

Copepods from ground waters of Western Australia, V. *Phyllopodopsyllus wellsi* sp. nov. (Crustacea: Copepoda: Harpacticoida) with a key to world species

T. Karanovic¹, G.L. Pesce² and W.F. Humphreys³

¹ Via Brescia 3, 84092 Bellizzi (SA), Italy

² Dipartimento di Scienze Ambientali, University of L'Aquila, Via Vetoio, 67100 L'Aquila, Italy

³ Western Australian Museum, Francis Street, Perth, Western Australia 6000, Australia

Abstract – *Phyllopodopsyllus wellsi* sp. nov. is described from anchialine ground waters of the Cape Range karst area in north-western Australia and has clear stygomorphies, being colourless and lacking the nauplius eye. The genus is for the first time recorded from Australia, as well as for the first time from outside strictly marine habitats. A key to all the species of the genus *Phyllopodopsyllus* T. Scott, 1906 is presented.

INTRODUCTION

Arid north-western Australia is proving to contain a diverse stygofauna inhabiting both ancient freshwater systems (Bradbury and Williams, 1997; Poore and Humphreys, 1999a; Watts and Humphreys, in press) as well as anchialine waters (Humphreys, in press). Recently, a number of stygal cyclopoid copepods have been described from the ground waters of Western Australia in both near-coastal (Pesce *et al.*, 1996a, 1996b; Pesce and De Laurentiis, 1996) and ancient continental regions (De Laurentiis *et al.*, 1999). The present paper concerns an harpacticoid copepod from anchialine ground waters of north-western Australia, belonging to a genus previously recorded only in strictly marine habitats.

According to Bodin (1997), the tetragonicipitid genus *Phyllopodopsyllus* T. Scott, 1906 is, one of the most speciose marine harpacticoid genera, together with *Halectinosoma* Lang, 1944 and *Stenhelia* Boeck, 1865, and marine harpacticoid genus with the largest number of new described species in the last fifty years. Lang (1948) initially divided the genus *Phyllopodopsyllus* into two genera (*Phyllopodopsyllus* and *Paraphyllopodopsyllus*), based upon the shape of the second segment of the antennula and setation of second and third swimming legs in females. Many authors followed this revision, and Vervoort (1964) provided an useful key to species of the genus *Phyllopodopsyllus*, although not for *Paraphyllopodopsyllus*. After several new species were described possessing intermediate characteristics, Lang (1965) synonymized *Paraphyllopodopsyllus* with *Phyllopodopsyllus* and compiled an excellent key to 21 species then recognized. He subdivided the genus into three morphological groups based on the second antennular segment (i.e. presence or

absence, and dimensions of an unguiform projection). Coull (1973) presented a very detailed survey of the genus *Phyllopodopsyllus*, and compiled an instructive table listing the most salient morphological characteristics. His key included 33 species and subspecies. Finally Kunz (1984) reviewed the genus, and tabulated setal formulae of the second, third, and fourth swimming legs in female, as well as the antennulae segmentation and shape. He subdivided the genus into nine species groups, based on these characteristics: 1 – *bradyi*, 2 – *furciger*, 3 – *aegypticus*, 4 – *borutzkyi*, 5 – *pauli*, 6 – *opistoceratus*, 7 – *mossmani*, 8 – *xenus*, and 9 – *longipalpatus* group. Fiers (1995) doubted the “naturalness of these groups”, but proposed nothing new, placing his new species (*P. yucatanensis*) within one of Kunz’s groups. Subsequent to the last review of the genus (Kunz, 1984) 13 new species and subspecies have been described: *P. alatus* Fiers, 1986; *P. crenulatus* Wells and Rao, 1987; *P. gracilipes* Wells and Rao, 1987; *P. stigmatosus* Wells and Rao, 1987; *P. tenuis* Wells and Rao, 1987; *P. galapagoensis* Mielke, 1989; *P. kunzi* Mielke, 1989; *P. ancylus* Mielke, 1992; *P. carinatus* Mielke, 1992; *P. mossmani chiloensis* Mielke, 1992; *P. hartmannorum* Kunz, 1995; *P. pallaresae* Kunz, 1995; and *P. yucatanensis* Fiers, 1995. In addition Wells and Rao (1987) described the male of *P. aegypticus* Nicholls, 1944 and Kunz (1995) described the male of *P. xenus* (Kunz, 1951). Kunz (1984) however did not mention three species already described: *P. laticauda* Por, 1964; *P. medius* Por, 1964; and *P. bahamensis* Geddes, 1968. Even though some of the species above are synonyms, the number of species in the genus *Phyllopodopsyllus* has increased considerably, and a key for their identification is therefore included in this paper. During an

investigation of the copepod fauna in Western Australia a new species of the genus *Phyllopodopsyllus* was identified. This new species is herein described as *P. wellsii* sp. nov.

HABITAT AND ASSOCIATED FAUNA

The copepods were sampled from ground water in karst terrain, accessed by temporary bores drilled for a seismic survey. The bores were located on a wave-cut limestone terrace overlain by Quaternary deposits on the north-western tip of the Cape Range peninsula, Western Australia. Bore A5 lies one kilometre south-east of Babjarrimannos at an altitude of a 12 m ASL and ca. 1000 m from the seashore; the water table approximates sea level and had a salinity of 24.7 g/dm³. Bore A7 is within one kilometre of Vlaming Head at an altitude of a 10 ASL and ca. 350 m from the seashore; the water is about sea level and had a salinity of 25.7 g/dm³. Ground water on the eastern side of the peninsula, where it has been recorded, typically tracks the marine tides but exhibits a temporal and amplitude lag (Humphreys *et al.*, 1999). The waters are typically anchialine (Stock *et al.*, 1986; Sket, 1996; Humphreys, 1999b) and exhibit a marked physico-chemical stratification (Humphreys, 1999b). Fauna sampled within the same boreholes as *Phyllopodopsyllus wellsii* sp. nov. were all stygal species and included the blind gudgeon *Milyeringa veritas* Whitley (Pisces: Eleotridae), calanoid copepods and melitid amphipods. These form part of a more widespread and diverse stygofauna inhabiting both fresh and anchialine waters of the Cape Range peninsula, with elements being found on Barrow Island 170 km to the north-east (Humphreys, 1999b; in press; Humphreys *et al.*, 1999). The following cyclopoid copepods are known from the area: *Apocyclops dengizicus* (Lepechkin), *Halicyclops longifurcatus* Pesce, De Laurentiis and Humphreys, *Metacyclops mortoni* Pesce, De Laurentiis and Humphreys, *Microcyclops varicans* G.O. Sars, and *Diacyclops humphreysi* Pesce and De Laurentiis. In addition, the wider anchialine fauna contains numerous widely disjunct taxa, many of which occupy a "Tethyan" track, such as *Lasinetes* (Remipedia), *Halosbaena* (Thermosbaenacea), *Haptolana* (Isopoda), *Liagoceradocus* (Amphipoda), *Danielopolina* (Ostracoda), as well as misophrioid and calanoid copepods (Yager and Humphreys, 1996; Poore and Humphreys, 1992; Bruce and Humphreys, 1993; Bradbury and Williams, 1996; Danielopol *et al.*, in press).

MATERIAL AND METHODS

The sites were sampled using baited traps and haul-nets from 'uphole' bores drilled to locate recording equipment for a seismic survey.

Permanent mounts were made in commercial polyvinyl-lactophenol and in Faure's medium. Dissected specimens were drawn at magnification of 630x and 1000x with drawing tube mounted on a Leica DMLS microscope, with C-plan achromatic objectives. All material is deposited in the Western Australian Museum (WAM) and BES denotes field numbers from the Invertebrate Biogeography and Ecology group. Abbreviations used in the key to species are: Fu – furcal rami; A1 – antennula; P1–P4 – first to fourth swimming leg; P5 – fifth leg; Enp – endopodite; Exp – exopodite; Enp2P3 – second endopodite segment of the third swimming leg.

SYSTEMATICS

Family Tetragnonicipitidae Lang, 1944

Genus *Phyllopodopsyllus* T. Scott, 1906

Phyllopodopsyllus wellsii sp. nov.

Figures 1–19

Material Examined

Holotype

♀ (WAM C24456), Cape Range, AB7, Western Australia, Australia, 21°49'S, 114°06'E, 11 November 1995, leg. R.D. Brooks (BES 4676.1).

Allotype

♂ (WAM C244457), Cape Range, AB7, Western Australia, Australia, 21°49'S, 114°06'E, 11 November 1995, leg. R.D. Brooks (BES 4676.1).

Paratypes

Australia: Western Australia: 14 ♂, 11 ♀ (9 ovigerous) (WAM 24458 – C24465, on slides, C24466 in alcohol) Cape Range, AB7, 21°49'S, 114°06'E, 11 November 1995, leg. R.D. Brooks (BES 4676.2).

Other material

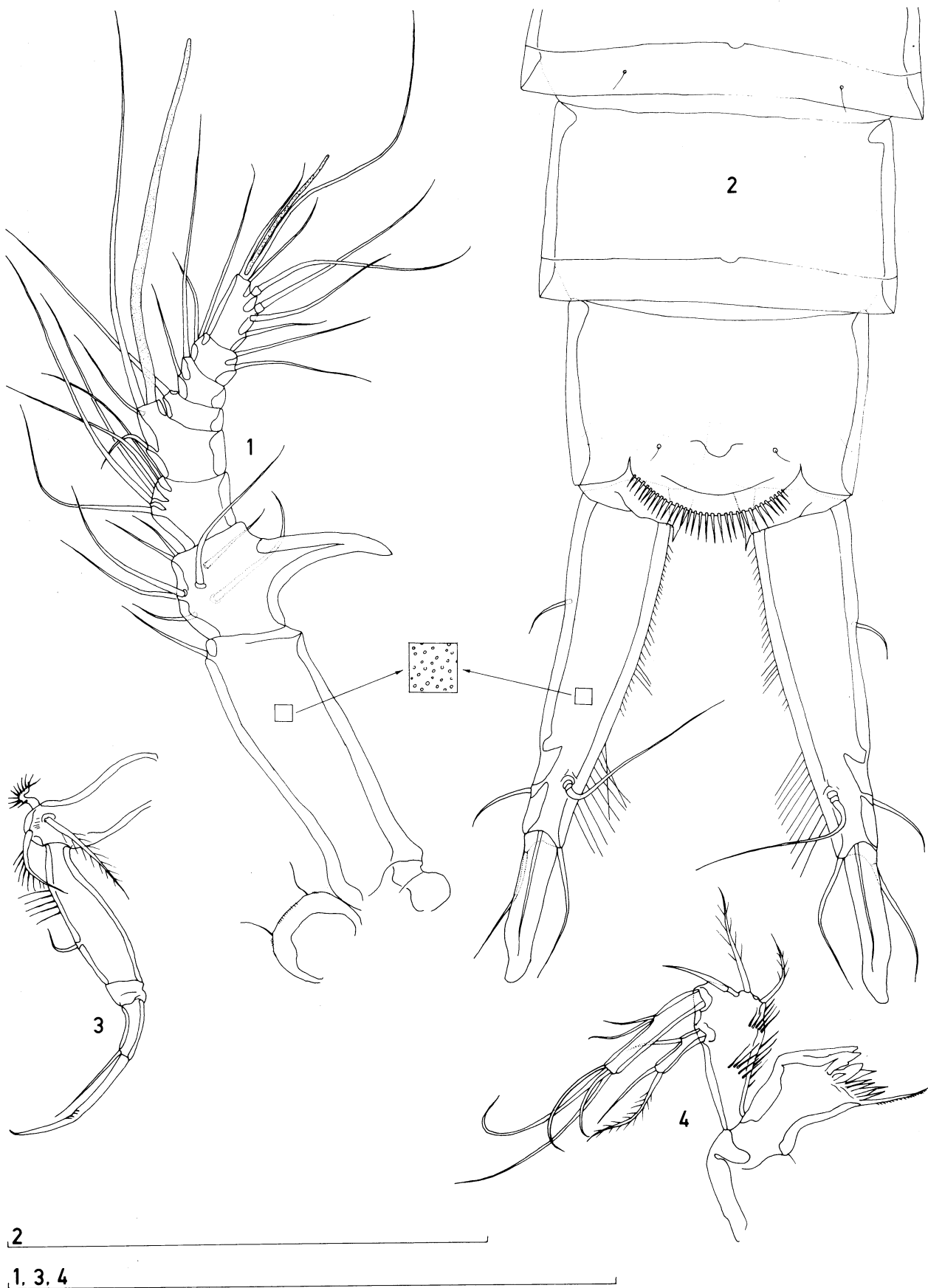
Australia: Western Australia: 3 ♂, 5 ♀ (4 ovigerous) (WAM C24467, in alcohol), Cape Range, AB7, 21°49'S, 114°06'E, 5 November 1995, leg. R.D. Brooks (BES 4673).

1 ♀ (WAM C24468, on slide), Cape Range, AB5, 21°50'S, 114°05'E, 4 November 1995, leg. R.D. Brooks (BES 4666).

Description

Female (holotype)

Habitus elongated, cylindrical. Body colourless, and nauplius eye absent. Cuticle densely furnished with minute pits, especially on furcal rami and antennula (Figures 1 and 2). Prosoma comprising cephalothorax, incorporating first pedigerous



Figures 1–4 *Phyllopodopsyllus wellsi* sp. nov., holotype (female): 1 – antennula and rostrum; 2 – abdomen, dorsal view; 3 – maxilliped; 4 – mandibula. Scales = 0.1 mm.

somite, and 3 free pedigerous somites. Surface of dorsal shield covering cephalothorax with many sensillae, as well as tergites of 3 free pedigerous somites. Hind margins of somites smooth. Rostrum almost quadrate, with single pair of sensillae, and with row of very fine spinules on distal margin (Figure 1). Urosome comprising fifth pedigerous somite, genital double-somite (representing fused genital and first abdominal somite), and 3 free abdominal somites. Genital double-somite almost as long as wide (Figures 6 and 9). Subdivision line visible dorsally, furnished with 6 sensillae, while laterally and ventrally marked by rigid internal sclerotized ridge. One ventral and one dorsal pair of sensillae presented posteriorly on genital double-somite, as well as on first free abdominal somite (Figure 2); second free abdominal somite lacking sensillae. Their hind margins smooth, too. Anal somite (last abdominal somite) ornamented only with pair of sensillae dorsally. Anal operculum convex, not reaching beyond limit of anal somite, with many marginal spines (Figure 2).

Furcal rami divergent, about 3.8 times longer than wide, with complete armature (2 lateral, 1 dorsal and 3 apical setae), and without dorsal chitinous ridge. Their inner margins with row of fine hairs, especially long in distal part (Figure 2). Dorsal seta attached at distal sixth of furcal length, well developed, while lateral setae very short. Outer apical seta somewhat moved to ventral side, as long as inner apical seta. Middle apical seta extraordinary strong, slightly curved at end, and long as other two apical setae.

Antennula 8-segmented, with 1 slender aesthetasc on apical segment, 1 very long aesthetasc on fourth segment (more than twice longer than 4 distal segments taken together), and with setal formula as follows: 1.8.5.2.1.2.4.7 (Figure 1). All setae smooth. Second segment with very large, posteriorly directed, unguiform process, and lacking anterior process. First segment about 3 times as long as wide.

Antenna with almost completely reduced coxa, 1-segmented basis and exopodite, and 2-segmented endopodite (Figure 12). Inner margin of basis furnished with long spinules. Exopodite with 3 elements, of which outer one basally fused with segment. First endopodite segment only with few small spinules on outer margin. Second endopodite segment with 2 lateral spines and 6 apical setae, as well as with many spinules along outer margin (Figure 12).

Mandibula with cutting edge of coxa with row of teeth of different thickness and with single lateral seta (Figure 4). Basis large, bearing 3 setae on inner margin (1 smooth and 2 plumose), and furnished with 2 transverse rows of long slender spinules. Endopodite twice longer than exopodite, armed with 2 lateral and 4 apical smooth setae. Exopodite

armed with 1 lateral and 2 apical (1 smooth and 1 plumose) setae (Figure 4). Both rami 1-segmented.

Maxillula with 13 setae on precoxa, 5 setae on coxa, 8 on basis, 4 on endopodite and 3 setae on exopodite.

Maxilla with 10 seta on syncoxa (2 setae on each of proximal 2 endites; 3 setae on each of distal 2 endites), 4 on basis and 6 setae altogether on 2-segmented endopodite.

Maxilliped with unornamented syncoxa, which armed with 3 plumose setae (Figure 3). Basis with 1 seta and row of long spinules on inner margin. Endopodite 1-segmented, armed with strong recurved apical claw and slender smooth subapical seta (Figure 3).

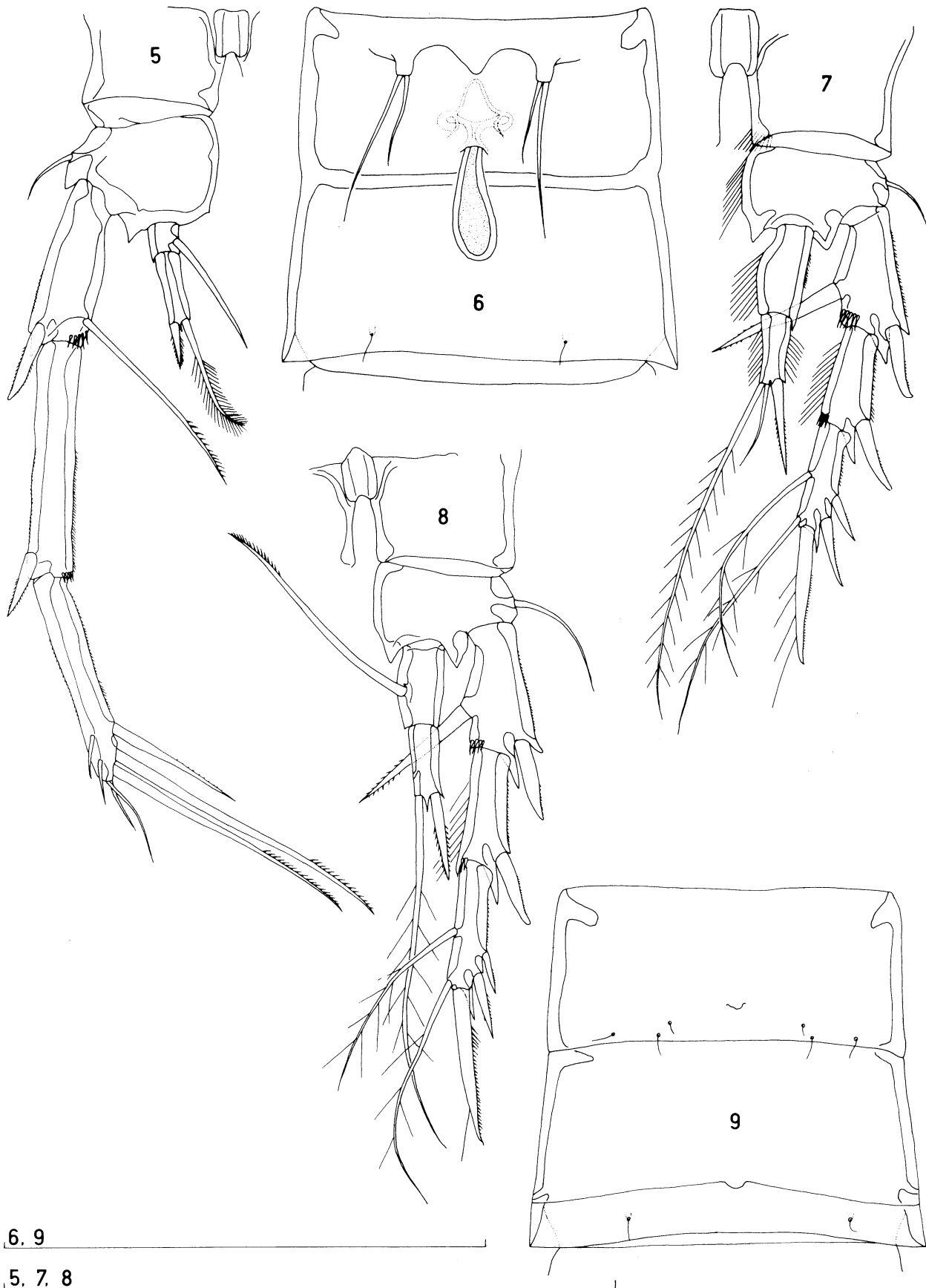
All swimming legs with 3-segmented exopodites and 2-segmented endopodites (Figures 5, 7, 8 and 11). Spine and setal formula on exopodites and endopodites from first to fourth swimming legs (legend: inner / outer spine or seta; inner / terminal / outer):

Segments	Exopodite			Endopodite	
	1	2	3	1	2
First leg	0/1	0/1	0/2/2	1/0	0/2/0
Second leg	1/1	0/1	1/2/2	0/0	0/3/0
Third leg	1/1	0/1	1/2/2	1/0	0/2/0
Fourth leg	1/1	0/1	3/2/2	1/0	0/2/0

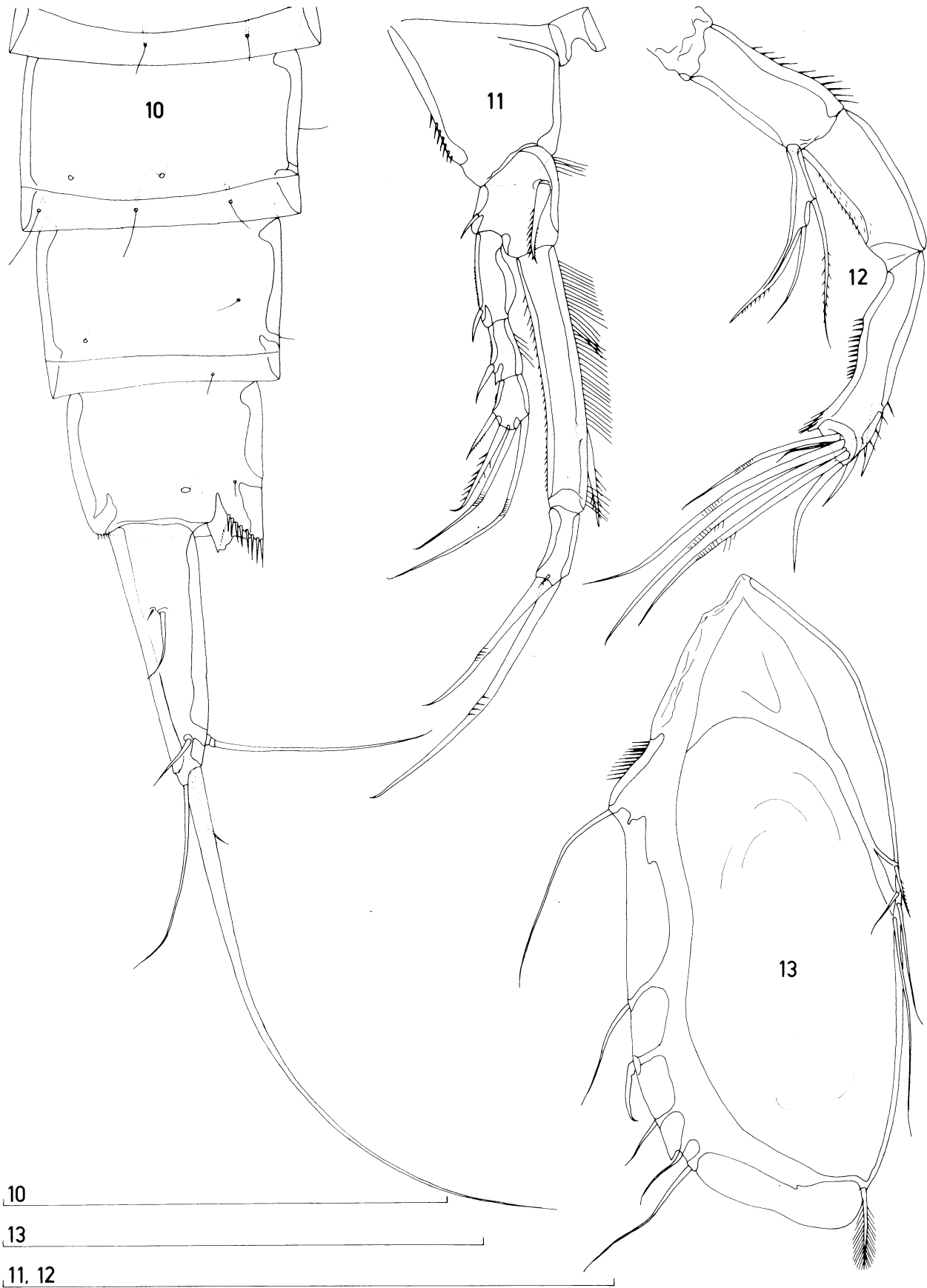
Couplers (intercoxal sclerites) of all swimming legs with concave distal margin and without surface ornamentation. Coxa of third and fourth swimming legs unornamented, while coxa of second leg bearing row of hairs on inner-distal corner and coxa of first leg ornamented with row of spinules on outer margin. Basis of first and second swimming legs with row of hairs on inner margin, while those of third and fourth legs without ornamentation. Basis of first swimming leg bearing 1 strong spine on inner margin (attached at first third of segment's length). All swimming legs with smooth epipodite setae, on outer margin of basis. Apical and outer elements on distal exopodite segment of fourth swimming leg reduced, setiform (Figure 5).

Fifth leg typically foliaceous, with completely fused basoendopodite and exopodite, but with clear chitinous suture marking original separation (Figure 13). Epipodite seta well developed, and between it and proximal margin of basis 1 row of slender spinules exists. Former basoendopodite armed with 4 slender setae. Former exopodite segment armed with 6 setae, of which only innermost one plumose. Fifth seta on that segment, from inner margin, characteristically curved (Figure 13). Fifth leg cavity without eggs.

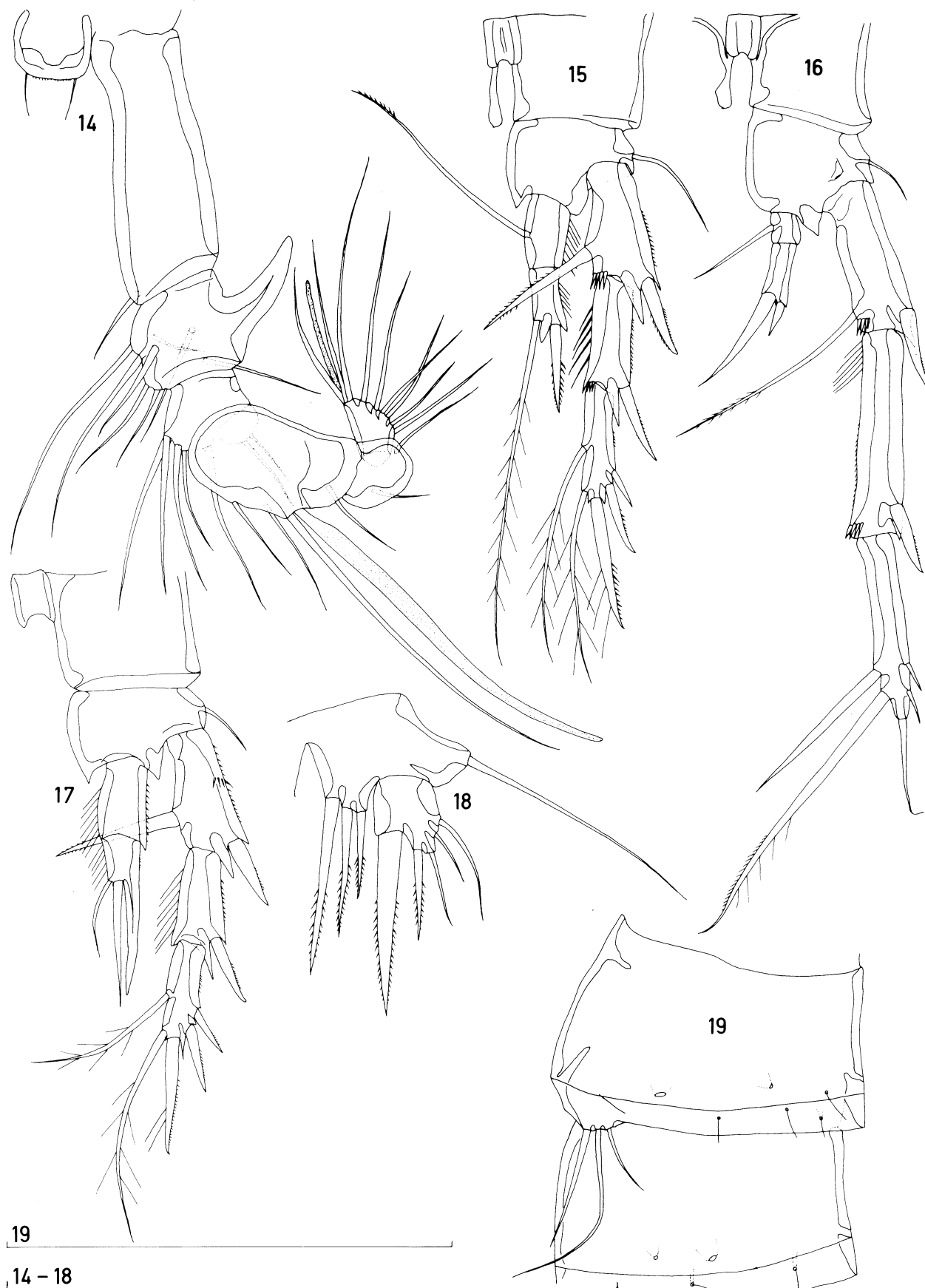
Sixth leg fused with genital double-somite, bearing 2 smooth setae, of which outer one about 1.8 times longer than inner (Figure 6). Genital field present in distal half of first genital somite, having short copulatory ductus connecting wide copulatory pore and small paired seminal



Figures 5-9 *Phyllopodopsyllus wellsi* sp. nov., holotype (female): 5 - fourth swimming leg; 6 - genital double-somite, ventral view; 7 - second swimming leg; 8 - third swimming leg; 9 - genital double-somite, dorsal view. Scales = 0.1 mm.



Figures 10–13 *Phyllopodopsyllus wellsi* sp. nov.; 10, allotype (male); 11–13, holotype (female): 10 – abdomen, lateral view; 11 – first swimming leg; 12 – antenna; 13 – fifth leg. Scales = 0.1 mm.



Figures 14–19 *Phyllopodopsyllus wellsi* sp. nov., allotype (male): 14 – antennula and rostrum; 15 – third swimming leg; 16 – fourth swimming leg; 17 – second swimming leg; 18 – fifth leg; 19 – genital somite with sixth leg, lateral view. Scales = 0.1 mm.

receptacles. Small, tongue-like, spermatophore attached to genital pore (Figure 6).

Male (allotype)

Body similar to female in general appearance, slightly more slender. Urosome comprising fifth pedigerous somite, genital somite, and 4 free abdominal somites. Genital somite about 1.5 times broader than long. All somites with smooth hind margins, and with different number of sensillae.

Furcal rami similar to female, but outer and middle apical setae much longer (Figure 10). Outer apical seta more than twice longer than inner apical one, while middle apical seta almost as long as abdomen.

Antennula strongly geniculate, with almost completely fused fourth and fifth segments (only 1 cuticular suture remained between them), and with completely fused sixth and seventh segments (Figure 14). First and second, as well as ultimate, segments very similar to female.

Antenna, mandibula, maxillula, maxilla, maxilliped, first swimming leg, exopodite of second (Figure 17) and third swimming legs (Figure 15) also very similar to those of female.

Outermost apical seta on distal endopodite segment of second swimming leg very strong and basally fused with segment (Figure 17). Innermost apical seta on that segment short and smooth. Endopodite of fourth swimming leg similar to female, except for inner apical seta on distal segment being much stronger, curved, and smooth (Figure 16). Distal exopodite segment of fourth swimming leg with only 5 appendages (2 inner, 1 apical and 2 outer).

Basoendopodite of fifth leg with 3 strong, plumose and spiniform endopodite setae (innermost seta longest), and with very long and smooth epipodite seta (Figure 18). Exopodite subquadrangular, somewhat longer than broad, and armed with 5 elements (of which innermost spine extraordinary strong and longest). Outer-distal corner of exopodite distinctly produced, but without sharp extension.

Sixth leg consisting of small triangular chitinous plate bearing 3 setae (Figure 19). Middle seta about 1.6 times longer than inner one, and 2.8 times longer than outermost seta.

Variability

Thirty-six specimens (18 males and 18 females) of *Phyllopodopsyllus wellsii* sp. nov., from 3 different localities, were found and examined. Eleven specimens were completely dissected and mounted on slides. Body length, measured from the tip of rostrum to the posterior margin of furcal rami, ranges from 0.41 mm to 0.523 mm (0.455 mm average) in males, and from 0.47 mm to 0.592 mm (0.527 mm average) in females. In both sexes the

distal endopodite segment of the third swimming leg can have either 2 or 3 apical setae. In specimens with 3 setae, the pattern is very similar to that of the distal endopodite segment of the second swimming leg in females (Figure 7). Sometimes left and right third legs of the same specimen can bear different number of setae on that segment. No such variability has been noted in the number of setae and spines of the other swimming legs. The exopodite of the male fifth leg with or without very small sharp extension on outer-distal corner (between second and third setae, from outer side). Moreover, sometimes one leg displays such extension, while opposite leg does not in same animal. The outer seta on the female sixth leg can be more or less plumose. Anal somite in female usually with 1 row of very small, equal, spinules at base of furcal rami ventrally, but sometimes with a few larger spinules in the middle of that row. Holotype female is without eggs, but ovigerous females always with only two large eggs in the fifth leg cavity. The eggs are with very thin chorion.

Etymology

The species is named in honour of Dr J.B.J. Wells, Victoria University of Wellington, New Zealand.

DISCUSSION

Phyllopodopsyllus wellsii sp. nov. differs from all other species in the genus by its characteristic furcal rami shape in the female, and especially by the middle apical seta, which is very short, stout, and slightly and characteristically curved distally. Basoendopodite of the fifth leg in male with innermost seta the longest is also a rare characteristic in the genus *Phyllopodopsyllus*. Only three other species possess a similar basoendopodite: *P. xenus* (Kunz, 1951); *P. paraxenus* Coull, 1970; and *P. hermani* Coull, 1969. *P. xenus* has indeed only two setae on that segment (Kunz, 1995), and differs from the new species also by many other characters such as antennula segmentation, swimming legs setation, furcal rami shape, etc. *P. paraxenus* has 9-segmented antennula without unguiform process on second segment, possesses different setation of swimming legs, and a different furcal rami shape (Coull, 1970). Also, the middle seta on fifth leg basoendopodite in male of that species is extremely short. *P. hermani* differs from the new species by many characteristics (Coull, 1969). Regarding the shape of the fourth swimming leg endopodite in female (1 seta on basal and 2 setae on distal segment) *P. wellsii* is similar with the four following species: *P. minutus* Lang, 1948; *P. bahamensis* Geddes, 1968; *P. paraxenus* Coull, 1970; and *P. tenuis* Wells and Rao, 1987. They all differ from the new species by their swimming leg setation and shape of the furcal rami, whereas *P. bahamensis* and *P. paraxenus* also differ by the

antennula segmentation (Lang, 1948; Geddes, 1968; Coull, 1970; Wells and Rao, 1987). *P. wellsi* does not fit well within any of nine species group created by Kunz (1984), which maybe confirms suspicions about its naturalness expressed by Fiers (1995), but the phylogenetical grouping of the species is outside the scope of this paper. Because we do not want to create a new group for this species, we provide a key to all species and subspecies in the genus *Phyllopodopsyllus*. In that key have used mainly female morphological characteristics, unless stated otherwise.

**Key to species and subspecies of the genus
*Phyllopodopsyllus***

1. EnpP4 1-segmented 2
EnpP4 2-segmented 3
2. Enp1P2 and Enp1P3 with inner seta
..... *P. geddesi* Kunz, 1984
Enp1P2 and Enp1P3 unarmed
..... *P. opisthoceratus* Geddes, 1968
3. Enp1P4 unarmed 4
Enp1P4 with inner seta 8
4. A1 9-segmented *P. xenus* (Kunz, 1951)
A1 8-segmented 5
5. ExpP1 2-segmented
..... *P. biarticulatus* (Wells, 1967)
ExpP1 3-segmented 6
6. Enp2P4 with 3 setae
..... *P. longipalpalpatus hawaiiensis* Kunz, 1984
Enp2P4 with 2 setae 7
7. Fu with dorso-lateral cuticular process
.... *P. longipalpalpatus madagascarensis* Kunz, 1984
Fu without that process
P. longipalpalpatus longipalpalpatus (Chappuis, 1954)
8. Enp2P4 with only 1 seta
..... *P. hermani* Coull, 1969
Enp2P4 with more than 1 seta 9
9. Enp2P4 with 2 setae 10
Enp2P4 with 3 setae 14
10. A1 9-segmented 11
A1 8-segmented 12
11. A1 with unguiform process
..... *P. bahamensis* Geddes, 1968
A1 without unguiform process
..... *P. paraxenus* Coull, 1970
12. Enp1P3 without seta *P. minutus* Lang, 1948
Enp1P3 with inner seta 13
13. Exp3P2 and Exp3P3 with 4 setae/spines
..... *P. tenuis* Wells and Rao, 1985

- Exp3P2 and Exp3P3 with 5 setae/spines
..... *P. wellsi* n.sp.
14. Enp1P3 without seta 15
Enp1P3 with inner seta 21
15. Exp2P4 without inner seta
..... *P. medius* Por, 1964
Exp2P4 with inner seta 16
16. Enp2P2 and Enp2P3 with 2 setae
..... *P. hartmannorum* Kunz, 1995
Enp2P2 and Enp2P3 with 3 setae 17
17. Enp1P1 without inner seta
..... *P. punctatus* Kitazima, 1981
Enp1P1 with inner seta 18
18. Exp3P2 with 4 setae/spines
..... *P. laticauda* Por, 1964
Exp3P2 with 5 setae/spines 19
19. A1 8-segmented *P. bermudae* Lang, 1948
A1 9-segmented 20
20. Enp1P1 almost as long as ExpP1
..... *P. angolensis* Kunz, 1984
Enp1P1 about 1.5 times longer than ExpP1
..... *P. aegypticus* Nicholls, 1944
21. Enp1P2 without seta 22
Enp1P2 with inner seta 32
22. Exp2P4 without inner seta 23
Exp2P4 with inner seta 24
23. A1 9-segmented *P. borutzkyi* Lang, 1965
A1 8-segmented *P. simplex* Kitazima, 1981
24. Exp3P3 with 5 setae/spines
..... *P. langi* Kunz, 1975
Exp3P3 with 6 setae/spines 25
25. A1 9-segmented 26
A1 8-segmented 28
26. Fu about 7 times as long as wide
..... *P. longicaudatus* A. Scott, 1909
Fu less than 2.5 times as long as wide 27
27. Fu with large proximal inner bulge
..... *P. bradyi* (T. Scott, 1892)
Fu without proximal inner bulge
..... *P. pallaresae* Kunz, 1995
28. A1 with additional sharp process on the
anterior distal corner of second segment 29
A1 without additional sharp process (just one
unguiform, posteriorly directed) 30
29. Dorsal seta attached almost at end of Fu
..... *P. parafurciger parafurciger* Geddes, 1968
Dorsal seta attached at 2/3 of furcal length
..... *P. parafurciger caroliensis* Coull, 1971

30. Fu with well developed dorsal chitinous ridge.
..... *P. furciger* Sars, 1907
Fu without dorsal ridge 31
31. Fu more than 6 times longer than wide
..... *P. curtus* Marcus, 1976
Fu about 4 times longer than wide
..... *P. stigmosus* Wells and Rao, 1987
32. Exp2P4 without inner seta 33
Exp2P4 with inner seta 43
33. A1 8-segmented 34
A1 9-segmented 35
34. Exp3P3 with 4 setae *P. danielae* Bodin, 1964
Exp3P3 with only 3 setae . *P. kunzi* Mielke, 1989
35. A1 with strong, sharp, unguiform process on
second segment 36
A1 without or with small blunt process 37
36. Exp3P4 with 6 setae and spines
..... *P. paraborutzkyi* Kunz, 1975
Exp3P4 with 7 setae and spines
..... *P. carinatus* Mielke, 1992
37. A1 with small blunt process on second segment
..... 38
A1 without any process 39
38. Exp3P4 with 7 setae/spines, Fu 1.5 times longer
than wide *P. hibernicus* (Roe, 1955)
Exp3P4 with 6 setae/spines. Fu 3 times longer
than wide *P. hardingi* (Roe, 1955)
39. Exp3P4 with 6 setae/spines
..... *P. paramossmanni* (Lang, 1934)
Exp3P4 with 7 setae/spines 40
40. Fu about 3.5 times as long as broad
..... *P. berrieri* Monard, 1936
Fu about 1.5 times as long as broad 41
41. Middle apical seta on Fu not broadened basally
..... *P. laspalmensis* Marinov, 1973
Middle apical seta on Fu broadened basally
..... 42
42. ExpP5 with 5 setae in male
..... *P. mossmanni* T. Scott, 1912
ExpP5 with 4 setae in male
..... *P. mossmanni chiloensis* Mielke, 1992
43. A1 8-segmented 44
A1 9-segmented 47
44. Exp3P2 and Exp3P3 with 4 setae/spines 45
Exp3P2 with 5, while Exp3P3 with 6 setae/
spines 46
45. Middle apical seta on Fu minute compared to
furcal length *P. pauli* Crisafi, 1960
- Middle apical seta on Fu long and stout
..... *P. ancylus* Mielke, 1992
46. Exp3P4 with 6 setae/spines
..... *P. chavei* Coull, 1970
Exp3P4 with 7 setae/spines
..... *P. galapagoensis* Mielke, 1989
47. Exp3P3 with 5 setae/spines 48
Exp3P3 with 6 setae/spines 51
48. A1 with unguiform process on second segment
..... *P. parabradyi* Lang, 1965
A1 without such process 49
49. Abdominal somites with spiniform cuticular
extensions *P. alatus* Fiers, 1986
Abdominal somites without such extensions 50
50. ExpP5 with 5 setae in male
..... *P. thiebaudi thiebaudi* Petkovski, 1955
ExpP5 with 4 setae in male
..... *P. thiebaudi santacruzensis* Mielke, 1989
51. A1 with strong, sharp, unguiform process on
second segment
..... *P. setouchinensis* Kitazima, 1981
A1 without or with small blunt process 52
52. A1 without any process on second segment
..... *P. gracilipes* Wells and Rao, 1987
A1 with small blunt process 53
53. Enp1P1 about as long as ExpP1
..... *P. briani briani* Petkovski, 1955
Enp1P1 longer than ExpP1
..... *P. briani petkovskii* Kunz, 1984 stat. nov.

Large harpacticoid genera frequently accumulate numerous synonyms during the course of their taxonomic history. The genus *Phyllopodopsyllus* is especially rich with synonyms, many known of long standing. In such a way *P. pirkos* Apostolov, 1969 is a synonym of *P. briani* Petkovski, 1955, what was noticed by Coull (1973) and accepted by Apostolov and Marinov (1988), although Kunz (1984) claimed it to be a synonym of *P. thiebaudi* Petkovski, 1955. Lang (1965) noticed that *P. intermedius* (Noodt, 1955) is a synonym of *P. thiebaudi* Petkovski, 1955. Two species were synonymized by their authors themselves: Kunz (1963) synonymized his *P. trichophorus* (Kunz, 1951) with *P. mossmanni* T. Scott, 1912; and Apostolov (1972) synonymized his *P. ponticus* Apostolov, 1968 with *P. pauli* Crisafi, 1960. *P. mielkei mielkei* Kunz, 1984 and *P. mielkei californicus* Kunz (1984) are synonyms of *P. setouchiensis* Kitazima, 1981, which was nicely noticed by Mielke (1992), but also *P. crenulatus* Wells and Rao, 1987 is a synonym of *P. setouchiensis*. Although Wells and Rao (1987) said that *P. crenulatus* "is unique in no single character but the combination is not matched by any other species of

the genus", furcal rami shape, setal formula, antennulae, and many other characteristics are quite the same as in *P. setouchiensis*. *P. gertrudi* Kunz, 1984 and *P. gertrudi costaricensis* Mielke, 1992 are synonyms of *P. aegypticus* Nicholls, 1944. As a result of the description of *P. g. costaricensis*, Mielke (1992) unintentionally returned the nominal species *P. gertrudi* within the range of the species *P. aegypticus*, because the only traditionally used differentiating character (i.e. distal exopodite segment of third swimming leg with 5 or 6 elements) become invalid. Both species have, among other characters, quite the same extraordinary strong spines on the distal endopodite segments of second and third swimming legs (see Kunz, 1984; Wells and Rao, 1987; and Mielke, 1992). *P. yucatanensis* Fiers, 1995 is an obvious synonym of *P. parafurciger* Geddes, 1968, and it is very strange how Fiers (1995) tried to make differential diagnosis of his species on the base of the relative length of some setae. Several species are included in the key, because we could not claim with the great certainty that they are synonyms. Thus, the differential character (furcal length/width ratio) between *P. curtus* Marcus, 1976 and *P. stigmosus* Wells and Rao, 1987 applied in our key should be used with caution since the variability of the first species is unknown. Although Marcus (1976) mentioned that the furcal index is 9, from the drawings that she provided it appears that the ratio is not higher than 6.4. *P. carinatus* Mielke, 1992 is very similar to *P. paraborutzky* Kunz, 1975, but the variability of the latter is practically unknown (Kunz, 1975). The same applies to *P. galapagoensis* Mielke, 1989 and *P. chavez* Coull, 1970 (see Mielke, 1989; Coull, 1970). *P. petkovskii* Kunz, 1984 is so similar to *P. briani* Petkovski, 1955 that, since their populations are located on two completely opposite parts of the world, the former can be at most considered as a subspecies of *P. briani*, and so has been treated in our key (as *P. briani petkovskii* Kunz, 1984 stat. nov.). Two species are not included in the key although they clearly belong to the genus *Phyllopodopsyllus*: *P. minor* (T. and A. Scott, 1903) and *P. tristanensis* (Wiborg, 1964). These two species are considered incertae sedis, because of the incompleteness of their descriptions. Lang (1965) and Coull (1973) included *P. minor* in their keys on the basis of the furcal rami shape, but today this is impossible.

REFERENCES

- Apostolov, A. (1972). Catalogue des Copepodes harpacticoides marins de la Mer Noire. *Zoologischer Anzeiger* 188: 202–254.
- Apostolov, A.M. and Marinov, T.M. (1988). Copepoda, Harpacticoida (morski harpaktikoidi). *Fauna na Bulgariia* 18: 1–384.
- Bodin, P. (1997). *Catalogue of the new marine harpacticoid copepods* (1997 Edition). Documents travail l'Institut royal des Sciences naturelles de Belgique, Bruxelles.
- Bradbury, J.H. and Williams, W.D. (1996). Two new species of anchialine amphipod (Crustacea: Hadziidae: *Liagoceradocus*) from Western Australia. *Records of the Western Australian Museum* 17: 395–409.
- Bradbury, J.H. and Williams, W.D. (1997). The amphipod (Crustacea) stygofauna of Australia: description of new taxa (Melitidae, Neoniphargidae, Paramelitidae), and a synopsis of known species. *Records of the Australian Museum* 49: 249–341.
- Bruce, N.L. and Humphreys, W.F. (1993). *Haptolana pholeta*, sp. nov., the first subterranean flabelliferan isopod crustacean (Cirolanidae) from Australia. *Invertebrate Taxonomy* 7: 875–884.
- Coull, B.C. (1969). *Phyllopodopsyllus hermani*, a new species of harpacticoid copepod from Bermuda. *Crustaceana* 16: 27–32.
- Coull, B.C. (1970). Two new species of *Phyllopodopsyllus* (Copepoda, Harpacticoida) from Bermuda. *Crustaceana* 19: 119–124.
- Coull, B.C. (1973). Harpacticoid copepods (Crustacea) of the family Tetragnipitidae Lang: a review and revision, with keys to the genera and species. *Proceedings of the Biological Society of Washington* 86: 9–24.
- Danielopol, D.L., Baltanas, A. and Humphreys, W.F. (in press). *Danielopolina kornickeri* sp. n. (Ostracoda: Thaumatoceprididae) from a western Australian anchialine cave – morphology and evolution. *Zoologica Scripta*.
- De Laurentiis, P., Pesce, G.L. and Humphreys, W.F. (1999). Copepods from ground waters of Western Australia, IV. Cyclopids from basin and craton aquifers (Crustacea: Copepoda: Cyclopidae). *Records of the Western Australian Museum* 19: 243–257.
- Fiers, F. (1995). New Tetragnipitidae (Copepoda, Harpacticoida) from the Yucatan continental shelf (Mexico), including a revision of the genus *Diagoniceps* Willey. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, biologie* 65: 151–236.
- Geddes, D.C. (1968). Marine biological investigations in the Bahamas, 3. Harpacticoid copepods belonging to the family Tetragnipitidae Lang. *Sarsia* 32: 21–38.
- Humphreys, W.F. (1999a). Relict stygofaunas living in sea salt, karst and calcrete habitats in arid north-western Australia contain many ancient lineages: 219–227 in W. Ponder and D. Lunney (eds), *The Other 99%. The Conservation and Biodiversity of Invertebrates*. Transactions of the Royal Zoological Society of New South Wales, Mosman.
- Humphreys, W.F. (1999b). Physico-chemical profile and energy fixation in Bundera Sinkhole, an anchialine remiped habitat in north-western Australia. *Journal of the Royal Society of Western Australia* 82: 89–98.
- Humphreys, W.F. (2000). The hypogean fauna of the Cape Range peninsula and Barrow Island, north-west Australia. In H. Wilkens, D.C. Culver and W.F. Humphreys (eds). *Ecosystems of the World, vol. 30. Subterranean Ecosystems*. Elsevier, Amsterdam.
- Humphreys, W.F., Poole, A., Eberhard, S.M. and Waren, D. (1999). Effects of research diving on the physico-

- chemical profile of Bundera Sinkhole, an anchialine remiped habitat at Cape Range, Western Australia. *Journal of the Royal Society of Western Australia* 82: 99–108.
- Kunz, H. (1963). Weitere Harpacticoiden (Crustacea, Copepoda) von der sudwestafrikanischen Kuste. *Zoologischer Anzeiger* 171: 33–51.
- Kunz, H. (1975). Copepoda Harpacticoida aus dem Litoral des sudlichen Afrika. *Kieler Meeresforschungen* 31: 179–212.
- Kunz, H. (1984). Funf Beitrage zur Kenntnis mariner Harpacticoida. *Mitteilungen Zoologische Museum Universitat Kiel* 2: 1–56.
- Kunz, H. (1995). Contribution to the knowledge of the genus *Phyllopodopsyllus* T. Scott (Copepoda, Harpacticoida) from Africa with description of two new species. *Hydrobiologia* 297: 83–98.
- Lang, K. (1948). *Monographie der Harpacticiden*. A-B. Nordiska Bokhandeln, Lund, Stockholm.
- Lang, K. (1965). Copepoda Harpacticoida from the Californian Pacific coast. *Kungliga Svenska Vetenskapsakademiens Handlingar* 10: 1–560.
- Marcus, A. (1976). *Phyllopodopsyllus curtus* sp. n. (Copepoda, Harpacticoida) from the Mediterranean. *Cercetari Marine* 9: 117–125.
- Mielke, W. (1989). Interstitielle Fauna von Galapagos. XXXVI. Tetragnonipitidae (Harpacticoida). *Microfauna Marina* 5: 95–172.
- Mielke, W. (1992). Six representatives of the Tetragnonipitidae (Copepoda) from Costa Rica. *Microfauna Marina* 7: 101–146.
- Pesce, G.L. and De Laurentiis, P. (1996). Copepods from ground waters of Western Australia. III. *Diacyclops humphreysi* n.sp. and comments on the *Diacyclops crassicaudis* – complex (Copepoda: Cyclopidae). *Crustaceana* 69: 524–531.
- Pesce, G.L., De Laurentiis, P. and Humphreys, W.F. (1996a). Copepods from ground waters of Western Australia. I. The genera *Metacyclops*, *Mesocyclops*, *Microcyclops* and *Apocyclops* (Crustacea Copepoda: Cyclopidae). *Records of the Western Australian Museum* 18: 67–76.
- Pesce, G.L., De Laurentiis, P. and Humphreys, W.F. (1996b). Copepods from ground waters of Western Australia. II. The genus *Halicyclops* (Crustacea Copepoda: Cyclopidae). *Records of the Western Australian Museum* 18: 77–85.
- Poore, G.C.B. and Humphreys, W.F. (1992). First record of Thermosbaenacea (Crustacea) from the Southern Hemisphere: a new species from a cave in tropical Western Australia. *Invertebrate Taxonomy* 6: 719–725.
- Poore, G.C.B. and Humphreys, W.F. (1998). First record of Spelaeogriphacea from Australia: a new genus and species from an aquifer in the arid Pilbara of Western Australia. *Crustaceana* 71: 721–742.
- Sket, B. (1996). The ecology of anchihaline caves. *Trends in Ecology and Evolution* 11: 221–225.
- Stock, J.H., Iliffe, T.M. and Williams, D. (1986). The concept 'anchialine' reconsidered. *Stygologia* 2: 90–92.
- Vervoort, W. (1964). Free-living Copepoda from Ifaluk Atoll in the Caroline Islands with notes on related species. *Bulletin of the Smithsonian Institution United States National Museum* 236: 1–431.
- Watts, C.H.S. and Humphreys, W.F. (2000). Three new genera and five new species of Dytiscidae (Coleoptera) from underground waters in Australia. *Records of the South Australian Museum* 32: 000–000.
- Wells, J.B.J. and Rao, G.C. (1987). Littoral Harpacticoida (Crustacea, Copepoda) from Andaman and Nicobar Islands. *Memoirs of the Zoological Survey of India* 16: 1–385.
- Yager, J. and Humphreys, W.F. (1996). *Lasionectes exleyi*, sp. nov., the first remipede crustacean recorded from Australia and the Indian Ocean, with a key to the world species. *Invertebrate Taxonomy* 10: 171–187.