Two new genera and three new species of subterranean cyclopoids (Crustacea, Copepoda) from New Zealand, with redescription of *Goniocyclops silvestris* Harding, 1958

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Abstract

A small collection of copepod samples from several wells in the Canterbury region, South Island, was examined. It contained a few cosmopolitan cyclopoid species, three interesting harpacticoids, as well as two new cyclopoid genera. The latter are presented in this paper, together with a redescription and first description of the male of *Goniocyclops silvestris* Harding, 1958, a cyclopoid species previously known only from North Island. Both new genera are from the *Diacyclops-Acanthocyclops* complex. *Abdiacyclops* gen. nov. is easily distinguishable from the complex by its unique swimming legs segmentation formula (2/2, 3/3, 3/3, 3/3), and is so far monospecific and known only after females. The most important characters of the second new genus, *Zealandcyclops* gen. nov. are: the swimming legs segmentation formula of 2/2, 3/2, 3/2, 3/2; a very small and two-segmented fifth leg; 11-segmented antennula; and sexual dimorphism in the swimming legs, with a transformed apical spine on the third leg endopod in the male. Four species were included in this genus: *Zealandcyclops fenwicki* sp. nov., from a well in the South Canterbury region; *Z. haywardi* sp. nov., from a well in the North Canterbury region; *Z. eulitoralis* (Alekseev and Arov, 1986) comb. nov., from the interstitial of several beaches on the southern shore of Lake Baikal; and *Z. biceri* (Boxshall *et al.*, 1993) comb. nov., from a sandy beach on the western shore of Lake Baikal. *Zealandcyclops* gen. nov. seems to be an archaic cyclopoid genus, having survived only in New Zealand and in the ancient Lake Baikal. With the present report, the New Zealand cyclopoid fauna numbers 16 species, a systematic list of which is presented in this paper. The majority of them are cosmopolitan elements, probably introduced here by early European settlers. Only one genus (8%) and six species (38%) are endemic, which is probably a reflection of the absence of any comprehensive research on the New Zealand cyclopoids.

Contents

Introduction

Our present knowledge of the New Zealand copepods is fragmentary regarding all types of habitats and all major copepod groups. The marine fish parasitic copepod fauna is neither isolated nor distinctive, and the copepods associates of the invertebrates are still virtually unknown (Jones, 1988). Knowledge of the New Zealand marine harpacticoids is slight, as only about 65 species, excluding pelagic forms, have been recorded (see Hicks, 1971; Wells *et al.*, 1982). Freshwater harpacticoids received even less attention, and then mostly from surfacewater habitats (Brehm, 1928; Harding, 1958; Barclay, 1969; Lewis, 1972a, 1972b). Only about 25 species are known, although Lewis (1984) listed 10 additional freshwater harpacticoids, the majority identified to generic level only. Freshwater harpacticoids showed high endemism at the specific level, but not at generic or family levels. Freshwater calanoid genera of New Zealand are also not endemic and even Brehm (1928) and Percival (1937) noticed the close relationship with Australian and South American calanoids.

All our knowledge of the New Zealand cyclopoid fauna comes from 10 publications (Thomson, 1879, 1882; Brady, 1906; Kiefer, 1928a, 1931a, 1931b; Harding, 1958; Lewis, 1974; Karaytug and Boxshall, 1998a, 1998b). Thomson (1879) reported the first New

Zealand cyclopoid as a new species: *Cyclops novae-zealandiae*. Although his drawings were quite inadequate for a close comparison, the species is now one of the accepted synonyms of *Eucyclops serrulatus* (Fischer, 1851) (see Dussart and Defaye, 1985). In a few years Thomson's drawing skills had improved substantially, when he (Thompson, 1882) reported *Cyclops novae-zealandiae* again (unfortunately without additional drawings), together with four other species: *Cyclops gigas* Claus, *C. serrulatus* Fischer, *C. aequoreus* Fischer, and *C. chiltoni. Cyclops gigas* that Thomson reported was considered by Dussart and Defaye (1985) a synonym of *Diacyclops bicuspidatus* (Claus, 1857); *C. serrulatus* is today in the genus *Eucyclops* Claus, 1893; *C. aequoreus* is a well established synonym of *Halicyclops magniceps* (Lilljeborg, 1853); and Thomson's *C. chiltoni* (described as a new species) is, in my opinion, a synonym of *Paracyclops fimbriatus* (Fischer, 1853), although it has been considered as a separate subspecies of the latter species by Dussart and Defaye (1985) and as a valid species by Karaytug and Boxshall (1998a). Brady (1906) was the next, after Thompson, to work on New Zealand cyclopoids and he reported two species: *Cyclops distinctus* Richard (probably a synonym of *Macrocyclops albidus* (Jurine, 1820)) and *C. serrulatus* Fischer (already recorded by Thompson (1882)). Kiefer (1928a) also reported *Eucyclops serrulatus* and described two other cyclopoid species as new: *Cyclops monacanthus* (today in the genus *Metacyclops* Kiefer, 1927) and *Cyclops crassicaudoides*. The latter species is today in the genus *Diacyclops* Kiefer, 1927, but rightly considered by Morton (1985) as a synonym of *Diacyclops bisetosus* (Rehberg, 1880). Later, Kiefer (1931a) had a chance to study cyclopoids from numerous surfacewater localities from New Zealand and identified 10 species altogether: *Macrocyclops albidus* (Jurine), *Eucyclops serrulatus* (Fischer), *Paracyclops finitimus* Kiefer (synonym of *P. fimbriatus* (Fischer, 1853)), *Cyclops (Acanthocyclops) robustus* Sars, *C. (A.) vernalis* Fischer, *C. (Diacyclops) bicuspidatus* Claus, *C. (D.) bisetosus* Rehberg, *C. (D.) crassicaudoides* Kiefer, *C. (Microcyclops) varicans* Sars, and *C. (Metacyclops) monacanthus* Kiefer. All above-mentioned subgenera are today accepted as valid genera, and all species, except *Metacyclops monacanthus*, are cosmopolitan and eurytopic. In a subsequent paper Kiefer (1931b) was able to add only one cosmopolitan

species to the previous list: *Eucyclops (Tropocyclops) prasinus* (Fischer). Kiefer's results were not very encouraging and the already sluggish research on the New Zealand cyclopoids slowed even more. Only two new species were described in the last 70 years: Harding (1958) described *Goniocyclops silvestris* and Lewis (1974) described *Paracyclops waiariki*. I have transferred the latter species into a newly established genus (Karanovic, in press), comprising the elements from Indonesia (Java, Sumatra, Bali), Australia and New Zealand. Finally, Karaytug and Boxshall (1998a) redescribed *Paracyclops chiltoni* (Thompson, 1882), and almost simultaneously they (Karaytug and Boxshall, 1998b) redescribed *Paracyclops waiariki* Lewis, 1974 from topotype specimens. A list of New Zealand cyclopoids, with their current valid names, is provided at the end of this paper. Lewis (1974) concluded that "further collecting in open-water systems will probably not expand this list greatly". The small percentage of endemic species is really surprising, as an endemic (archaic) element in the New Zealand fauna is also recognized. These unusual animals have persisted in isolation from 'more advanced' forms and well known examples include ratite birds, leiopelmid frogs, hyridellid freshwater mussels, and freshwater parastacid crayfish.

Investigations of subterranean ecosystems in New Zealand started very early, with the pioneering work of late Mr Charles Chilton (see Chilton, 1881, 1882, 1894). Unfortunately, his taxonomic skills were limited to isopods and amphipods, but probably even his collecting and sorting techniques were not suitable for small subterranean cyclopoids. However, he did provide several cyclopoids for Thomson (1882), some even from "gravel pits". Unfortunately, nothing important happened after that in this field. In the most recent paper dealing with groundwater aquifers in New Zealand, Scarsbrook and Fenwick (2003) concluded "that groundwater ecology in New Zealand is restricted by lack of knowledge of taxonomy and ecology of key groups, particularly the Copepoda". They also stated that "there are no described species of stygobitic (restricted to groundwaters) copepods from New Zealand". However, few attempts to find stygobitic elements have been made, and it would be unjust not to mention them here, although they only produced stygophilic copepods. Barclay (1969) described harpacticoid *Phyllognathopus volcanicus* from "the sands of some lake beaches in North Island";

this species was synonymized with eurytopic *P. viguieri* (Maupas, 1892) by Karanovic and Ranga Reddy (2004). Harding (1958) described previously mentioned *Goniocyclops silvestris*, as well as the harpacticoid *Bryocamptus stouti*, as new species from "the beech litter of a New Zealand forest". Lewis (1984) sampled some interstitial waters in New Zealand, but only found three harpacticoid species in that habitat: the above mentioned *Phyllognathopus volcanicus*, the cosmopolitan *Epactophanes richardi* Mrazek, 1894, as well as one unidentified species from the genus *Elaphoidella* Chappuis, 1929. Finally, Scarsbrook and Fenwick (2003) collected numerous subterranean copepods from "17 groundwater wells at five locations in North and South Island of New Zealand", all of them remaining unidentified.

Recently, Dr Graham D. Fenwick, from the National Institute of Water and Atmospheric Research in Christchurch, has entrusted to me some 18 vials containing copepods from different wells in the Canterbury region, South Island. Most of the samples contained already recorded, cosmopolitan, and eurytopic cyclopoid species: *Eucyclops serrulatus* (Fischer, 1851), *Paracyclops fimbriatus* (Fischer, 1853), *Acanthocyclops robustus* (Sars, 1863), and *Diacyclops bisetosus* (Rehberg, 1880). Three interesting harpacticoid species (two from the family Ameiridae Monard, 1927 and one from the family Canthocamptidae Sars, 1906) were represented by a single adult specimen each; they will await further resampling and will be published at a later stage. However, two new cyclopoid genera (one monospecific, other containing two species) were discovered in two wells and presented in this paper. One of these two samples also contained several specimens of *Goniocyclops silvestris* Harding (1958), a species previously known only from North Island and only after females. This species is redescribed in the present paper, with the first description of the male.

Material and methods

Both samples studied here were collected from freshwater wells in the Canterbury region, South Island. Campbell's Well is a disused well in the South Canterbury region. It is seven meters deep and the sample was taken by filtering water from the pump. The

second well is in the North Canterbury region. It is still used for domestic purposes and the sample was obtained by cleaning the pump filter. The material was preserved in 4% formaldehyde, and later sorted under a dissecting microscope and placed in 70% ethanol. Specimens were dissected in Faure's medium, prepared following the procedure of Stock and Von Vaupel Klein (1996), and dissected appendages were then covered with a coverslip. For the urosome or the entire animal, two human hairs were mounted between the slide and coverslip, so the parts could not be compressed. By manipulating the coverslip carefully by hand, the whole animal or a particular appendage could be positioned in different aspects, thus making possible the observation of morphological details. During the examination water slowly evaporated, and appendages or whole animals eventually remained in completely dry Faure's medium. All drawings were prepared using a drawing tube attached to a Leica-DMLS brightfield compound microscope, with C-PLAN achromatic objectives. Specimens which were not drawn, were examined in a mixture of equal parts of distilled water and glycerol. Samples for the scanning electron microscopy were coated in gold and observed under the LEO FEG VPSEM microscope on the in-lens detectors, with working distances between 2 and 6 mm and accelerating voltages between 2 and 5 kV. Morphological terminology follows Huys and Boxshall (1991), except for 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 groups of crustaceans. The material is deposited in the Zoological Museum Amsterdam (prefix ZMA) and in the Western Australian Museum (prefix WAM).

Systematic results

Order Cyclopoida Burmeister, 1834
Family Cyclopidae Burmeister, 1834
Subfamily Cyclopinae Burmeister, 1834

Genus ***Abdiacyclops*** **gen. nov.**

Type (and only) species. *Abdiacyclops cirratus* sp. nov. by original designation.

Generic diagnosis. Moderately large Cyclopinae, with robust habitus and greatest width near posterior margin of cephalotorax. Free pedigerous somites with posterior corners slightly expanded laterally, especially second and third. Membranous joint between prosome and urosome well developed dorsally. No sclerotized joint between prosome and urosome, or between fifth pedigerous somite and genital double-somite. Genital double-somite wider than long; copulatory pore small, ovoid, positioned just anterior of double-somite midlength; copulatory duct siphon-like, rigidly sclerotized; seminal receptacle large, clearly divided into anterior (larger) and posterior expansions. Anal operculum smooth, broad, very short and convex. Caudal rami parallel, about three times as long as wide; distal margin ventrally with cuticular tube pore; dorsal seta about 1.3 times as long as ramus; innermost apical seta about 2.4 times as long as outermost and 1.4 times as long as ramus. Antennula 11-segmented in female, reaching 3/4 of cephalothorax in length, with one slender aesthetasc on each eighth, tenth and eleventh segments. Antenna slender, four-segmented, comprising coxobasis and three-segmented endopod; setal formula 2.1.9.7; seta representing exopod absent. Labrum trapezoidal; cutting edge almost straight, with 13 teeth between weakly produced, rounded lateral corners. Mandibula with distinct palp, armed with three setae; cutting edge armed with six teeth (four complex) and two setae and ornamented with row of six spinules. Maxillula with two-segmented palp; arthrite of praecoxa with four apical spines; praecoxa with five armature elements along inner margin. Maxilla five-segmented, with complete armature. Maxilliped four-segmented, with armature formula 2.2.1.3. First swimming leg with two-segmented endopod and exopod, while other legs with three-segmented exopods and endopods; last exopodal segment spine formula 3.3.3.3.; all coxae with inner seta and basis of each leg with outer seta; basis of first leg with strong inner spine; third endopodal segment of fourth swimming leg armed apically with two strong spines, inner spine about 1.2 times as long as outer one. Fifth leg two-segmented, basal segment about twice as wide as long, with lateral seta on long setophore; distal segment much narrower, about twice as long as wide, armed with bipinnate apical seta and subapical, smooth inner spine; apical seta more than four times longer than segment, spine half as long as

segment. Sixth leg in female with two minute spines and one seta.

Generic etymology. The genus name is composed of the Latin preposition 'ab' (meaning 'from') and the existing generic name *Diacyclops*. Gender masculine.
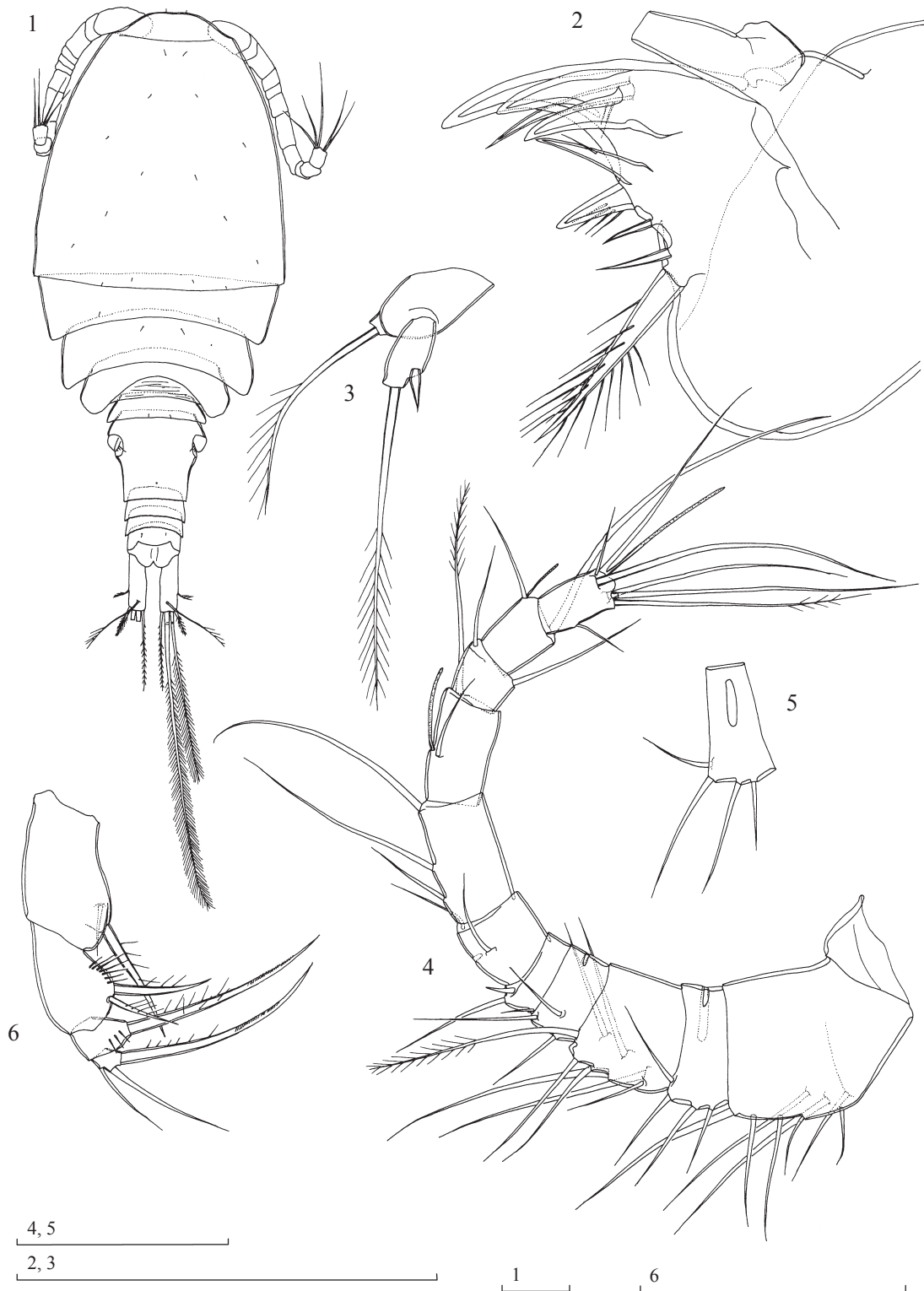
Abdiacyclops cirratus sp. nov.
(Figs. 1-16)

Type material. Holotype female (ZMA Co. 204 696), New Zealand, South Island, North Canterbury Region, Spotswood, Waiau West Road, well GS0249, 1997, leg. S. Hayward (sample GW3), 42º45'S 173º16'E: dissected on two slides.

Description of female (holotype). Body length, excluding caudal setae, 870 µm. Habitus (Fig. 1) relatively robust, with prosome/urosome ratio 1.8 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.4; cephalothorax 2.5 times as wide as genital double-somite. Rostral expansion not well developed. Free pedigerous somites with posterior corners expanded laterally, especially those of second and third free somites. Membranous joint between prosome and urosome well developed dorsally. Fifth pedigerous somite narrower than genital double-somite. Preserved specimen colourless. Nauplius eye not visible. Rostrum well developed, membranous, almost triangular and furnished with two large sensilla.

Cephalothorax (Fig. 1) about 1.1 times as long as its greatest width; representing 46% of total body length. Surface of cephalothoracic shield with several large sensilla, as well as surface of free pedigerous somites; no other ornamentation visible. Hyaline fringes of prosomites narrow and smooth. No sclerotized joint between prosome and urosome, or between fifth pedigerous somite and genital double-somite. Fifth pedigerous somite with smooth fringe dorsally and ventrally, ornamented only with two dorsal sensilla.

Genital double-somite (Fig. 7) about 0.8 times as long as wide, ornamented dorsally with single cuticular pore medially at 4/5 of its length and ventrally with two posterior cuticular pores. Hyaline fringe of genital double- and two subsequent somites sharply serrated both ventrally and dorsally. Copulatory pore small, ovoid, positioned just anterior of double-somite midlength; copulatory duct relatively long,

Figs. 1-6. Abdiacyclops cirratus gen. nov., sp. nov., holotype (female, 871 µm). (1) Habitus, dorsal view. (2) Maxillula. (3) Fifth leg. (4) Right antennula. (5) Second segment of left antennula. (6) Maxilliped. (Scale bars = 100 µm)

Figs. 7-11. *Abdiacyclops cirratus* gen. nov., sp. nov., holotype (female, 871 µm). (7) Urosome, ventral view. (8) Mandibula. (9) Palp of maxillula. (10) Labrum. (11) Antenna. (Scale bars = 100 µm)

siphon-like, rigidly sclerotized. Seminal receptacle large, clearly divided into anterior and posterior expansions, about 1.7 times as wide as long (ventral view), representing 62% of double-somite width and 47% of its length; anterior expansion larger and wider than posterior one. Lateralmost parts of oviducts rigidly sclerotized, with two loops; part of oviduct closer to receptacle membranous, relatively wide. Ovipores situated somewhat dorsolaterally, at 1/3 of double-somite's length, covered with reduced sixth legs, which bear two minute spines and one smooth seta. Third urosomite (Fig. 7) ornamented only with two posterior cuticular pores ventrally; fourth urosomite without any visible ornamentation. Anal somite with smooth, broad, very short and convex anal operculum (Fig. 1), which represents 61% of somite's width and not reaching posterior margin of somite; ornamented with two large sensilla dorsally and with two pores and transverse row of spinules on posterior margin ventrally (Fig. 7). Anal sinus widely open, without visible ornamentation.

Caudal rami (Fig. 7) parallel, with space between them of about half of one ramus' width and almost 3.1 times as long as wide; ornamented with several spinules at base of lateral and outermost apical setae, as well as with anterior cuticular pore ventrally; distal margin ventrally with small protuberance medially, which seems to be cuticular tube with pore on top. Dorsal seta about 1.3 times as long as ramus, inserted at 5/6 of ramus length, uniarticulate at base and uniplumose distally. Lateral seta arising very slightly dorsolaterally at 2/3 of ramus length, uniplumose and about 1.2 times as long as ramus' width. Outermost apical seta stout, spiniform, about 0.6 times as long as ramus, bipinnate. Innermost apical seta also bipinnate but much more slender and longer, about 2.4 times as long as outermost one and 1.4 times as long as ramus. Principal apical setae plumose and with breaking planes; inner seta about 1.7 times as long as outer one, 0.5 times as long as body.

Antennula (Figs. 4 and 5) 11-segmented, strongly curled, with remnants of ancestral segmentation on second and fourth segment caudally and on sixth segment anteriorly, unornamented, reaching 3/4 of cephalothorax in length, with one slender aesthetasc on eighth segment, one minute aesthetasc on tenth segment and long slender aesthetasc on eleventh segment; setal formula: 8.4.8.3.3.2.3.2.2.2.7. No setae with breaking planes and only one apical seta on eleventh

segment articulating on basal part. One seta on fifth segment spiniform and very short; all other setae slender and most setae smooth, only one seta on third segment, one on eight and one on eleventh segment pinnate distally. Length ratio of antennular segments, from proximal end and along caudal margins, 1 : 0.4 : 0.7 : 0.4 : 0.2 : 0.5 : 1 : 0.8 : 0.4 : 0.6 : 0.8.

Antenna (Fig. 11) slender, four-segmented, comprising slender coxobasis and three-segmented endopod; all endopodal segments of about same length; coxobasis somewhat longer than endopodal segments, about 2.2 times as long as wide, ornamented with few spinules near outer margin proximally, armed with two smooth, subequal setae at distal inner corner; seta representing exopod absent. First endopodal segment armed with one smooth seta in middle, ornamented with longitudinal row of small spinules along external margin. Second endopodal segment about 2.5 times as long as wide, ornamented with longitudinal row of spinules along external margin distally, armed with nine smooth setae (seven lateral and two subapical; one subapical seta somewhat longer and much stronger than any other seta on that segment). Third endopodal segment 3.3 times as long as wide, armed with seven smooth apical setae (four of them strong and geniculate) and ornamented as previous two segments.

Labrum (Fig. 10) trapezoidal, ornamented with two rows of six to eight long spinules and relatively large. Cutting edge almost straight, with 13 large and more or less sharp teeth between weakly produced, rounded lateral corners.

Mandibula (Fig. 8) with small and clearly distinct palp, armed with two very long, plumose setae and one short, smooth seta on distal end. Coxal gnathobase cutting edge with six very strong teeth (four of them complex; innermost strongest) and two setae, as well as with row of six slender and long spinules; outer seta pinnate, 1.7 times as long as inner smooth seta and 0.7 times as long as short seta on palp.

Maxillula (Figs. 2 and 9) composed of well developed praecoxa and two-segmented palp. Arthrite of praecoxa with four strong and smooth apical spines; only one distinct, others completely fused to praecoxa. Praecoxa armed with five armature elements along inner margin, longest one plumose. Palp (Fig. 9) with distinct endopod bearing three pinnate apical setae, and armed laterally with one smooth exopodal seta and apically with two slender setae and one
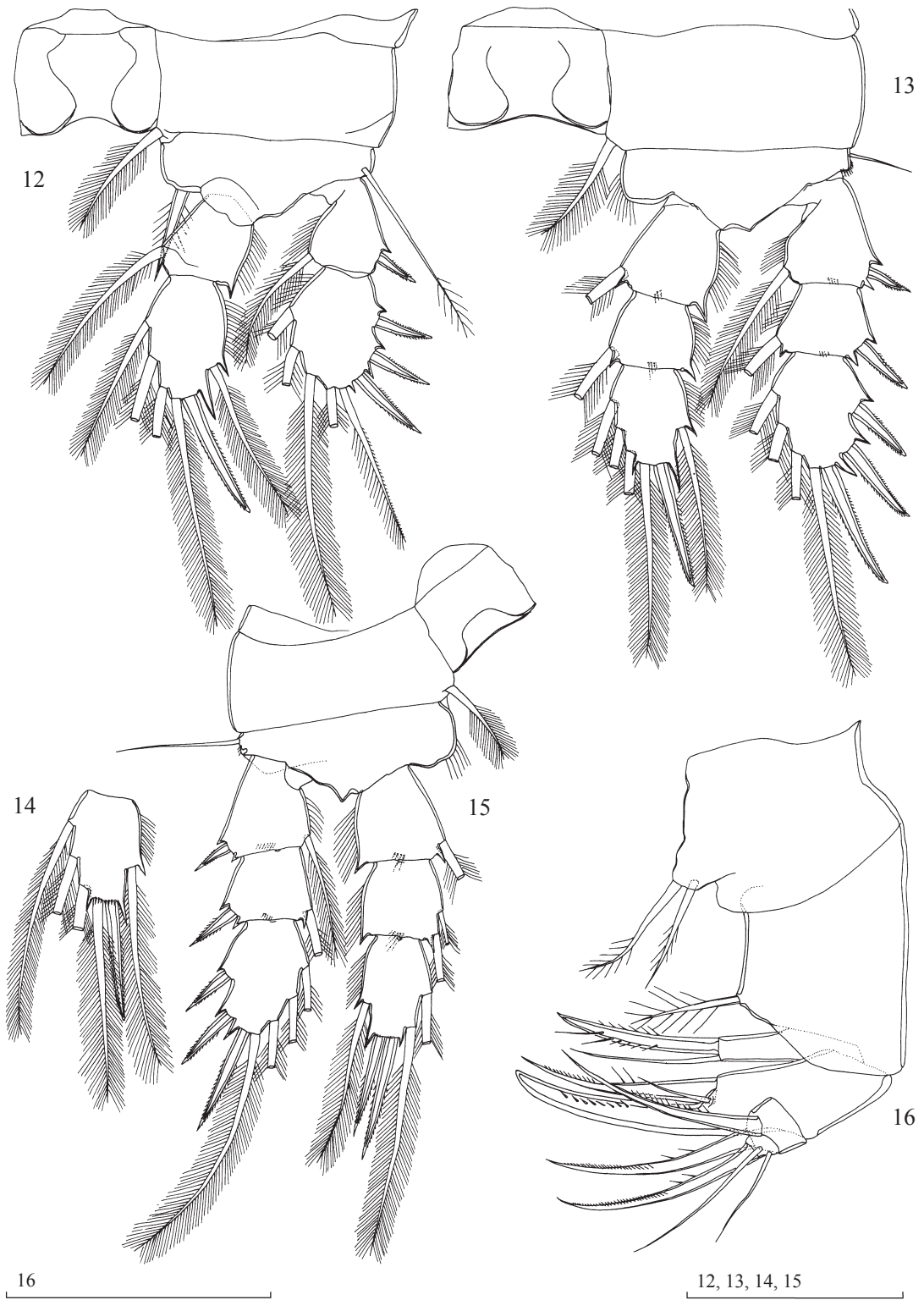
Figs. 12-16. *Abdiacyclops cirratus* gen. nov., sp. nov., holotype (female, 871μm). (12) First swimming leg. (13) Second swimming leg. (14) Third endopodal segment of third swimming leg. (15) Fourth swimming leg. (16) Maxilla. (Scale bars = 100 μm)

robust, strongly bipinnate spine. Palp somewhat shorter than arthrite of praecoxa.

Maxilla (Fig. 16) unornamented and five-segmented but praecoxa fused to coxa on posterior surface. Proximal endite of praecoxa well developed, about as long as wide, armed with two pinnate setae; distal endite small, unarmed. Proximal endite of coxa with one short, bipinnate seta; distal endite highly mobile, elongate and armed apically with two setae (proximal seta bipinnate, very strong, and somewhat longer than distal smooth one). Basis expanded into robust unipinnate claw, armed with two setae; strong seta as long as claw, unipinnate; other seta minute. Endopod two-segmented; proximal segment armed with two robust, unipinnate setae; distal segment very small, armed with one robust, unipinnate apical seta and two slender and smooth subapical setae. Longest seta on distal endopodal segment slightly longer than strong seta on basis.

Maxilliped (Fig. 6) four-segmented, composed of syncoxa, basis and two-segmented endopod. Syncoxa about 1.5 times as long as wide, unornamented and armed with two setae; distal seta unipinnate, much stronger and about 2.6 times as long as proximal smooth seta. Basis 1.6 times as long as wide, ornamented with single arched row of long spinules at middle, armed with two bipinnate setae; proximal seta stronger and longer. First endopodal segment small, ornamented with three strong spinules and armed with one strong, pinnate seta; this seta longest and strongest on maxilliped. Second endopodal segment very small, unornamented, armed with three setae; innermost seta unipinnate, about 1.6 times as long as middle, smooth seta and 2.5 as long as outermost seta.

First swimming leg (Fig. 12) with two-segmented endopod and exopod, while other legs with three-segmented rami (Figs. 13-15). Armature formula of swimming legs as follows:

	coxa	basis	exopod	endopod
leg 1	0-1	1-I	I-1; II, I, 5	0-1; 1, I+1, 3
leg 2	0-1	1-0	I-1; I-1; II, I, 4	0-1; 0-1; 1, I+1, 3
leg 3	0-1	1-0	I-1; I-1; II, I, 4	0-1; 0-1; 1, I+1, 3
leg 4	0-1	1-0	I-1; I-1; II, I, 4	0-1; 0-2; 1, II, 2

Last exopodal segment spine formula: 3.3.3.3. Intercoxal sclerites of all swimming legs unornamented, with smooth and bilobate distal margin. All coxae unornamented and armed with plumose seta on their inner distal corner. Basis of first swimming leg also unornamented, those of other legs with few setules along inner margin and with row of small spinules along outer margin; each basis armed with slender lateral seta on outer margin. Spine at inner corner of basis of first leg stout, reaching second endopodal segment (Fig. 12). All setae slender and plumose, outer apical seta on third exopodal segment of first leg pinnate along outer margin, plumose along inner one. First and second endopodal and exopodal segments of second, third and fourth legs with few spinules on posterior margin; all endopodal segments with row of hairs along outer margin; hairs also present along inner margin of most exopodal segments. Apical spine on second endopodal segment of first swimming leg very robust, about as long as segment (Fig. 12). Apical spine on third endopodal segment of second and third leg also very strong; second and third leg (Figs. 13 and 14) without any important difference. Third endopodal segment of fourth swimming leg about 1.4 times as long as wide; armed apically with two strong spines; inner apical spine about 1.2 times as long as outer one and almost 1.3 times as long as segment (Fig. 15).

Fifth leg (Figs. 3 and 7) two-segmented, unornamented and inserted ventrolaterally. Basal segment about twice as wide as long, armed with lateral uniplumose seta inserted on long setophore. Distal segment much narrower, about twice as long as wide, armed with bipinnate apical seta and subapical, smooth inner spine; apical seta 4.1 times as long as segment, reaching 2/3 of genital double-somite in length (Fig. 7); subapical spine about 0.5 times as long as segment.

Sixth leg distinct, more or less semicircular, cuticular plate, armed with two almost equally long minute smooth spines and one smooth, much longer seta; median spine distinct, other completely fused to leg.

Male. Unknown.

Variability. Unfortunately, only one female of this species was found. The only asymmetric feature of the holotype is the size of an ancestral segmentation 'window' on the second antennular segment (Figs. 4 and 5).

Species etymology. The species is named with the Latin adjective 'cirratus', meaning 'curly' and refer-

ring to its unusually curled antennulae. It is consequently an adjective agreeing with the masculine generic name.

Genus *Zealandcyclops* gen. nov.

Type species. *Zealandcyclops fenwicki* sp. nov.

Additional species. *Zealancyclops haywardi* sp. nov.; *Diacyclops eulitoralis* Alekseev and Arov, 1986; *Diacyclops biceri* Boxshall *et al*., 1993.

Generic diagnosis. Small to moderately large Cyclopinae, living in subterranean waters, colourless, no visible nauplius eye, and with not very robust habitus. Free pedigerous somites without particular expansions laterally. Rostrum well developed, membranous, almost triangular. Cephalothorax about as long as its greatest width; surface of cephalothoracic shield with several large sensilla and cuticular pores. Hyaline fringes of prosomites narrow and smooth. All free pedigerous somites ornamented dorsally with few sensilla and pores. Hyaline fringe of genital double- and two subsequent somites sharply and irregularly serrated both ventrally and dorsally. Genital double-somite about as long as wide; seminal receptacle large, clearly divided into anterior and posterior expansions, anterior expansion wider; ovipores situated somewhat dorsolaterally, at 2/5 of double-somite's length. Anal somite with smooth, broad, very short and convex anal operculum. Caudal rami almost parallel, from 2.4 to 3.5 times as long as wide; dorsal seta as long as or shorter than ramus, as well as innermost and outermost apical setae; principal apical setae with breaking planes. Antennula 11-segmented in female and 15-segmented in male. Antenna slender, four-segmented, seta representing exopod absent. Labrum trapezoidal, cutting edge almost straight, with 11-14 small and more or less sharp teeth between produced, rounded lateral corners. Mandibula with distinct palp, armed with one or three setae. Maxillula composed of well developed praecoxa and two-segmented palp. Maxilla five-segmented, with complete armature. Maxilliped four-segmented, with two setae on ultimate segment. First swimming leg with two-segmented exopod and endopod; all other swimming legs with three-segmented exopods and two-segmented endopods; last exopodal segment spine formula: 3.3.3.3. Second endopodal segment of fourth swimming leg from 1.4 to 2 times as long as wide, armed apically with two spines; inner apical spine somewhat longer than outer and shorter than segment. Apical spine on second endopodal segment of third leg in male modified, much smaller than in female, unipinnate and claw-like. Fifth leg relatively small, two-segmented, inserted ventrolaterally; basal segment about twice as wide as long, armed with lateral short and uniplumose seta, inserted on setophore; distal segment much narrower about 1.5 times as long as wide, armed with apical seta and subapical, inner spine; apical seta hardly reaching 1/3 of genital double-somite in length. Sixth leg in female more or less semicircular, cuticular plate, armed with two minute smooth spines and one smooth and equally minute dorsal seta. Sixth leg in male armed with two setae and innermost spine.

Generic etymology. The genus name is derived from the second word of the country name, where it was collected, prefixed to the existing generic name *Cyclops*. Gender masculine.
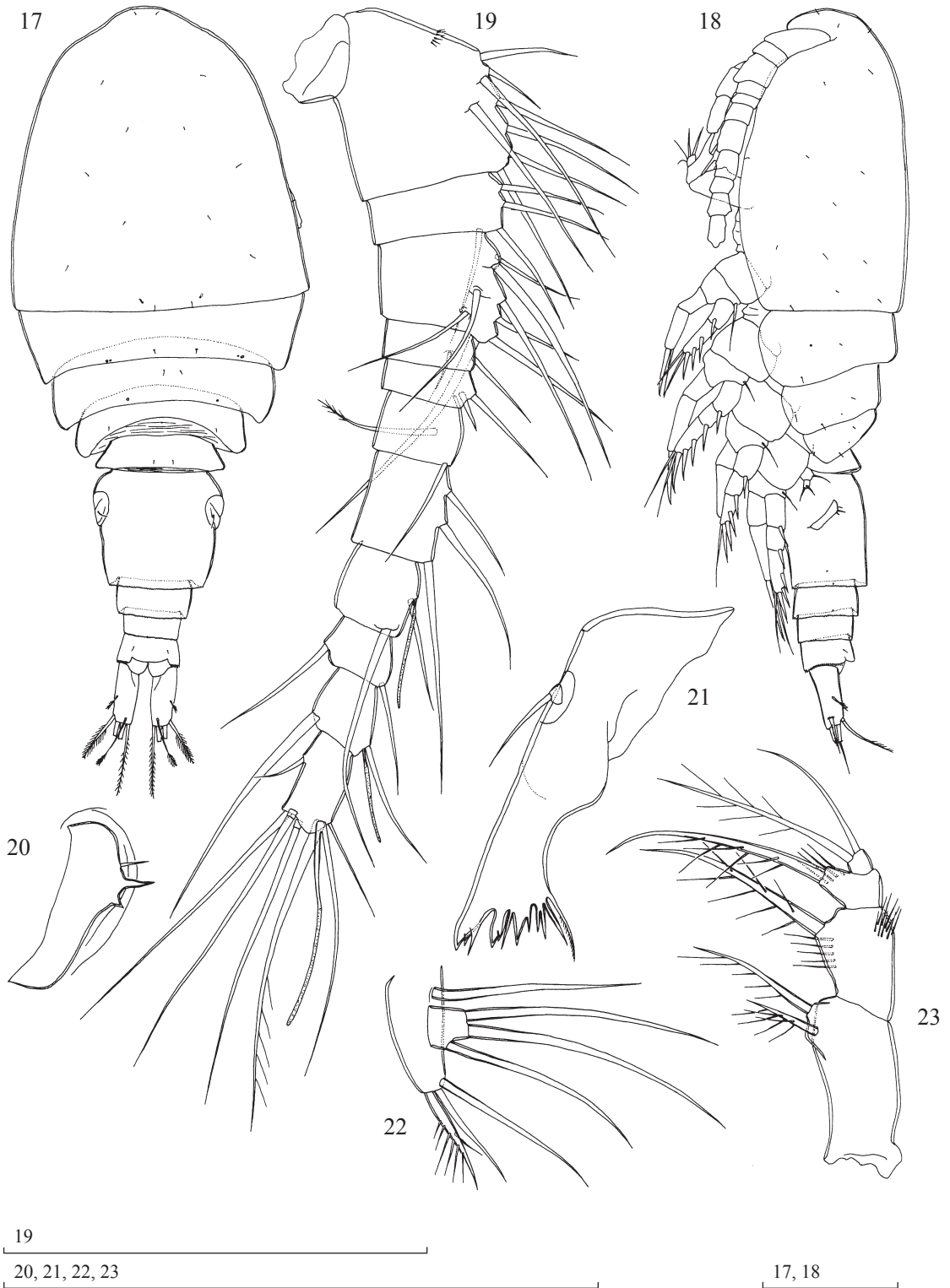
Zealandcyclops fenwicki sp. nov.
(Figs. 17-47, 87-89)

Description of female (holotype). Body length, excluding caudal setae, 517 µm. Habitus (Figs. 17 and 18) not very robust, somewhat dorsoventrally compressed, with prosome/urosome ratio 1.5 and greatest width at posterior end of cephalothorax. Body length/width

Figs. 17-23. Zealandcyclops fenwicki gen. nov., sp. nov., holotype (female, 517 μm). (17) Habitus, dorsal view. (18) Habitus, lateral view. (19) Antennula. (20) Sixth leg. (21) Mandibula. (22) Palp of maxillula. (23) Maxilliped. (Scale bars = 100 μm)
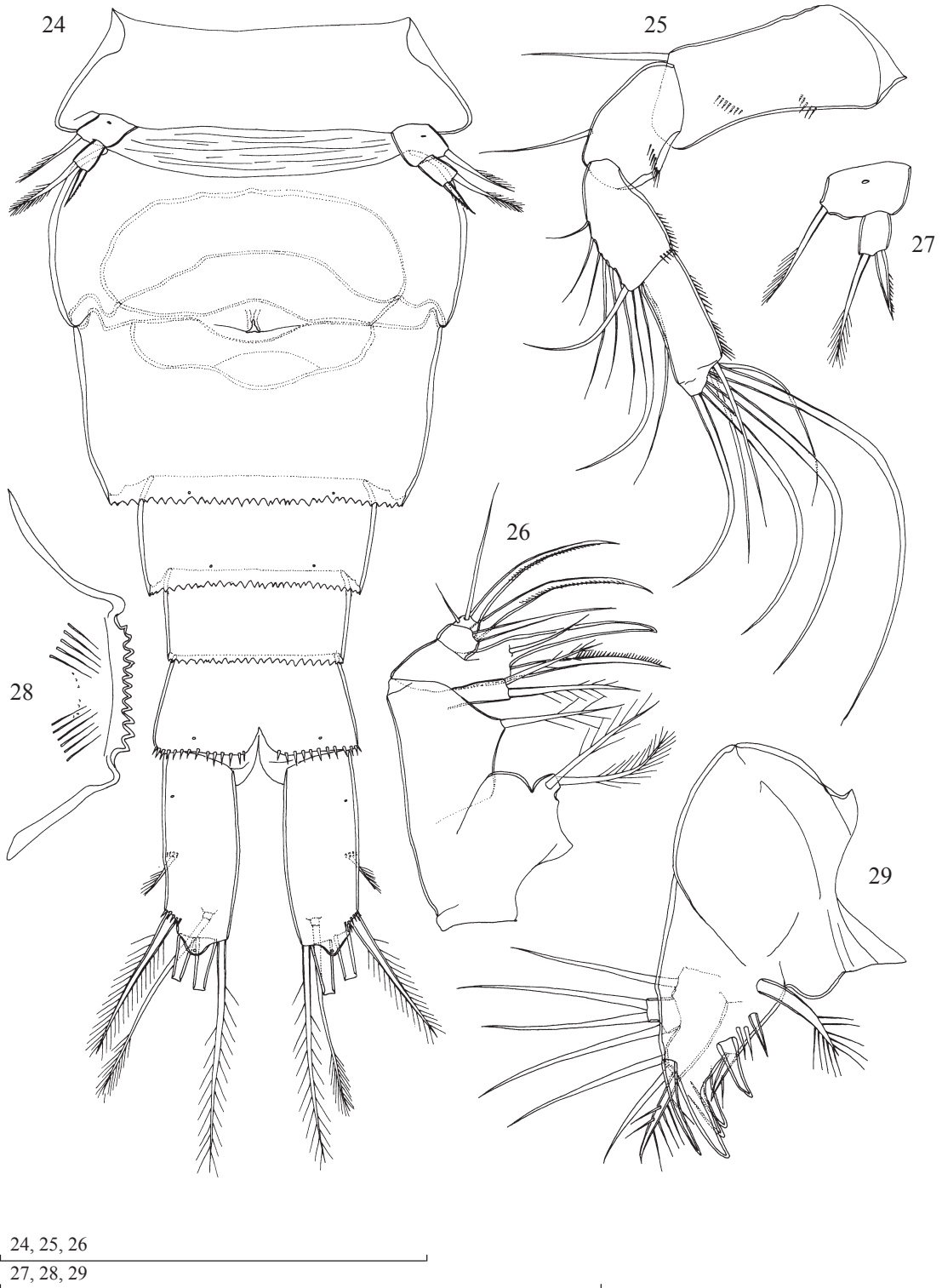
Figs. 24-29. Zealandcyclops fenwicki gen. nov., sp. nov., holotype (female, 517 μm). (24) Urosome, ventral view. (25) Antenna. (26) Maxilla. (27) Fifth leg. (28) Labrum. (29) Maxillula. (Scale bars = 100 μm)

ratio about 2.4; cephalothorax 2.3 times as wide as genital double-somite. Rostral expansion well developed. Free pedigerous somites without particular expansions laterally, except in fifth pedigerous somites, which have somewhat protruded lateral corners. Preserved specimen colourless. Nauplius eye not visible. Rostrum well developed, membranous, almost triangular and furnished with two large sensilla.

Cephalothorax (Fig. 17) about as long as its greatest width; representing 42% of total body length. Surface of cephalothoracic shield with several large sensilla and cuticular pores. Hyaline fringes of prosomites narrow and smooth. All free pedigerous somites ornamented dorsally with few sensilla and pores. No sclerotized joint between prosome and urosome or between fifth pedigerous somite and genital double-somite. Fifth pedigerous somite with smooth fringe dorsally and ventrally, ornamented only with two dorsal sensilla.

Genital double-somite (Fig. 24) about as long as wide, ornamented with four lateral (two on each side) and two ventral cuticular pores. Hyaline fringe of genital double- and two subsequent somites sharply and irregularly serrated both ventrally and dorsally. Copulatory pore relatively large, T-shaped, positioned just anterior of double-somite midlength; copulatory duct relatively short, rigidly sclerotized. Seminal receptacle large, clearly divided into anterior and posterior expansions, about 1.5 times as wide as long (ventral view), representing 73% of double-somite width and 60% of its length; anterior expansion larger and wider than posterior one. Lateralmost parts of oviducts rigidly sclerotized, with two loops. Ovipores situated somewhat dorsolaterally, at 2/5 of double-somite's length, covered with reduced sixth legs, which bear two minute spines and one minute seta. Third urosomite ornamented with two lateral and two ventral cuticular pores. Fourth urosomite without any visible ornamentation and much narrower than subsequent somite, very characteristically constricting urosome. Anal somite with smooth, broad, very short and convex anal operculum (Fig. 17), which represents 57% of somite's width and not reaching posterior margin of somite; ornamented with two large sensilla dorsally and with two cuticular pores and transverse row of spinules on posterior margin ventrally (Fig. 24). Anal sinus widely open, without visible ornamentation.

Caudal rami (Fig. 24) parallel, with space between them less than one ramus' width and almost 2.6 times as long as wide; ornamented with several spinules at base of lateral and outermost apical setae as well as with anterior cuticular pore ventrally; distal margin ventrally with large protuberance medially, with pore on top (which opened ventrocaudally). Dorsal seta about as long as ramus, inserted at 5/6 of ramus length, uniarticulate at base and plumose distally. Lateral seta arising somewhat dorsolaterally at 3/5 of ramus length, uniplumose and 0.6 times as long as ramus' width. Outermost apical seta stout, spiniform, about 0.7 times as long as ramus, bipinnate. Innermost apical seta also bipinnate but much more slender and about 1.5 times as long as outermost one. Principal apical setae with breaking planes and all broken in holotype female.

Antennula (Fig. 19) 11-segmented, ornamented only with few spinules on first segment, reaching 2/3 of cephalothorax in length, with one slender aesthetasc on eighth, tenth and eleventh segments each, and setal formula: 8.4.8.2.2.2.3.2.2.2.7. No setae with breaking planes and only two apical setae on eleventh segment articulating on basal part. One seta on fifth segment spiniform and very short; all other setae slender and most setae smooth, only one seta on sixth and one on eleventh segment pinnate distally; 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 : 0.7 : 0.4 : 0.3 : 0.6 : 0.9 : 0.7 : 0.5 : 0.6 : 0.9.

Antenna (Fig. 25) slender, four-segmented, comprising large coxobasis and three-segmented endopod; all endopodal segments of about same length; coxobasis considerably longer than endopodal segments, about 2.2 times as long as wide, ornamented with few spinules near outer margin proximally and one row of spinules at distal part, armed with single smooth setae at distal inner corner; seta representing exopod absent. First endopodal segment armed with one smooth seta at 3/4, ornamented with diagonal row of slender spinules along external margin. Second endopodal segment about 1.9 times as long as wide, ornamented with longitudinal row of spinules along external margin, armed with nine smooth setae (seven lateral and two subapical; one subapical seta somewhat longer and much stronger than any other seta on that segment). Third endopodal segment 2.5 times as long as wide, armed with seven smooth apical setae (four of them strong and geniculate) and ornamented as previous two segments.

Labrum (Fig. 28) trapezoidal, ornamented with two rows of five or six long spinules and not very large. Cutting edge almost straight, with 11 small and more or less sharp teeth between produced, rounded lateral corners.

Mandibula (Fig. 21) with very small but clearly distinct palp, armed with single smooth short seta. Coxal gnathobase cutting edge with six strong teeth (three of them complex; innermost one strongest) and two setae; outer seta unipinnate, about 1.5 times as long as inner seta and 0.8 times as long as single palpal seta.

Maxillula (Figs. 22 and 29) composed of well developed praecoxa and two-segmented palp. Arthrite of praecoxa with four strong and smooth apical spines; only one distinct, others completely fused to praecoxa. Praecoxa armed with six armature elements along inner margin, longest one plumose. Palp (Fig. 22) with distinct endopod, bearing three smooth apical setae, and armed laterally with one exopodal smooth seta and apically with two smooth slender setae and one robust, strongly bipinnate spine. Palp clearly shorter than arthrite of praecoxa.

Maxilla (Fig. 26) unornamented and five-segmented but praecoxa fused to coxa on posterior surface and partly on anterior. Proximal endite of praecoxa well developed, about as long as wide, armed with two pinnate setae; distal endite small, unarmed. Proximal endite of coxa with one short, bipinnate seta; distal endite highly mobile, elongate and armed apically with two bipinnate setae (proximal seta about 1.3 times as long as distal one). Basis expanded into robust smooth claw, armed with two setae; strong seta somewhat longer than claw, unipinnate; other seta much shorter, slender and smooth. Endopod two-segmented; proximal segment armed with two robust, pinnate setae; distal segment very small, armed with one robust, pinnate, apical seta and two slender and smooth subapical setae. Longest seta on distal endopodal segment about as long as strong seta on basis.

Maxilliped (Fig. 23) four-segmented, composed of syncoxa, basis and two-segmented endopod. Syncoxa about twice as long as wide, unornamented and armed with two pinnate setae; distal seta stronger and about 1.7 times as long as proximal one. Basis 1.4 times as long as wide, ornamented with single row of long spinules in middle inner margin and with bunch of spinules on distal outer corner, armed with single, strong, bipinnate seta. First endopodal segment orna-

mented with four strong spinules and armed with one strong, pinnate seta; this seta longest and strongest on maxilliped. Second endopodal segment very small, unornamented, armed with two setae; inner seta bipinnate, about 1.5 times as long as outer smooth seta. All pinnate setae with very long pinnules.

First swimming leg (Fig. 30) with two-segmented exopod and endopod; all other swimming legs with three-segmented exopods and two-segmented endopods (Figs. 31, 32 and 33). Armature formula of swimming legs as follows:

	coxa	basis	exopod	endopod
leg 1	0-1	1-0	I-0; II, I, 5	0-1; 1, I+1, 2
leg 2	0-1	1-0	I-0; I-1; II, I, 4	0-1; 1, I+1, 3
leg 3	0-1	1-0	I-0; I-1; II, I, 4	0-1; 1, I+1, 3
leg 4	0-1	1-0	I-0; I-1; II, I, 4	0-1; 1, II, 3

Last exopodal segment spine formula: 3.3.3.3. Intercoxal sclerites of all swimming legs unornamented, with smooth and bilobate distal margin. All coxae ornamented with few spinules on outer distal corner, and armed with plumose seta on inner distal corner. Basis of each leg ornamented with few spinules at base of endopod, armed with slender lateral seta on outer margin. Spine at inner corner of basis of first leg absent (Fig. 30). Distal inner margin of fourth leg basis (Fig. 33) with characteristic recess. All setae slender and plumose; outer apical seta on third exopodal segment of first leg pinnate along outer margin, plumose along inner one. All exopods and endopods with small spinules at base of all armature elements and first endopodal segment with row of spinules along posterior margin; all endopodal segments with row of hairs along outer margin; hairs also present along inner margin of most exopodal segments. Apical spine on second endopodal segment of first swimming leg very robust, about 1.2 times as long as segment (Fig. 30). Apical spine on second endopodal segment of second and third leg shorter than segment; second and third leg (Figs. 31 and 32) without any difference. Second endopodal segment of fourth swimming leg about 1.8 times as long as wide, armed apically with two spines; inner apical spine about 1.2 times as long as outer one and 0.7 times as long as segment (Fig. 33).

Fifth leg (Figs. 24 and 27) relatively small, two-segmented, ornamented with single large cuticular pore on basal segment ventrally. Basal segment about
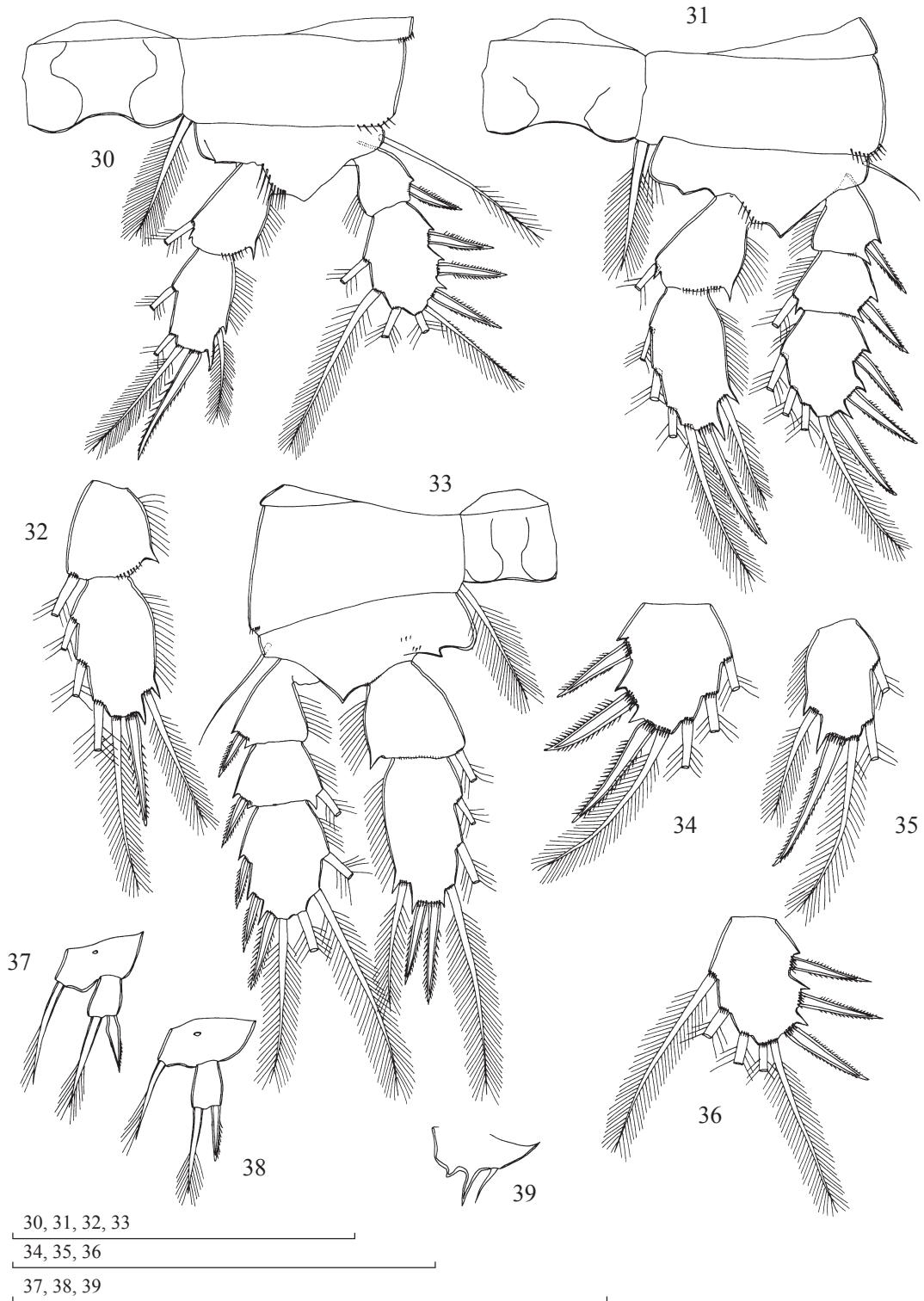
Figs. 30-39. Zealandcyclops fenwicki gen. nov., sp. nov., 30-33, holotype (female, 517 µm). 34, paratype female (493 µm). 35, 36 and 39, paratype female (437 µm). 37, paratype male (425 µm). 38, paratype male (443 µm). (30) First swimming leg. (31) Second swimming leg. (32) Endopod of third swimming leg. (33) Fourth swimming leg. (34) Third exopodal segment of third leg. (35) Second endopodal segment of third leg. (36) Third exopodal segment of third leg. (37) and (38) Fifth leg. (39) Sixth leg. (Scale bars = 100 µm)
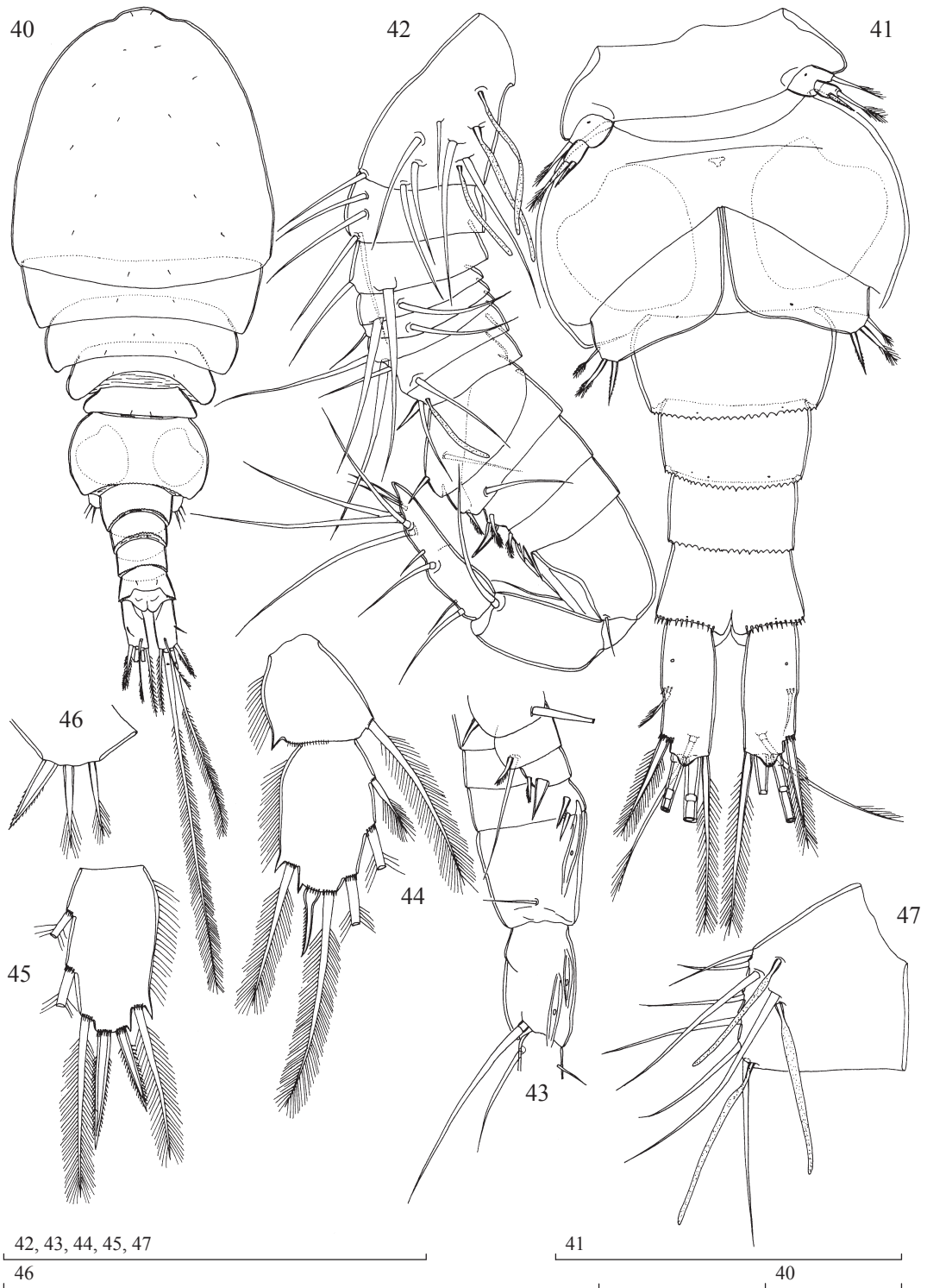
Figs. 40-47. Zealandcyclops fenwicki gen. nov., sp. nov., 40-46, allotype (male, 462 µm). 47, paratype male (443 µm). (40) Habitus, dorsal view. (41) Urosome, ventral view. (42) Antennula. (43) Detail of antennula. (44) Endopod of third swimming leg. (45) Second endopodal segment of fourth leg. (46) Sixth leg, lateral view. (47) First antennular segment. (Scale bars = 100 µm)

1.9 times as wide as long, armed with lateral short and uniplumose seta, inserted on short setophore. Distal segment much narrower (about 0.4 times as wide as basal one), about 1.3 times as long as wide, armed with apical seta and subapical, inner spine; apical seta 2.5 times as long as segment, pinnate distally, hardly reaching 1/3 of genital double-somite in length (Fig. 24); subapical spine strong, unipinnate, about 1.6 times as long as segment.

Sixth leg (Fig. 20) distinct, unornamented, more or less semicircular, cuticular plate, armed with two minute smooth spines and one smooth and equally minute dorsal seta; both spines basally fused to leg.

Description of male (allotype). Habitus (Fig. 40) more slender than in female, but prosome/urosome ratio just above 1.5 and greatest width also at posterior end of cephalothorax. Body length/width ratio about 2.4; cephalothorax 1.9 times as wide as genital somite. Rostral expansion well developed.

Cephalothorax (Fig. 40) somewhat longer than its greatest width, representing 44% of body length. Ornamentation of prosomites, colour and nauplius eye similar to those of female. Hyaline fringe of fifth pedigerous somite smooth, ornamented only with two dorsal sensilla; next three urosomites without any ornamentation, except two ventral cuticular pores, with hyaline fringes serrated.

Genital somite (Figs. 40 and 41) about twice as wide as long (dorsal view), with two spermatophores completely formed inside. Preanal somite narrower than anal and without any ornamentation. Anal somite and anal sinus similar to those of female.

Caudal rami (Fig. 41) parallel and about 2.5 times as long as wide. Armature and ornamentation similar to female, although innermost apical seta proportionally shorter.

Antennula (Fig. 42) 15-segmented, unornamented, digeniculate, with geniculations between eighth and ninth and between thirteenth and fourteenth segments, slightly longer than cephalothorax. Three aesthetascs present on first segment and one on eighth segment. Setal formula as follows: 7.4.2.2.2. 2.2.2.2.2.2.2.2.1.1.10. One seta on eighth, ninth and tenth segment, as well as two setae on eleventh and twelfth segment very short, spiniform; all other setae slender and most setae (except one seta on tenth, eleventh and twelfth segment each) smooth. Just one seta on fourteenth and five setae on fifteenth

segment articulating on basal part.

Antenna, labrum, mandibula, maxillula, maxilla, maxilliped and swimming legs armature formula similar to female. Apical spine on second endopodal segment of third leg (Fig. 44) modified, much smaller than in female, unipinnate and claw-like. Second endopodal segment of fourth swimming leg (Fig. 45) almost 1.8 times as long as wide; inner apical spine 1.4 times as long as outer one and 0.7 times as long as segment. Fifth leg (Fig. 41) very similar to female, although with less robust spine.

Sixth leg (Figs. 41 and 46) distinct, large cuticular plate, ornamented with single cuticular pore and armed with one bipinnate spine and two bipinnate setae; all armature elements of about same length.

Variability. Body length of females ranges from 427 µm to 517 µm (474 µm average; n = 14), while in males it ranges from 393 µm to 462 µm (436 µm average; n = 13). One paratype female (437 µm) has only two medial setae on the second endopodal segment of the third leg (Fig. 35), one additional seta on the third exopodal segment of the third leg (Fig. 36) and somewhat stronger outer spine on the sixth leg (Fig. 39). Most specimens have the armature formula of the swimming legs same as the holotype, with only four setae on the third exopodal segment of the third leg (Fig. 34). One paratype male (443 µm) has eight setae on the first antennular segment (Fig. 47) and a more robust spine on the fifth leg (Fig. 38). The spine on the fifth leg is somewhat deformed in another paratype male (Fig. 37). All paratype males have the apical spine of the third leg endopod transformed in the same way as allotype. Few paratypes, examined with a SEM microscope, show that the integument of all somites and caudal rami is covered with minute pits (Figs. 88 and 89) (otherwise invisible with a compound microscope); the true nature of the 'T'-shaped copulatory pore is also much clearer under a SEM microscope (Fig. 87), as well as the correct position of the terminal tubular pore on the caudal ramus (Fig. 89).

Species etymology. The species is named in honour of Dr Graham D. Fenwick from the National Institute of Water and Atmospheric Research Limited in Christchurch, New Zealand, who made material available for this study. The name is a noun in the genitive singular.

Zealandcyclops haywardi sp. nov.
(Figs. 48-64)

Type material. Holotype female (ZMA Co. 204 704), New Zealand, South Island, North Canterbury Region, Spotswood, Waiau West Road, well GS0249, 1997, leg. S. Hayward (sample GW3), 42º45'S 173º16'E, dissected on two slides.
Paratype female (WAM C34236), New Zealand, South Island, North Canterbury Region, Spotswood, Waiau West Road, well GS0249, 1997, leg. S. Hayward (sample GW3), 42˚45'S 173˚16'E, dissected on one slide.

Description of female (holotype). Body length, excluding caudal setae, 476 µm. Habitus (Fig. 48) spindle-shaped, only slightly dorsoventrally compressed, with prosome/urosome ratio 1.5 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.6; cephalothorax 1.9 times as wide as genital double-somite. Rostral expansion well developed. Free pedigerous somites without particular expansions laterally. Preserved specimen colourless. Nauplius eye not visible. Rostrum well developed, membranous, almost triangular and furnished with two large sensilla.

Cephalothorax (Fig. 48) about as long as its greatest width; representing 41% of total body length. Surface of cephalothoracic shield with several large sensilla and cuticular pores. Hyaline fringes of prosomites narrow and smooth. All free pedigerous somites ornamented dorsally with few sensilla and pores. No sclerotized joint between prosome and urosome or between fifth pedigerous somite and genital double-somite. Fifth pedigerous somite with smooth fringe dorsally and ventrally, ornamented only with two dorsal sensilla.

Genital double-somite (Fig. 49) about 0.8 times as long as wide, ornamented with four lateral (two on each side) and two ventral cuticular pores. Hyaline fringe of genital double- and two subsequent somites sharply and irregularly serrated both ventrally and dorsally. Copulatory pore relatively small, ovoid, positioned somewhat anteriorly of double-somite midlength; copulatory duct relatively short, rigidly sclerotized. Seminal receptacle not very large, clearly divided into anterior and posterior expansions, about 1.4 times as wide as long (ventral view), representing 60% of double-somite width and 57% of its length; anterior expansion larger and slightly wider than posterior one. Lateralmost parts of oviducts rigidly sclerotized, with two loops. Ovipores

situated dorsolaterally, at 2/5 of double-somite's length, covered with reduced sixth legs, bearing two minute spines and one minute seta. Third urosomite ornamented with two lateral and two ventral cuticular pores. Fourth urosomite without any visible ornamentation, normally built (not restricted like in previous species). Anal somite with smooth, broad, very short and convex anal operculum (Fig. 48), which represents 54% of somite's width and not reaching posterior margin of somite; ornamented with two large sensilla dorsally and with two cuticular pores and transverse row of spinules near posterior margin ventrally (Fig. 49). Anal sinus widely open, without visible ornamentation.

Caudal rami (Fig. 49) parallel, with very small space between them, and about 2.4 times as long as wide; ornamented with several spinules at base of lateral and outermost apical setae as well as with anterior cuticular pore ventrally; distal margin ventrally with large protuberance medially, with pore on top (which opened caudally). Dorsal seta about as long as ramus, inserted at 5/6 of ramus length, uniarticulate at base and plumose distally. Lateral seta arising clearly dorsolaterally at 3/5 of ramus length, uniplumose and half as long as ramus' width. Outermost apical seta stout, spiniform, about 0.7 times as long as ramus, bipinnate. Innermost apical seta also bipinnate but more slender and slightly shorter than outermost one. Principal apical setae with breaking planes and plumose; inner seta about 1.7 times as long as outer one and 0.45 times as long as body.

Antennula (Fig. 50) 11-segmented, unornamented, reaching 2/3 of cephalothorax in length, with one slender aesthetasc on seventh, eighth, tenth and eleventh segments each, and setal formula: 8.4.8.2.2.2. 3.2.2.2.7. Only one seta on tenth segment with breaking planes and only two apical setae on eleventh segment articulating on basal part. One seta on fifth segment spiniform and very short; all other setae slender and most setae smooth, only one seta on third and one on eleventh segment pinnate distally; 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 : 0.8 : 0.4 : 0.3 : 0.6 : 1.3 : 0.9 : 0.6 : 0.8 : 1.1.

Antenna (Fig. 61) slender, four-segmented, comprising large coxobasis and three-segmented endopod; all endopodal segments of about same length;
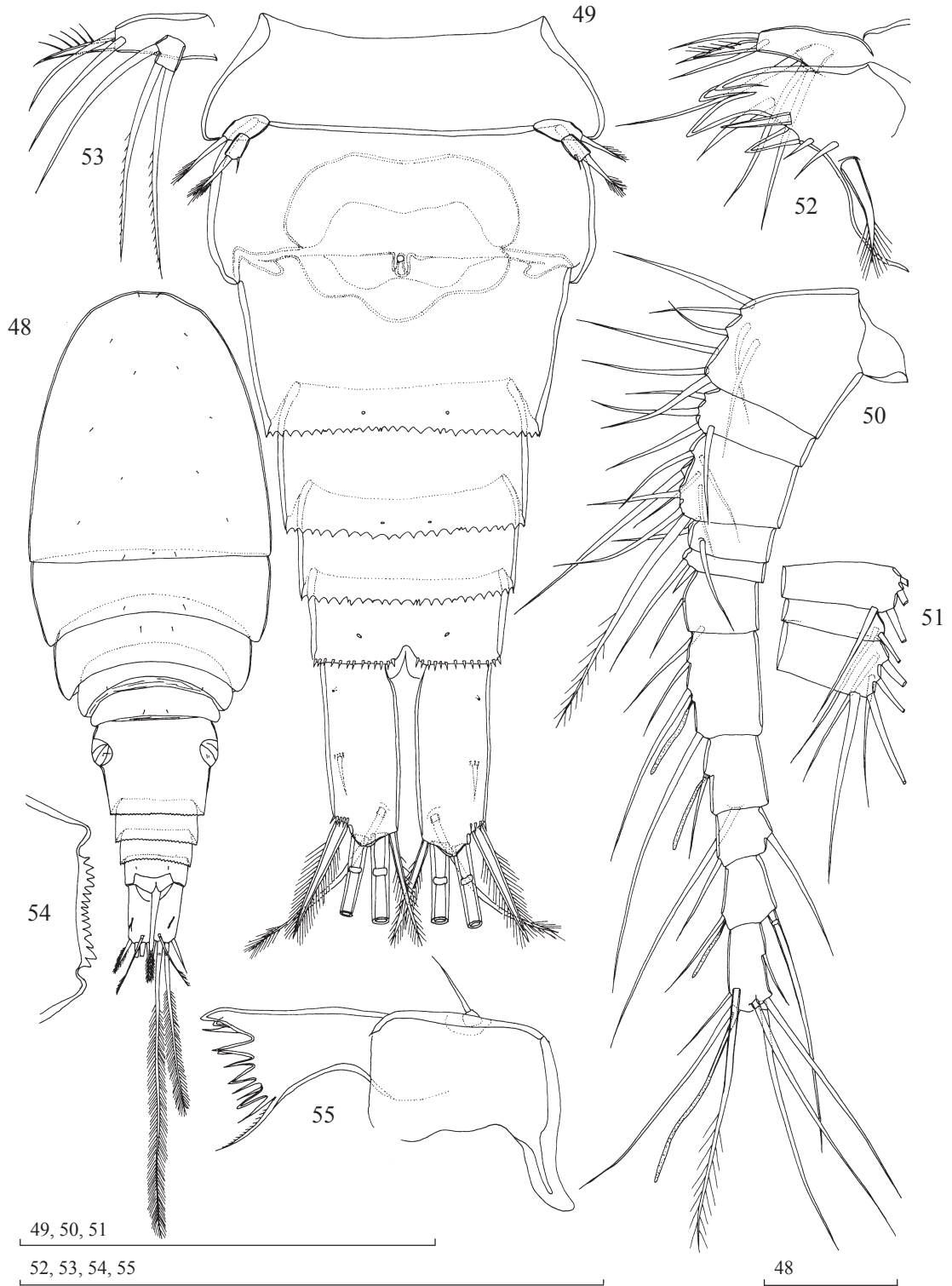
Figs. 48-55. Zealandcyclops haywardi gen. nov., sp. nov., holotype (female, 476 µm). (48) Habitus, dorsal view. (49) Urosome, ventral view. (50) Left antennula. (51) Second and third segments of right antennula. (52) Maxillula. (53) Palp of maxillula. (54) Labrum. (55) Mandibula. (Scale bars = 100 µm)

Figs. 56-64. Zealandcyclops haywardi gen. nov., sp. nov., 56-61, holotype (female, 476 µm). 62-64, paratype female (493 µm). (56) First swimming leg. (57) Second swimming leg. (58) Third swimming leg. (59) Fourth swimming leg. (60) Maxilliped. (61) Coxobasis of antenna. (62) Third exopodal segment of third leg. (63) Second endopodal segment of fourth leg. (64) Fifth leg. (Scale bars = 100 µm)

coxobasis considerably longer than endopodal segments, about 2.3 times as long as wide, ornamented with transverse row of spinules near outer margin proximally and one longitudinal row of spinules at distal part, armed with single smooth setae at distal inner corner; seta representing exopod absent. First endopodal segment armed with one smooth seta and ornamented with row of spinules along external margin. Second endopodal segment twice as long as wide, ornamented with longitudinal row of spinules along external margin, armed with nine smooth setae (seven lateral and two subapical; one subapical seta somewhat longer and much stronger than any other seta on that segment). Third endopodal segment 2.5 times as long as wide, armed with seven smooth apical setae (four of them strong and geniculate) and ornamented as previous two segments.

Labrum (Fig. 54) trapezoidal, unornamented; cutting edge almost straight, with 14 small and sharp teeth between produced, rounded lateral corners.

Mandibula (Fig. 55) with very small but clearly distinct palp, armed with single smooth, short seta. Coxal gnathobase cutting edge with six strong teeth (three of them complex; innermost one strongest) and two setae; outer seta unipinnate, about twice as long as inner seta and 1.2 times as long as single palpal seta.

Maxillula (Figs. 52 and 53) composed of well developed praecoxa and two-segmented palp. Arthrite of praecoxa with four strong and smooth apical spines; only one distinct, others completely fused to praecoxa. Praecoxa armed with five armature elements along inner margin, longest one plumose. Palp (Fig. 53) with distinct endopod, which bears three slender apical setae, without exopodal seta, and armed apically with two smooth slender setae and one robust, strongly pinnate spine.

Maxilla same as in previous species.

Maxilliped (Fig. 60) four-segmented, composed of syncoxa, basis and two-segmented endopod. Syncoxa about 1.8 times as long as wide, ornamented with three slender spinules, and armed with single pinnate seta. Basis 1.3 times as long as wide, ornamented with arched row of very long spinules near inner margin, armed with single, strong, bipinnate seta. First endopodal segment small, unornamented and armed with one strong, bipinnate seta; this seta longest and strongest on maxilliped. Second endopodal segment minute, unornamented, armed with

two setae; inner seta bipinnate, about 1.8 times as long as outer smooth seta. All pinnate setae with very long pinnules.

First swimming leg (Fig. 56) with two-segmented exopod and endopod; all other swimming legs with three-segmented exopods and two-segmented endopods (Figs. 57, 58 and 59). Armature formula of swimming legs as follows:

	coxa	basis	exopod	endopod
leg 1	0-1	1-I	I-0; II, I, 4	0-1; 1, I+1, 2
leg 2	0-1	1-0	I-0; I-1; II, I, 4	0-1; 1, I, 2
leg 3	0-1	1-0	I-0; I-1; II, I, 5	0-1; 1, I+1, 2
leg 4	0-1	1-0	I-0; I-1; II, I, 4	0-1; 1, II, 2

Last exopodal segment spine formula: 3.3.3.3. Intercoxal sclerites of all swimming legs unornamented, with smooth and bilobate distal margin. All coxae ornamented with few spinules on outer distal corner, and armed with strong, plumose seta on their inner distal corner. Basis of first leg ornamented with few spinules at base of endopod (others only with few hairs along inner margin), armed with slender lateral seta on outer margin. Spine at inner corner of basis of first leg reaching posterior margin of first endopodal segment (Fig. 56). All setae slender and plumose; outer apical seta on third exopodal segment of first leg pinnate along outer margin, plumose along inner one. All exopods and endopods with small spinules at base of all armature elements; all endopodal segments with row of hairs along outer margin; hairs also present along inner margin of most exopodal segments. Apical spine on second endopodal segment of first swimming leg very robust, about 1.2 times as long as segment (Fig. 56). Apical spine on second endopodal segment of second leg longer than segment (Fig. 57), while that on third leg (Fig. 58) somewhat shorter; proximal-most seta on third exopodal segment of third leg (Fig. 58) much shorter than other setae. Second endopodal segment of fourth swimming leg about 1.4 times as long as wide; armed apically with two spines; inner apical spine about 1.6 times as long as outer one and only slightly shorter than segment (Fig. 59).

Fifth leg (Fig. 49) relatively small, two-segmented, inserted ventrolaterally, and unornamented. Basal segment twice as wide as long, armed with lateral short and uniplumose seta, inserted on large setophore. Distal segment much narrower (about 0.3

times as wide as basal one), about 1.5 times as long as wide, armed with apical seta and subapical, inner spine; apical seta twice as long as segment, pinnate distally, hardly reaching 1/3 of genital double-somite in length; subapical spine small, about half as long as segment.

Sixth leg similar to that in previous species.

Male. Unknown.

Variability. Unfortunately, besides the holotype, only one paratype female (493 μm long) was collected and studied. It has only four setae on the third exopodal segment of the third leg (Fig. 62) and somewhat shorter second endopodal segment of fourth leg (Fig. 63), but very similar fifth leg (Fig. 64). One antennula in the holotype has the third segment subdivided on one side (Fig. 51).

Species etymology. The specific name is dedicated to the collector of this species. The name is a noun in the genitive singular.

Genus *Goniocyclops* Kiefer, 1955

Goniocyclops silvestris Harding, 1958
(Figs. 65-86, 90)

Material. New Zealand, South Island, South Canterbury Region, Waiariari (near Hook), Lower Hook Road, Campbell's Well, 15 October 1998, leg. S. Hayward (sample GW39-3), 44°41'S 171°05'E, seven males + one female + three copepodids [one male (ZMA Co. 204 705) and one female (ZMA Co. 204 706) dissected on two slides each; three males (ZMA Co. 204 707, 204 708 and 204709) dissected on one slide each; two males (WAM C34237) on a SEM stub; one male and three copepodids (ZMA Co. 204710) in alcohol].

Redescription of female. Habitus (Figs. 65 and 66) robust, wide and strongly dorsoventrally compressed, with prosome/urosome ratio 1.6 and greatest width at posterimmr end of cephalothorax. Body length/width ratio about 2; cephalothorax about 1.7 times as wide as genital double-somite. Rostral expansion well developed. 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. 65) as long as wide (dorsal view); represents 49% of total body length. Surface of cephalothorax shield with several large sensilla; no other ornamentation visible. Hyaline fringes of prosomites narrow and smooth. Fifth pedigerous somite ornamented with two dorsal large sensilla; hyaline fringe smooth both dorsally and ventrally.

Genital double-somite (Fig. 76) with deep lateral recesses at level of sixth legs, twice as wide as long (ventral view), ornamented with one dorsal cuticular pore in middle and two ventral pores near hind margin; hyaline fringe of genital double-somite, as well as of two subsequent urosomites, sharply serrated both ventrally and dorsally. Copulatory pore very small, ovoid, situated at 1/3 of somite length; copulatory duct narrow, siphon-shaped, well sclerotized. Seminal receptacle with very small anterior expansion and much larger and very wide posterior expansion (Fig. 76), represents 44% of double-somite's length; oviducts broad and weakly sclerotized. Ovipores situated dorsolaterally, covered with reduced sixth legs. Third and fourth urosomites without any ornamentation. Anal somite ornamented with two large sensilla dorsally and transverse row of minute spinules on posterior margin (Fig. 76). Anal sinus smooth. Anal operculum large, linguiform, produced posteriorly beyond somite limit (reaching 1/2 of caudal rami in length), irregularly serrated near posterior margin, represents 50% of anal somite width.

Caudal rami (Fig. 76) parallel, very close, and 1.9 times as long as wide; ornamented with few spinules at base of lateral seta and with long row of large spinules at base of outermost apical seta; distal margin ventrally with large protuberance medially, with pore on top (which opened caudally). Dorsal seta about 1.4 times as long as ramus, inserted at 4/5 of ramus length, uniarticulate at base and pinnate at distal part. Lateral seta arising somewhat dorsolaterally at 3/5 of ramus length, slightly shorter than ramus width. Outermost apical seta stout, spiniform, about as long as ramus, bipinnate. Innermost apical seta 0.6 times as long as dorsal one and about 0.7 times as long as outermost apical seta. Principal apical setae with braking planes; inner seta about 1.6 times as long as outer one and 0.7 times as long as body length.

Antennula (Fig. 67) 11-segmented, reaching slightly beyond middle of cephalothorax in length, ornamented with arched row of spinules on first segment, armed with slender aesthetascs on eighth, tenth and eleventh segments and with setal formula as follows: 8.2.5.2.1.2.3.1.2.2.7. Only a few setae articulat-
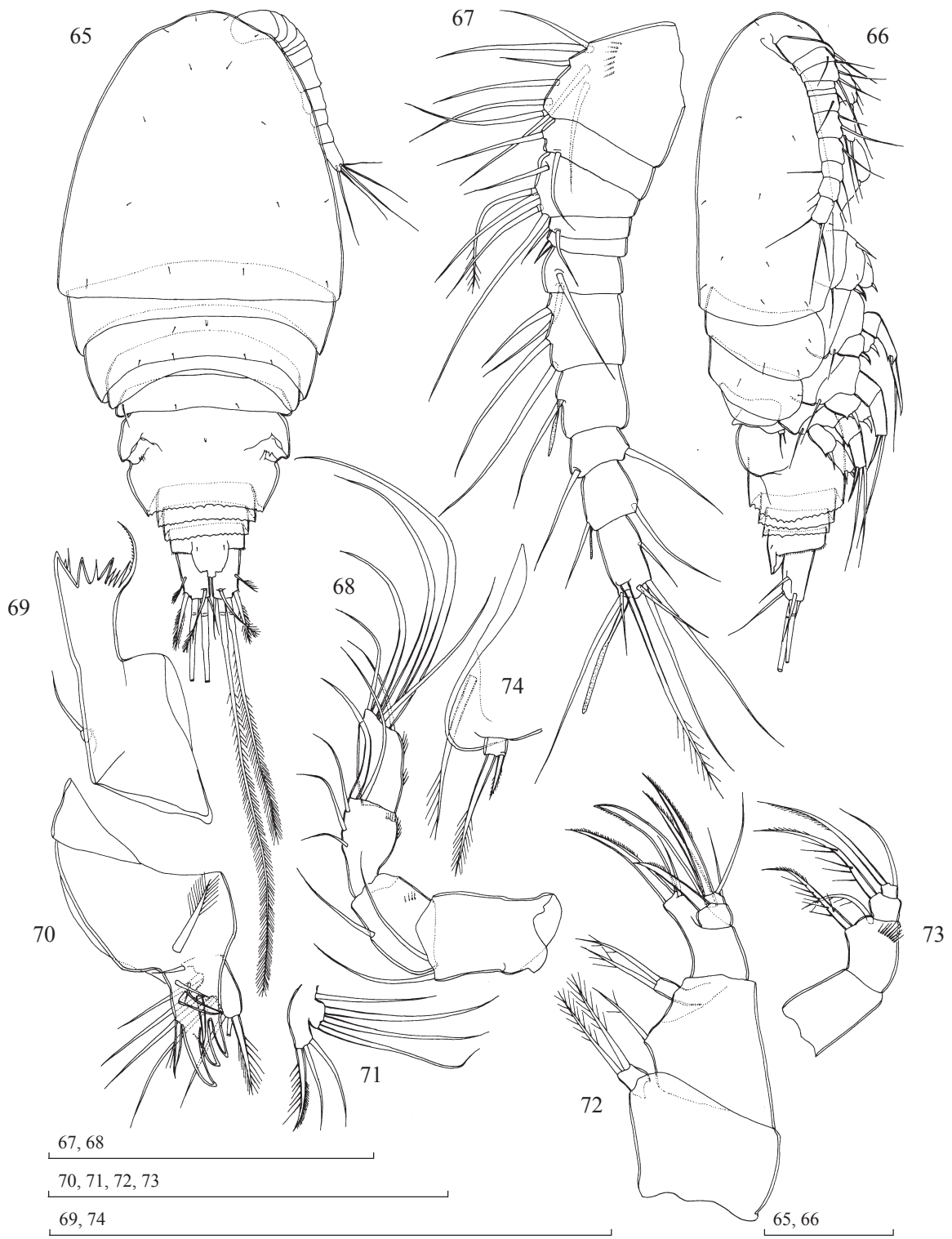
Figs. 65-74. Goniocyclops silvestris Harding, 1958, female (448 µm). (65) Habitus, dorsal view. (66) Habitus, lateral view. (67) Antennula. (68) Antenna. (69) Mandibula. (70) Maxillula (71) Palp of maxillula. (72) Maxilla. (73) Maxilliped. (74) Fifth leg. (Scale bars = 100 µm)
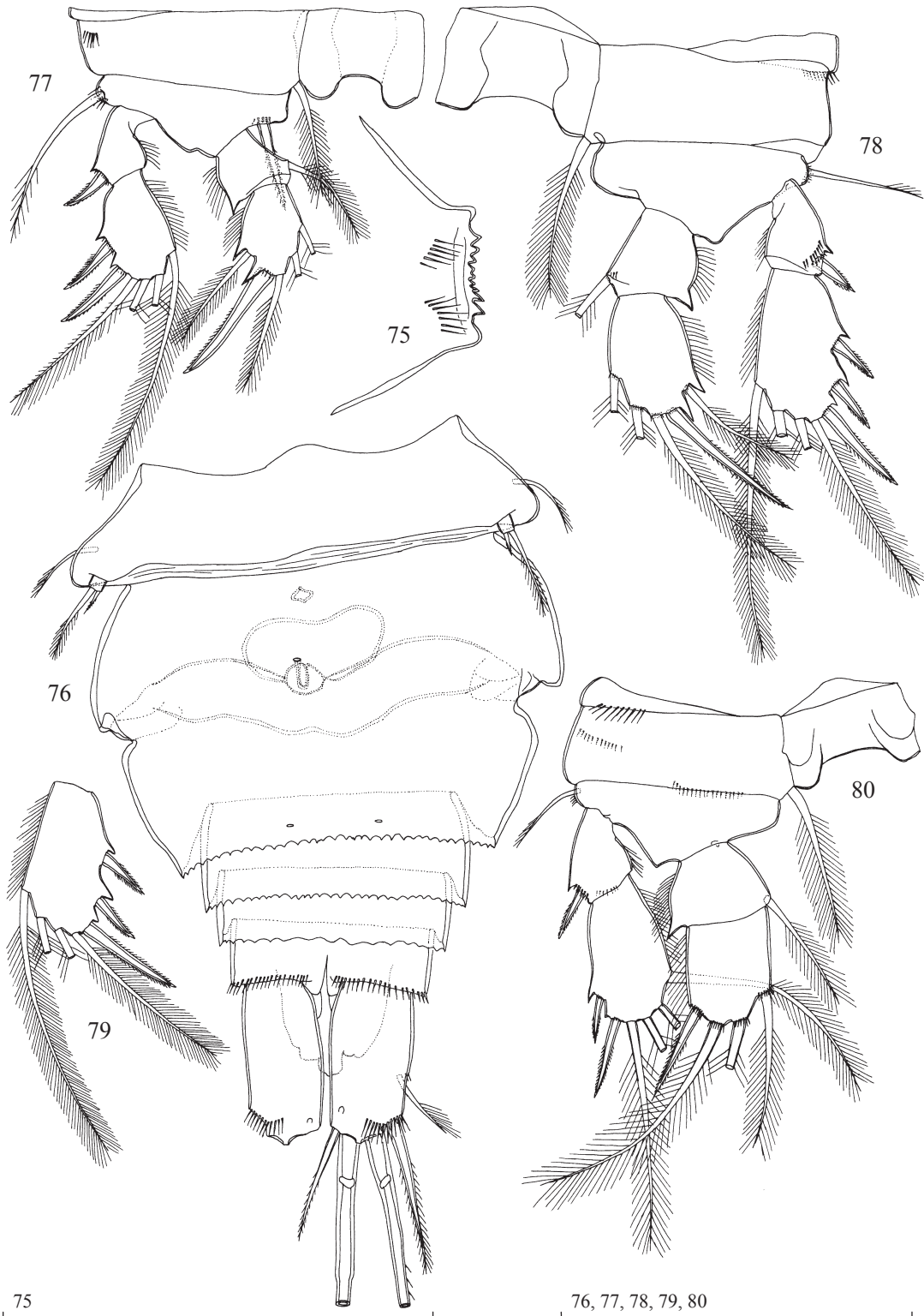
Figs. 75-80. Goniocyclops silvestris Harding, 1958, female (448 µm). (75) Labrum. (76) Urosome, ventral view. (77) First swimming leg. (78) Third swimming leg. (79) Second exopodal segment of second leg. (80) Fourth swimming leg. (Scale bars = 100 µm)

ing on basal part and just one apical seta on eleventh and one on third segment pinnate; all other setae smooth. 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 : 0.5 : 0.3 : 0.3 : 0.3 : 0.6 : 1.1 : 0.9 : 0.5 : 0.8 : 1.2.

Antenna (Fig. 68) four-segmented, comprising stout coxobasis and three-segmented endopod. Coxobasis unornamented, armed with two smooth setae at distal inner corner; seta representing exopod absent. First endopodal segment ornamented with one short transverse row of spinules; armed with one smooth seta at 2/3 of its length. Second endopodal segment about 1.7 times as long as wide, ornamented with longitudinal row of minute spinules, armed with five smooth setae (three lateral, one subapical and one apical). Third endopodal segment twice as long as wide, ornamented also with longitudinal row of spinules, armed with six smooth apical setae (three of them very strong and geniculate).

Labrum (Fig. 75) relatively small, trapezoidal, ornamented with two rows of six or seven long spinules. Cutting edge slightly concave, with nine sharp teeth between produced rounded lateral corners.

Mandibula (Fig. 69) with one-segmented, very small but distinct palp, bearing one smooth, short seta (hardly reaching middle of coxal gnathobase). Coxal gnathobase cutting edge armed with six teeth (innermost tooth strongest and complex) and two setae one dorsal corner (outer seta unipinnate, 2.5 times as long as inner smooth one, and about as long as palpal seta).

Maxillula (Figs. 70 and 71) composed of well developed praecoxa and one-segmented palp. Arthrite of praecoxa with four very strong apical spines, only one of which is distinct at base. Praecoxa armed with five armature elements along inner margin, proximalmost longest one and plumose; others smooth. Palp with endopod fused basally to coxobasis, bearing three apical smooth setae; exopodal seta also smooth, as well as two apical slender setae; apical spine robust and bipinnate.

Maxilla (Fig. 72) five-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 shorter. Basis expanded into robust claw, ornamented with longitudinal short row of minute spinules along concave margin distally, and armed with two setae; strong seta as long as claw, pinnate. Endopod two-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 strong seta on basis. All strong setae, as well as basal claw, prehensile.

Maxilliped (Fig. 73) four-segmented, composed of syncoxa, basis and two-segmented endopod. Syncoxa 1.4 times as long as wide, unarmed and unornamented. Basis ornamented with row of slender spinules near distal outer corner, armed with two pinnate setae on inner margin; proximal seta stronger and 1.3 times as long as distal one. First endopodal segment somewhat wider than long, unornamented, armed with single strong and bipinnate seta. Second endopodal segment minute, also unornamented, armed with two setae; inner seta strong, unipinnate and 1.6 times as long as outer smooth seta.

All swimming legs relatively short, with two-segmented exopods and endopods (Figs. 77-80). Endopods only slightly shorter on all legs. Swimming legs armature formula as follows:

	coxa	basis	exopod	endopod
leg 1	0-1	1-I	I-0; I, I,4	0-1; 1, I+1, 2
leg 2	0-1	1-0	I-0; II, I, 4	0-1; 1, I+1, 2
leg 3	0-1	1-0	I-0; II, I, 4	0-1; 1, I+1, 2
leg 4	0-1	1-0	I-0; I, I, 4	0-1; 0, I, 3

Second exopodal segment spine formula: 2.3.3.2. Second and third swimming legs without any difference (Figs. 78 and 79). Intercoxal sclerite of all swimming legs with deeply concave distal margins and without any ornamentation. Praecoxae short and ornamented with row of spinules. All coxae armed with long and plumose seta on distal inner corner; coxae of second and third leg unornamented, that of first leg with short row of spinules near outer margin, and coxa of fourth leg ornamented with two long rows of spinules. Spine inserted at inner corner of basis of first leg longer than first endopodal segment (Fig. 77). Outer seta on basis of first swimming leg very long, bipinnate at distal end; those on other legs shorter and unipinnate. All setae on endopods and
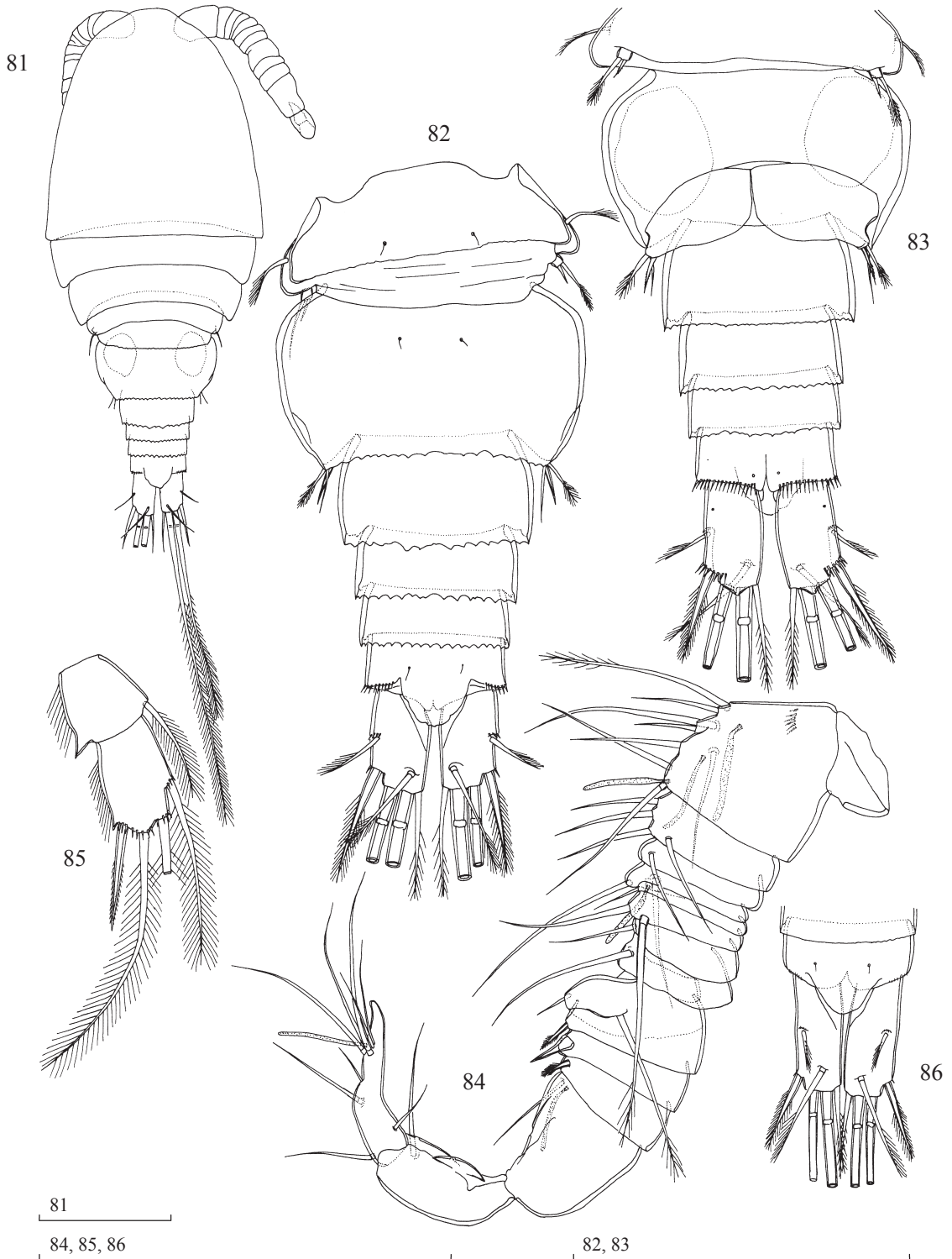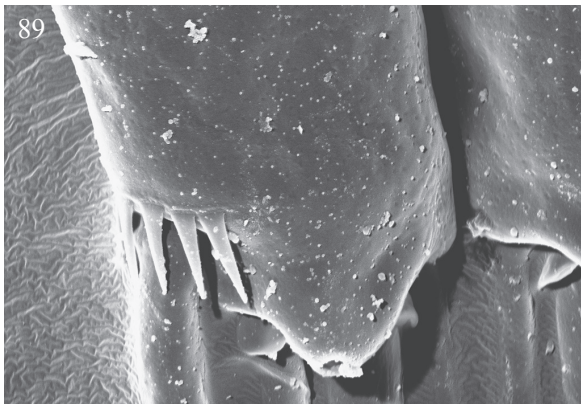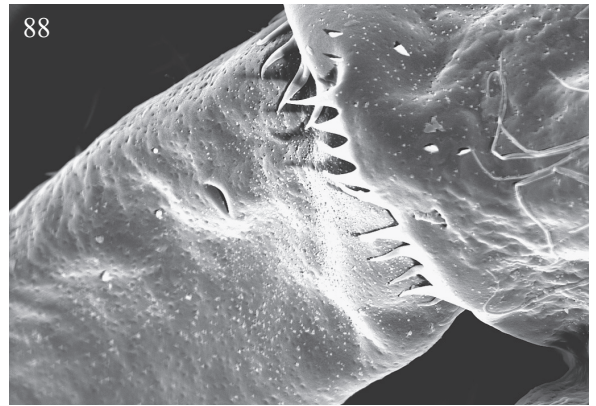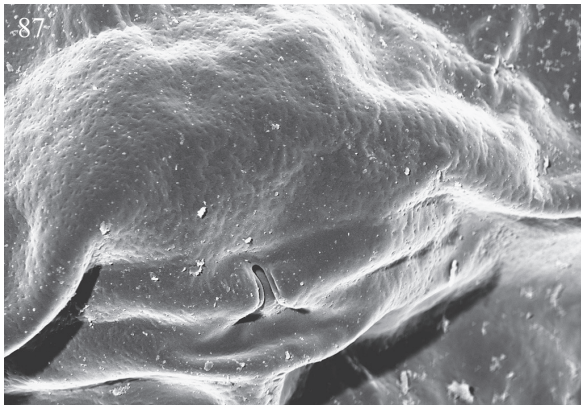
Figs. 81-86. Goniocyclops silvestris Harding, 1958, 81-85, male (373 µm). 86, male (304 µm). (81) Habitus, dorsal view. (82) Urosome, dorsal view. (83) Urosome, ventral view. (84) Antennula. (85) Endopod of fourth swimming leg. (86) Anal somite and caudal rami, dorsal view. (Scale bars = 100 µm)

exopods slender and plumose; outer apical seta on second exopodal segment of first leg pinnate along outer margin, plumose along inner one; no modified setae observed. Endopod of fourth swimming leg (Fig. 80) wider than exopod; second endopodal segment about 1.2 times as long as wide; only apical spine as long as segment and about 0.4 times as long as apical seta; outer endopodal seta absent.

Fifth leg (Figs. 74 and 76) with basal segment completely fused to somite, remnant of which slender, relatively short, and unipinnate at distal end, basal seta. Distal segment distinct, inserted ventrolaterally, about 0.8 times as long as wide, armed apically with outer bipinnate seta and inner bipinnate spine; seta on distal segment about 2.8 times as long as spine and 0.8 times as long as basal seta; apical spine relatively stout and 2.5 times as long as distal segment.

Sixth leg (Fig. 65) indistinct, small cuticular plate, armed with two short spines and one smooth seta.

First description of male. Habitus (Fig. 81) much more slender than in female, with prosome/urosome ratio about 1.6 and greatest width at posterior end of cephalothorax. Body length/width ratio about 2.3; cephalothorax about 1.8 times as wide as genital somite. Rostral expansion not well developed. Cephalothorax only slightly longer than its greatest width; represents 45% of total body length. Ornamentation of prosomites and colour similar to female. Hyaline fringe of fifth pedigerous somite smooth ventrally and finely serrated dorsally; somite ornamented only with two dorsal sensilla. Genital somite almost twice as wide as long, with serrated hyaline fringe dorsally; armed with two dorsal sensilla (Fig. 82). Next three urosomites unornamented, with serrated hyaline fringes both dorsally and ventrally. Anal somite ornamented with two large dorsal sensilla, two ventral cuticular pores, and with transverse row of spinules along posterior margin (Figs. 82 and 83). Anal operculum

Figs. 87-90. Scanning electron micrographs. 87-89, *Zealandcyclops fenwicki* gen. nov., sp. nov.; 87 and 89, paratype female (481 µm); 88, paratype male (439 µm); 90, *Goniocyclops silvestris* Harding, 1958, male (358 µm). (87) Copulatory pore. (88) Anterior part of right caudal ramus, ventral view. (89) Posterior part of right caudal ramus, ventral view. (90) Detail of left caudal ramus, ventral view.

somewhat shorter than in female and with less pronounced recesses near distal margin (Fig. 82).

Caudal rami (Figs. 82, 83, 90) slightly divergent, with very small space between them, and about 1.7 times as long as wide. Armature and ornamentation similar to female, except small cuticular pore at proximal part, ventrolaterally; innermost apical seta proportionally longer than in female.

Antennula (Fig. 84) 15-segmented (with completely fused sixteenth and seventeenth and seventh and eighth ancestral segments), with geniculations between ninth and tenth and between thirteenth and fourteenth segments, shorter than cephalothorax. First segment with three aesthetascs; one aesthetasc present on fourth, one on thirteenth and one on apical segment. All aesthetascs linguiform and short. Setal formula as follows: 8.4.1.2.1.2.1.1.0.3.1.1.1.1.9. Two setae on tenth segment, one on eleventh and one on twelfth segment very short, spiniform (that on twelfth and distal one on tenth segment also pinnate). Two T-shaped plates on fourteenth segment and one on thirteenth segment with pore in the middle.

Antenna, labrum, mandibula, maxillula, maxilla, maxilliped, and swimming legs similar to female.

Endopod of fourth swimming leg (Fig. 85) not so broad as in female (normally built). Second endopodal segment about 1.4 times as long as wide and about as long as apical spine.

Fifth leg (Figs. 82 and 83) similar to female. Inner apical spine on distal segment somewhat shorter than in female.

Sixth leg (Figs. 82 and 83) large, unornamented cuticular plate, armed with two setae and innermost spine. Inner seta plumose, slightly shorter than outer smooth one and somewhat longer than spine.

Variability. Body length of males ranges from 304 μm to 417 μm (365 μm average; n = 7); only one female was collected and studied. The smallest male in the series has somewhat more slender habitus and caudal rami, as well as almost triangular and smooth anal operculum (Fig. 86), but does not have any other differences.

Discussion

The present state of the Cyclopidae taxonomy and systematics is such that all three new species de-

scribed in this paper could easily be assigned to the genus *Diacyclops* Kiefer, 1927, which is the most specious and the most problematic cyclopoid genus (Monchenko and Von Vaupel Klein, 1999; Monchenko, 2000; Stoch, 2001). Even Kiefer, who created this genus (Kiefer, 1927), was well aware of its polyphyletic nature, which was obvious from his (Kiefer, 1928b: 547) proposed phylogenetic tree. Despite that and a very problematic position of closely related genus *Acanthocyclops* Kiefer, 1927, *Diacyclops* continued to be no more than a repository for all cyclopoids with even superficially similar fifth leg. A large number of those are stygobitic representatives, for which copepodologists believed that stygomorphic reductions were completely responsible for their morphology (oligomerization of appendages), although they are hardly more reduced than closely related surfacewater relatives (see Reid and Strayer, 1994). Monchenko and Von Vaupel Klein (1999) chose the genera *Diacyclops* and *Acanthocyclops* for their study of oligomerization in Copepoda "because these exhibit the highest diversity in segmentation of the appendages among their representatives within the subfamily Cyclopinae". Pesce (1996) stated that "due to the noteworthy variation among species and the clear overlap between the genera, the complex *Diacyclops-Acanthocyclops* is in urgent need of exhaustive revision". Unfortunately, that revision has not been published yet, but some initial attempts were made to, at least, separate obviously unrelated species into newly established genera (Lescher-Moutoue, 1976; Reid *et al*., 1999; Reid and Ishida, 2000; Karanovic, 2000). The present paper follows the same course, establishing two new genera: *Abdiacyclops* gen. nov. and *Zealandcyclops* gen. nov. Both *Diacyclops* and *Acanthocyclops* have a pretty large flock of morphologically very similar congeners around their type species. Furthermore, the evidence from crossbreeding studies (Monchenko, 2000) suggests that there are a number of cryptic species in what we now know as the type species of *Diacyclops*. Current overlap between *Diacyclops* and *Acanthocyclops* is certainly artificial.

The genus *Abdiacyclops* gen. nov. has the segmentation of the swimming legs 2/2, 3/3, 3/3, 3/3, which could not be found in any species of *Diacyclops* or *Acanthocyclops*, or any other representative of the subfamily Cyclopinae. The shape of the fifth leg of its only representative, *Abdiacyclops cirratus* sp.

nov., is superficially similar to that of *Diacyclops bicuspidatus* (Claus, 1857), which is the type species of the genus *Diacyclops*. However, many other characters are different in these two species, including the segmentation of the antennula, armature of the antenna, and relative lengths of apical spines on the endopod of the fourth swimming leg. But even the fifth leg is different in these two species, and closer examination will reveal a much shorter and smooth subapical spine in *Abdiacyclops cirratus* sp. nov., as well as considerably more robust proximal segment (Fig. 3). The shape of the fifth leg was always considered to be very important in the Cyclopinae taxonomy (see Kiefer, 1927, 1928b; Pesce, 1996; Reid *et al.*, 1999; Karanovic, 2000), and it is not a secret that most taxonomists would find it almost impossible to identify to the generic level cyclopoids with the fifth legs removed. However, because of this convenience other morphological characters received less attention, and Ferrari (1998) is probably theoretically correct to conclude "that transformations of P1-P4 more clearly reflect evolution of the Cyclopidae, and that convergences, including reversals, are more likely to have occurred to P5". The problem with the *Diacyclops-Acanthocyclops* complex is, in my opinion, that the *'Diacyclops-Acanthocyclops'*-type of the fifth leg (two-segmented, with apical seta and subapical spine on the distal segment) is probably a plesiomorphic character in the subfamily, and as such without any phylogenetic importance on the generic level (other than confirming that all species with this type of leg belong to Cyclopinae). Anyway, I still believe that a fine structure of the fifth leg (not its general plan) could be useful in the revision of the *Diacyclops-Acanthocyclops* complex, combined with other characters, such as the swimming legs segmentation and armature and the segmentation of the antennula. For example, all representatives of the *'languidoides'*-group of species of *Diacyclops* I had a chance to examine (mostly unpublished data) have a very wide basal segment of the fifth leg (which is relatively narrow in the type species of *Diacyclops*), in addition to their characteristic segmentation of the swimming legs (2/2, 3/2, 3/3, 3/3), and the 11-segmented antennula. This group seems to be monophyletic and should have a generic status. Also, revising groups of species, rather than the whole *Diacyclops-Acanthocyclops* complex, could be a much easier and more fruitful approach. The phylogenetic

relationships of *Abdiacyclops* gen. nov., like those of any other monospecific genus, are very hard to assess, but hopefully with further investigations of the subterranean waters in New Zealand, and around the world, more species will be found and the picture will be much clearer. Unfortunately, even males of *Abdiacyclops cirratus* sp. nov. are unknown, so some important generic characters may still be missing from its diagnosis. Atavistic remains of articulations on the antennula of *A. cirratus* sp. nov. are of very little importance, and not so uncommon in the *Diacyclops-Acanthocyclops* complex. Fiers *et al.* (1996), for example, described two very closely related species from the Yucatán Peninsula, one with and the other without remains of the articulation on the antennula.

The genus *Zealandcyclops* gen. nov. could also be distinguished from the rest of the *Diacyclops-Acanthocyclops* complex by its unique swimming legs segmentation formula (2/2, 3/2, 3/2, 3/2). Two closely related New Zealand species show better than anything how unimportant is the length of the subapical spine on the fifth leg (Figs. 27 and 64) in this group of cyclopoids. Yet, in both species the fifth leg is very small, with apical seta hardly reaching 1/3 of the genital double-somite in female, which is very different from the situation in the type species of *Diacyclops* or *Acanthocyclops*, as well as from that in *Abdiacyclops* gen. nov. Two species from Lake Baikal share the same segmentation of the swimming legs, and are here included in the genus *Zealandcyclops* gen. nov. *Diacyclops eulitoralis* was described by Alekseev and Arov (1986) from the interstitial of seven beaches on the southern shore of Lake Baikal. Besides the swimming legs segmentation, it shares with two New Zealand species the 11-segmented antennula, relatively slender habitus, a very small fifth leg, as well as the apical armature of the fourth leg endopod. However, *Zealandcyclops eulitoralis* (Alekseev and Arov, 1986) comb. nov. could be distinguished from *Z. fenwicki* sp. nov. and *Z. haywardi* sp. nov. by the plesiomorphic armature of the swimming legs (with inner setae present on the first exopodal segments of all swimming legs), as well as by somewhat longer caudal rami and a shorter innermost apical setae on them. Unfortunately, many details of the *Z. eulitoralis* morphology were not described (antenna, mouth-parts), and its proper redescription would certainly help to establish its closer phylogenetic relationships. Second Baikal

species was described from a sandy beach on the western shore by Boxshall *et al.* (1993) as *Diacyclops biceri*. *Zealandcyclops biceri* (Boxshall *et al.*, 1993) comb. nov. is very similar to *Z. eulitoralis*, but the authors were unaware of the latter species and the paper by Alekseev and Arov (1986). However, they were well aware of the polyphyletic nature of *Diacyclops* and an unnatural positioning of their species in it, as they (Boxshall *et al.,* 1993) wrote: "We, therefore, place the new species in *Diacyclops*, although we recognize that this placement may change after revision". Reid and Strayer (1994) had a chance to compare some specimens of the two Baikal species, concluding "that the description of both species contain some inaccuracies" and that they may even be synonyms. The only good distinguishing character between the two seems to be the armature of the second endopodal segment of the third leg. However, Reid and Strayer (1994) did not formally synonymize them, and I have even less arguments to do so without any material examined.

Transformed apical spine on the endopod of the third leg in male of *Zealandcyclops fenwicki* sp. nov. (Fig. 44) is a type of sexual dimorphism recorded so far only in the genera *Bryocyclops* Kiefer, 1927, *Paleocyclops* Monchenko, 1972, and *Itocyclops* Reid and Ishida, 2000 (see Monchenko, 1972; Reid, 1999; Reid and Ishida, 2000). *Bryocyclops* and *Paleocyclops* are very close genera, and the latter was described, and still considered by some, as a subgenus of the former. *Itocyclops* is probably very close to *Zealandcyclops* gen. nov. as it would be very easy to imagine its evolution from a *Zealandcyclops*-like ancestor. The only recorded case of sexual dimorphism in the swimming legs in the *Diacyclops-Acanthocyclops* complex is that of *Diacyclops chakan* Fiers and Reid, 1996, where the inner setae on the middle and terminal endopodal segments of the third leg in male are more spiniform than in female (Fiers *et al.*, 1996). It is very hard to judge the importance of this character in the genus *Zealandcyclops* gen. nov. as males of *Z. haywardi* sp. nov. are still unknown, and descriptions of *Z. eulitoralis* and *Z. biceri* are not completely accurate. However, this is another character that distinguishes *Zealandcyclops* gen. nov. from the *Diacyclops-Acanthocyclops* complex. Sexual dimorphism in the swimming legs of any kind was known in the subfamily Cyclopinae only in seven genera (Karanovic, 2000). The genus *Zealandcyclops* gen. nov. is obviously one

of those archaic elements in the New Zealand fauna, mentioned in the Introduction section of this paper, having survived only here and in the ancient Lake Baikal.

Current record of *Goniocyclops silvestris* Harding, 1958 in South Island is not surprising, as this species seems to be a stygophile, rather than a stygobite. It was described from the beech litter of a forest in Hutt Valley (Wellington region, North Island), some 400 km NE from the locality reported in this paper. But, even if the passive dispersal potential of this species was not large enough to bridge Cook Strait, the North and South Islands were joined together during the penultimate glaciation (Lewis, 1984), making it possible for *G. silvestris* to disperse actively. The genus *Goniocyclops* Kiefer, 1955 is an eastern Gondwanan element, with representatives known from Africa, Madagascar, Australia, New Zealand, New Caledonia, and southern China (Karanovic, 2004). New Zealand had been a part of the Gondwana supercontinent until very late in the Cretaceous (Knox, 1980), although it is now more than 2000 km from either Australia or Antarctica. *Goniocyclops silvestris* is the only New Zealand representative, and differs from the other eight species 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.

With the present report, the New Zealand cyclopoid fauna numbers 16 species, and they are given below in a systematic order. Endemic species are marked with an asterisk.

Systematic list of the New Zealand cyclopoids

Order Cyclopoida Burmeister, 1834
Family Cyclopidae Burmeister, 1834
Subfamily Halicyclopinae Kiefer, 1927
Genus *Halicyclops* Norman, 1903
   1) *Halicyclops magniceps* (Lilljeborg, 1853)
Subfamily Eucyclopinae Kiefer, 1927
Genus *Macrocyclops* Claus, 1893
   2) *Macrocyclops albidus* (Jurine, 1820)
Genus *Eucyclops* Claus, 1893
   3) *Eucyclops serrulatus* (Fischer, 1851)
Genus *Paracyclops* Claus, 1893
   4) *Paracyclops fimbriatus* (Fischer, 1853)
   5) *Paracyclops waiariki* Lewis, 1974*

Genus *Tropocyclops* Kiefer, 1927
   6) *Tropocyclops prasinus* (Fischer, 1860)
Subfamily Cyclopinae Burmeister, 1834
Genus *Acanthocyclops* Kiefer, 1927
   7) *Acanthocyclops robustus* (Sars, 1863)
   8) *Acanthocyclops vernalis* (Fischer, 1853)
Genus *Diacyclops* Kiefer, 1927
   9) *Diacyclops bicuspidatus* (Claus, 1857)
   10) *Diacyclops bisetosus* (Rehberg, 1880)
Genus *Abdiacyclops* gen. nov.
   11) *Abdiacyclops cirratus* sp. nov.*
Genus *Zealandcyclops* gen. nov.
   12) *Zealandcyclops fenwicki* sp. nov.*
   13) *Zealandcyclops haywardi* sp. nov.*
Genus *Metacyclops* Kiefer, 1927
   14) *Metacyclops monacanthus* (Kiefer, 1928)*
Genus *Goniocyclops* Kiefer, 1955
   15) *Goniocyclops silvestris* Harding, 1958*
Genus *Microcyclops* Claus, 1893
   16) *Microcyclops varicans* (Sars, 1863)

Majority of the New Zealand cyclopoids are cosmopolitan and eurytopic species, with probably enormous passive dispersal potentials. I have examined four species during this study (*Eucyclops serrulatus* (Fischer, 1851), *Paracyclops fimbriatus* (Fischer, 1853), *Acanthocyclops robustus* (Sars, 1863), and *Diacyclops bisetosus* (Rehberg, 1880)), and could not find any difference between them and my European specimens. This makes me strongly believe that these species could be introduced in New Zealand by early European settlers. In those days ships would carry over 100 water-butts, and the water came straight out of the local river into which the sewage of the local town poured (see, for example, Hood, 2003: 8). This water was used mainly for cooking, washing and hot drinks, as the principal beverages during the voyage were alcoholic. The butts would be refilled every now and then in distant locations and most probably washed with fresh water. And, when Captain Cook in 1769 first landed on New Zealand (Horwitz, 2000) and refilled his butts with local freshwater, first few cyclopoids could have been introduced. At present, only one cyclopoid genus (8%) and six species (38%) are endemic to New Zealand, which is not that bad, considering more than 70 years of almost complete inactivity in this field. Thus, I find it very appropriate to finish this paper with a citation from Kiefer (1931a): "We may therefore conclude that ... our knowledge of the New Zealand cyclopoids is still highly incomplete, and there is a wide field for investigation by local zoologists".

Acknowledgements

References

Alekseev VR, Arov IV. 1986. A new cyclop from the genus *Diacyclops* (Crustacea, Copepoda) from the eulittoral of Lake Baikal. *Zool. Zhur.* **65**: 1084-1087. [in Russian]

Barclay MH. 1969. First records and a new species of *Phyllognathopus* (Copepoda; Harpacticoida) in New Zealand. *N. Z. J. Mar. Fresh. Res.* **3**: 296-303.

Boxshall GA, Evstigneeva TD, Clark PF. 1993. A new interstitial cyclopoid copepod from a sandy beach on the western shore of Lake Baikal, Siberia. *Hydobiologia* **268**: 99-107.

Brady GS. 1906. On the entomostracan fauna of the New Zealand lakes. *Proc. Zool. Soc. Lond.* **2**: 692-701.

Brehm V. 1928. Contributions to a knowledge of fresh-water fauna of New Zealand. *Trans. Proc. N. Z. Inst.* **59**: 779-812.

Chilton C. 1881. On some subterranean Crustacea. *Trans. Proc. N. Z. Inst.* **14**: 174-180.

Chilton C. 1882. Notes on, and a new species of subterranean Crustacea. *Trans. Proc. N. Z. Inst.* **15**: 87-92.

Chilton C. 1894. The subterranean Crustacea of New Zealand: with some general remarks on the fauna of caves and wells. *Trans. Linn. Soc. London* **2**: 163-284.

Dussart B, Defaye D. 1985. *Répertoire mondial des Copépodes Cyclopoïdes*. CNRS, CRP de Bordeaux, Bordeaux, 1-236.

Ferrari FD. 1998. Setal developmental patterns of thoracopods of the Cyclopidae (Copepoda: Cyclopoida) and their use in phylogenetic inference. *J. Crust. Biol.* **18**: 471-489.

Fiers F, Reid JW, Iliffe TM, Súarez-Morales E. 1996. New hypogean cyclopoid copepods (Crustacea) from the Yucatán Peninsula, Mexico. *Contrib. Zool.* **66**: 65-102.

Harding JP. 1958. *Bryocamptus stouti* and *Goniocyclops silvestris*, two new species of copepod crustacean from forest litter in New Zealand. *Ann. Mag. Nat. Hist.* **13**: 309-314.

Hicks GRF. 1971. Some littoral harpacticoid copepods, including five new species, from Wellington, New Zealand. *N. Z. J. Mar. Fresh. Res.* **5**: 86-119.

Hood J. 2003. *Marked for misfortune: An epic tale of shipwreck, human endeavour and survival in the age of sail.* Conway Maritime Press, London, 1-288.

Horwitz T. 2000. *Into the blue: Boldly going where Captain Cook has gone before.* Allen and Unwin, Crows Nest, 1-480.

Huys R, Boxhall GA. 1991. *Copepod evolution.* The Ray Society, London, 1-468.

Jones JB. 1988. Zoogeography of parasitic Copepoda of the New Zealand region. *Hydrobiologia* **167/168**: 623-627.

Karanovic T. 2000. On *Reidcyclops*, new genus (Crustacea, Copepoda), with the first description of the male of *Reidcyclops trajani* (Reid & Strayer, 1994), new combination. *Beaufortia* **50**: 79-88.

Karanovic T. 2004. Subterranean Copepoda from arid Western Australia. *Crustaceana Monographs* **3**: 1-366.

Karanovic T. (in press). Subterranean copepods (Crustacea, Copepoda) from the Pilbara region in Western Australia. *Rec. West. Austr. Mus., Suppl.*

Karanovic T, Ranga Reddy Y. 2004. First record of *Phyllognathopus bassoti* Rouch, 1972 from India, with remarks on the family Phyllognathopodidae Gurney, 1932 (Crustacea, Copepoda, Harpacticoida). *Ann. Limnol.* **40**: 121-132.

Karaytug S, Boxshall GA. 1998a. The *Paracyclops fimbriatus* complex (Copepoda, Cyclopoida): a revision. *Zoosystema* **20**: 563-602.

Karaytug S, Boxshall GA. 1998b. Partial revision of *Paracyclops* Claus, 1893 (Copepoda, Cyclopoida, Cyclopidae) with descriptions of four new species. *Bull. Nat. Hist. Mus. London* **64**: 111-205.

Kiefer F. 1927. Versus eines Systems der Cyclopiden. *Zool. Anz.* **73**: 302-308.

Kiefer F. 1928a. Beiträge zur Copepodenkunde (VIII). *Zool. Anz.* **76**: 5-18.

Kiefer F. 1928b. Über Morphologie und Systematik der Süsswasser-Cyclopiden. *Zool. Jahrb. Abt. Syst.* **54**: 495-555.

Kiefer F. 1931a. Report on a collection of fresh-water Cyclopidae from New Zealand. *Trans. Proc. N. Z. Inst.* **62**: 129-133.

Kiefer F. 1931b. Neuseeländische Süsswassercopepoden. *Zool. Anz.* **11/12**: 273-282.

Knox GA. 1980. Plate tectonics and the evolution of intertidal and shallow-water benthic biotic distribution patterns of the southwest Pacific. *Palaeogeogr. Palaeoclim. Palaeoecol.* **31**: 267-297.

Lescher-Moutoué F. 1976. Création du genre *Kieferiella* a la suite de nouvelles observations sur l'espèce *delamarei* (Crustacé, Copépode); Recherches sur les eaux souterraines 31, Les cyclopides de la zone noyée d'un karst III. *Ann. Spél.* **31**: 91-98.

Lewis MH. 1972a. Freshwater harpacticoid copepods of New Zealand, 1. *Attheyella* and *Elaphoidella* (Canthocamptidae). *N. Z. J. Mar. Fresh. Res.* **6**: 23-47.

Lewis MH. 1972b. Freshwater harpacticoid copepods of New Zealand, 2. *Antarctobiotus* (Canthocamptidae). *N. Z. J. Mar. Fresh. Res.* **6**: 277-297.

Lewis MH. 1974. *Paracyclops waiariki* sp. nov. (Copepoda: Cyclopoida) from thermal waters in Rotorua. *N. Z. J. Mar. Fresh. Res.* **8**: 275-281.

Lewis MH. 1984. The freshwater Harpacticoida of New Zealand: a zoogeographical discussion. *Crustaceana, suppl.* **7**: 305-314.

Monchenko VI. 1972. Subterranean water cyclops (Copepoda, Cyclopoidae) from Kisilkum. *Trudi Zool. Inst. Akad. Nauk SSSR* **51**: 78-97.

Monchenko VI. 2000. Cryptic species in *Diacyclops bicuspidatus* (Copepoda: Cyclopoida): evidence from crossbreeding studies. *Hydrobiologia* **417**: 101-107.

Monchenko VI, Vaupel Klein JC von. 1999. Oligomerization in Copepoda Cyclopoida as a kind of orthogenetic evolution in the Animal Kingdom. *Crustaceana* **72**: 241-264.

Morton DW. 1985. Revision of the Australian Cyclopidae (Copepoda: Cyclopoida), I. *Acanthocyclops* Kiefer, *Diacyclops* Kiefer and *Australocyclops*, gen. nov. *Austral. J. Mar. Fresh. Res.* **36**: 615-634.

Percival E. 1937. New species of Copepoda from New Zealand lakes. *Rec. Canterbury Mus.* **4**: 169-175.

Pesce GL. 1996. Towards a revision of Cyclopinae copepods (Crustacea, Cyclopidae). *Fragm. Entomol. Roma* **28**: 189-200.

Reid. JW. 1999. New records of *Bryocyclops* from the continental U.S.A., Puerto Rico, and Brazil (Copepoda: Cyclopoida: Cyclopidae). *J. Crust. Biol.* **19**: 84-92.

Reid JW, Ishida T. 2000. *Itocyclops*, a new genus proposed for *Speocyclops yezoensis* (Copepoda: Cyclopoida: Cyclopidae). *J. Crust. Biol.* **20**: 589-596.

Reid JW, Strayer DL. 1994. *Diacyclops dimorphus*, a new species of copepod from Florida, with comments on morphology of interstitial cyclopine cyclopoids. *J. N. Am. Benth. Soc.* **13**: 250-265.

Reid JW, Strayer DL, McArthur JV, Stibbe SE, Lewis JJ. 1999. *Rheocyclops*, a new genus of copepods from the southeastern and central U.S.A. (Copepoda: Cyclopoida: Cyclopidae). *J. Crust. Biol.* **19**: 384-396.

Scarsbrook MR, Fenwick GD. 2003. Preliminary assessment of crustacean distribution patterns in New Zealand groundwater aquifers. *N. Z. J. Mar. Fresh. Res.* **37**: 405-413.

Stoch F. 2001. How many species of *Diacyclops*? New taxonomic characters and species richness in a freshwater cyclopid genus (Copepoda, Cyclopoida). *Hydrobiologia* **453/454**: 525-531.

Stock JH, Vaupel Klein JC von. 1996. Mounting media revisited: the suitability of Reyne's fluid for small crustaceans. *Crustaceana* **69**: 794-798.

Thomson GM. 1897. New Zealand Crustacea, with descriptions of new species. *Trans. Proc. N. Z. Inst.* **11**: 230-263.

Thomson GM. 1882. On the New Zealand Copepoda. *Trans. Proc. N. Z. Inst.* **15**: 93-116.

Wells JBJ, Hicks GRF, Coull BC. 1982. Common harpacticoid copepods from New Zealand harbours and estuaries. *N. Z. J. Zool.* **9**: 151-184.