquila, Italy
2 Western Australian Museum, Francis Street, Perth, Western Australia 6000, Australia

Abstract – Metacyclops mortoni sp. nov. and Mesocyclops brooksi sp. nov. are described from ground waters of the Cape Range karst area, northwestern Australia. New localities for the species Microcyclops varians G. O. Sars, 1863 and Apocyclops dengizicus (Lepechkin, 1900) are reported from the same area. The distribution of the above species is greatly extended to northwestern Australia.

INTRODUCTION

Until recently, notwithstanding the great extent and diverse geological, climatic and hydrological conditions of the Australian continent, very few studies were devoted to the taxonomy of copepods, especially of groundwater-inhabiting species. Even less is known of the copepod fauna of Australia outside Victoria, New South Wales and the Northern Territory.

The apparent scarcity of copepods in Australia probably results from a lack of collections over much of the continent, particularly from subterranean biotopes.

The number of recent publications on Australian freshwater copepods, especially groundwater species (Dumont and Maas 1985; Morton 1985, 1990; Hamond 1987; Dussart and Fernando 1988; Timms and Morton 1988; Pesce et al. 1996), reflect the growing recognition world wide of the extent and importance of groundwater communities (Marmonier et al. 1993). Nevertheless, the freshwater cyclopoid copepods, particularly those from northwestern Australia, remain almost completely unknown. Therefore, it is not surprising that collections from different subterranean habitats in this region included two hitherto undescribed species of the genera Metacyclops Kiefer and Mesocyclops G. O. Sars, and the widespread species Microcyclops varians (G. O. Sars, 1863) and Apocyclops dengizicus (Lepechkin, 1900).

The discovery of Metacyclops mortoni sp. nov. increases to two the number of congeneres from Australia, the others being M. arnoldi (G.O. Sars, 1908) and the subspecies M. arnoldi platypus Kiefer, 1967.

The genus Mesocyclops is better represented in Australia and, besides the new species, includes at least five species viz. M. notius Kiefer, 1981, from Queensland and the Northern Territory, M. darwini Dussart and Fernando, 1988, from the Northern Territory, M. australiensis (= M. thermocyclopoides australiensis) (G. O. Sars, 1908), from New South Wales, Victoria and Tasmania, M. cuttacutae Dumont and Maas, 1985, from the Northern Territory and M. thermocyclopoides Harada, 1931, from New South Wales and Victoria (Defaye and Kawabata 1993). M. pehepiensis Hu, 1943, was recorded by Lim and Fernando (1985), but without locality data.

Finally, this paper considerably extends to the wet the known distribution of both M. varians and A. dengizicus, which were previously known within Australia only from New South Wales, Victoria and Northern Territory.

HABITAT AND ASSOCIATED FAUNA

Northwestern Australia is arid and on the Cape Range peninsula the available water is mostly groundwater accessible in a few caves within the Cape Range karst and in the general water table of the surrounding coastal plain where a freshwater lens overlies salt water (Humphreys 1993a, 1993c; 1993d). The area has a rich stygofauna with tethyan affinities (Humphreys 1993b, 1994; Humphreys and Adams 1991; Knott 1993). Metacyclops mortoni was found only in hand-dug wells on the coastal plain of the Cape Range peninsula (C-25, C-149, C-273 and Warooa Well) and on the Ashburton River (Geebena Well) in water ranging in temperatures between 19.6 and 28.2°C and salinity between 2,550 and 17,044 mg L⁻¹. It was associated with an aquatic fauna that included Turbellaria, harpacticoid and calanoid
copepods, melitid amphipods (undescribed genus; W.D. Williams, pers. comm.), *Halosbaena tulki* Poore and Humphreys (Thermosbenacea), *Stygicaris lancifer* Holtzuis (Decapoda: Natantia), *Hydracrina* (Acarina), *Millyeringa veritas* Whitely (Perciformes: Eleotridae) and *Ophisternon candidum* (Mees) (Synbranchiformes: Synbranchidae).

*Mesocyclops brooksi* is known only from the type locality, Bobs Well, a hand-dug well in the Ashburton River valley, a river now remote from Cape Range but which formerly flowed past the tip of the peninsula (Wyrwoll *et al.* 1993). The water temperature was 25.0°C and the salinity was 1121 mg L\(^{-1}\).

*Apolyclops dengizicus* was found only in a small piezometric tube located in a recently dug test pit in a back dune area adjacent to the ocean. The water temperature was 26.9°C and the salinity was 22,000 mg L\(^{-1}\).

*Microcyclops varians* was collected in a variety of habitats containing waters ranging in temperatures between 23.9 and 26.9°C and salinity between 99 and 9448 mg L\(^{-1}\). These sites included a bore and a hand-dug well at the base of the Cape Range peninsula, a hand-dug well on the Ashburton River and, interestingly, water in the dark zone of an 80 m deep cave (C-18) within central Cape Range—where it occurs with a second species of the undescribed genus of melitid amphipod mentioned above, the only other aquatic species known from the range. This cave contains a diverse troglobitic fauna derived from a rain forest (both temperate and tropical) litter fauna – the area is now arid (Humphreys 1993a, 1993c). In addition, the aquatic insect *Copelatus irregularis* Macl. (Coleoptera: Dytiscidae) has been recorded in this cave (itself a big range extension from the Kimberley, central Australian Ranges and North-east Queensland).

**MATERIAL AND METHODS**

Groundwater was sampled for fauna at 261 sites on the Cape Range peninsula and in the Ashburton River valley in 1993; 185 of these sites yielded stygofauna (Figure 29). The groundwater was accessed through bores, wells, soaks, piezometers and caves. Bores were sampled for fauna using a plankton net with a 125 μm mesh and of a size suitable for the bore, the nets ranged from 30 mm to 180 mm in diameter. Wells were sampled by hand nets (125 μm mesh) and by Cvetkov (1968) phreatobiological nets (300 mm diameter, 250 μm mesh). Samples were variously taken through the entire water column and from various depths within the water column – occasionally the outflow from bore pumps was sampled by straining through a net (125 μm mesh). In all situations baited traps were sometimes used.

Comprehensive water analyses are available for seven of the eleven sites mentioned in this paper (Humphreys 1994). Where direct measurements were not made the salinity (total soluble salt: TSS) was estimated from the electrical conductivity measured in the field.

Permanent mounts were made in commercial polyvinyl-lactophenol medium. Dissected specimens were drawn at magnification of 400x and 1000x, the latter using an oil immersion lens and “camera lucida” mounted on a Leitz Laborlux D phase-contrast microscope. Type material is deposited in the Western Australian Museum (WAM). Terminalia applied to body and appendages according to Huys and Boxshall (1991).

**SYSTEMATICS**

Family Cyclopidae Burmeister, 1834

Genus *Metacyclops* Kiefer, 1927; sensu Lindberg, 1961

*Metacyclops mortoni* sp. nov.

(Figures 1–15)

**Material Examined**

Holotype

♀ (WAM 183–94), Kudamurra Well (C–25), Cape Range peninsula, Western Australia (station BES 2199), Australia, 21°54′S, 113°49′E, 1 June 1993, R.D. Brooks.

Paratypes


**Description**

Female

Length of holotype, excluding antennule and caudal setae, 555 μm; range of length of 6 paratypes 540–560 μm. Body widest at first prosomite. Genital segment about as long as broad, anterior 2/3 faintly expanded laterally; seminal receptacle with well developed subcircular anterior expansion, lateral canals almost horizontal. First urosomites naked, anal somite with small spinules along posterior margin; anal operculum not well defined.
Figures 1–8 *Metacyclops* mortoni sp. nov., 1–3, 5–8 (holotype), 4 (allotype): 1, mandible; 2, ♀ antennule; 3, basal segment of antennule, ventral; 4, ♂ antennule; 5, antenna; 6, maxilliped, posterior side; 7, maxilla; 8, maxillula.
Figures 9–15 *Metacyclops mortoni* sp. nov., 9, 11–13, 15 (holotype), 14 (allotype), 10 (female paratype): 9, urosome and caudal rami, ventral; 10, endopodite 3 of leg 4; 11, leg 1; 12, leg 5; 13, exopodite of leg 4; 14, urosome and caudal rami, ventral; 15, endopodite, basis, coxa and connecting plate of leg 4 (a: frontal side; b: caudal side).
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Caudal rami, 3.6 (holotype), 3.5–3.7 (6 paratypes) times longer than broad; lateral seta inserted at distal half of ramus; dorsal seta shorter than ramus; terminal inner seta slightly longer than outermost.

Antennule 11-segmented, shorter than first prosome; basipodite armed with 9 rows of small spinules, three dorsal, well-developed plumose setae and 7–8 lateral setae; remaining setation as in Figure 2.

Antenna 4-segmented; basipodite with well developed exopodal seta reaching about tip of the second segment, and one inner, subdistal plumose seta [type 3a, according to Reid (1991)]; first segment with one seta, second segment with eight setae, terminal segment with seven setae; no spine pattern was observed on both frontal and caudal side of the basipodite.

Maxillipeds 4-segmented, comprising syncoxa, basis and 2-segmented endopodite; syncoxa armed with 3 inner plumose setae representing vestigial endites and a row of small spinules; basis with two inner plumose setae and numerous long spinules; first endopodal segment bearing a single spinulose seta and a row of 5–6 spinules, second endopodal segment with a spinulose seta and two shorter naked setae.

Mandible, maxillule and maxilla without particular characteristics as compared to those of congeners.

Swimming legs 1–4 with 2-segmented rami. Spine and setae formula of distal segments of exopodites 3.4.4.2 and 5.5.5.5, respectively. Couplers of all legs lacking ornament. Spine on the basipodite of leg 1 well developed, reaching about tip of distal segment of endopodite.

Leg 4, coxa with four rows of spinules, arranged as in Figure 15; distal segment of the endopodite about 2 times longer than broad, armed with one apical spine, slightly longer or about as long as the segment.

Leg 5 consisting of one free segment, slightly longer than broad; spine slightly shorter than segment.

Male (Allotype)

Length 530 μm. Habitus slender. Antennule geniculate, 17-segmented. Leg 5 similar to that of female. Leg 6 consisting of two spiniform setae, ventral seta shorter and stouter than dorsal one. Caudal rami sexually dimorphic, shorter (L/1 = 2.9–3.1) than those of female.

Affinities

The genus *Metacyclops* (sensu Lindberg 1961) is widespread in tropical and temperate regions. At present it includes 52 named species and subspecies, only two, *M. arnaudi* and *M. arnaudi platypus*, are recorded from Australia.

Lindberg (1961) established two species-groups within the genus, viz. the minetus-group and the gracilis-group, embracing species characterized by one or two distal spines on the endopodite 3 of leg 4, respectively. *M. mortoni* is a member of the minetus-group, but it does not match any species in either Lindberg’s (1961) or Herbst’s (1988, 1990) keys of *Metacyclops*, because of the combination of the following characters: antennula 11-segmented, with first segment spinulose; basipodite of the antenna with 2 setae; legs 1–4 spine formula 3.4.4.2, endopodite 3 of leg 4 with one apical spine; couplers of legs 1–4 lacking ornament; inner caudal seta longer than outermost, male leg 6 consisting of 2 setae.

The spine formula 3.4.4.2 of legs 1–4 is a striking feature of the new species; within the genus *Metacyclops* deviation from the characteristic formula 3.4.4.3 has been reported only in *M. trispinosus* Dumont, 1981, from West Africa, which has a spine formula 3.3.3.3.

Etymology

The species is dedicated to Mr D.W. Morton in recognition of his recent valuable contributions to the knowledge of Australian copepods.

Genus *Mesocyclops* G. O. Sars, 1914

*Mesocyclops brooksi* sp. nov.

Figures 16–28

Material Examined

Holotype


Paratypes

Australia: Western Australia: 1 ♀, 1 ♂, same data as holotype (WAM 194, 195–94).

Description

Female

Total body length 1350 μm (holotype), 1320 μm (paratype). Fifth thoracic segment with few setules laterally. Genital segment about as long as broad. Owing to the preparation the seminal receptacle is partially obscured in both specimens, pore canal recurved.

Antennule 17-segmented, reaching the distal margin of the third thoracic segment; spinule patterns are present on segments II–X; segments IV–V with two (IV) or one (V) crenate lamellas; segments I–IV with several rows or groups of small integumental circular pits on dorsal surface; distal
Figures 16–22 *Mesocyclops brooksi* sp. nov. (holotype): 16, antenna; 17, antenna, basipodite (caudal side); 18, antennule; 19, antenna, basipodite (frontal side); 20, antennule, distal segment; 21, antennule, segment 4; 22, maxillulary palp.
Figures 23–28 *Mesocyclus broksi* sp. nov., 23 (male paratype), 24–28 (holotype): 23, ♂ leg 6; 24, leg 5; 25, ♀ leg 6; 26, endopodite 3 of leg 4; 27, basis, coxa and connecting plate of leg 4 (a: frontal side; b: caudal side); 28, urosome and caudal rami.
segment with hyaline lamella provided with one deep notch; remaining ornamentation as in Figures 18, 20, 21.

Antenna. Endopodite 3-segmented; first segment with one inner seta, second segment with eight setae, third segment with an apical group of seven setae; segments I–II with rows of small integumental pits. All segments with a row of setules on the external side. Basipodite with vestigial exopodal seta overreaching tip of the distal segment of the endopodite, and two short subdistal setae, frontal side with the characteristic row of long spinules along the outer margin, 2–3 rows of small spinules on the inner margin, and a transverse row of spinules below.

Maxillulary palp not provided with spines. Other mouthparts as usual in the genus.

Legs 1–4, spine and setae formula typical for the genus; couplers without setules on the caudal side. Leg 1, inner margin of the basipodite not armed with a spine. Leg 4: endopodite about 3.5 times longer than broad; apical spines subequal, outer spine equally serrated on both margins, inner spine with outer margin completely set with spinules, internal margin regularly serrated; couplers with pair of blunt tubercles, coxopodite armed with 3 (frontal side) and 4 (caudal side) rows of spines/setules; caudal side of the basipodite on its distal

Figure 29  The location of the samples in northwestern Australia: _Metacyclops mortoni_ sp. nov. (●); _Mesocylops brooksi_ sp. nov. (●); _Apocylops dengizicus_ (○); _Microcylops varicans_ (●). The small dots denote sites where stygofauna was found.
internal margin with a row of small spinules, on its
distal and subdistal margin with 4–5 rows of thin
setules.

Leg 5. Spinous seta about as long as the plumose
setae; setae not reaching to the posterior margin of
the genital segment.

Leg 6 consisting of two small spines and one long
plumose seta; characteristic group of small pores
present at its basis.

Caudal rami about 3 times longer than broad,
without cilia on the inner margins; dorsal seta
longer than the apical outer seta, inner seta about
2.5 times longer than corresponding outermost.

Male
Smaller than females, total body length,
excluding antennule and caudal setae, 1270 μm.
Antennule geniculate, with integumental pits as in
females. Spine and pit pattern on the basipodite
and endopodite of antenna, structure of legs 1–5
and ornamentation of fifth thoracic segment as in
females. Leg 6 consisting of a protuberance bearing
one stout spine and two plumose setae.

Circular pits on some segments of the antennule in
Mesocyclops species were firstly pointed out by Von
Daday (1906), who interpreted them as
testamental tubercles. Subsequently, Reid and
Saunders (1986) reported similar structures in
specimens of Mesocyclops aspericornis (Von Daday,
1906) from Venezuela, considering them as sensory
structures, advantageous in spatially restricted
habitats. Nishida (1986) showed identical structures
in marine cyclopoids of the genus
Oithona, interpreting them as chemo- or
mechanoreceptors in mating behaviour, which
could represent “areas of increased friction during
copulation”. Reid and Saunders (1986) also
referred to such testamental pits in species of the
genus Thermocyclops, suggesting that closer
investigations of these structures should be carried
out in future species descriptions.

Etymology
Named after Mr R.D. Brooks, a collector of the
new species.

Genus Microcyclops Claus, 1893

Microcyclops varicans (G. O. Sars, 1863)

Material Examined
Australia: Western Australia: 2 ♀ (WAM 196,
197–94), Cashen Well, Exmouth Gulf Station (BES
2146), 22°29′S, 114°06′E, 24 May 1993, W.F.
Humphreys and R.D. Brooks; 1 ♀ (WAM 198–94),
River Well, Ashburton River (BES 2318), 22°00′S,
115°02′E, 26 June 1993, W.F. Humphreys and R.D.
Brooks; 1 ♀ (WAM 199–94), Dry Swallet Cave (C-
18), Cape Range (BES 2372), 22°05′S, 114°00′E, 12
July 1993, R.D. Brooks; 1 ♀ (WAM 200–94),
Number 8 Bore, Cape Range peninsula (BES 2379),

Genus Apocyclops Lindberg, 1942

Apocyclops dengiczicus (Lepechkin, 1900)

Material Examined
Australia: Western Australia: 1 ♀ (WAM 201–
94), Marina piezometer bore C, Exmouth (BES
2234); 21°57′S, 114°08′E, 16 June 1993, R.D. Brooks.

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n. sp. from a cave in Northern Australia (Crustacea:
Copepoda, Cyclopoida). The Beagle, Occasional Papers
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