A CLADISTIC ANALYSIS AND TAXONOMIC REVISION OF AUSTRALIAN *METACYCLOPS* AND *GONIOCYCLOPS*, WITH DESCRIPTION OF FOUR NEW SPECIES AND THREE NEW GENERA (COPEPODA, CYCLOPOIDA)

BY

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ABSTRACT

Four new small subterranean cyclopid species are described from Australia in a newly erected genus Anzcyclops n. gen.: A. yarriensis n. sp. (type), A. belli n. sp., A. ballensis n. sp., and A. euryantennula n. sp. Three species are from the Pilbara region in Western Australia, the fourth species from central Queensland. Another previously described species from New Zealand is transferred to this genus, A. silvestris (Harding, 1958) n. comb., originally described in the genus Goniocyclops Kiefer, 1955. The new genus has a number of unique features, including dorsoventrally compressed habitus, reticulated integument of prosomites, and a characteristic shape of the fifth leg. It is most closely related to the South American genus Muscocyclops Kiefer, 1937, and the two share the same spine formula of the swimming legs (2.3.3.2), but they can be distinguished by a number of characters in the shape of the genital double-somite, caudal rami, and anal operculum, as well as in the armature of the first leg. Our preliminary cladistic analysis revealed the polyphyletic nature of the endemic Australian genus Fierscyclops Karanovic, 2004. As a result, the subgenus Pilbaracyclops Karanovic, 2006 is upgraded to full generic rank and its two species are given as new combinations: P. supersensus (Karanovic, 2006) n. comb. (type) and P. frustratio (Karanovic, 2006) n. comb. The assemblage of Australian species previously considered members of the genus Metacyclops Kiefer, 1927 is also found to be polyphyletic and all five Australian representatives and one New Zealand species of the so-called "trispinosus"-goup are transferred into a newly erected genus Pescecyclops n. gen.: P. laurentiisae (Karanovic, 2004) n. comb. (type), P. pilanus (Karanovic, 2004) n. comb., P. arnaudi (G. O. Sars, 1908) n. comb., P. monacanthus (Kiefer, 1928) n. comb., P. kimberlevi (Karanovic, 2004) n. comb., and P. pilbaricus (Karanovic, 2004) n. comb. After this, only two Australian species are left in the genus Metacyclops: M. mortoni Pesce, De Laurentiis & Humphreys, 1996 and M. superincidentis Karanovic, 2004. Pescecyclops is defined by the presence

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of three spines on the distal exopodal segment of all swimming legs, only one apical spine on the fourth leg endopod, and absence of any sexual dimorphism in postantennular appendages, in addition to a *Metacyclops*-like fifth leg. Two Australian species previously considered members of *Goniocyclops* and one as a member of *Allocyclops* Kiefer, 1932 proved to be relatively closely related to each other and quite separate from other members of their respective genera. They are transferred into a third new genus, *Dussartcyclops* n. gen., although subdivided into two subgenera: *D*. (s. str.) *uniarticulatus* (Karanovic, 2004) n. comb. (type), *D*. (s. str.) *mortoni* (Karanovic, 2004) n. comb., and *D*. (*Barrowcyclops*) *consensus* (Karanovic, 2003) n. comb. They all have a reduced armature of the swimming legs (spine formula 2.2.2.2), vermiform habitus, and the fifth leg exopod armed with two subequal apical setae, but the subgenus *Barrowcyclops* n. subgen. has the exopod of the fifth leg fused basally to the somite and the inner spine on the first leg basis absent, in addition to a more plesiomorphic endopodal armature of the first and fourth legs.

RÉSUMÉ

Ouatre nouvelles espèces de petits cyclopides souterrains sont décrites d'Australie, appartenant à un genre nouveau, Anzcyclops n. gen.: A. yarriensis n. sp. (type), A. belli n. sp., A. ballensis n. sp., et A. euryantennula n. sp. Trois d'entre elles proviennent de la région de Pilbara en Australie Occidentale, la quatrième de la région centrale du Queensland. Une autre espèce, antérieurement décrite de Nouvelle-Zélande, est transférée dans ce genre, A. silvestris (Harding, 1958) n. comb., attribuée auparavant au genre Goniocyclops Kiefer, 1955. Le nouveau genre présente un ensemble de traits uniques, incluant un habitus comprimé dorso-ventralement, un tégument réticulé des prosomites, et une forme caractéristique de la cinquième paire de pattes. Il apparaît le plus étroitement apparenté au genre sud-américain Muscocyclops Kiefer, 1937, et les deux genres partagent la même formule des épines des exopodites des pattes natatoires (2.3.3.2), mais ils peuvent être distingués par d'autres caractères, dans la forme du double-somite génital, les rames furcales et l'opercule anal, comme par l'armature de la première patte. Notre analyse cladistique préliminaire a révélé la nature polyphylétique du genre endémique australien Fierscyclops Karanovic, 2004. Comme résultat, le sous-genre Pilbaracyclops Karanovic, 2006 est élevé au rang de genre et ses deux espèces sont nommées comme nouvelles combinaisons: P. supersensus (Karanovic, 2006) n. comb. (type) et P. frustratio (Karanovic, 2006) n. comb. L'assemblage des espèces australiennes auparavant considérées comme membres du genre Metacyclops Kiefer, 1927 se révèle aussi être polyphylétique et tous les cinq représentants australiens et une espèce de Nouvelle-Zélande du groupe "trispinosus" sont transférés dans un nouveau genre Pescecyclops n. gen.: P. laurentiisae (Karanovic, 2004) n. comb. (type), P. pilanus (Karanovic, 2004) n. comb., P. arnaudi (G. O. Sars, 1908) n. comb., P. monacanthus (Kiefer, 1928) n. comb., P. kimberleyi (Karanovic, 2004) n. comb., et P. pilbaricus (Karanovic, 2004) n. comb. Seules deux espèces australiennes sont maintenues dans le genre Metacyclops: M. mortoni Pesce, De Laurentiis & Humphreys, 1996 et M. superincidentis Karanovic, 2004. Pescecyclops est défini par la présence de trois épines sur le segment distal de l'exopodite des pattes natatoires, par une seule épine apicale à l'endopodite de la quatrième patte, et l'absence de tout dimorphisme sexuel sur les appendices post-antennulaires, en plus d'une cinquième patte de type Metacyclops. Deux espèces australiennes auparavant considérées comme membres du genre Goniocyclops et une du genre Allocyclops Kiefer, 1932 se révèlent relativement proches l'une de l'autre et distinctes des autres membres de leurs genres respectifs. Elles sont transférées dans un troisième nouveau genre, Dussartcyclops n. gen., bien que subdivisé en deux sous-genres: D. (s. str.) uniarticulatus (Karanovic, 2004) n. comb. (type), D. (s. str.) mortoni (Karanovic, 2004) n. comb., et D. (Barrowcyclops) consensus (Karanovic, 2003) n. comb. Elles présentent toutes une armature réduite des pattes natatoires (formule des épines 2.2.2.2), un habitus vermiforme, et l'exopodite de la cinquième patte armé de deux soies apicales subégales; mais le sous-genre Barrowcyclops n.

subgen. présente l'exopodite de la cinquième patte fusionné à sa base au somite et l'épine interne du basipodite de la première patte est absente, en plus d'une armature plus plésiomorphe de l'endopodite des premières et quatrièmes pattes.

INTRODUCTION

While redescribing the New Zealand Goniocyclops silvestris Harding, 1958, as well as providing the first description of the male. Karanovic (2005) noted that this species differs from all other representatives of the eastern Gondwanan genus Goniocyclops Kiefer, 1955 by a number of morphological characters, including a unique spine formula of the swimming legs, as well as a very broad and dorsoventrally compressed habitus. The genus was established twice by Kiefer (1955, 1956) for two new species inhabiting mosses on Madagascar: G. primus Kiefer, 1955 and G. alter Kiefer, 1955. Although barely more than a repeated description with identical illustrations, the latter publication (Kiefer, 1956) did contain somewhat broader descriptions of both species, as well as some additional illustrations. At about the same time, and apparently unaware of Kiefer's publications, Fryer (1956) described a new species from the interstitial of Lake Nyasa in a separate new genus: Psammophilocyclops baccaroi Fryer, 1956. The genus Psammophilocyclops Fryer, 1956 was considered a junior subjective synonym of Goniocyclops by Pesce (1996), Karanovic (2004a), and Dussart & Defaye (2006). Harding (1958) described the above-mentioned G. silvestris from litter of beech forest in the southern part of the New Zealand North Island, and Dussart (1984) reported another new species from the interstitial of New Caledonia, G. arenicola Dussart, 1984. Two relatively closely related species were described from China by Shen & Tai (1964) (see also Shen et al., 1979) in the genus Psammophilocyclops: P. trispinosus Shen & Tai, 1964 and P. bispinosus Shen & Tai, 1964. They were formally transferred to the genus *Goniocyclops* by Karanovic (2004a), who also described two new subterranean species from the arid Murchison region in Western Australia, G. uniarticulatus Karanovic, 2004 and G. mortoni Karanovic, 2004, and provided a key to all nine species. We describe in this paper three new species from the Western Australian Pilbara region and one from central Queensland, all of which are very closely related to each other and to the New Zealand G. silvestris. In fact, four of them have exactly the same spine formula (2.3.3.2) and dorsoventrally compressed habitus, characters that were recognized as unusual for the genus Goniocyclops by Karanovic (2005).

However, some of the characters of the four new species were even more unusual for the genus and two species were provisionally identified as members of the genus *Metacyclops* Kiefer, 1927. Clearly, we had to examine the phylogenetic relationships of this group with other Australian *Goniocyclops* and *Metacyclops* members, as well as with other closely related genera from the "Metacyclops complex". This complex was never previously recognized formally, but we define it here as those Cyclopinae with ovipores situated in the anterior half of the genital double-somite, 11-segmented (or rarely 10-segmented) antennula in the female, two-segmented exopods and endopods of all swimming legs and no sexually dimorphic armature elements on them, as well as the fifth leg composed of a protopod completely fused to the somite, except outer seta, and a free exopod, which is armed apically with two armature elements (most usually an inner spine and an outer seta). Our analysis included all Australian species that were at one stage or another considered members of the genera Metacyclops, Goniocyclops, or Fierscyclops Karanovic, 2004, as well as worldwide members of the genera Goniocyclops, Muscocyclops Kiefer, 1937, Fimbriocyclops Reid, 1993, Menzeliella Lindberg, 1954, and Hesperocyclops Herbst, 1984 (see the material and methods section for the full list of species). The last four genera are all South American. In addition to previously known species of the genus Hesperocyclops, we included characters of an as yet undescribed new species from tropical Queensland (the first report of this genus from Australia) and one possible member of this genus from North America, currently considered a member of Metacyclops.

Sars (1908) described Cyclops arnaudi Sars, 1908 from material collected by O. A. Sayce in 1901 from a swamp at St. Arnaud in Victoria. This species was to become the first Australian representative of the genus Metacyclops, which was initially established as a subgenus of the genus Mesocyclops Sars, 1914 by Kiefer (1927). It took more than a century for this species to be properly redescribed, based mostly on material from southwestern Western Australia (Tang & Knott, 2009), and it seems that the species occurs throughout the southern half of Australia. Kiefer (1967), obviously unaware of the diversity of this group in Australia, reported Metacyclops arnaudi for the second time from two lakes in Victoria and also described a new subspecies of this species from a lake in South Australia. However, re-examination of this material by Fiers (2001) showed that Kiefer (1967) was not dealing with M. arnaudi at all, but with two distinct species, for which he erected a new genus: Meridiecyclops Fiers, 2001. Both Meridiecyclops baylyi Fiers, 2001 and M. platypus (Kiefer, 1967) share, among other things, the same novel transformations of the fourth swimming leg in the female and the maxilla in the male, synapomorphies that clearly separate them from the rest of the Metacyclops complex. An unnamed and as yet undescribed species of Metacyclops was reported by Timms & Morton (1988) from Australian tropical surface waters, but the majority of the species were described recently from subterranean waters of northern Western Australia.

Pesce et al. (1996) described Metacyclops mortoni Pesce, De Laurentiis & Humphreys, 1996 from Cape Range and the adjacent Pilbara region, and De Laurentiis et al. (1999) reported it from two additional localities in the latter region. From the Murchison region De Laurentiis et al. (2001) described Metacyclops fiersi De Laurentiis, Pesce & Humphreys, 2001 and provisionally reported one other species as the New Zealand Metacyclops cf. monacanthus (Kiefer, 1928). Karanovic (2004a) transferred the former into a newly erected genus Fierscyclops Karanovic, 2004, and described the latter as a new species, Metacyclops laurentiisae Karanovic, 2004, after some additional material. At the same time, Karanovic (2004a) described two other new Metacyclops species from the Murchison region: M. superincidentis Karanovic, 2004 and M. pilanus Karanovic, 2004. Finally, Karanovic (2005) described two new species from the Pilbara and Kimberley regions of Western Australia, respectively: M. kimberleyi Karanovic, 2005 and M. pilbaricus Karanovic, 2005. Another two new species from the Metacyclops complex were described from the Pilbara region by Karanovic (2006), both in the above-mentioned genus Fierscyclops, although in a separate subgenus Pilbaracyclops Karanovic, 2006. A key to Australian species of Metacyclops was provided both by Karanovic (2005) and Tang & Knott (2009). We should mention here that the presence of three spines on the distal exopodal segments of all swimming legs was recognized as a synapomorphy of five Australian, one Indian, and one African species, and the assemblage was termed the "trispinosus"-group by Karanovic (2004a). Thus, the latter two species were also included in our preliminary cladistic analysis.

It is interesting that all four new species described in this paper come from arid regions, and were collected from groundwaters in fractured rocks basalts. Three of these (Callawa Ridge, Quarry 8, and Balla Balla) are in the Western Australian Pilbara region, while Clermont lies in central Queensland. The stygofauna of the Pilbara region is relatively well surveyed (see Eberhard et al., 2005, 2009; Humphreys, 2006; Karanovic, 2006, 2007), as opposed to almost no data from eastern Australia (Hancock & Boulton, 2009; Karanovic & Hancock, 2009).

Callawa Ridge (fig. 18C) is located within the catchment of the De Gray River, some 160 km east of Port Hedland. It is part of a series of ridges and plateau landforms rising about 150 m above surrounding alluvial plains. The geology of the habitat consists of the Archaean-aged Nimingarra Iron Formation, which is mineralized, fractured, and strongly weathered. Local aquifers with a well-developed secondary porosity are associated with hematite orebodies that have developed within the iron formation horizons that form the prominent ridges and plateaux. The top of the Callawa ridge is perforated by many mineral exploration drill holes, which provided the access points for sampling groundwater fauna. The local water table, which lies between 60 and 120 m below the ridge top, is much

higher than beneath the surrounding plains, owing to limited hydraulic connections between the ridge aquifer and the surrounding alluvial plain aquifers. The ridges and plains are underlain by basalts and granitoid rocks. The ridge aquifers are recharged solely by direct local rainfall infiltration.

The Quarry 8 collection site (fig. 18D) is located 235 km south of Port Hedland, in the Chichester Ranges, in the headwaters of the Western Shaw River catchment. The geology of this area consists of strongly jointed basalt, which is thus relatively permeable and indicates prospective habitat for subterranean fauna.

The Balla Balla collection sites (fig. 18E) comprise bores situated on Sherlock Station, which lies on the coastal plain approximately mid-way between Karratha and Port Hedland. The bedrock geology of this area comprises late Archaean rocks of the Pilbara Craton (Myers & Hocking, 1998). Overlying the bedrock are Quaternary silts, clays, and sands, which occur mainly as floodplain alluvium, associated with the Balla Balla River. Below the alluvium, the bedrock is weathered and fractured, thus both the alluvium and bedrock may provide prospective habitat for stygofauna.

On the other side of the Australian continent, the Clermont site in Queesland (fig. 18F) is less arid and receives about twice the average annual rainfall as the Pilbara region (600 vs. 300 mm). Samples were collected from bores developed for domestic, pastoral, and mining purposes, and laying some 12 km north-west from the city of Clermont. The samples came from an aquifer in fractured basalt and schist, and that is likely to be connected to the alluvial aquifer associated with Wolfang Creek located approximately 5 km distant. Surface flow in Wolfang Creek is seasonally intermittent, and drains into the Mackenzie River.

MATERIAL AND METHODS

All specimens of the four new species studied here were collected from subterranean waters by private environmental consulting agencies (Subterranean Ecology, Outback Ecology, Ecowise Australia) and sent for identification to the senior author. They resulted from various impact assessment and monitoring projects, primarily done for the mining industry. Most specimens were collected from or near proposed or existing mining sites, but due to the sensitivity of such data no further information about mining operations or plans will be given here. Locality data and number of specimens are listed for every species separately and all material is deposited in the Western Australian Museum (WAM), Perth.

Samples were collected with haul-nets (mesh size 50, 150, 250, or 350 μ m) or a groundwater sampling pump from bores. Bores are holes mainly made by mining companies or agricultural enterprises for the purpose of water monitoring

and abstraction or mineral exploration. They are usually 10 to 20 cm in diameter and may be lined entirely, or in part, by PVC tubing (the casing). This tubing may be open only at the bottom, or it may be pierced at one or more levels by holes of various sizes ("slots"). The top may be securely capped or entirely open to the elements. Some bores record the water pressure at a given level in the aquifer (piezometers), while others, together with hand dug wells (ca. 1×1.5 m) equipped with windmills, provide water for pastoral use. Many of these features are derelict. Haul-nets are actually simple plankton nets of a different size, suitable for the bore; the collar can range from 30 to 200 mm in diameter and is made of stainless steel. Weighted nets (using simple fishing leads, or more complicated brass intermediate collars) were lowered down into the bore with a bottle screwed on its distal part and then hauled through the water column, usually a number of times. Samples were sorted live under a dissecting microscope and the copepods picked out and fixed in 70% or 100% ethanol and assigned a field number (every consulting agency has a different system of numbering its samples), or were preserved in the field in 100% ethanol and sorted in a laboratory. Many bores established for hydrogeological work, mineral exploration, and water monitoring have prefixes or suffixes of relevance only to that drilling program. These codes are cited in the material examined for each species to aid specification of the location, although precise coordinates are also provided for each sample.

Specimens were dissected and mounted on microscope slides in Faure's medium, which was prepared following the procedure discussed by Stock & Von Vaupel Klein (1996), and dissected appendages were then covered by a coverslip. For the urosome or the entire animal two human hairs were mounted between the slide and coverslip, so the parts would not be compressed. By manipulating the coverslip carefully by hand, the whole animal or a particular appendage could be positioned in different aspects, making possible the observation of morphological details. During the examination water slowly evaporates and appendages eventually remained in a completely dry Faure's medium, ready for long term depositing. All drawings were prepared using a drawing tube attached to a Leica-DMLS brightfield compound microscope, with C-PLAN achromatic objectives. Specimens that were not drawn were examined in a mixture of equal parts of distilled water and glycerol and, after examination, were again preserved in 70% ethanol. Specimens for scanning electron micrography were dehydrated in progressive ethanol concentrations, critical-point dried, coated in gold, and observed under the LEO 1525 microscope on the in-lens detector, with working distances between 2 and 6 mm and accelerating voltages between 2 and 5 kV.

Morphological terminology follows Huys & Boxshall (1991), except for caudal ramus setae numbering and small differences in the spelling of some appendages (antennula, mandibula, maxillula instead of antennule, mandible, maxillule), as an

attempt to standardize the terminology for homologous appendages in different crustacean groups. Biospeleological terminology follows Humphreys (2000).

The preliminary cladistic analysis was performed on 41 species of the Metacyclops Kiefer, 1927 complex, including all 20 species from Australia: four described in this paper as new, one undescribed representative of the genus Hesperocyclops Herbst, 1984, and 15 previously described species. Others are non-Australian members of the closely related genera Hesperocyclops, Muscocyclops Kiefer, 1937, Psammophilocyclops Fryer, 1956, Goniocyclops Kiefer, 1955, Fimbriocyclops Reid, 1993, and Menzeliella Lindberg, 1954, as well as three non-Australian species from the genus Metacyclops. Two species, both almost cosmopolitan in distribution and also known from Australia (see Karanovic, 2004a), were chosen as outgroup: Apocyclops dengizicus (Lepeschkin, 1900) and Microcyclops varicans (G. O. Sars, 1863). Except for the four new species described here and as yet undescribed species of Hesperocyclops (H. sp. 1), all characters were taken from the literature and most often from the original descriptions. Here is the full list of the 43 species analysed, in alphabetical order, and with their current generic allocation; any additional literature information consulted (apart from the original description) is given in square brackets:

Allocyclops (Psammocyclops) consensus Karanovic, 2003; Anzcyclops ballensis n. gen., n. sp.; A. belli n. gen., n. sp.; A. euryantennula n. gen., n. sp.; A. yarriensis n. gen., n. sp.; Apocyclops dengizicus (Lepeschkin, 1900) [Karanovic, 2004a]; Fierscyclops (Pilbaracyclops) frustratio Karanovic, 2006; F. (P.) supersensus Karanovic, 2006; F. (F.) fiersi (De Laurentiis, Pesce & Humphreys, 2001) [Karanovic, 2004a]; Fimbricyclops jihmensoni Reid, 1993; Goniocyclops alter Kiefer, 1955 [Kiefer, 1956]; G. arenicola Dussart, 1984; G. mortoni Karanovic, 2004; G. primus Kiefer, 1955 [Kiefer, 1956]; G. silvestris Harding, 1958; G. uniarticulatus Karanovic, 2004; Hesperocyclops herbsti da Rocha & de Carvalho Bjornberg, 1987; H. improvisus Herbst, 1984 [Pesce, 1985; Galassi & Pesce, 1992]; H. inauditus Dussart & Frutos, 1986; H. pescei Petkovski, 1988; H. sp. 1; H. venezuelanus Galassi & Pesce, 1992; Menzeliella staheli (Chappuis, 1917) [Kiefer, 1928a, 1937; Lindberg, 1954]; Meridiecyclops baylyi Fiers, 2001; M. platypus (Kiefer, 1967) [Fiers, 2001]; Metacyclops arnaudi (G. O. Sars, 1908) [Tang & Knott, 2009]; M. cushae Reid, 1991; M. kimberlevi Karanovic, 2004; M. laurentiisae Karanovic, 2004; M. margaretae (Lindberg, 1938); M. monacanthus (Kiefer, 1928); M. mortoni Pesce, De Laurentiis & Humphreys, 1996 [De Laurentiis et al., 1999]; M. pilanus Karanovic, 2004; M. pilbaricus Karanovic, 2004; M. superincidentis Karanovic, 2004; M. trispinosus Dumont, 1981; Microcyclops varicans (G. O. Sars, 1863); Muscocyclops bidentatus Reid, 1987; M. operculatus (Chappuis, 1917) [da Rocha & de Carvalho Bjornberg, 1987]; M. therasiae Reid, 1987;

Psammophilocyclops bispinosus Shen & Tai, 1964 [Shen et al., 1979]; *P. boccaroi* Fryer, 1956; *P. trispinosus* Shen & Tai, 1964 [Shen et al., 1979].

Note: The habitus for *M. margaretae* was obviously given by mistake on fig. 1/6 in Lindberg (1938); and the caudal rami index for *H. inauditus* is slightly smaller (3 instead of 3.8) when measured from the figures provided by Dussart & Frutos (1986). The latter species was also reported with a different spine formula in male and female, which would need to be checked.

A total of 78 morphological characters was used in the analysis (see the list below). Characters were coded, optimized, and weighted using the computer program WinClada, version 1.00.08 (Nixon, 2002), and then analysed using NONA, version 2 (Goloboff, 1999). Standard coding was used in the analysis: "0" representing a presumably plesiomorphic character state, and "1" a presumed apomorphy [if not obviously apomorphic, then at least obviously not plesiomorphic]. All armature elements are named according to their position in the outgroup species. Unknown or missing values were coded "-" and all characters were equally weighted. We did not have any polymorphic characters. All characters were coded as additive (representing an ordered multistate character as a linked series of binary characters). One data matrix was created (table I) and characters were analysed using the Rachet Island Hopper searches with the WinClada default parameters: 200 replications; 1 tree to hold; 3 characters to sample; 10 random constraint level and amb-poly (amb = collapses a branch if the ancestor and descendant have different states under same resolutions of multistate characters or if "-"; poly = treats trees as collapsed). Rachet is a method that searches tree space very effectively by reducing the search effort spent on generating new starting points and retaining more information from existing results of tree searches.

The list of 78 morphological characters used in the preliminary cladistic analysis, with character states in parentheses (note: NONA requires characters to start with 0, rather than 1) is as follows:

- 0. Habitus: cyclopiform (0); transformed (1).
- 1. Habitus: spindle-shaped (0); not spindle-shaped (1).
- 2. Habitus: musciform (0); not musciform (1).
- 3. Habitus: vermiform (0); not vermiform (1).
- 4. Habitus: dorsoventrally compressed (anziform) (0); not anziform (1).
- 5. Integument: smooth (0); ornamented (1).
- 6. Integument: with pits (0); without pits (1).
- 7. Integument: with reticulum pattern (0); without reticulum pattern (1).
- 8. Anal operculum: much shorter than somite (0); as long as or longer than (1).
- 9. Anal operculum: produced to posterior margin of somite (0); shorter or longer (1).
- 10. Anal operculum: produced beyond posterior margin, serrulated (0); different (1).
- 11. Anal operculum: produced beyond posterior margin, not serrulated (0); different (1).
- 12. Caudal rami, spinules at base of dorsal seta: absent (0); present (1).
- 13. Caudal rami, additional row of spinules anteriorly: absent (0); present (1).

Data IIIaui VIII (ine species of the metacyclops related, 1727 complex in Australia and source other, non-rausu anali crossery related species and general species are
	material and methods for non-abbreviated species names
Taxon/Char.	012345678961226666666666666666
A. (Psa.) consensus	-1111011111110000111111111111111111101111
Anz. ballensis	0111110111110001101110101101010101010101
Anz. belli	-111110111110001101111100010100100100100
Anz. euryantennula	
Anz. yarriensis	111110111011100001101011011011000000000
Apo. dengizicus	011111101011110000111000000000000000000
F. (Pil.) frustratio	$0 \\ 1 \\ 1 \\ 1 \\ 1 \\ 0 \\ 1 \\ 1 \\ 0 \\ 0 \\ $
F. (Pil.) supersensus	601111011011100001101000010101010000001000101
Fie. fiersi	011110110111000011100000000000000000000
Fim. jimhensoni	110110111011001001011100110111111111111
Gon. alter	111000110110010100001000011100000-11100000100000000000000000000-0000-00000-0000
Gon. arenicola	101111 111000110110
Gon. mortoni	
Gon. primus	1110001101110000-000-000-000
Gon. silvestris	11111001111100011011011011111111111111010
Gon. uniarticulatus	111101011111101001101101101101101101101
Hes. herbsti	10111101110011100111001000000000001011101010010
Hes. improvisus	1011110111001110011100000000000101000101
Hes. inauditus	101111011011001110011100000000000100000000000
Hes. pescei	1011101110111001110011100000000000000
Hes. sp. 1	101111011100111001110011100010100000000
Hes. venezuelanus	0111011000111000-00001011000-01000000

Sec. Genera 7 ralated ralian clos 4 TABLE I evelons Kiefer, 1927 comulex in Australia and s of the Meto 0000 Data matrix for the

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T. KARANOVIC, S. M. EBERHARD & A. MURDOCH

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TABLE]	(Continued

	(Continued)
Taxon/Char.	012345678901234587800000000000000000000000000000000000
Men. staheli	001111110100000001111000000000000
Mer. baylyi	011111010111100011100111001000000000110000
Mer. platypus	0111110101111000111001110010000000000110000
Met. arnaudi	011111011011011001111000000000000000000
Met. cushae	1011110110110110011101010101010101010101
Met. kimberleyi	0111110111011100110011010000101010000101
Met. laurentiisae	011111011011011001111001000000000000000
Met. margaretae	011111100-111100
Met. monacanthus	
Met. mortoni	011111011011100001111000000000000000000
Met. pilanus	011111011011011001111001000000000000000
Met. pilbaricus	1011101110111001100101010000010101000000
Met. superincidenti	$ \times 0111110011110011110010101000011000010000$
Met. trispinosus	011100-11100-01010000001111111
Mic. varicans	011111011011110000111100000000000000000
Mus. bidentatus	
Mus. operculatus	1101101111011011011110111110111110-1101111100101111100101111100101111101111
Mus. therasiae	110110111101101101111011111111011110111101111011111011111001011110000
Psa. bispinosus	01111101111001111011111101101-01110111101111100111111
Psa. boccaroi	1111000111010010110110110100011011
Psa. trispinosus	$0 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ $

- 14. Caudal rami, lateral sensilla: present (0); absent (1).
- 15. Caudal rami l/w index: less than 1.5 (0); more than 1.5 (1).
- 16. Caudal rami l/w index: between 1.5 and 2 (0); outside this range (1).
- 17. Caudal rami l/w index: between 2 and 3 (0); outside this range (1).
- 18. Caudal rami l/w index: more than 3 (0); less than 3 (1).
- 19. Antennula, first and second segment: free (0); fused (1).
- 20. Antennula, number of setae on first segment: 8 or more (0); 7 or less (1).
- 21. Antennula, number of setae on second segment: 4 (0); 2 (1).
- 22. Antennula, number of setae on third segment: 6 (0); 5 or less (1).
- 23. Antennula, number of setae on fifth segment: 2 (0); 1 (1).
- 24. Antennula, number of setae on seventh segment: 3 (0); 2 (1).
- 25. Antenna, exopodal seta: present (0); absent (1).
- 26. Antenna, coxobasis, outer distomedial seta: present (0); absent (1).
- 27. Antenna, second endopodal segment, proximal first and second seta: present (0); absent (1).
- 28. Antenna, second endopodal segment, third seta from proximal end: present (0); absent (1).
- 29. Antenna, second endopodal segment, fourth seta from proximal end: present (0); absent (1).
- 30. Mandibular palp, small (innermost) seta: present (0); absent (1).
- 31. Mandibular palp, outer large seta: present (0); absent (1).
- 32. Mandibular palp with middle (or only) seta: longer than mandibula (0); shorter (1).
- 33. Maxillula, praecoxal arthrite, number of medial elements: 7 (0); 6 (1).
- 34. Maxilla, basis in male: similar to that of female (0); transformed (1).
- 35. Maxilliped, syncoxa, distal (smallest) seta: present (0); absent (1).
- 36. Maxilliped, syncoxa, proximal seta: present (0); absent (1).
- 37. Maxilliped, syncoxa, middle seta: present (0); absent (1).
- 38. Maxilliped, basis, seta on posterior surface: present (0); absent (1).
- 39. Maxilliped, second endopodal segment, number of setae: 3 (0); 2 (1).
- 40. First leg, basis, inner spine: present (0); absent (1).
- 41. First leg, second endopodal segment, proximal inner seta: present (0); absent (1).
- 42. First leg, second endopodal segment, second seta: present (0); absent (1).
- 43. First leg, first exopodal segment, inner seta: present (0); absent (1).
- 44. First leg, second exopodal segment, proximal inner seta: present (0); absent (1).
- 45. First leg, second exopodal segment, proximal outer spine: present (0); absent (1).
- 46. Second leg, second endopodal segment, proximal inner seta: present (0); absent (1).
- 47. Second leg, second endopodal segment, second seta: present (0); absent (1).
- 48. Second leg, first exopodal segment, inner seta: present (0); absent (1).
- 49. Second leg, second exopodal segment, proximal inner seta: present (0); absent (1).
- 50. Second leg, second exopodal segment, proximal outer spine: present (0); absent (1).
- 51. Second leg, second ecopodal segment, second spine: present (0); absent (1).
- 52. Third leg, second endopodal segment, proximal inner seta: present (0); absent (1).
- 53. Third leg, second endopodal segment, second seta: present (0); absent (1).
- 54. Third leg, first exopodal segment, inner seta: present (0); absent (1).
- 55. Third leg, second exopodal segment, proximal inner seta: present (0); absent (1).
- 56. Third leg, second exopodal segment, proximal outer spine: present (0); absent (1).
- 57. Third leg, second exopodal segment, second spine: present (0); absent (1).
- 58. Fourth leg, second endopodal segment, proximal inner seta: present (0); absent (1).
- 59. Fourth leg, second endopodal segment, apical armature: 2 robust spines (0); one spine smaller, transformed, or reduced (1).
- 60. Fourth leg, second endopodal segment, apical armature: robust and minute spine (0); different (1).
- 61. Fourth leg, second endopodal segment, apical armature: spine and seta (0); no setae (1).
- 62. Fourth leg, second endopodal segment, apical armature: only 1 spine (0); two elements (1).

- 63. Fourth leg, second endopodal segment, outer seta: present (0); absent (1).
- 64. Fourth leg: basis and endopod with lamellar transformations in female: present (0); absent (1).
- 65. Fourth leg endopod in female: inflated (0); not inflated (1).
- 66. Fourth leg, second exopodal segment, proximal inner seta: present (0); absent (1).
- 67. Fourth leg, second exopodal segment, proximal outer spine: present (0); absent (1).
- 68. Fifth leg exopod: large article, long seta, small spine (0); different (1).
- 69. Fifth leg exopod: large article, short seta, huge spine (0); different (1).
- 70. Fifth leg exopod: small rectangular article, long spine, longer seta (0): different (1).
- 71. Fifth leg exopod: small semicircular article, long spine, longer seta (0); different (1).
- 72. Fifth leg exopod: small article, two setae (0); different (1).
- 73. Fifth leg exopod: elongated article, one seta (0); different (1).
- 74. Fifth leg exopod: large article, small spine and long curved seta with convex space between them (0); different (1).
- 75. Fifth leg exopod: short article, small spine and long seta with concave space between them (0); different (1).
- 76. Sixth leg in female, outer seta: present (0); absent (1).
- 77. Sixth leg in male, number of elements: 3 (0); less than 3 (1).

TAXONOMIC PART

Family CYCLOPIDAE Rafinesque, 1815 Subfamily CYCLOPINAE Rafinesque, 1815 Genus Anzcyclops n. gen.

Diagnosis. — Very small cyclopoids, with total body length from tip of rostrum to posterior margin of caudal rami (excluding caudal setae) from 304 to 500 μ m in females and from 323 to 468 μ m in males. Habitus robust, wide, strongly dorsoventrally compressed or primitive cyclopiform (latter just in one species), with prosome/urosome ratio from 1.6 to 2.1 in females and 1.6 to 1.7 in males and greatest width at posterior end of cephalothorax. Body length/width ratio in dorsal view from 2 to 2.5 in females and from 2.3 to 3.1 in males; cephalothorax from 1.5 to 2.2 times as wide as genital double-somite in females and from 1.8 to 2.1 times as wide as free genital somite in males. Surface of cephalothoracic shield and pleurotergites of free pedigerous somites ornamented with large sensilla and cuticular pores; integument in some species with irregular pattern of pits and striae on all somites (mostly internal), creating interesting reticulum. Hyaline fringes of prosomites narrow and smooth; those of urosomites mostly irregularly serrated. Genital double-somite in female large, with inflated anterior part, and laterally with deep lateral recesses at level of sixth legs, from 1.3 to 2 times as wide as long (dorsal view). Anal operculum large, linguiform, produced posteriorly beyond somite limit, and mostly smooth. Caudal rami cylindrical, parallel, very close, and from 1.7 to 2 times as long as wide; armed with six setae; ornamented with one pore on tip of protuberance on distal margin ventrally (between two

terminal setae) and several spinules at base of two lateral setae; terminal setae with or without breaking planes. Antennula in female 11- or 10-segmented (latter caused by failure to separate of second and third segment), with only five setae on third segment and one seta on fifth. Antennula in male digeniculate, 15-segmented. Antenna 4-segmented, without exopodal seta, and with armature formula 2.1.6(5).7. Labrum small and trapezoidal, ornamented with two diagonal rows of six to eight long spinules on anterior surface. Mandibula composed of coxa and small palp; palpal armature variously reduced. Maxillula composed of praecoxa and 2-segmented palp; praecoxal arthrite bearing four apical and six or seven medial elements; palpal coxobasis with one exopodal and three medial setae, endopod with three setae. Maxilla 5-segmented, with armature formula 2.3.2.2.3. Maxilliped 4-segmented, with armature formula 2(0).2(1).1.2. All swimming legs relatively short, with 2-segmented exopods and endopods; endopods only slightly shorter than exopods on all legs and endopod of fourth leg not markedly inflated; first exopodal segment without inner seta on all legs and second exopodal segment spine formula 2.3.3.2 or 2.3.2.2 (latter in only one species); second endopodal segment of first leg with three inner setae; second exopodal segments with four or five setae, but always four on fourth leg; second endopodal segment of fourth leg from 1.2 to 1.5 times as long as wide, armed with single apical spine (reduced in one species) two or three inner setae, and with or without outer seta. Intercoxal sclerite of all swimming legs with concave distal margins and without any surface ornamentation; all coxae with inner seta and basis of first leg with inner spine. Basis and endopod of fourth leg without any special chitinous structures. Fifth leg held ventrolaterally, composed of protopod completely fused to somite and free exopod; protopodal seta strong, visible in dorsal view; exopod small, quadriform, armed apically with inner slender and long spine, and outer longer seta. Sixth leg with two or three elements.

Etymology. — The genus name is composed from the first letters of Australia and New Zealand (where the five known species live) and the existing generic name *Cyclops*. Gender masculine.

Type species. — Anzcyclops yarriensis n. sp.

Other species. — *Goniocyclops silvestris* Harding, 1958; *Anzcyclops belli* n. sp.; *Anzcyclops ballensis* n. sp.; and *Anzcyclops euryantennula* n. sp.

Remarks. — The new genus is a group of closely related species from the Western Australian Pilbara region (three species), central Queensland (one species), and New Zealand (also one species), that share a number of apomorphic characters, including a dorsoventrally compressed habitus, a reticulated integument, and a reduced armature of the antennula, antenna and the swimming legs (with the spine formula 2.3.3.2 or 2.3.2.2; latter in only one species). The spine formula 2.3.3.2 is exactly the same as in the South American genus *Muscocyclops* Kiefer,

1937 and the two genera are indeed closely phylogeneticly related, as illustreated on our cladogram (fig. 19). The genus Muscocyclops is currently containing three closely related species (Reid, 1987; da Rocha & de Carvalho Bjornberg, 1987) that live in mossy habitats. It differs from Anzcyclops n. gen. by a very characteristic habitus (musciform, as we call it in our preliminary cladistic analysis), ovoid genital double-somite, serrulated anal operculum, shorter caudal rami, presence of a transverse row of large spinules at base of dorsal caudal seta, absence of inner basal spine and reduced armature on the second endopodal segment of the first swimming leg, and shorter and less quadriform exopod of the fifth leg. The other genus relatively closely related to Anzcyclops is the here below described Dussartcyclops n. gen., but the latter has a number of important apomorphic characters in the armature of the antenna and swimming legs, as well as a different armature of the fifth leg (see the remarks section for the genus Dussartcyclops). As mentioned in the introduction section, the genera Goniocyclops Kiefer, 1955 and Psammophilocyclops Fryer, 1956 were only partly described and many characters cannot be compared or included in the cladistic analysis, but what little we know about them all suggests a relatively close relationship with Anzcyclops. However, all three species of Goniocyclops have the same spine formula (3.3.3.2), despite the difference in antennula segmentation (as in Anzcyclops it can be 10- or 11segmented) and relative length of the fifth leg exopodal spine (see Kiefer, 1956; Dussart, 1984). We speculate that further differences will be discovered with complete redescription of its members. The genus Psammophilocyclops has the spine formula 3.3.3.3 or 2.2.2.2 and it is a major question if the three species currently placed here form a monophyletic group at all. Incomplete species descriptions (see Fryer, 1956; Shen & Tai, 1964; Shen et al., 1979) also preclude any meaningful discussion, but it seems that the two Chinese species cluster well together due to their longer caudal rami and short anal operculum, while the type species clusters more closely with the genus Goniocyclops, and especially with the two Madagascan species. We think this is not a coincidence, since the type was described by Fryer (1956) from Lake Nyasa, Africa. However, at this stage we prefer to leave all six species in the genus Goniocyclops and await a full redescription of all morphological characters. The genus Psammophilocyclops was considered to be a junior subjective synonym of Goniocyclops already by Pesce (1996), which was accepted by Karanovic (2004a) and Dussart & Defaye (2006). Other genera from the Metacyclops complex are only remotely related to Anzcyclops and can be distinguished by a combination of characters related to the shape of their habitus, anal operculum, caudal rami, and fifth leg, in addition to the more plesiomorphic armature of the swimming legs and in most cases also of the antennula, antenna, and mouth appendages (see preliminary cladistic analysis in the discussion section). The same spine formula (2.3.3.2) as in Anzcyclops, can be found in all six species of the

nominotypical subgenus of the genus *Haplocyclops* Kiefer, 1952 (see da Rocha et al., 1998; Fiers, 2002; Karanovic & Ranga Reddy, 2005). However, this genus has the fifth leg completely fused to the somite, the ovipores situated in the posterior half of the genital double-somite, as well as an antennula without lateral seta on the ultimate segment, and caudal rami with the anterolateral seta inserted in the proximal half.

KEY TO THE FEMALES OF ANZCYCLOPS N. GEN.

1 – I – I	Endopod of fourth leg with outer seta Endopod of fourth leg without outer seta	3 2
2 – I – I	Habitus dorsoventrally compressed A. silvestris (Harding, 1958) n. com Habitus cyclopiform A. ballensis n. s	ıb. p.
3 – I – I	Fourth leg endopod with apical spine	.4 p.
4 – I – I	Fourth leg endopod with three inner setae on second segment	р. р.

Anzcyclops yarriensis n. sp.

(figs. 1-4, 16)

Type locality. — Australia, Western Australia, Pilbara region, De Grey River catchment, Yarrie, Callawa Ridge, BHP tenement, bore CA0023 on the top of the ridge, $20^{\circ}38'26''S$ $120^{\circ}18'24''E$, water temperature $30.8^{\circ}C$, pH 5.75, electric conductivity 427 μ S/cm; interstitial water at 40.1 m (fig. 18C).

Material examined. — Holotype female dissected on one slide (WAM C37454). Allotype male also dissected on one slide (WAM C37455). Other paratypes are 15 males, 15 females, and two copepodids in alcohol (WAM C37458), and one male and one female dissected on one slide each (WAM C37456 and C37457, respectively); all collected at type locality; leg. P. Bell & S. Eberhard, 26 April 2008.

Description. — Holotype female. Total body length from tip of rostrum to posterior margin of caudal rami (excluding caudal setae) 371 μ m. Habitus (figs. 1A, 2A) robust, wide, and strongly dorsoventrally compressed, with prosome/urosome ratio 1.7 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.5 (dorsal view); cephalothorax almost twice as wide as genital doublesomite. Free pedigerous somites without particular expansions laterally. Preserved specimen colourless. Nauplius eye not visible. Rostrum well developed, membranous, broadly rounded and furnished with two large sensilla.

Cephalothorax (figs. 1A, C, 2A) slightly longer than greatest width (dorsal view); representing 44% of total body length. Surface of cephalothoracic shield and pleurotergites of free pedigerous somites with many large sensilla and several cuticular pores; integument with irregular pattern of pits and striae (mostly internal), creating interesting reticulum; this present more or less on all somites,

16



Fig. 1. *Anzcyclops yarriensis* n. sp., holotype female. A, habitus, lateral; B, cuticular ornamentation of genital double-somite, detail; C, cuticular ornamentation of cephalothoracic shield and pleural areas of three free pedigerous somites, detail; D, antennula, dorsal; E, antenna, frontal; F, labrum, anterior; G, mandibula, posterior. Scales 0.1 mm.



Fig. 2. Anzcyclops yarriensis n. sp., A-F, holotype female; G, paratype female (0.362 mm).
A, habitus, dorsal; B, urosome, dorsal; C, maxillula, posterior; D, maxillular palp, anterior; E, maxilla, posterior; F, maxilliped, posterior; G, urosome, ventral. Scales 0.1 mm.

but absent from all appendages. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite (fig. 2B) ornamented with six large dorsal sensilla; hyaline fringe smooth ventrally and finely serrated dorsally.

Genital double-somite (figs. 1A, B, 2B) large, with deep lateral recesses at level of sixth legs, 1.5 times as wide as long (dorsal view), also ornamented with pits and striae and two large dorsal sensilla; hyaline fringe of genital double-somite, as well as of two subsequent urosomites, sharply serrated both ventrally and dorsally. Copulatory pore small, ovoid, situated at 2/5 of somite length; copulatory duct narrow, siphon-shaped, well sclerotized. Seminal receptacle with large anterior expansion and much smaller and narrow posterior expansion, representing 57% of double-somite's length; oviducts broad and weakly sclerotized. Ovipores situated dorsolaterally, covered with reduced sixth legs. Third and fourth urosomites short, of similar length, without any pores or sensilla, ornamented just with cuticular pits. Anal somite ornamented with 2 large sensilla dorsally and transverse row of minute spinules along posterior margin ventrally and laterally (fig. 2B). Anal sinus smooth. Anal operculum large, linguiform, produced posteriorly slightly beyond somite limit, smooth, with almost straight caudal margin, representing 54% of anal somite width.

Caudal rami (fig. 2B) cylindrical, parallel, very close, and 1.9 times as long as wide; ornamented with one lateral cuticular pore at anterior part, one pore on tip of protuberance on distal margin ventrally (between two terminal setae) and several spinules at base of two lateral setae. Dorsal seta about 1.2 times as long as ramus, inserted at 3/4 of ramus length, biarticulate at base and plumose at distal part. Anterolateral seta arising somewhat dorsolaterally at 2/3 of ramus length, half as long as dorsal seta. Posterolateral seta stout, spiniform, slightly shorter than ramus, bipinnate. Terminal accessory seta (innermost one) small and slender, bipinnate, half as long as posterolateral seta. Terminal setae without breaking planes, bipinnate; inner seta (principal terminal one) about 1.4 times as long as outer seta and 0.45 times as long as body length.

Antennula (fig. 1D) 11-segmented, almost reaching posterior margin of cephalothoracic shield, ornamented just with arched proximoventral row of spinules on first segment (no pits or other integumental structures), with armature formula as follows (ae = aesthetasc): 7.2.5.2.1.2.2.2 + ae.2.3.7 + ae. No setae biarticulating on basal part and just one apical seta on eighth and one on eleventh segment pinnate; all other setae smooth; both aesthetascs very slender. Only seta on fifth segment spiniform and very short; one apical seta on eleventh segment fused basally with aesthetasc. Length ratio of antennular segments, from proximal end and along caudal margins, 1:0.4:0.6:0.4:0.3:0.6:1:1:0.7:0.8:1.1.

Antenna (fig. 1E) 4-segmented, comprising coxobasis and 3-segmented endopod. Coxobasis large, cylindrical, twice as long as wide, ornamented with three spinules on caudal surface at 1/3, armed with two smooth distomedial setae; seta representing exopod absent; original segmentation of coxa marked by partial transverse surface suture. First endopodal segment ovoid, 1.5 times as long as wide, with inner smooth seta at 2/3 and patch of spinules along lateral margin. Second endopodal segment more slender, about 1.8 times as long as wide, with narrower proximal part, bearing six medial setae (fifth from proximal end strongest) and one spinular row on lateral margin. Third endopodal segment cylindrical, twice as long as wide, with two spinular rows on lateral margin and armed with seven smooth apical setae (four of them strong and geniculate). Length ratio of antennal segments from proximal end, 1:0.7:0.7:0.7.

Labrum (fig. 1F) relatively small, trapezoidal plate, ornamented with two diagonal, short rows of eight long spinules on anterior surface. Cutting edge slightly concave, with 15 small blunt teeth between produced rounded lateral corners.

Mandibula (fig. 1G) composed of coxa and small palp. Coxal gnathobase cutting edge with five spinules on anterior surface, five apical teeth (ventralmost tooth strongest and complex, tridentate), and two setae on dorsal corner (dorsalmost seta unipinnate, 1.2 times as long as other smooth seta, but slightly shorter than shortest palpal seta). Palp 1.4 times as wide as long, unornamented but armed with three apical setae: two long and plumose and one short and smooth; longest plumose seta twice as long as entire mandibula.

Maxillula (fig. 2C, D) composed of praecoxa and 2-segmented palp. Praecoxal arthrite bearing four very strong distal spines (three smooth, blunt, and fused at base; one distinct at base, sharp, and spinulate) and seven medial elements (proximal longest and plumose, others naked). Palp composed of coxobasis and endopod. Coxobasis with smooth proximal (exopodal) seta and three medial setae (two smooth and slender, one strong and bipinnate); endopod with three mooth setae. Smooth medial setae of about same length and 1.6 times as long as bipinnate seta.

Maxilla (fig. 2E) 5-segmented, but praecoxa partly fused to coxa on posterior surface. Proximal endite of praecoxa robust, armed with two subequal, pinnate setae; distal endite small, unarmed. Proximal endite of coxa with one bipinnate seta; distal endite highly mobile, elongate, and armed apically with two pinnate setae, proximal one slightly longer; coxa ornamented with single longitudinal row of minute spinules on posterior surface. Basis expanded into robust claw, ornamented with two longitudinal rows of spinules, and armed with two setae; strong seta as long as claw, pinnate. Endopod 2-segmented; proximal segment armed with two robust, unipinnate setae; distal segment with one robust, unipinnate, apical seta and two slender and smooth subapical setae. Longest seta on distal endopodal segment 1.1 times as long as longest seta on proximal endopodal segment. All strong setae, as well as basal claw, prehensile. Maxilliped (fig. 2F) 4-segmented, composed of syncoxa, basis, and 2-segmented endopod. Ornamentation consisting of several longitudinal rows of spinules on first three segments. Armature formula: 2.2.1.2.

All swimming legs relatively short, with 2-segmented exopods and endopods (fig. 3A, B, C, D, E). Endopods only slightly shorter than exopods on all legs. Swimming legs armature formula as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-I	I-0; I,I $+$ 1,4	0-1; 1, I+1, 2
Leg 2	0-1	1-0	I-0; II, $I + 1,4$	0-1; 1,I + 1,3
Leg 3	0-1	1-0	I-0; II, $I + 1,4$	0-1; 1(0),I + 1,3
Leg 4	0-1	1-0	I-0; I,I $+$ 1,3	0-1; 1,I,3

Second exopodal segment spine formula 2.3.3.2 and setal formula 5.5.5.4. All setae on endopods and exopods slender and plumose; apical seta on exopod of first leg pinnate along outer margin, plumose along inner; no modified setae observed. All spines strong and bipinnate. Intercoxal sclerite of all swimming legs with deeply concave distal margins and without any surface ornamentation. Praecoxae short and ornamented with row of spinules on posterior surface (except fourth leg). All coxae ornamented with short distal row of minute spinules on both anterior and posterior surface; that of fourth leg with additional arched row of larger spinules on posterior surface at middle, close to outer margin. Bases with round inner distal corners, ornamented with long setules. Exopods with long setules on inner margin, endopods on outer margin and both rami additionally ornamented with minute spinules (sometimes too small to be figured) at base of each armature element, as well as with several at base of each segment. Outer seta on basis of first swimming leg very long, bipinnate at distal end; those on other legs shorter and unipinnate. Inner spine on basis of first leg (fig. 3A) curved inwards, sharp, reaching slightly beyond middle of second endopodal segment. Second (fig. 3B) and third (fig. 3C, D) swimming legs very similar, except for abnormal endopod on left third leg with outer seta missing (fig. 3D, arrowed). Endopod of fourth swimming leg (fig. 3E) as wide as exopod; second endopodal segment about 1.5 times as long as wide; only apical spine 0.85 times as long as segment and about 0.7 times as long as distal inner seta.

Fifth leg (figs. 1A, 3F) held ventrolaterally, composed of protopod completely fused to somite and free exopod. Protopodal seta strong, visible in dorsal view (fig. 2A, B), arising from prominent setophore, unisetulate along outer margin. Exopod quadriform, about 1.2 times as long as wide, armed apically with outer bipinnate seta and inner smooth spine; seta about 2.6 times as long as adjacent spine, three times as long as segment and half as long as protopodal seta.



Fig. 3. Anzcyclops yarriensis n. sp., holotype female. A, first swimming leg, anterior; B, second swimming leg, posterior; C, second endopodal segment of right third leg, anterior; D, left third swimming leg, anterior; E, fourth swimming leg, posterior; F, fifth leg, ventrolateral; G, sixth leg, lateral. Scale 0.1 mm.

Sixth leg (fig. 3G) indistinct, small, semicircular cuticular plate, armed with two short spines; inner spine fused to plate, outer articulated basally.

Allotype male. Total body length 356 μ m. Urosome comprised of fifth pedigerous somite, genital somite, and four free abdominal somites. Habitus (fig. 4A) slightly more slender than in female, but prosome/urosome ratio also about 1.7 and greatest width at posterior end of cephalothorax. Body length/width ratio 2.45; cephalothorax about 2.1 times as wide as genital somite. Cephalothorax 1.1 times as long as wide (dorsal view); representing 44% of total body length. Ornamentation of prosomites (fig. 4A, B) and colour similar to female. Hyaline fringe of fifth pedigerous somite (fig. 4C) smooth both ventrally and dorsally; somite ornamented with six dorsal sensilla, as in female. Genital somite (fig. 4C) almost twice as wide as long, with serrated hyaline fringe dorsally, ornamented with two large dorsal sensilla; two relatively small, ovoid spermatophores visible inside. Next three urosomites without any sensilla, integument ornamented only with pits, with sharply serrated hyaline fringes (coarser dorsally and finer ventrally). Anal somite (fig. 4C) ornamented with two large dorsal sensilla and transverse row of spinules along caudal margin. Anal operculum more rounded than in female.

Caudal rami (fig. 4A, C) slightly more set apart than in female (space between them about 1/5 of ramus width, twice as long as wide). Armature and ornamentation similar to female, except slightly shorter outer terminal seta.

Antennula (fig. 4D, E) digeniculate, 15-segmented (with completely fused seventh and eighth, and sixteenth and seventeenth ancestral segments), ornamented with spinules only on first segment (as in female), with anvil-shaped cuticular structures on thirteenth and fourteenth elements (distal geniculation). Armature formula as follows: 7 + 3ae.4.1.2 + ae.1.2.2.3 + ae.2.2.2.2 + ae.0.1.9 + ae. All aesthetascs linguiform and short; most setae slender and smooth; short unipinnate setae present on tenth and twelfth segments (one each); short smooth elements on eighth (one), ninth (one), and eleventh (two) segments; long pinnate setae on first (one), sixth (one), fourteenth (one), and fifteenth (two) segments.

Antenna, labrum, mandibula, maxillula, maxilla, maxilliped, swimming legs, and fifth leg similar to those of female.

Sixth leg (fig. 4F) large, unornamented cuticular plate, armed with inner spine and outer seta on outer distal corner; seta unipinnate and 1.3 times as long as bipinnate spine.

Etymology. — The species is named after the type locality, Yarrie Station in Western Australia. The name is an adjective for place, made with the Latin suffix "-ensis".

Variability. — Body length of males ranges from 323 μ m to 356 μ m (338 μ m average; n = 9), while that of females ranges from 355 μ m to 385 μ m (368 μ m



Fig. 4. *Anzcyclops yarriensis* n. sp., A-F, allotype male; G, paratype male (0.333 mm). A, habitus, dorsal; B, detail of cuticular ornamentation of first three free pedigerous somites, dorsal; C, urosome, dorsal; D, antennula, dorsal; E, detail of antennula between two geniculation points, dorsal; F, sixth leg, ventrolateral; G, urosome with complete ornamentation illustrated, ventral. Scales 0.1 mm.

average; n = 10). The holotype female has asymmetric endopods of the third swimming leg, with outer seta present on the right leg (fig. 3C) and absent on the left one (fig. 3D). All paratypes (including the allotype male) have this seta present. One paratype female has its outer principal seta on the right caudal ramus abnormal (fig. 2G) and one paratype male has somewhat longer dorsal caudal setae (fig. 4G). The reticular integumental pattern is very variable. It can be very dense, as in the holotype and allotype (figs. 1B, C, 4B), or almost completely absent. However, most specimens are somewhere in between (fig. 4G). Scanning electron microscope photographs of two paratype females (fig. 16A, B, C, D) and one paratype male (fig. 16E, F) reveal some of these characters in more detail, very similar to those in the holotype and allotype.

Remarks. — Anzcyclops varriensis n. sp. differs from its four congeners in the most plesiomorphic armature of the swimming legs, with three inner setae on the second endopodal segment of second and third legs (two in other species) and five setae on the second exopodal segment of second and third legs (four in other congeners) (fig. 3B, C, D). It also has the shortest anal operculum of all species, only slightly produced beyond the posterior margin of the anal somite (fig. 16B), and proportionately the largest exopod of the fifth leg. It is interesting that these are all plesiomorphic character states. However, the new species cannot be identified as an ancestral form of the other four congeners, as it has a dorsoventrally compressed habitus (fig. 16A) and a reticulated integument (fig. 16C). These two apomorphic character states distinguish A. yarriensis from A. ballensis n. sp. (see below) and it is quite plausible that the ancestor of the genus Anzcyclops n. gen. had a combination of characters displayed by these two species. Other small differences include the size of the inner basal spine on the first leg (figs. 16E, 17E), and dorsal ornamentation of the second pedigerous somite (no sensilla in the latter species; fig. 17C). Additionally, A. yarriensis can be distinguished from each congener by a number of differences, that are additionally stressed in the remarks section for each new Australian species (see below) and also quite often arrowed in their drawings. It differs from the New Zealand A. silvestris (Harding, 1958) n. comb. by a much shorter terminal accessory seta on the caudal rami, as well as the armature of the mandibula, maxilliped, and endopod of the fourth swimming leg (see Karanovic, 2005 for the redescription of the latter species).

Anzcyclops belli n. sp.

(figs. 5-7)

Type locality. — Australia, Western Australia, Pilbara region, Chichester Ranges, Western Shaw River catchment, Quarry 8, BHP tenement, bore NS0007, $22^{\circ}05'47''S$ $118^{\circ}59'59''E$, water temperature 25.9°C, pH 6.89, electric conductivity 820 μ S/cm; water table at 12.5 m below ground level (fig. 18D).

Material examined. — Holotype female dissected on one slide (WAM C37459); leg. P. Bell & S. Eberhard, 28 April 2008.

Description. — Holotype female. Total body length 323 μ m. Habitus (figs. 5A, 6A) robust, wide, and even more strongly dorsoventrally compressed than in previous species, with prosome/urosome ratio 2.1 and greatest width at posterior end of cephalothorax. Body length/width ratio also about 2.5 (dorsal view); but cephalothorax only 1.5 times as wide as genital double-somite. Free pedigerous somites without particular expansions laterally; colour, nauplius eye, and rostrum similar to previous species.

Cephalothorax (figs. 5A, B, 6A, B) large, 1.2 times as long as greatest width (dorsal view); representing 50% of total body length. Surface of cephalothoracic shield and pleurotergites of free pedigerous somites ornamented with several large sensilla (fewer than in previous species) and with irregular reticulum of pits and striae; integumental reticular pattern present more or less on all somites, but absent from all appendages. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite (fig. 6A, C) ornamented with two dorsal and two lateral (one on each side) large sensilla; hyaline fringe smooth on all sides.

Genital double-somite (fig. 6A, C, D) massive, with laterally produced anterior part (arrowed in fig. 6D) and deep lateral recesses at level of sixth legs, 1.75 times as wide as long (dorsal view), also ornamented with pits and striae but without sensilla; hyaline fringe of genital double-somite, as well as of two subsequent urosomites, sharply and irregularly serrated both ventrally and dorsally, although serration much finer ventrally than dorsally. Copulatory pore larger than in previous species, ovoid, situated at 1/3 of somite length; copulatory duct narrow, siphon-shaped, well sclerotized. Seminal receptacle with small anterior expansion and somewhat larger posterior expansion, but representing 78% of double-somite's length; oviducts broad and strongly sclerotized. Ovipores situated somewhat dorsolaterally. Third and fourth urosomites small when compared to genital double-somite, without any pores and sensilla, ornamented just with cuticular pits; third urosomite 1.3 times as long as fourth. Anal somite ornamented with 2 large sensilla dorsally and transverse row of minute spinules along posterior margin ventrally and laterally (fig. 6C, D). Anal sinus smooth and completely covered by huge anal operculum (arrowed in fig. 6C), linguiform, produced posteriorly well beyond somite limit and reaching 1/3 of caudal rami, smooth, with strongly convex caudal margin, representing 58% of anal somite width.

Caudal rami (fig. 6A, C, D, E) cylindrical, almost parallel, closely inserted (with space between them about 1/3 of ramus width), and about 1.8 times as long as wide; ornamented with one pore on tip of protuberance on distal margin ventrally (between two terminal setae) and several spinules at base of two lateral



Fig. 5. *Anzcyclops belli* n. sp., holotype female. A, habitus, lateral; B, cuticular ornamentation of cephalothoracic shield and pleural areas of three free pedigerous somites, detail; C, antennula, ventral; D, antenna, caudal; E, labrum, anterior; F, left mandibula, posteroventral; G, right mandibula, anterodorsal. Scales 0.1 mm.



Fig. 6. Anzcyclops belli n. sp., holotype female. A, habitus, dorsal; B, detail of cuticular ornamentation of cephalothoracic shield and first two free pedigerous somites, dorsal; C, urosome, lateral; D, urosome, ventral; E, last three urosomites and caudal rami, dorsal; F, maxillula, posteroventral; G, maxillular palp, posteroventral; H, praecoxa and coxa of maxilla, anterior; I, maxilliped, anterior. Scales 0.1 mm.

setae. Dorsal seta strong and long (arrowed in fig. 6C), about 2.5 times as long as ramus, inserted at 5/6 of ramus length, biarticulate at base and plumose at distal part. Anterolateral seta arising somewhat dorsolaterally at middle of ramus length, 0.2 times as long as dorsal seta. Posterolateral seta stout, spiniform, about as long as ramus, bipinnate. Terminal accessory seta also bipinnate, 0.6 times as long as posterolateral seta but not as strong. Terminal setae without breaking planes, bipinnate. Inner terminal seta about 1.4 times as long as outer one and half as long as body length.

Antennula (fig. 5C) also 11-segmented but proportionally shorter than in previous species, reaching 3/4 of cephalothoracic shield in length, unornamented. Armature formula same as in previous species. No setae biarticulating on basal part, same setae spiniform and fused to aesthetasc as in previous species. Apical aesthetasc somewhat more robust, as long as ultimate and penultimate segments combined. Length ratio of segments, 1:0.4:0.6:0.3:0.2:0.5:1:0.8:0.5:0.7:1.

Antenna (fig. 5D) with same segmentation, armature, and ornamentation as in previous species, but with proportionally shorter coxobasis. Length ratio of segments from proximal end, 1:0.9:0.9:0.7.

Labrum (fig. 5E) small trapezoidal plate, ornamented with two diagonal, short rows of seven long spinules on anterior surface. Cutting edge slightly concave, with 12 large and sharp teeth between produced rounded lateral corners.

Mandibula (fig. 5F, G) with same segmentation and armature on coxal gnathobase as in previous species (note: not figured in same position). Palp proportionately smaller, 1.4 times as wide as long, unornamented, armed with three slender and short apical setae (two pinnate and one smooth); pinnate setae (arrowed in fig. 5F) of about same length, only 0.25 times as long as entire mandibula, and about twice as long as smooth seta (length of smooth seta different on left and right mandibula).

Maxillula (fig. 6F, G) more robust, but with same segmentation and armature as in previous species. Strongest blunt spine on praecoxal arthrite ornamented with row of spinules along convex margin. Outer apical seta on endopod also unipinnate. All medial setae on coxobasis of about same length.

Maxilla (fig. 6H) with same segmentation, armature and ornamentation as in previous species (note: basis and endopod not figured).

Maxilliped (fig. 6I) segmented as in previous species, ornamented with stronger spinules on syncoxa and basis and without ornamentation on first endopodal segment. Basis armed with only one strong seta (arrowed in fig. 6I), resulting in maxillipedal armature formula: 2.1.1.2.

All swimming legs short, with 2-segmented exopods and endopods (fig. 7A, B, C, D). Endopods only slightly shorter than exopods on all legs, most obvious on



Fig. 7. *Anzcyclops belli* n. sp., holotype female. A, first swimming leg, anterior; B, second swimming leg, anterior; C, third swimming leg, anterior; D, fourth swimming leg, anterior; E, fifth leg, ventrolateral. Scale 0.1 mm.

fourth leg. Swimming legs armature formula:

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

Second exopodal segment spine formula 2.3.3.2 and setal formula 5.4.4.4. All setae on endopods and exopods slender and plumose; all spines strong and bipinnate. Intercoxal sclerite of all swimming legs with concave distal margins (least prominent on fourth leg) and without any surface ornamentation. Praecoxae short and unornamented. All coxae ornamented with short distal row of minute spinules on both anterior and posterior surface; that of fourth leg with additional arched row of spinules on posterior surface at middle, close to outer margin. Basis of fourth leg with round inner distal corners, ornamented with long setules; those of second and third leg with small spiniform process (arrowed in fig. 7B, C). Ornamentation of exopods and endopods and size of outer basal setae as in previous species. Inner spine on basis of first leg (arrowed in fig. 7A) short and stout, reaching slightly beyond distal margin of first endopodal segment. Second (fig. 7B) and third (fig. 7C) swimming legs very similar, except apical spine on second leg endopod somewhat larger; proximal inner setae on endopods and exopods of both legs missing (arrowed in fig. 7B, C). Endopod of fourth swimming leg (fig. 7D) as wide as exopod but shorter; second endopodal segment about 1.4 times as long as wide; apical spine missing (arrowed in fig. 7D).

Fifth leg (figs. 6C, D, 7E) held almost laterally, composed of protopod completely fused to somite and free exopod. Protopodal seta strong, visible in dorsal view (fig. 6A), arising from prominent setophore, unisetulate along outer margin. Exopod quadriform, proportionally smaller than in previous species (arrowed in fig. 7E), about 0.8 times as long as wide, armed apically with outer bipinnate seta and inner smooth spine; seta about 2.1 times as long as adjacent spine, four times as long as segment and 0.6 times as long as protopodal seta.

Sixth leg (fig. 6C) small, semicircular cuticular plate, armed with two short spines as in previous species; inner spine fused to plate, outer articulated.

Male unknown.

Etymology. — The species is named after one of the collectors, Mr Peter Bell, in recognition of his tremendous effort in helping to collect subterranean fauna in the Pilbara region, including this species at Quarry 8. The name is a noun in the genitive singular.

Variability. — Only one female was collected and examined. The length of the smallest seta on the mandibular palp (fig. 5F, G) is somewhat asymmetrical.

Remarks. — Anzcyclops belli n. sp. differs from all four congeners in the reduced armature of the second maxillipedal segment (fig. 6I), and the apical spine

on the second endopodal segment of the fourth leg absent (fig. 7D). It also has the longest dorsal seta on the caudal rami (fig. 6C), which is about 2.5 times as long as the ramus itself. Long dorsal caudal setae put the Western Australian A. belli close to the Queensland A. euryantennula n. sp., and both species share an unusual mandibular palp armature (figs. 5F, G, 14D), but can be distinguished by a number of differences in the armature of the antennula and swimming legs. Anzcyclops belli can be additionally distinguished from the above described Western Australian A. yarriensis n. sp., by the armature of the swimming legs (arrowed in fig. 7) and mandibula (fig. 5F), wider and more compressed habitus (figs. 5A, 6A), larger lateral protrusions on the genital double-somite (fig. 6D), longer anal operculum (fig. 6C, E), smaller exopod of the fifth leg (fig. 7E), and shorter inner spine on the first leg basis (fig. 7A). From the below described Western Australian A. ballensis n. sp., A. belli can be additionally distinguished by the segmentation and armature of the antennula, habitus shape, and somite ornamentation, as well as some other characters in the armature of mandibula and maxilla. From the New Zealand A. silvestris (Harding, 1958) n. comb., A. belli differs in the armature of the mandibula, maxilliped, exopod of the first leg, and exopod of the fourth leg, in addition to those unique characters stressed above.

Anzcyclops ballensis n. sp.

(figs. 8-12, 17, 18A, B)

Type locality. — Australia, Western Australia, Pilbara region, Balla Balla, bore BBWP10, $20^{\circ}46'56''S 117^{\circ}48'19''E$; interstitial water (fig. 18E).

Type material. — Holotype female dissected on one slide (WAM C37460). Allotype male also dissected on one slide (WAM C37461). Other paratypes are 24 females and four copepodids in alcohol (WAM C37464), two females dissected together on one slide (WAM C37462), and two females on one slide in toto (WAM C37463); all collected at type locality; leg. V. Campagna, 6 August 2008.

Other material. — Australia, Western Australia, Pilbara region, Balla Balla, bore BBWP09, 20°47′14″S 117°48′19″E, leg. V. Campagna, 6 August 2008: one male, 13 females, and six copepodids in alcohol (WAM C37465), and one female dissected on one slide (WAM C37466).

Australia, Western Australia, Pilbara region, Balla Balla, bore BBMB007, 20°44′59″S 117°46′ 43″E, leg. V. Campagna, 5 August 2008: two copepodids in alcohol (WAM C37467).

Description. — Holotype female. Total body length 470 μ m. Habitus (figs. 8A, 9A) very robust, but not dorsoventrally compressed (arrowed in fig. 8A) as in previous two species, with prosome/urosome ratio 1.74 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.5 (dorsal view); cephalothorax 2.2 times as wide as genital double-somite. Free pedigerous somites without particular expansions laterally. Preserved specimen colourless. Nauplius eye not visible. Rostrum well developed, membranous, broadly rounded, and furnished with two large sensilla.



Fig. 8. *Anzcyclops ballensis* n. sp., holotype female. A, habitus, lateral; B, cuticular ornamentation of cephalothoracic shield and pleural areas of three free pedigerous somites, detail; C, urosome, lateral; D, antennula, dorsal; E, antenna, frontal. Scales 0.1 mm.

Cephalothorax (figs. 8A, B, 9A) about as long as greatest width (dorsal view), but much narrower at anterior part (almost triangular from dorsal view); representing 40% of total body length. Surface of cephalothoracic shield (figs. 8B, 9A) and pleurotergites of free pedigerous somites (figs. 8B, 9B) with many large sensilla and several cuticular pores, but second pedigerous somite without dorsal sensilla; integument completely smooth, without any pits and almost no striae; all other somites also smooth. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite (fig. 9C, D) ornamented with four dorsal sensilla (two large and two small); hyaline fringe also smooth.

Genital double-somite (figs. 8C, 9C, D) proportionally smaller than in previous two species, but also with expanded anterior part and lateral recesses at level of sixth legs, 1.3 times as wide as long (dorsal view), ornamented with two cuticular pores ventrocaudally and single pore dorsomedially at 1/3 of double somite length; hyaline fringe of genital double-somite, as well as of two subsequent urosomites, serrated, but not as deeply as in previous species and also more coarsely dorsally than ventrally. Copulatory pore small, ovoid, situated at 1/3 of somite length; copulatory duct narrow, siphon-shaped, well sclerotized. Seminal receptacle ellipsoid, with equally large anterior and posterior expansion, representing 53% of double-somite's length; oviducts broad and weakly sclerotized. Ovipores situated somewhat dorsolaterally, covered with reduced sixth legs. Third urosomite about 1.6 times as long as fourth, both without any ornamentation. Anal somite ornamented with 2 large sensilla dorsally, two pores anterodorsally, two pores posteroventrally, and transverse row of minute spinules along posterior margin ventrally and laterally (figs. 8C, 9C, D). Anal sinus smooth. Anal operculum large, linguiform, produced posteriorly beyond somite limit, smooth, with convex caudal margin, representing 58% of anal somite width.

Caudal rami (figs. 8C, 9C, D) cylindrical, parallel, closely spaced, and about 1.7 times as long as wide; ornamented with one pore on tip of protuberance on distal margin ventrally (between two terminal setae) and several spinules at base of two lateral setae. Dorsal seta slightly longer than ramus, inserted at 5/6 of ramus length, biarticulate at base and plumose at distal part. Anterolateral seta arising somewhat dorsolaterally at 3/5 of ramus length, half as long as dorsal seta. Posterolateral seta stout, spiniform, 0.6 times as long as ramus, bipinnate. Terminal accessory seta (innermost one) also bipinnate but not spiniform, 1.4 times as long as posterolateral seta. Terminal setae with breaking planes and plumose; inner seta 2.1 times as long as outer seta and 0.46 times as long as body length.

Antennula (fig. 8D) 10-segmented, with ancestral second and third segments not separated (arrowed in fig. 8D), reaching 5/6 of cephalothoracic shield in length but spread outwards on specimen, ornamented just with arched proximoventral row of spinules on first segment, with armature formula: 7.7.2.1.2.3.2 + ae.2.3.7 + ae. All



Fig. 9. Anzcyclops ballensis n. sp., holotype female. A, habitus, dorsal; B, detail of cuticular ornamentation of last two prosomites and first urosomite, dorsal; C, urosome, ventral; D, urosome, dorsal; E, labrum, anterior; F, mandibula. Scales 0.1 mm.

armature elements present as in previous two species, with addition of proximal seta on sixth (seventh in previous species) segment (arrowed in fig. 8D). No setae biarticulating on basal part, just five setae pinnate and only one spiniform. Apical aesthetasc somewhat longer than ultimate and penultimate segments combined. Length ratio of segments, 1:1:0.2:0.2:0.4:0.9:0.8:0.6:0.7:0.9.

Antenna (fig. 8E) segmentation and armature same as in previous two species. Coxobasis 2.2 times as long as wide, unornamented. Endopodal segments ornamented as in previous two species with spinules on lateral margin. Length ratio of segments, 1:0.5:0.6:0.5.

Labrum (fig. 9E) small trapezoidal plate, ornamented with two diagonal, short rows of eight long spinules on anterior surface. Cutting edge slightly concave, with 15 sharp teeth between produced rounded lateral corners.

Mandibula (fig. 9F) composed of coxa and small palp. Coxal gnathobase cutting edge with six apical teeth (ventralmost tooth strongest and complex, quadridentate), and two setae on dorsal corner (dorsalmost seta unipinnate, 1.7 times as long as other smooth seta; no spinules on anterior surface. Palp 1.4 times as wide as long, unornamented and armed only with two long and plumose seae of about same length and 1.5 times as long as entire mandibula (not figured completely).

Maxillula (fig. 11A) segmentation and armature similar to two previous species, just one small medial element (at base of proximal bipinnate element) missing. One smooth medial seta on coxobasis as long as bipinnate strong seta; other smooth seta 1.6 times as long.

Maxilla (fig. 10A) somewhat more slender than in previous two species, but segmentation and armature the same. Longest seta on distal endopodal segment (arrowed in fig. 10A) just half as long as longest seta on proximal endopodal segment.

Maxilliped (fig. 11B) segmentation same as in previous two species; 4segmented, composed of syncoxa, basis, and 2-segmented endopod. Ornamentation consisting of two rows of large spinules on basis (longitudinal row on posterior surface and transverse distal row on anterior surface), single spinule on fist endopodal segment, and several spinules on syncoxa, close to outer margin. Syncoxa without any armature (arrowed in fig. 11B) and thus maxillipedal armature formula: 0.2.1.2.

All swimming legs with 2-segmented and subequal exopods and endopods (figs. 10B, C, D, 11C). Swimming legs armature formula:

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



Fig. 10. Anzcyclops ballensis n. sp., holotype female. A, maxilla, anterior; B, first swimming leg, anterior; C, second exopodal segment of second swimming leg, anterior; D, third swimming leg, anterior. Scale 0.1 mm.



Fig. 11. Anzcyclops ballensis n. sp., A-E, holotype female; F-G, paratype female (0.488 mm);
H, allotype male. A, maxillula, anterodorsal; B, maxilliped, posterior; C, fourth swimming leg, anterior; D, fifth leg, ventral; E, sixth leg, lateral; F, proximal part of antennula without armature, ventral; G, fifth leg, ventrolateral; H, antennula, dorsal. Scales 0.1 mm.

Second exopodal segment spine formula 2.3.3.2 and setal formula 5.4.4.4. All setae on endopods and exopods slender and plumose; apical seta on exopod of first leg pinnate along outer margin, plumose along inner; no modified setae observed. All spines strong and bipinnate. Intercoxal sclerites of all swimming legs with concave distal margins and without any surface ornamentation. Praecoxae short and unornamented. All coxae ornamented with short distal row of minute spinules on both anterior and posterior surface and with large cuticular pore on anterior surface (arrowed in fig. 10D). Bases of second, third, and fourth legs with sharp process on inner distal corner and ornamented with long setules; additional transverse row of small, even minute spinules at base of outer seta and on first leg at base of inner spine. Exopods with long setules on inner margin and fourth leg also with minute spinules on outer margin; endopods with setules on outer margin; both rami additionally ornamented with minute spinules at base of each armature element, as well as with several at base of each segment. Outer seta on basis of first swimming leg bipinnate, reaching middle of second exopodal segment; those on other legs shorter and smooth. Inner spine on basis of first leg (fig. 10B) short and sout, reaching slightly beyond distal margin of first endopodal segment. Second (fig. 10C) and third (fig. 10C) swimming legs very similar, except second exopodal segment of third leg somewhat larger. Endopod of fourth swimming leg (fig. 11C) as wide as exopod; second endopodal segment about 1.5 times as long as wide; only apical spine (arrowed in fig. 11C) just half as long as segment and half as long as distal inner seta; outer seta missing (also arrowed in fig. 11C).

Fifth leg (figs. 9C, 11D) held ventrolaterally, composed of protopod completely fused to somite and free exopod. Protopodal seta small and slender but visible in dorsal view (fig. 9A, D), without prominent setophore, unisetulate along outer margin. Exopod quadriform and very small, about 0.8 times as long as wide, armed apically with outer bipinnate seta and inner smooth spine; seta about 1.9 times as long as adjacent spine, four times as long as segment and almost as long as protopodal seta.

Sixth leg (fig. 11E) similar to that in two previous species: small, semicircular cuticular plate, armed with just two short spines.

Allotype male. Total body length 472 μ m. Habitus (fig. 12A) much more slender than in female, prosome/urosome ratio about 1.7 and greatest width at posterior end of cephalothorax. Body length/width ratio 3.1; cephalothorax about 2.1 times as wide as genital somite. Cephalothorax 1.2 times as long as wide (dorsal view); representing 39% of total body length. Ornamentation of prosomites (fig. 12A) and colour similar to female. Hyaline fringe of fifth pedigerous somite (fig. 12B, C) smooth ventrally and serrated dorsally; somite ornamented as in female. Genital somite (fig. 12B, C) almost twice as wide as long, with serrated hyaline fringe



Fig. 12. Anzcyclops ballensis n. sp., allotype male. A, habitus, dorsal; B, urosome, ventral;C, urosome, dorsal; D, labrum, anterior; E, mandibula, posteroventral; F, sixth leg, ventrolateral. Scales 0.1 mm.

dorsally, ornamented with single pore dorsally; no spermatophores visible inside. Third urosomite with two ventral pores (arrowed in fig. 12B); next two urosomites without any ornamentation; all three with sharply serrated hyaline fringes (coarser dorsally and finer ventrally). Anal somite (fig. 12B, C) ornamented as in female; anal operculum somewhat narrower.

Caudal rami (fig. 12B, C) with ventral cuticular pore proximally; other ornamentation, as well as armature and proportions same as in female.

Antennula (fig. 11H) digeniculate, 15-segmented, with anvil-shaped cuticular structures on thirteenth and fourteenth elements (distal geniculation). Armature formula: 7 + 3ae.4.1.2 + ae.1.2.2.3 + ae.2.2.2.1 + ae.0.1.10 + ae. Slender smooth seta on twelfth segment missing, but additional seta on fifteenth segment present (both arrowed in fig. 11H), when compared to other male described (see fig. 4D, E); other armature elements very similar.

Antenna, labrum (fig. 12D), mandibula (fig. 12E), maxillula, maxilla, maxilliped, swimming legs, and fifth leg similar to those of female.

Sixth leg (fig. 12F) large, unornamented cuticular plate, armed with inner spine and outer seta on outer distal corner; seta bipinnate and 1.6 times as long as bipinnate spine.

Etymology. — The species is named after the type locality, the mining settlement Balla Balla in Western Australia. The name is an adjective for place, made with the Latin suffix "-ensis".

Variability. — Body length of two examined males is 472 μ m and 468 μ m (470 μ m average), while that of females ranges from 461 μ m to 500 μ m (485 μ m average; n = 10). One paratype female has the ancestral segmentation of the second and third antennular segments marked by a partial transverse surface suture ventrocaudally (arrowed on fig. 11F) on one antennula, as well as a more slender exopod of the fifth leg (fig. 11G). Scanning electron microscope photographs of several paratype females (fig. 17A, B, C, E, F) and one paratype male (figs. 17D, 18A, B) show some of the characters in more detail, which are very similar to those in the holotype and allotype.

Remarks. — Anzcyclops ballensis n. sp. is the only member of its genus with a plesiomorphic cyclopiform habitus (figs. 8A, 9A, 17A), an apomorphic 10-segmented antennula (fig. 8A), and a unique armature of the mandibular palp (fig. 9F), which has only two long setae. It differs additionally from the other three Australian species described here by a completely reduced armature on the first maxillipedal segment (figs. 11B, 18A), which is an apomorphic character that it shares with the New Zealand A. silvestris (Harding, 1958) n. comb. It is interesting to note that both species also have an apomorphic armature of the second endopodal segment of the fourth leg (with the outer seta reduced; arrowed

in fig. 11C) and a plesiomorphic armature of the ancestral seventh antennular segment (sixth in *A. ballensis*; arrowed in fig. 8D), which may suggest a close phylogenetic relationship. However, the two species differ in the armature of the mandibula and exopod of the first leg, in addition to those unique characters mentioned above.

Anzcyclops euryantennula n. sp.

(figs. 13-15)

Type locality. — Australia, Queensland, Bowen Basin, Clermont, bore, sample #4570, $22^{\circ}42'$ 50"S 146°36'20"E; water temperature 25.5°C, pH 7.01, electric conductivity 1524 pS/cm, dissolved oxygen 6.5 mg/L; interstitial water at 4.82 m (fig. 18F).

Material examined. — Holotype female dissected on one slide (WAM C37468); one paratype female dissected on one slide (WAM C37469); both collected at type locality; leg. G. Bennison, 3 April 2008.

Description. — Holotype female. Total body length 358 μ m. Habitus (fig. 13A, C) robust, wide and strongly dorsoventrally compressed, with prosome/urosome ratio 1.7 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.3 (dorsal view); cephalothorax twice as wide as genital double-somite. Free pedigerous somites without particular expansions laterally. Preserved specimen colourless. Nauplius eye not visible. Rostrum well developed, membranous, broadly rounded and furnished with two large sensilla.

Cephalothorax (fig. 13A, B, C, D) slightly longer than greatest width (dorsal view); representing 44% of total body length. Surface of cephalothoracic shield and pleurotergites of free pedigerous somites with pattern of large sensilla as figured (fig. 13A, B, D); integument with irregular pattern of pits and striae (mostly internal), creating characteristic reticulum; this present more or less on all somites, but absent from all appendages. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite (fig. 13A) ornamented just with two large dorsal sensilla; hyaline fringe smooth.

Genital double-somite (fig. 13A, C, F) large, trapezoidal (dorsal or ventral view), with inflated anterior part but without deep lateral recesses at level of sixth legs, 1.3 times as wide as long (dorsal view), also ornamented with pits and striae but without sensilla or cuticular pores; hyaline fringe of genital double-somite, as well as of two subsequent urosomites, narrow and smooth. Copulatory pore small, ovoid, situated at 1/3 of somite length; copulatory duct narrow, siphon-shaped, well sclerotized. Seminal receptacle ellipsoid, with equally large anterior and posterior expansion, representing 56% of double-somite's length; oviducts broad and well sclerotized. Ovipores situated dorsolaterally, covered with reduced sixth legs. Third and fourth urosomites short, third 1.4 times as long as fourth), both without any pores or sensilla, ornamented just with cuticular pits. Anal somite



Fig. 13. *Anzcyclops euryantennula* n. sp., holotype female. A, habitus, dorsal; B, detail of cuticular ornamentation of cephalothoracic shield and first two free pedigerous somites, dorsal; C, habitus, lateral; D, cuticular ornamentation of cephalothoracic shield and pleural areas of three free pedigerous somites, detail; E, anal somite and caudal rami, dorsal; F, urosome, ventral; G, anal somite and caudal rami, lateral. Scales 0.1 mm.

ornamented with 2 large sensilla dorsally and transverse row of minute spinules along posterior margin ventrally and laterally (fig. 13E, F, G). Anal sinus smooth. Anal operculum large, linguiform, produced posteriorly slightly beyond somite limit, smooth, with convex caudal margin, representing 51% of anal somite width.

Caudal rami (fig. 13A, E, F, G) cylindrical, parallel, very closely spaced (space between them less than 1/5 or ramus width), and 1.7 times as long as wide; ornamented with one pore on tip of protuberance on distal margin ventrally (between two terminal setae) and several spinules at base of two lateral setae. Dorsal seta about 1.7 times as long as ramus, inserted at 3/4 of ramus length, biarticulate at base and plumose at distal part. Anterolateral seta arising dorsolaterally at middle, 0.2 times as long as dorsal seta. Posterolateral seta stout, spiniform, 0.7 times as long as ramus, bipinnate. Terminal accessory seta also bipinnate but more slender, 0.85 times as long as posterolateral seta. Terminal setae without breaking planes and plumose; inner (principal) terminal seta about 1.3 times as long as outer seta and 0.44 times as long as body length.

Antennula (figs. 13A, C, 14A) 11-segmented, very short and unusually broad, hardly reaching 3/5 of cephalothoracic shield in length, unornamented, with armature formula: 7.4.5.2.1.2.2.2 + ae.2.3.7 + ae. Two additional setae (arrowed in fig. 14A) present on second segment, which are missing in the other species described here. No setae biarticulating on basal part and only seven setae pinnate; only seta on fifth segment spiniform and very short, all others slender; one apical seta on eleventh segment fused basally with aesthetasc. Length ratio of antennular segments, from proximal end and along caudal margins, 1:0.6:0.8:0.4:0.3:0.4:1.1:0.9:0.6:0.7:1.2.

Antenna (fig. 14B) segmentation and armature same as in the other three species, except that original segmentation of coxa is not visible even as surface sutures. Coxobasis and first endopodal segment without any ornamentation; second and third endopodal segments with few spinules along lateral margin distally. Length ratio of segments, 1:0.6:0.5:0.6.

Labrum (fig. 14C) relatively small, trapezoidal plate, ornamented with two diagonal, short rows of eight long spinules on anterior surface. Cutting edge almost straight, with 13 sharp teeth between produced rounded lateral corners.

Mandibula (fig. 14D) composed of coxa and small palp. Coxal gnathobase cutting edge with five spinules on anterior surface, six apical teeth (ventralmost tooth strongest and complex, tridentate), and two setae on dorsal corner (dorsalmost seta unipinnate, 1.6 times as long as adjacent smooth seta, and 1.3 times as long as shortest palpal seta). Palp not well chitinized, almost semicircular, nearly 1.4 times as wide as long, unornamented but armed with three apical slender setae: two plumose and one smooth; plumose setae (arrowed in fig. 14D) of about same



Fig. 14. *Anzcyclops euryantennula* n. sp., holotype female. A, antennula, dorsal; B, antenna, frontal; C, labrum, anterior; D, mandibula, posterior; E, maxillula, posterior; F, maxilla, posterior; G, maxilliped, anterior. Scale 0.1 mm.

length, 2.5 times as long as adjacent smooth seta but only 0.4 times as long as entire mandibula.

Maxillula (fig. 14E) segmentation as in the other three species; armature same as in *A. ballensis* n. sp., but with small, smooth medial element at base of proximal plumose element missing (arrowed in fig. 14E). Two endopodal and two medial coxobasal setae (one strong and spiniform, one slender) bipinnate; exopodal seta and third medial coxobasal seta smooth. Spiniform medial coxobasal seta 1.1 times as long as adjacent smooth seta and 0.7 times as long as adjacent pinnate seta.

Maxilla (fig. 14F) segmentation and armature formula same as in the other three species; no visible surface ornamentation. Longest seta on distal endopodal segment 0.7 times as long as longest seta on proximal endopodal segment.

Maxilliped (fig. 14G) segmented as in the other three species. Ornamentation consisting of single transverse distal row of spinules on anterior surface of basis. Armature formula: 2.2.1.2.

All swimming legs short, with 2-segmented exopods and endopods (fig. 15A, B, C, D, E). Endopod of first leg slightly longer than exopod, those of second and third leg slightly shorter than exopods, while endopod of fourth leg 0.75 times as long as exopod. Armature formula:

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

Second exopodal segment spine formula 2.3.2.2 and setal formula 4.4.4.4. Armature most reduced when compared to other species described here, with following elements missing: proximal seta on second exopodal segment of first leg (arrowed in fig. 15A), proximal spine on second exopodal segment of third leg (arrowed in fig. 15D), and one inner seta on second endopodal segment of fourth leg (arrowed in fig. 15E). All setae on endopods and exopods slender and plumose; apical seta on exopod of first leg pinnate along outer margin, plumose along inner; no modified setae observed. All spines strong and bipinnate. Intercoxal sclerite of all swimming legs with concave distal margins and without any surface ornamentation. Praecoxae and coxae without surface ornamentation, except short distal row of minute spinules on anterior surface of third leg coxa. Bases with round inner distal corners, ornamented with long setules. Exopods with long setules on inner margin; second exopodal segment of third leg additionally with spinules on outer margin; endopods with setules on outer margin; both rami additionally ornamented with minute spinules (sometimes too small to be figured) at base of each armature element, as well as with several at base of each segment. Outer seta on basis of first swimming leg very long, bipinnate at distal end; those on other



Fig. 15. *Anzcyclops euryantennula* n. sp., holotype female. A, first swimming leg, anterior; B, second endopodal segment of second swimming leg, anterior; C, second exopodal segment of second swimming leg, anterior; E, fourth swimming leg, anterior; F, fifth leg, ventral. Scale 0.1 mm.

legs shorter and unipinnate. Inner spine on basis of first leg (fig. 15A) curved inwards, sharp, reaching 1/4 of second endopodal segment in length. Second (fig. 15B, C) and third (fig. 15D) swimming legs similar, except for proximal exopodal spine on third leg absent and longer apical endopodal spine on second leg absent. Endopod of fourth swimming leg (fig. 15E) narrower than exopod; second endopodal segment about 1.4 times as long as wide; only apical spine 0.8 times as long as segment and half as long as distal inner seta.

Fifth leg (figs. 14F, 15F) held ventrolaterally, composed as in the other three species. Protopodal seta strong, visible in dorsal view (fig. 13A), arising from visible setophore, bipinnate distally. Exopod quadriform, about 1.2 times as long as wide, armed apically with outer bipinnate seta and inner slender spine (also bipinnate, but this hardly visible); seta about 1.4 times as long as adjacent spine, 2.3 times as long as segment and 0.6 times as long as protopodal seta.

Sixth leg (fig. 13C) same as in the other three species, armed with two short spines; inner spine fused to plate, outer articulated basally.

Male unknown.

Etymology. — The species name is composed from the Greek adjective "eurys" (meaning: broad, wide) and the Latin name for the first crustacean appendage "antennula". It refers to the unusually broad antennula of the new species, and it should be treated as a noun in apposition.

Variability. — Only two females were collected and studied. Their body lengths are 358 μ m and 364 μ m (361 μ m average). No other form of variability was observed.

Remarks. — Anzcyclops euryantennula n. sp. differs from its four congeners by the following four autapomorphic characters: unusually wide antennula (fig. 14A), proximal seta on the second exopodal segment of the first leg absent (fig. 15A), proximal spine on the second exopodal segment of the third leg absent (fig. 15D), and proximal inner seta on the second endopodal segment of the fourth leg absent (fig. 15E). It additionally differs from all species by the plesiomorphic armature of the second antennular segment, which bears four setae (two extra setae arrowed in fig. 14A). The unusual armature of the mandibula (fig. 14) is similar to that of the Western Australian A. belli n. sp. (see fig. 5F, G) and the two species also share a very long dorsal caudal seta, although that of A. belli is somewhat longer. These two characters may signify a closer phylogenetic relationship of the two congeners, in addition to their dorsoventrally compressed habitus and reticulated integument. The last character is also shared with another Western Australian species, A. yarriensis n. sp., and the three species cluster together on our cladogram (fig. 19). Anzcyclops euryantennula can additionally be distinguished from each congener by a number of small differences, most of which have already been emphasized in the remarks section for each new species.



Fig. 16. SEM photographs of *Anzcyclops yarriensis* n. sp. A, female habitus, dorsal; B, female anal somite and caudal rami, dorsal; C, female tergite of third pedigerous somite; D, female maxillula, ventral; E, male first swimming leg, anterior; F, male antennula, segments 10-13, anterior.

Genus Dussartcyclops n. gen.

Diagnosis. — Very small cyclopoids, with total body lengths from 385 to 493 μ m in females and from 359 to 416 μ m in males. Habitus vermiform (harpacticoidal), but not dorsoventrally compressed, with prosome/urosome ratio from 1.8 to 1.9 in females and 1.5 in males and greatest width from middle of cephalothorax to second pedigerous somite. Body length/width ratio in dorsal view from 3.1 to 3.5 in females and 3.7 in males; cephalothorax from 1.5 to 1.6 times as wide as genital double-somite in females and about 1.5 times as wide as free genital somite in males. Surface of cephalothoracic shield and pleurotergites of free pedigerous somites ornamented with large sensilla and cuticular pores;



Fig. 17. SEM photographs of *Anzcyclops ballensis* n. sp. A, female habitus, dorsal; B, female anal somite and caudal rami, dorsal; C, female tergites of second and third pedigerous somites; D, male maxillula, ventral; E, female first swimming leg, anterior; F, female left fifth leg, ventral.

integument otherwise smooth. Hyaline fringes of all somites narrow and smooth. Genital double-somite in female large, with somewhat inflated anterior part but without lateral recesses, from 1.2 to 1.33 times as wide as long (dorsal view). Anal operculum large, linguiform, produced posteriorly beyond somite limit, and smooth. Caudal rami almost cylindrical (with somewhat narrower anterior part), parallel, close, and from 1.6 to 1.8 times as long as wide; armed with six setae; ornamented with several spinules at base of two lateral setae and in one species also at base of dorsal seta; terminal setae without breaking planes. Antennula in female 11-segmented, with only five setae on third segment and one seta on fifth. Antennula in male digeniculate, 15-segmented. Antenna 4-segmented,



Fig. 18. A-B, SEM photographs of *Anzcyclops ballensis* n. sp.; C-F, photographs of the type localities of four new species. A, male maxilla and maxilliped, ventral; B, male labrum and cutting edge of mandibular coxal gnathobase, ventral; C, Callawa Ridge, the type locality of *Anzcyclops yarriensis* n. sp.; D, Quarry 8, the type locality of *A. belli* n. sp.; E, plains near Balla Balla, with volcanic Depuch Island in the background, type locality of *A. ballensis* n. sp.; F, area near Wolfang in Clermont, type locality of *A. euryantennula* n. sp. This figure is published in colour in the online edition of this journal, which can be accessed via http://www.brill.nl/cr

without exopodal seta, and with armature formula 1.1.5.7. Labrum trapezoidal, without ornamentation on anterior surface. Mandibular palp reduced to small knob with single smooth seta, which is shorter than mandibula. Maxillula composed of praecoxa and 2-segmented palp; praecoxal arthrite bearing four apical and six medial elements; palpal coxobasis with one exopodal and three medial setae, endopod with three setae. Maxilla 5-segmented, with armature formula 2.3.2.2.3. Maxilliped 4-segmented, with armature formula 1.2(1).1.2. All swimming legs relatively short, with 2-segmented exopods and endopods, although endopod of

fourth leg sometimes fused in females; endopods only slightly shorter than exopods on all legs and endopod of fourth leg not markedly inflated; first exopodal segment without inner seta on all legs and second exopodal segment spine formula 2.2.2.2; second endopodal segment of first leg with three inner setae; second exopodal segments with three or four setae; second endopodal segment of fourth leg from 1.3 to 1.5 times as long as wide, armed with single apical spine, two inner setae, and with or without outer seta. Intercoxal sclerite of all swimming legs with concave distal margins and without any surface ornamentation; all coxae with inner seta; basis of first leg with or without inner spine. Basis and endopod of fourth leg without any special chitinous structures. Fifth leg held almost laterally, composed of protopod completely fused to somite and free or fused exopod; protopodal seta slender and short but visible in dorsal view; exopod small and quadriform (when free), armed apically with two slender setae of similar length, which are not much shorter than protopodal seta. Sixth leg with two elements.

Etymology. — The generic name is dedicated to the late Dr Bernard Dussart, in memory of his enormous contribution to our knowledge of freshwater copepods. His surname is prefixed to the existing generic name *Cyclops*. Gender masculine.

Type species. — Goniocyclops uniarticulatus Karanovic, 2004.

Other species. — Goniocyclops mortoni Karanovic, 2004; Allocyclops (Psammocyclops) consensus Karanovic, 2003.

Remarks. — The new genus can easily be distinguished from all other genera from the Metacyclops complex by the spine formula of its swimming legs (2.2.2.2) and the armature of the fifth leg (two equally long setae on the exopod). In addition to the three species currently included here, we have at least two other closely related members that await publication (T. Karanovic, unpubl.), and they also share the same reduced armature of the antennula, antenna, mandibula, and maxilliped, as well as the vermiform habitus, linguiform anal operculum, and short caudal rami. The only other species from the Metacyclops complex with a spine formula 2.2.2.2 is the Chinese Psammophilocyclops bispinosus Shen & Tai, 1964 (see also Shen et al., 1979), but this species is only remotely related to the three Australian Dussartcyclops n. gen. members. As mentioned in the remarks section for the genus Anzcyclops n. gen. (see above), P. bispinosus is only partly described but it clusters well with another Chinese species. Both differ from Dussartcyclops in their cyclopiform habitus, much longer caudal rami, very short anal operculum, and more plesiomorphic armature of the exopods of the swimming legs. Thus, we believe the same spine formula originated convergently in this case. The same spine formula can also be found in two Indian small cyclopoids: Haplocyclops (Kiefercyclops) fiersi Karanovic & Ranga Reddy, 2005 and Rybocyclops dussarti Ranga Reddy & Defaye, 2008 (see Karanovic & Ranga Reddy, 2005; Ranga Reddy & Defaye, 2008). However, they both belong to the Bryocyclops Kiefer, 1927

complex of genera and have the fifth leg completely fused to the somite, as well as some other important differences. For example, the genus Haplocyclops Kiefer, 1952 has the ovipores situated in the posterior half of the genital double-somite, as well as an antennula without lateral seta on the ultimate segment, and caudal rami with the anterolateral seta inserted in the proximal half (see da Rocha et al., 1998; Fiers, 2002; Karanovic & Ranga Reddy, 2005). The Indian representative, which belongs to a separate subgenus Kiefercyclops Karanovic & Ranga Reddy, 2005, is also the most reduced free-living cyclopoid and it is not surprising that the same spine formula may be a consequence of convergent evolution. The other Indian species may be somewhat more closely related to Dussartcyclops, but it has a number of significant differences: more cyclopiform habitus, ovoid genital double-somite, completely reduced armature on the mandibular palp, two setae on the first maxillipedal segment, coxal setae on the first and fourth legs absent, more apomorphic armature of the endopods of the swimming legs, and more plesiomorphic armature of the exopods of the swimming legs. We think that this combination of apomorphic and plesiomorphic features is enough to justify a separate generic status. Rybocyclops dussarti is more closely related to the Pilbaran Dussartcyclops consensus (Karanovic, 2003) n. comb. than to the other two species (both from the Murchison region), which can be seen in the reduced inner basal spine of the first leg and basally fused exopod of the fifth leg. That is why we decided to erect a separate subgenus for this species (see below).

Subgenus Dussartcyclops n. subgen.

Diagnosis. — Caudal rami without spinules at base of dorsal seta. Basis of first swimming leg with inner spine. Second endopodal segment of first leg with two inner setae. Second endopodal segment of fourth leg without outer seta. Exopod of fifth leg small but distinct segment.

Type species. — Goniocyclops uniarticulatus Karanovic, 2004.

Other species. — Goniocyclops mortoni Karanovic, 2004.

Remarks. — The nominotypical subgenus at this point contains only two species from the Western Australian Murchison region, both described by Karanovic (2004a), but as we mentioned above, there are at least two other closely related new species from this region that await publication (T. Karanovic, unpubl.). Also, *Dussartcyclops* (*D.*) *uniarticulatus* (Karanovic, 2004) n. comb. and *Dussartcyclops* (*D.*) *mortoni* (Karanovic, 2004) n. comb. have been collected subsequently from several additional localities, which will be examined carefully and presented together with the description of the new species.

Subgenus Barrowcyclops n. subgen.

Diagnosis. — Caudal rami with small spinules at base of dorsal seta. Basis of first swimming leg without inner spine. Second endopodal segment of first leg with three inner setae. Second endopodal segment of fourth leg with outer seta. Exopod of fifth leg fused to somite basally, forming with protopod a simple cuticular plate with three subequal smooth and slender setae.

Etymology. — The subgeneric name is composed of the name of the island where the type species was collected (Barrow Island) and the existing generic name *Cyclops*. Gender masculine.

Type and only species. — *Allocyclops (Psammocyclops) consensus* Karanovic, 2003.

Remarks. — The new subgenus is so far known only from one female described by Karanovic (2003) from Barrow Island in the Western Australian Pilbara region. Unfortunately, an extensive survey of this region failed to produce any more specimens of this interesting species (Karanovic, 2006). It was originally assigned to the genus Allocyclops Kiefer, 1932 mostly based on the general structure of the fifth leg, despite numerous differences in the swimming legs armature. Unfortunately, most Allocyclops species are incompletely described, and cannot be included in the cladistic analysis presented here with any meaningful outcome. We describe this species in a separate subgenus rather than a genus, mostly because of the lack of males. Hopefully, future sampling in the Pilbara region will result in more specimens and the status of *Dussartcyclops* (Barrowcyclops) consensus (Karanovic, 2003) n. comb. may then be re-examined and discussed more confidently. Its relationship with the Indian Rybocyclops dussarti Ranga Reddy & Defaye, 2008 (see above), as well as with some species of the genus Allocyclops is particularly intriguing. However, it seems very logical that its closest relatives are the two Dussartcyclops n. gen. species from the neighbouring Murchison region, as they share the greatest number of apomorphic morphological characters.

Genus Pescecyclops n. gen.

Diagnosis. — Relatively large cyclopoids, with body lengths from 680 to 1100 μ m in females and from 651 to 839 μ m in males. Habitus robust, cyclopifrom (except in *Pescecyclops pilbaricus* (Karanovic, 2004) n. comb., where fusiform), with prosome/urosome ratio from 1.4 to 1.5 in females and from 1.2 to 1.7 in males and greatest width from middle of cephalothorax to second pedigerous somite, but mostly at posterior end of cephalothorax. Body length/width ratio in dorsal view from 2.8 to 3.25 in females and from 2.8 to 3.7 in males; cephalothorax from 2.1 to 2.6 times as wide as genital double-somite in females and from 1.9

to 2.4 times as wide as free genital somite in males. Surface of cephalothoracic shield and pleurotergites of free pedigerous somites ornamented with large sensilla and cuticular pores; integument with or without cuticular pits. Hyaline fringes of prosomites narrow and smooth; those of urosomites very finely serrated. Genital double-somite in female relatively small, with somewhat inflated anterior part but without lateral recesses, from 0.9 to 1.2 times as wide as long (dorsal view). Anal operculum not large but produced to posterior margin of anal somite, with almost straight and always smooth posterior margin. Caudal rami cylindrical, almost parallel, closely spaced, and from 3.25 to 6.2 times as long as wide (except in P. pilbaricus, where 2.6 times); armed with six setae; ornamented with several spinules at base of two lateral setae; terminal setae with or without breaking planes. Antennula in female 11-segmented, with six setae on third segment and two setae on fifth. Antennula in male digeniculate, 15-segmented. Antenna 4-segmented, with or without exopodal seta, and with armature formula 3(2).1.9(6).7. Labrum small and trapezoidal, ornamented with two rows or bunches of long spinules on anterior surface. Mandibula composed of coxa and small palp; palp armed with two long and one short setae. Maxillula composed of praecoxa and 2-segmented palp, although endopod sometimes fused basally to coxobasis; praecoxal arthrite bearing four apical and six or seven medial elements; palpal coxobasis with one exopodal and three medial setae, endopod with three setae. Maxilla 5-segmented, with armature formula 2.3.2.2.3. Maxilliped 4-segmented, with armature formula 3.2.1.3 (except in P. kimberlevi (Karanovic, 2004) n. comb., where 2.2.1.2). All swimming legs relatively short, with 2-segmented exopods and endopods; endopods only slightly shorter than exopods on all legs and endopod of fourth leg not inflated; armature formula the same in all species with first exopodal segment without inner seta on fourth leg but with seta on others, second exopodal segment with three spines and five setae (spine formula 3.3.3.3), second endopodal segments of all legs with outer seta and three inner setae on first leg, four on second and third leg, and three on fourth leg; second endopodal segment of fourth leg from 1.6 to 2.4 times as long as wide, armed apically with single robust spine. Intercoxal sclerite of all swimming legs with concave distal margins and without any surface ornamentation; all coxae with inner seta and basis of first leg with inner spine. Basis and endopod of fourth leg without any special chitinous structures. Fifth leg held ventrolaterally, composed of protopod completely fused to somite and free exopod; protopodal seta strong, visible in dorsal view; exopod relatively large, quadriform, longer than wide, armed with subapical spine on inner side and long apical seta on outer side; spine significantly smaller than seta. Sixth leg with three elements.

Etymology. — The genus name is dedicated to Prof. Giuseppe Lucio Pesce, University of L'Aquila, for his significant contribution to our knowledge of freshwater copepods and especially those from Australia. His surname is prefixed to the existing generic name *Cyclops*. Gender masculine.

Type species. — Metacyclops laurentiisae Karanovic, 2004.

Other species. — *Metacyclops pilanus* Karanovic, 2004; *Cyclops arnaudi* G. O. Sars, 1908; *Cyclops monacanthus* Kiefer, 1928; *Metacyclops kimberleyi* Karanovic, 2004; *Metacyclops pilbaricus* Karanovic, 2004.

Remarks. - These six species from Australia and New Zealand share the same fifth leg shape and armature with members of the cosmopolitan genus Metacyclops Kiefer, 1927, but can be distinguished from it by the presence of three spines on the distal exopodal segment of all swimming legs. This synapmorphy they also share with the African Metacyclops trispinosus Dumont, 1981 and the Indian M. margaretae (Lindberg, 1938), which was recognized by Karanovic (2004a), who also termed this small assemblage of species the "trispinosus"-group. Unfortunately, the Indian and African representatives are only partly described (Lindberg, 1938; Dumont, 1981) and many characters cannot be compared with other members and are hence missing in our matrix (see above). Despite this, it seems that the two species are morphologically quite similar and they form a separate clade on our cladogram. This is mostly due to the unusual apical armature of the fourth leg endopod, which consists of one huge and one minute spine, but the two species also have a similar fifth leg exopod (with a minute inner spine) and caudal rami (with the outer terminal seta only slightly shorter than the inner terminal one). However, incomplete descriptions prevent us from formally recognizing this clade and we leave these two species in the genus Metacyclops, pending their full redescription. On the other hand, we cannot leave the Australian and New Zealand species in this genus anymore, if we do not want to create polyphyletic taxa. Namely, the genus Meridiecyclops Fiers, 2001 separates these species from the rest of Metacyclops (see fig. 19) and the only other alternative would be to return the two members of the former genus back into a broader definition of the latter one. This would be taxonomically possible but phylogenetically quite wrong, as the genus Meridiecyclops can be distinguished from all other species studied here by two synapomophies that concern novel structures on the female fourth leg and a sexually dimorphic maxilla (Fiers, 2001). That is why we decided to erect a new genus to accommodate these five species.

The genus *Pescecyclops* n. gen. can be distinguished from all other genera of the *Metacyclops* complex by a combination of plesiomorphic and apomorphic characters. It differs from the genus *Hesperocyclops* Herbst, 1984 in the shape of the fifth leg and the spine formula of the swimming legs (3.4.3.3 or rarely 3.4.4.3 in *Hesperocyclops*), but the latter is also very well defined by its inflated endopod of the fourth swimming leg. The differences between *Pescecyclops* and *Pilbaracyclops* Karanovic, 2006 are discussed below (see the remarks section

for the latter genus) and all other species studied here are only remotely related to the members of the former genus. The monospecific South American genus Fimbricyclops Reid, 1993 also has the spine formula of the swimming legs 3.3.3.3 and only one apical spine on the fourth leg endopod (Reid, 1993), but this genus has a completely different fifth leg, with the exopod reduced to a barely visible segment, armed with an enormous inner spine and a shorter outer seta. Other differences include the shape of the caudal rami, reductions in the armature of the antennula, antenna, and mouthparts, but in addition to this Fimbricyclops has a unique and elaborate ornamentation of the last two prosomites and the first two (or three in males) urosomites. The genus Menzeliella Lindberg, 1954 was erected for a single, incompletely described South American species (see Chappuis, 1917; Kiefer, 1928a, 1937; Lindberg, 1954) and is still considered a valid genus (Dussart & Defaye, 2006). However, it is increasingly difficult to maintain this without a complete redescription of the type species, because many characters cannot be compared. Despite that, it is quite clear that the genus is only a distant relative of *Pescecvclops*, as it has a more plesiomorphic armature of the swimming legs (spine formula 3.4.4.3; two apical spines on the fourth leg endopod) in addition to a different shape of the fifth leg and caudal rami. Menzeliella can be distinguished from all other members of the Metacyclops complex by a transverse row of spinules at the anterior part of the caudal rami, in addition to a row of spinules at the base of the dorsal caudal seta (the latter character it shares only with the South American genus Muscocyclops Kiefer, 1937 and the above described Western Australian subgenus Barrowcyclops n. subgen.

The only New Zealand representative of the genus Pescecyclops, P. monacanthus (Kiefer, 1928) n. comb., was only partly described, and its affinities with other species could not be discussed. Kiefer (1928b) noted that the species is similar to the Australian P. arnaudi (G. O. Sars, 1908) n. comb., the only other member of this group known at that time. The latter species was recently redescribed by Tang & Knott (2009) from southwestern Western Australia. As noted by Karanovic (2004b), the five Australian species can be divided into two groups based of the presence of integumental cuticular pits and the armature of the antenna (presence of exopodal seta, and nine vs. six setae on the second endopodal segment). In the first group are the two subterranean species from the Western Australian Murchison region (P. laurentiisae (Karanovic, 2004) n. comb. and P. pilanus (Karanovic, 2004) n. comb.) and the above mentioned P. arnaudi, which is distributed in surface waters of the southern parts of Western Australia and South Australia, as well as in Victoria and Tasmania (see Sars, 1908; Tang & Knott, 2009). The other group contains two probably subterranean species, described by Karanovic (2004b) from the Kimberley and Pilbara regions of Western Australia, respectively: P. kimberleyi

(Karanovic, 2004) n. comb. and *P. pilbaricus* (Karanovic, 2004) n. comb. However, due to the fact that the latter species is known only from females and because the New Zealand representative is only partly described, we refrain from formally recognizing and naming these two groups. A key to species that contains all members of the newly erected genus *Pescecyclops* was provided both by Karanovic (2004b) and Tang & Knott (2009), and will not be repeated here.

Genus Pilbaracyclops Karanovic, 2006 n. stat.

Type species. — *Fierscyclops (Pilbaracyclops) supersensus* Karanovic, 2006. Other species. — *Fierscyclops (Pilbaracyclops) frustratio* Karanovic, 2006.

Remarks. — This genus was originally erected by Karanovic (2006) as a subgenus of the genus Fierscyclops Karanovic, 2004 to accommodate two new species from the Western Australian Pilbara region. However, after the phylogenetic analysis done in this paper (see the discussion section below), it is quite clear that Pilbaracyclops supersensus (Karanovic, 2006) n. comb. and P. frustratio (Karanovic, 2006) n. comb. are only remotely related to the monospecific genus Fierscyclops Karanovic, 2004, and in any case no more than to the genera Hesperocyclops Herbst, 1984, Pescecyclops n. gen., or even Metacyclops Kiefer, 1927 (fig. 19). Although the two species share a similar general shape of the fifth leg with Fierscyclops fiersi (De Laurentiis, Pesce & Humphreys, 2001), described originally in the genus Metacyclops from the Western Australian Murchison region (De Laurentiis et al., 2001), they also differ from this species by a number of important synapomorphies, including the shape of the caudal rami, a reduced armature of the antennula, antenna, maxilliped, and all swimming legs, as well as the inner apical element on the fourth leg endopod transformed from a spine into a slender and long seta. The last character is shared only with the outgroup in this analysis, the nearly cosmopolitan Apocyclops dengizicus (Lepeschkin, 1900), and it is quite plausible that the genus Pilbaracyclops Karanovic, 2006 originated from an Apocyclops Lindberg, 1942 like ancestor. This is probably also true for the closely related South American genus Hesperocyclops, where even the shape of the fifth leg can be traced back to Apocyclops origins. The former can be distinguished easily from Pilbaracyclops by a more plesiomorphic spine formula, fifth leg shape, and completely reduced inner apical element on the fourth leg endopod. The genera Pescecyclops and Meridiecyclops Fiers, 2001 can also be distinguished easily from Pilbaracyclops by the armature of the fourth leg endopod. Pescecyclops additionally differs in the shape of the fifth leg, which, on the other hand, is quite similar in the other two genera. However, Meridiecyclops can be distinguished from Pilbaracyclops (and all other species studied here) by two novel structures on the female fourth leg and also a sexually dimorphic maxilla (see Fiers, 2001).

DISCUSSION

This is the first ever attempt at a phylogenetic analysis of small cyclopids, in this case a group of closely related genera from the Metacyclops Kiefer, 1927 complex, defined in the introduction as those Cyclopinae with ovipores situated in the anterior half of the genital double-somite, 11- or 10-segmented antennula in the female, two-segmented exopods and endopods of all swimming legs without sexually dimorphic armature elements, and the fifth leg composed of a protopod completely fused to the somite (except outer protopodal seta) and a free exopod, armed apically with two armature elements. Our main objective was to analyse all Australian representatives from this complex, but we also included all those genera from around the world that we perceived as relatively closely related to our four new species. The cladistic analysis was performed at the species level, because it is more likely to represent true evolutionary relationships than one based on genera and a few characters (Walker-Smith & Poore, 2001). It was not our intention here to revise the cosmopolitan genus Metacyclops, which many authors believe is a polyphyletic taxon in urgent need of revision (Fiers, 2001; Karanovic, 2004a, b), because that would require prior redescriptions of many taxa that are currently known only after a very limited set of characters. The only phylogenetic analysis performed here is a cladistic one, using Rachet Island search for the most parsimonious tree in the NONA computer program (Goloboff, 1999), and it should be considered quite preliminary.

Unfortunately, because of incomplete descriptions of some species, the choice of morphological characters was limited, but nevertheless we managed to include in our analysis no less than 78 characters for the 43 species studied (table I). A great proportion of those (28 characters) are related to the armature of the swimming legs, because it was very easy to recognize homologous armature elements and to code their presence/absence in this group, with almost no reported variability at the species level. However, we made a great effort to code characters related to the armature of the cephalothoracic appendages, habitus shape, or somite ornamentation, despite the fact that they are unknown for some species analysed here. While it is not so easy to define characters related to the shape of the general habitus, it is quite clear that some species from well-defined groups have an easily recognizable habitus. For example, all three species of the South American genus Muscocyclops Kiefer, 1937 have a very similar and easily recognizable habitus, which they only share with one other monospecific genus, but it would be very difficult to define this numerically. Certainly, a habitus like this is a consequence of the characteristic, ovoid genital double-somite, the very short caudal rami, the proportions of the cephalothorax, prosomites, and urosomites, but rather than use this complicated terminology we just called this type of habitus "musciform".

As it is not clear whether these are single characters, combinations of multiple characters, or series of related characters, we decided to split them as much as possible and in this way test every option. We also decided to pay more attention to the characters related to the shape and size of the caudal rami and the anal operculum, which were not previously considered important at the generic level. As Pesce (1996), Ferrari (1998), Fiers (2001), Karanovic (2004a, 2005, 2006) and others have pointed out, the freshwater cyclopid genera have been defined in the past mostly using the general shape of the fifth leg, and hardly any other characters; and species were described incompletely, which resulted in a number of taxa for which monophyly could not be tested without complete redescription of most of its members.

The preliminary analysis here reported resulted in 19 equally parsimonious tree, all with a length of 193 steps, a consistency index (Ci) of 40 and a retention index (Ri) of 81, which is quite good considering the number of species with incomplete descriptions analysed (see table I). Presented below is tree number 19 (fig. 19), with support for each branch shown as a percentage of its occurrence among the other 18 trees. Amazingly, only six branches are not fully supported and just one of these is relevant to the taxa revised taxonomically in this paper. This, and the fact that almost all clades have a support from the zoogeographical distribution patterns already recognized in freshwater copepods (Karanovic, 2004a, 2006, 2008) gives us confidence that the results of this cladistic analysis will not change much as more evidence becomes available in a heuristic search for the ultimate, historically correct, cladogram, although it will be interesting to contrast them with future molecular data. All clades described as new genera in this paper are supported by what we perceive to be a combination of apomorphic and plesiomorphic characters. The values obtained of the Ci and Ri indices indicate a relatively high proportion of convergencies (homoplastic changes). This is obviously a result of the character choice, but it also reflects a general trait within the subterranean freshwater cyclopoids of a high proportion of convergency within almost any of its groups. That is why at least some of the alleged "symplesiomorphies" in this analysis must be interpreted as a series of homoplastic synapomorphies. Despite the fact that in a classical Hennigian sense symplesiomorphic similarity is not admitted as a criterion to recognize a clade, in order not to blur the picture resulting from the cladistic routine, no further interpretation of homoplastic developments in specific cases has been given here other than accepting the cladogram as it is.

The choice of two outgroup taxa was not equally successful. While *Apocyclops dengizicus* (Lepeschkin, 1900) is clearly separated from the rest of the terminal taxa and the ingroup is defined with a number of apomorphic character states (some not even coded as they are unique and thus uninformative), *Microcyclops varicans* (G. O. Sars, 1863) clusters together with the ingroup, and more precisely



Fig. 19. One of 19 equally parsimonious trees of Australian species of the *Metacyclops* Kiefer, 1927 complex and some other, non-Australian closely related species and genera, with support for each branch shown as a percentage. See text for further explanation, and material and methods section for non-abbreviated species names.

with *Fierscyclops* (*F.*) *fiersi* (De Laurentiis, Pesce & Humphreys, 2001). It should be mentioned here that the former species, unlike any other one analysed here, has a 12-segmented antennula (i.e., the third segment divided), which was not coded in our matrix as it would be uninformative. While it would be easy to exclude *M. varicans* from the analysis, we decided to leave it there, as it exposes

even more dramatically the polyphyletic nature of the endemic Western Australian genus *Fierscyclops* Karanovic, 2004. This genus was already subdivided by Karanovic (2006) into two subgenera: the monospecific nominotypical subgenus, which is endemic to the Murchison region, and the subgenus *Pilbaracyclops* Karanovic, 2006 with two species from the Pilbara region. In this paper we elevate *Pilbaracyclops* to genus rank and discuss its relationships with other genera from the *Metacyclops* complex (see above).

Another result that was not surprising was the polyphyletic nature of the currently recognized genus Metacyclops. For example, the North American M. cushae Reid, 1991 clusters together with the representatives of the genus Hesperocyclops Herbst, 1984, while the more primitive Australian M. mortoni Pesce, De Laurentiis & Humphreys, 1996 and M. superincidentis Karanovic, 2004 are separated from the Australian and New Zealand representatives of the "trispinosus"-group by a well-defined endemic Australian genus Meridiecvclops Fiers, 2001, as well as by the Indian Metacyclops margaretae (Lindberg, 1938) and the African M. trispinosus Dumont, 1981. The latter two species are known after very incomplete descriptions (Lindberg, 1938; Dumont, 1981) and were considered previously (Karanovic, 2004a) also as members of the "trispinosus"-group, but they seem to form a separate clade in the genus Metacyclops. However, we have to leave them in this genus for the time being, until complete redescriptions, based on full sets of morphological characters, will be presented. One New Zealand and five Australian representatives of the "trispinosus"-group were, however, transferred into a newly erected genus Pescecyclops n. gen. As mentioned above and noted by Karanovic (2004b), the five Australian species can be divided into two groups based on the presence of integumental cuticular pits and the armature of the antenna, which groups are also reflected in their different distribution. However, due to the fact that one species (P. pilbaricus (Karanovic, 2004) n. comb.) is known only after females and because the New Zealand representative is only partly described, we refrained from formally recognizing and naming these two groups. The habitus shape and relative length of the caudal rami of P. pilbaricus make it cluster somewhat more closely with the members of the genus Hesperocyclops, and this is the only branch we treated taxonomically in this paper that had a support of less than 100%. That was another reason we refrained from formally recognizing these groups.

Our preliminary cladistic analysis showed (fig. 19), as anticipated, that the four new species described in this paper form a well-defined, monophyletic clade together with the New Zealand *Goniocyclops silvestris* Harding, 1958. Unfortunately, the genus *Goniocyclops* Kiefer, 1955, as currently definded (see Karanovic, 2004a; Dussart & Defaye, 2006), is a paraphyletic taxon. Two previously described Australian representatives seem to be more closely related to the South American genus *Muscocyclops* than to other congeners and they cluster together with a

species that was reported as the first representative of the genus Allocyclops Kiefer, 1932 from Australia by Karanovic (2003). This most terminal clade was recognized as a new genus Dussartcyclops n. gen., but the genus was also subidived into two subgenera (see above). Another new genus, Anzcyclops n. gen., was erected to accommodate the four new species and the New Zealand A. silvestris (Harding, 1958) n. comb. As mentioned above, this genus is probably more closely related to Muscocyclops than to the six species left in the genus Goniocyclops. Unfortunately, incomplete descriptions of all six species left in *Goniocyclops* prevent us from discussing their phylogenetic relationships in more detail, but, as suspected by Karanovic (2004a), our cladistic analysis showed that from the members originally described in the synonymized genus Psammophilocyclops Fryer, 1956, the Chinese G. bispinosus (Shen & Tai, 1964) and G. trispinosus (Shen & Tai, 1964) cluster together, while the African G. boccaroi (Fryer, 1956) is more closely related to the three species originally described in *Goniocyclops*: the African G. primus Kiefer, 1955, and G. alter Kiefer, 1955, and the New Caledonian G. arenicola Dussart, 1984. The later species has two autapomorphic characters (armature of the second and third leg endopod) that were not included in the analysis as they would be uninformative.

Ironically, our preliminary cladistic analysis and taxonomic revision of Australian *Metacyclops* and *Goniocyclops* resulted in no representatives of the latter genus and only two of the former (*M. mortoni* and *M. superincidentis*) on this continent. Of the three newly erected genera, two are Australian and New Zealand endemics, which is a strong zoogeographical signal that gives us confidence in our character choice. We hope that future studies on small freshwater cyclopoids will pay more attention to the characters that were previously mostly ignored in the species descriptions and generic groupings, including the shape of the habitus, the ornamentation of somites, and the armature and ornamentation of the cephalothoracic appendages.

What does not stop to amaze are the regional differences in stygofauna assemblages in Australia, and especially those between the neighbouring Pilbara and Murchison regions of Western Australia (see also Karanovic, 2006, 2008). The discovery that Australian regions have different relationships to other Gondwanan areas was already anticipated by Weston & Crisp (1994). Giribet & Edgecombe (2006) showed the importance of looking at small-scale patterns when inferring Gondwanan biogeography for terrestrial invertebrates. Even the results of the present phylogenetic analysis reinforce this notion, which was already discussed by Karanovic (2006), who even proposed a "pulsating desert hypothesis" as a novel dynamic model that may explain some of the differences observed. Other, mostly unpublished research (T. Karanovic, unpubl.) done recently on subterranean waters in eastern Australia, showed a similar dividing line between the stygofaunas of Queensland and New South Wales, although we are not sure yet where this border lies precisely. In short, copepods found in Queensland are more closely related to those from the Western Australia Pilbara region, than to the neighbouring New South Wales. Representatives of the genus Anzcyclops, described in this paper, are a good example, as well as those of the small harpacticoid genus Stygonitocrella Reid, Hunt & Stanley, 2003 s. l. (Karanovic & Hancock, 2009). From other taxa treated taxonomically in this paper, Fierscyclops Karanovic, 2004 and Dussartcyclops (s. str.) n. gen. et subgen. are endemic to the Murchison region, while Pilbaracyclops Karanovic, 2006 and Dussartcyclops (Barrowcyclops) n. subgen. are endemic to the Pilbara region. No members of Anzcyclops are found in the Murchison region, while the genus is present in the Pilbara region, Queensland, and New Zealand. Even members of the newly established genus Pescecyclops n. gen. show some significant differences in the southern and northern parts of Australia (see above). Thus, we believe that further investigations of subterranean waters in other parts of Australia, and especially in eastern Australia, will reveal more members of the currently monospecific or bispecific endemic Western Australian genera and subgenera.

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