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THREE NEW GENERA AND NINE NEW SPECIES OF THE SUBFAMILY CANDONINAE (CRUSTACEA, OSTRACODA, PODOCOPIDA) FROM THE PILBARA REGION (WESTERN AUSTRALIA)

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ABSTRACT

Three new ostracod genera: *Humphreyscandona* n. gen., *Pilbaracandona* n. gen., and *Notacandona* n. gen., and nine new species are described from subterranean waters of the Pilbara Region, Western Australia. They belong to the subfamily Candoninae of the order Podocopida, and are characterized by a 5-segmented antennula and ornamented carapace. *Humphreyscandona* n. gen. contains five species, all with reduced posterior furcal claw and prominent external lobe on hemipenis. The other new genera each contain two species. *Pilbaracandona* n. gen. is also characterized by a reduced posterior furcal claw, but can be separated from the previous genus by the chaetotaxy of the antennula, mandibula, and general appearance of the hemipenis. *Notacandona* n. gen. is separated from the other two new genera by having both furcal claws well developed. The new genera are more closely related to subtropical Candoninae of South America, Africa, and India than to the European ones. Morphology and taxonomy of the new genera are discussed and compared with all other living genera of the subfamily Candoninae.

Key words: taxonomy, Ostracoda, Candoninae, Australia

RÉSUMÉ

Trois nouveaux genres d'Ostracodes Candoninae (*Humphreyscandona* n. gen., *Pilbaracandona* n. gen., et *Notacandona* n. gen.) et neuf nouvelles espèces sont décrites des eaux souterraines de la région de Pilbara en Australie de l'ouest. Ces Candoninae sont caractérisées par une antennule à cinq articles et une carapace ornementée. *Humphreyscandona* n. gen. regroupe cinq espèces, possédent toutes une griffe furcale postérieure réduite et un lobe externe du penis proéminent. Les deux autres genres contiennent deux espèces chacun. *Pilbaracandona* n. gen. possède lui-aussi une griffe furcale postérieure réduite, mais il peut être distingué du précédant par la chaetotaxie de l'antennule, de la mandibule et la forme générale du pénis. *Notacandona* n. gen. se distingue des deux autres genres par sa furca normalment développée. Ces nouveaux genres semblent proches des Candoninae d'Amerique du Sud, d'Afrique ou du sous-continent Indien. En fin d'article, la morphologie et la taxonomie de ces nouveaux genres sont discutées et comparées aux caracteristiques des autres genres actuels de la sous-famille des Candoninae.

Mots-clés: taxonomie, Ostracoda, Candoninae, Australie

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INTRODUCTION

The first record of recent ostracods from the Australian inland waters was given by King (1855), who described the genus *Newnhamia* King, 1855, and 13 new species from New South Wales. The correct systematic position for many of those species remains elusive owing to the standards of description at that time. Brady (1886) described six ostracods from South Australia and amended some of King's (1855) descriptions. Sars (1889, 1896a, b) described seven new species and the genus *Stenocypris* Sars, 1889, mainly raising the animals from dried mud and, in addition, he recorded ostracods already described from Australia (King, 1855; Brady, 1886), as well as from India, Sri Lanka and New Zealand (see Sars, 1889, 1896b). Henry (1919) confirmed some of the findings of King, Brady and Sars, and described one new species from New South Wales. He subsequently gave a brief synthesis of the Australian freshwater ostracods, and described four new species from New South Wales (Henry, 1923). Until the mid 1960's nothing further was published on freshwater ostracods from Australia. Chapman (1966) described three new species, and Hyssainy (1969a, b) described a new species and the male of one previously known species. The most significant contribution to our recent knowledge of living Podocopida Sars, 1866 from Australian inland waters was given by McKenzie (1966a, 1978), DeDeckker (1974, 1976, 1979a, b, 1981a, b, c, 1982a) and DeDeckker & McKenzie (1981), who described the following 13 podocopid genera found in the Australian inland waters: *Mytilocypris* McKenzie, 1966; *Australocypris* DeDeckker, 1974; *Trigonocypris* DeDeckker, 1976; *Reticypris* McKenzie, 1978; *Kennethia* DeDeckker, 1979; *Ngarawa* DeDeckker, 1979; *Bennelongia* DeDeckker & McKenzie, 1981; *Alboa* DeDeckker, 1981; *Gomphodella* DeDeckker, 1981; *Ampullacypris* DeDeckker, 1981; *Zonocypretta* DeDeckker, 1981; *Notiocypridopsis* DeDeckker, 1981; and *Caboncypris* DeDeckker, 1982. In these papers, as well as in some others (DeDeckker, e.g. 1978, 1983; McKenzie, e.g. 1966b, 1968) they described many new species, both in the new and in the previously known genera, and extended the known distributions. Further studies of all species would be required to establish the exact number of ostracods recorded from Australian inland waters, and this is beyond the scope of the present paper. The recorded species are mainly representatives of the families Limnocytheridae Sars, 1925, Ilyocyprididae Kaufmann, 1900, and Cyprididae Baird, 1845. Little is known about the family Candonidae Kaufmann, 1900 from the freshwaters, especially of the subfamily Candoninae Kaufmann, 1900. King (1855) described two species from New South Wales: *Candona stanleyana* King, 1855, and *Candona lutea* King, 1855. *Candona stanleyana* was later transferred by Sars (1894) to the genus *Ilyodromus* Sars, 1894. Chapman (1914) found fossils of *Candona lutea* in Tasmania, which DeDeckker (1982b), after finding the living representative of the species in Tasmania, described as *Candonocypris incosta* DeDeckker, 1982. King's (1855) record of *Candona lutea* has until today remained in the same genus. However, according to his descriptions and drawings this species appears to belong to the family Cyprididae rather than to the family Candonidae. Brady (1886) also recorded *Candona lutea*, but this is not the same species described by

King (1855) and the descriptions look more like some Candoninae species. This species should be redescribed, because its description and drawings are not in accordance with the standards of the modern taxonomy, as they give no information about the appearance of its soft parts. The other living representative of the subfamily Candoninae in Australia is *Candonopsis tenuis* (Brady, 1886), described as *Candona tenuis* and transferred to *Candonopsis* by Sars (1896a). There is also one record of the fossil species *Candona tecta* De-Deckker, 1982, described from the Tasmanian Holocene deposits (DeDeckker, 1982c).

Until recently, knowledge of the subfamily Candoninae was confined mainly to the Holarctic, except for the genus *Candonopsis* Vavra, 1891, of which some representatives were described a long time ago from tropical and subtropical regions (e.g. Vavra, 1897; Daday, 1910; Klie, 1932). A few species of *Candonopsis* live almost exclusively in the subterranean waters of Europe and these are considered to be Tertiary relicts with surface relatives today mainly occurring in tropical and subtropical surface waters. Almost nothing is known about the subfamily Candoninae outside of the Palearctic region. This might be because little groundwater sampling has been undertaken in the subtropical and tropical (except in the West Indies, see Broodbakker, 1983). In these regions, the Candoninae fauna in surface waters (except the genus *Candonopsis)* appears not to be rich. The great majority of the Candoninae in the Palearctic live in springs, subterranean habitats, and deep lakes. As exclusively benthic dwelling animals, they are morphologically adapted to colonise subterranean habitats (Danielopol, 1978; Marmonier & Danielopol, 1988).

The first intensive sampling of subtropical subterranean waters in the West Indies (Broodbakker, 1983) led to the description of the genera *Caribecandona* Broodbakker, 1983, and *Danielocandona* Broodbakker, 1983. Then, Gupta (1984) described the genus *Indocandona* Gupta, 1984, from the subterranean waters of Bihar (India). Another two Candoninae genera were described from Africa: *Namibcypris* from Namibia (Martens, 1992) and *Meischcandona* from Mali (Karanovic, 2001). Both these African genera were described from a few specimens collected in a spring (Namibia) and river (Mali) but, as both are clearly hypogean, their finding in above mentioned ecosystems was most probably accidental. This supports Martens' (1992) claim that "subterranean ostracod fauna of Africa is a virtually blank and unexplored area", but it most probably contains unique and undescribed taxa. Currently, 18 living Candoninae genera are known (see Meisch, 1996; Karanovic, 2001): *Candona* Baird, 1845; *Candonopsis* Vavra, 1891; *Paracandona* Hartwig, 1899; *Cryptocandona* Kaufmann, 1900; *Eucandona* Daday, 1900 (=*Fabaeformiscandona* Krstic, 1972); *Pseudocandona* Kaufmann, 1900; *Nannocandona* Ekman, 1914; *Trapezicandona*[1] Schornikov, 1969; *Baicalocandona* Mazepova, 1976; *Phreatocandona* Danielopol, 1978; *Terrestricandona* Danielopol & Betsch, 1980; *Caribecandona* Broodbakker, 1983; *Danielocandona* Broodbakker, 1983; *Indocandona* Gupta, 1984; *Namibcypris* Martens, 1992; *Schellencandona* Meisch, 1996; *Trajancandona* Karanovic, 1999; and *Meischcandona* Karanovic, 2001.

The ostracods known from Australian inland waters have been collected largely from surface water ecosystems, so it is not surprising that almost nothing was known about the subfamily Candoninae. The present paper is a result of an intensive survey of the subterranean fauna of Western Australia. Two papers on ostracods based on these researches have already been published containing the descriptions of one species of Darwinulidea Brady & Norman, 1889, species collected in a well (Martens & Rossetti, 2002), and one species from the order Myodocopida Sars, 1866, collected in the anchialine cave (Danielopol et al., 2000). We had an opportunity to study the ostracod material collected in the subterranean waters of Pilbara Region (Western Australia) and as a result in the present paper three new genera and nine new species of the subfamily Candoninae are described.

The Pilbara region is situated in the northwest part of Western Australia. This semi-arid zone is part of the Western Shield of Australia, which has been above sea level since the Proteozoic (Humphreys, 2001). The arid climate favored the

[1] The second author (PM) prefers to use the genus *Mixtacandona* as a senior synonym of *Trapezicandona.*

development of a special kind of karst, named calcrete. These carbonate rocks have typical karst features, which make them suitable for sampling. It is supposed that there are over 210 calcrete bodies in Western Australia and most of those that have been sampled until now contain unique fauna (see Humphreys, 1999, 2000, 2001; Watts & Humphreys, in press).

According to Humphreys (2001) the movement of the ground water in calcrete systems is slow, and furthermore, the rainfall in this region is episodic (>200 mm per year), while the evaporation is very high (>3000 mm per year). All of this results in substantial fluctuation of the water tables.

MATERIALS AND METHODS

Samples were collected with haul-nets (mesh size 250 or 350 micrometers) from bores and wells. Bores are holes in the calcrete systems mainly made by mining companies in the purpose of water monitoring and abstractions or mineral exploration. They are usually 10 to 20 cm in diameter, and may be lined entirely, or in part, by PVC tubing (the casing). This tubing may be open only at the bottom, or it may be pierced at one or more levels by holes of various sizes, referred to as 'slots'. The top may be securely capped or entirely open to the elements. Some bores record the water pressure at a given level in the aquifer (piezometers), while others, together with hand dug wells (ca. 1 x 1.5 m) equipped with windmills, provide water for pastoral use. Many of these features are derelict.

Haul-nets are actually simple plankton nets of a different size suitable for the bore, which can range from 30 to 180 mm in diameter. Weighed nets were lowered down into the bore with one bottle screwed on its distal part than hauled through the water column, usually a number of times. All samples were sorted while alive under dissecting microscope and the ostracods were then fixed in 70% or 100% ethyl-alcohol and assigned a field number (Prefix BES).

From springs, rivers and some pools, samples were taken by the Karaman-Chappuis method, or by a Bou-Rouch phreatic pump. A hand-net was used to collect from some pastoral wells, and open pools. In some cases baited traps were used.

Ostracods were dissected in a mixture of distilled water and glycerol (1 : 1) with fine entomological needles (size 000). Dissected appendages and valves of some specimens were mounted in Faure's medium. The appendages of some specimens were mounted on slides in glycerol, while their valves are kept on micropalaeontological slides or in glass test-tubes in 70% alcohol. All non-dissected material is preserved in 70% ethyl-alcohol in glass test-tubes. Drawings have been prepared using a drawing tube attachment on Leica-DMLS microscope, with C-PLAN achromatic objectives.

Some specimens of all *Humphreyscandona* n. gen. species were dissected by Dr Karel Wouters and Dr Koen Martens, both from the Royal Belgium Institute of Natural Science, and kindly given to us. All the material is deposited in the Western Australian Museum.

In the systematic part of this paper the length of all segments was measured in the middle of the segments, and length ratios are presented beginning with the proximal end. The names of the appendages are used according to Martens (1998). The chaetotaxy of the limbs follows the model proposed by Broodbakker & Danielopol (1982), revised for the antenna by Martens (1987), and for the third thoracopod by Meisch (1996). The lobes on the hemipenis are marked according to Danielopol (1969). In front of the abbreviations for the setae on the endopodal segments of the first and third thoracopods the letter 'T' is added, not to be confused with the abbreviations for the hemipenis parts.

Abbreviations used in text and figure legends: a = lateral (or outer) lobe on hemipenis; A1 = antennula; A2 = antenna; b = medial lobe on hemipenis; B-R = Bou-Rouche sample; BES = prefix for the field number; e = bursa copulatrix; d1, d2, dp = setae on basal segment T3; Fu = furca; g = part 'M' (middle chitinous part) of hemipenis; G1, G2, G3, GM, Gm = antennal claws; GWMB = Groundwater monitoring bore; H = height; h = inner lobe on hemipenis; L = length; LV = left valve; Md = mandible; Mxl = maxillula; P1, P2... = Piezometers; RV = right valve; Ta, Ta', Tb, Td = setae on T1; Te, Tf, Tg, Th1, Th2, Th3 = setae on endopodal segments T3; T1, T2, T3 = first, second and third thoracopods; t1, t2 = medial setae on the second endopodal segment A2; W =

width; WAM = Western Australian Museum; Y, ya, y1, y2, y3 = aesthetascs; z1, z2, z3 = apical setae on the second endopodal segment A2.

Many bores put in for hydrogeological work, mineral exploration and water monitoring have prefixes or suffixes of relevance only to that drilling program. These codes are cited in the examined material for each species to aid specification of the location.

SYSTEMATIC DESCRIPTIONS

Class Ostracoda Latreille, 1806
Order Podocopida Sars, 1866
Superfamily Cypridoidea Baird, 1845
Family Candonidae Kaufmann, 1900
Subfamily Candoninae Kaufmann, 1900

Genus **Humphreyscandona** n. gen.

TYPE SPECIES. - *Humphreyscandona adorea* n. sp.

OTHER SPECIES. - *Humphreyscandona fovea* n. sp., *H. pilbarae* n. sp., *H. woutersi* n. sp., and *H. waldockae* n. sp.

DIAGNOSIS. - Carapace trapezoidal, triangular or reniform, surface ornamented. Marginal zone wide (anteriorly more than 20% of total length). A1 five-segmented. Third and fourth segments as well as fifth and sixth fused. Posteriorly, chitinous margin between fused segments uninterrupted, anteriorly with one seta at the points of fusion. Exopodite A2 plate with one seta which can be less than twice, or more than 5 times as long as the other two short setae. Md palp with two setae on the outer side of second segment, penultimate segment with five setae intero-medially; terminal segment less than twice as long as wide, terminal claw strongly sclerotized and fused with terminal segment. Third endite on Mxl with two plumose claws. T1 with two 'Ta' setae, and three setae in exopodite; 'Tb' and 'Td' setae also present. T2 4- or 5-segmented, basal segment without, penultimate segment with short setae. T3 4- or 5-segmented. Basal segment with three setae (d1, d2, dp); terminal segment with two short (Th1 & Th2) and one long (Th3) seta, the latter with two spines at the beginning of its last third. Fu with posterior claw reduced to a seta; posterior as well as anterior seta not always present. Hemipenis with lobe 'a' which is square-shaped and extended compared to the other parts. Lobe 'b' with one well chitinous acutiform part positioned laterodistally. Lobe 'h' not well chitinised and double-folded. Medial chitinous part ('g' lobe) protruding between the lobes, well chitinised on distal margin, as well as medio-ventrally and on its basal part, while medio-dorsally very poorly sclerified. Zenker's organ with 5+2 rows of spines. Female's genital lobe rounded, and without extensions.

ETYMOLOGY. - The genus is named after Dr William F. Humphreys from the Western Australian Museum, in honour to his great contribution to our recent knowledge of the subterranean water system of Western Australia and its fauna. Dr W. F. Humphreys also collected most of the material for this paper. The name is prefixed to the genus name *Candona*, gender feminine.

Humphreyscandona adorea n. gen., n. sp.
Figs. 1-20

MATERIAL. - Holotype: male, dissected (WAM C28210). Allotype: female, dissected (WAM C28211). Paratypes: 3 males, all dissected (WAM C28212, WAM C28213, WAM C28214); 1 juvenile male, dissected (WAM C28215); 4 juveniles of unknown sex in alcohol (WAM C28216), from P1, Palm Springs, Millstream Aquifer, 21°34'24"S 116°57'59"E, 30-VII-1997, collectors: W. F. Humphreys & S. M. Eberhard (BES 4905).

Additional material: 1 male and 1 female, all in alcohol (WAM C28217), from P1, Palm Springs, Millstream Aquifer, 21°34'24"S 116°57'59"E, 19-X-1996, collector: W. F. Humphreys (BES 4004); 1 female and 1 juvenile in alcohol (WAM C28218), from P2, Palm Springs, Millstream Aquifer, 21°34'24"S 116°57'38"E, 30-VII-1997, collectors: W. F. Humphreys and S. M. Eberhard (BES 4888); 1 female, dissected (WAM C28219), from P4, Palm Springs, Millstream Aquifer, 21°34'44"S 116°58'07"E, 30-VII-1997, collectors: W. F. Humphreys and S. M. Eberhard (BES 4874); 1 male, dissected (WAM C28220), from P1 (trap), Palm Springs, Millstream Aquifer, Pilbara, 21°34'24"S 116°57'59"E, 31-VII-1997, collectors: W. F. Humphreys and S. M. Eberhard (BES 4895); 1 female, dissected (WAM C28221), from P2-77, Palm Springs, Millstream Aquifer, 21°34'37"S 117°03'12"E, 20-X-1996, collector: W. F. Humphreys (BES 4011).

Both soft parts and carapace of holotype, and 1 female (WAM C28219) were mounted on the slides in Faure's medium. Soft parts of the allotype and other dissected specimens were mounted on slides in glycerol, carapaces are kept on the micropalaeontological slides.

DESCRIPTION OF HOLOTYPE (MALE, L = 0.79 mm). - Carapace trapezoidal in lateral view (Fig. 1). L of LV = 0.79 mm; RV = 0.773 mm. Greatest H on both valves situated around middle, about 57% of L. Dorsal margin straight in middle, than curved towards anterior end, and sloping evenly towards posterior end. Anterior margin wider than posterior one. Posterior margin bulging. Ventral margin slightly concave around middle. Valve surface covered with long hairs (especially on posterior end), and ornamented ventrally and dorsally with longitudinal ridges. Both anterior and posterior marginal zones wide, anterior one being 30% and posterior one 26% of total L. Fused zone wide with long, dense (some branched) pore canals. Selvage present, peripheral. In dorsal view (Fig. 2) anterior end pointed and beak-like, posterior slightly more rounded, but also beak-like. LV overlapping RV on both ends. Greatest W situated around middle, equalling 32% of L.

A1 (Fig. 10) 5-segmented. First segment with one seta antero-proximally (not shown in Fig. 10), one antero-distally and two long posterior setae; second segment with one antero-distal seta (reaching slightly beyond middle of following segment); third segment with one antero-medial seta (slightly exceeding distal end of same segment), and two distal setae (both short and reaching middle of following segment); penultimate segment with one antero-medial seta (not reaching distal end of same segment), three long and one short seta (about twice as long as terminal segment); terminal segment with two long and one short seta (latter one about three times as long as terminal segment) and aesthetasc (ya) which is about 10 times as long as terminal segment (Fig. 11). L ratios of three distal segments 2.5 : 2.8 : 1.

A2 (Fig. 12) 4-segmented, without male's bristles. Exopodite plate with two short and one long seta (more than 8 times longer). Aesthetasc Y as long as first endopodal segment; aesthetasc y1 reaching distal margin of penultimate segment; y2 slightly exceeding distal margin of terminal segment; y3 1.1 times as long as first endopodal segment. Penultimate segment with two medial setae on each side of appendage: posterior (t1 and t2) longer; anterior short, not reaching distal end of penultimate segment. Penultimate segment also with three long distal claws - G2, z1 and z2 (all about 1.6 times as long as first endopodal segment); one weak claw medially - G1 (about twice as long as terminal segment) and one thin postero-distal z3 seta, located on external side of A2 (slightly shorter than G1). Claw G3 also reduced to a short seta (as long as seta z3), but not shown in Fig. 12. Terminal segment with long GM claw (1.4 times as long as first endopodal segment), claw Gm not observed, y3 with accompanying seta present. L ratios of three endopodal segments 6.7 : 4.4 : 1.

Md (Fig. 13) with strong coxa; palp 4-segmented, exopodite with more than four setae. First segment internally with two plumose setae (short-S2 and long-S1) and two smooth setae (short being alpha seta, and one long); second segment externally with two short setae, internally with 3+2 setae in bunch. Following segment with three extero-medial setae (one almost reaching distal end of terminal claw, one just exceeding distal end of same segment, one not reaching distal end); gamma seta extero-distally (almost reaching middle of terminal claw); and five intero-distal setae. Terminal segment with fused and distally pappose claw, one strong external seta, and two weaker internal setae. L ratios of three distal segments 1 : 2.8 : 1.3.

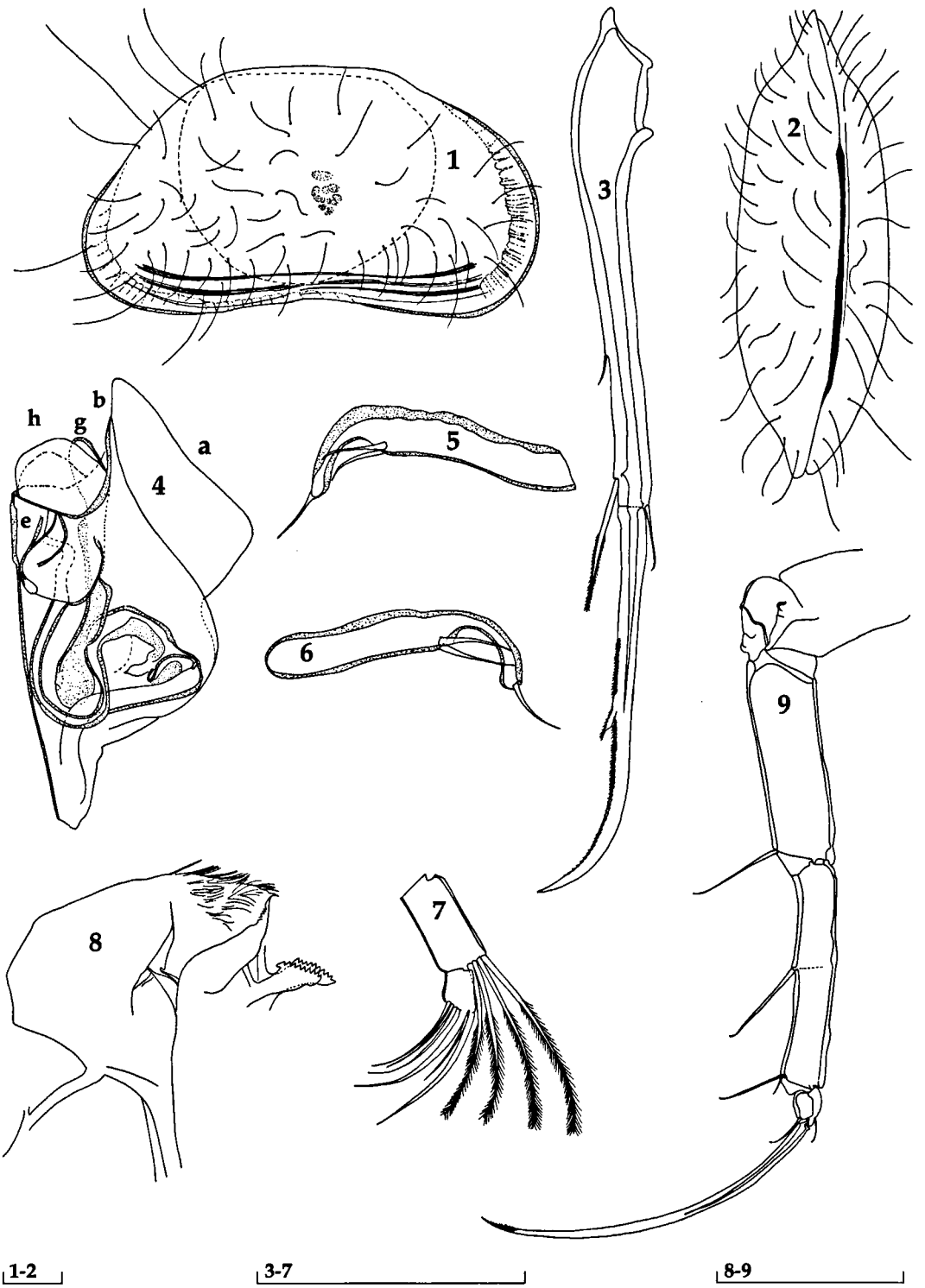
Mxl palp (Fig. 7) with square-shaped to trapezoidal terminal segment bearing two claw-like and three thin setae. Penultimate segment of same appendage with four pappose seta. Claws on third endite plumose.

Rake-like organ (Fig. 8) with nine and 10 teeth respectively.

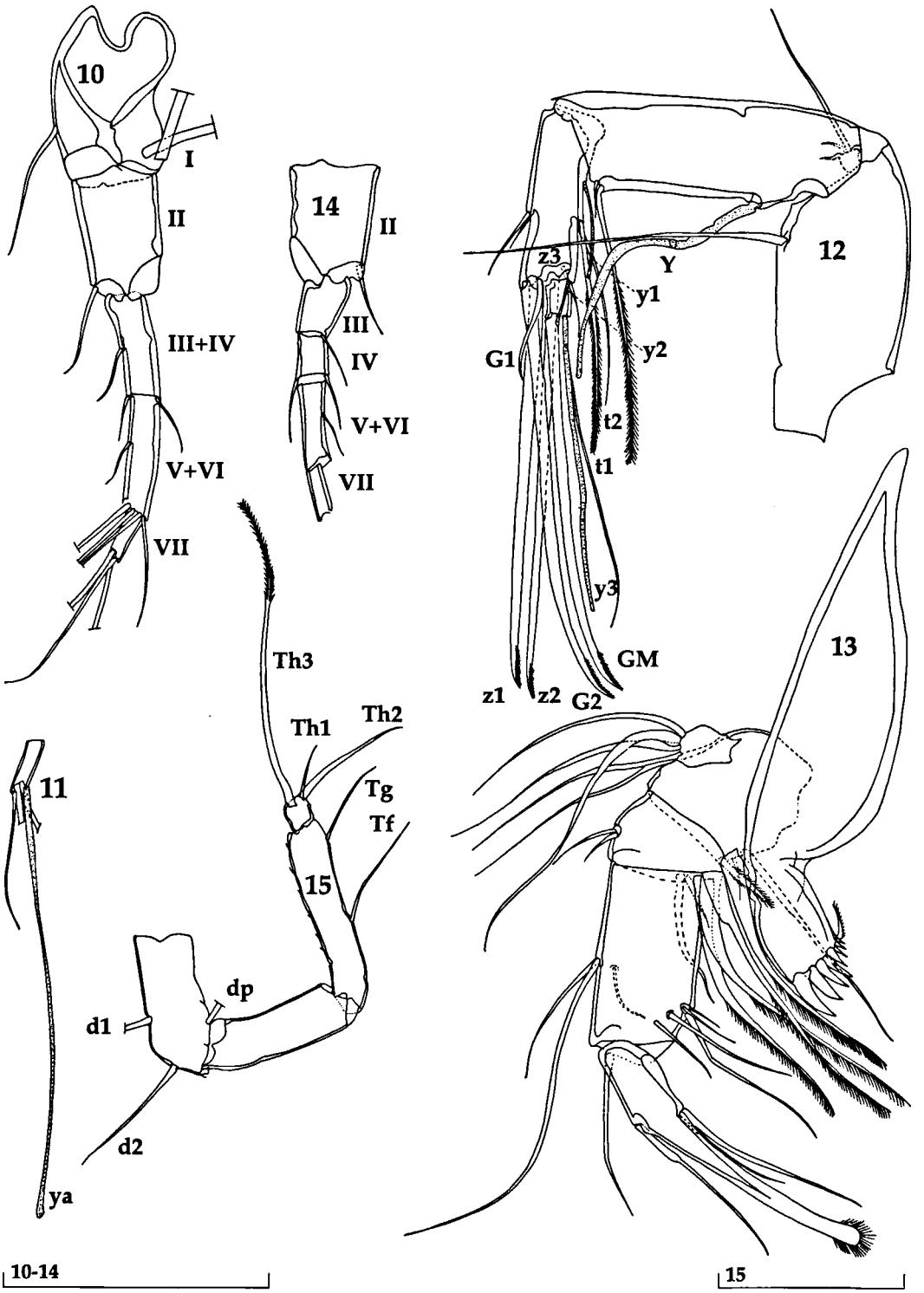
Prehensile palps (Figs. 5 and 6) almost symmetrical and with elongated fingers, and long, thin setae.

T2 4-segmented (Fig. 9), third and fourth segments fused and with uninterrupted external chitinous membrane. Basal segment of same appendage naked, first endopodal segment with one seta (almost reaching middle of following segment). Fused segments with one medial seta and two distal setae (medial one not reaching distal end, one of terminal setae twice as long as terminal segment, other minute). Terminal segment with two distal setae and claw, distally serrated and 1.3 times as long as three distal segments combined.

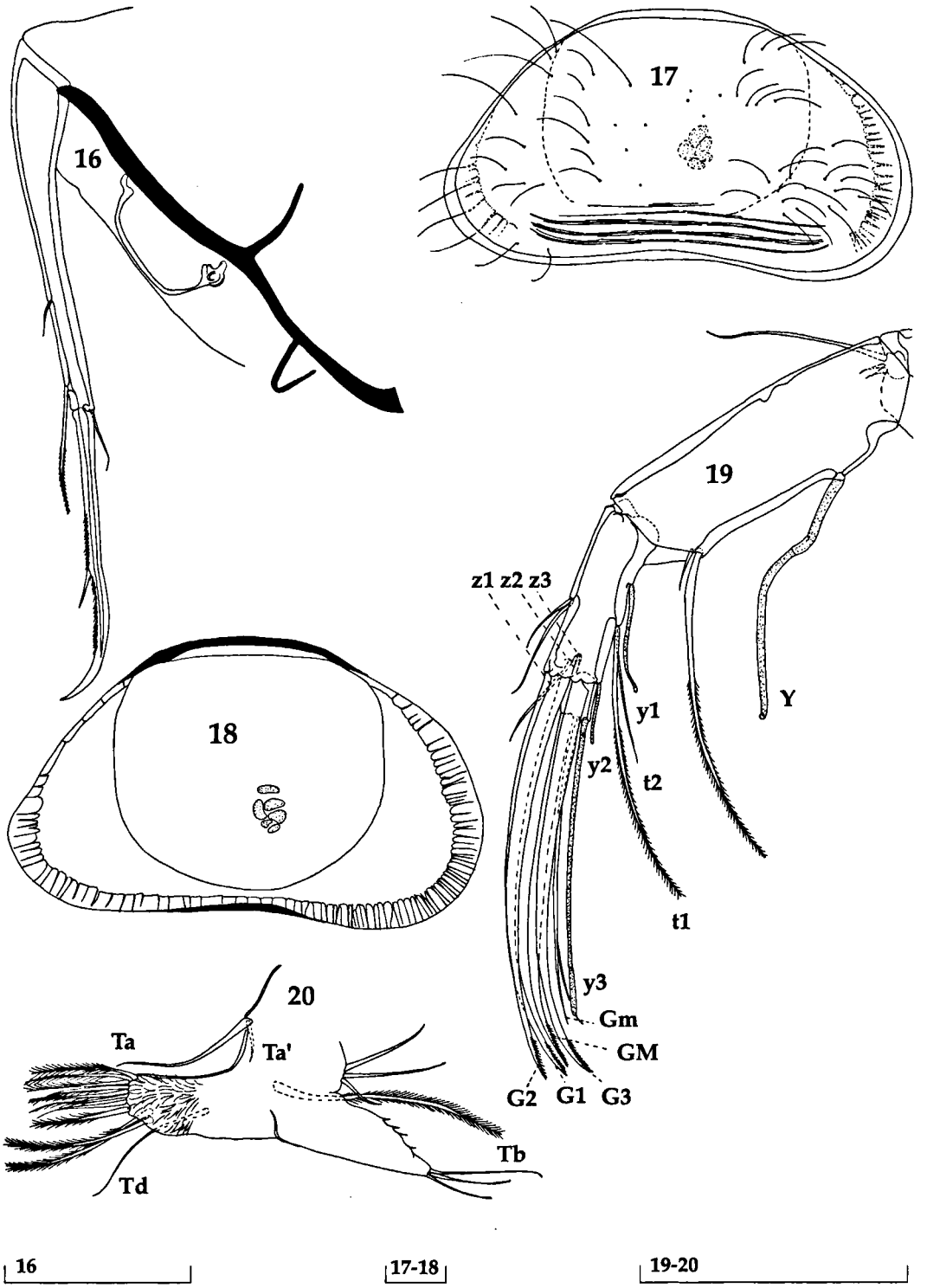
T3 4-segmented, third and fourth segments



Figs. 1-9. *Humphreyscandona adorea* n. gen., n. sp., holotype (male, L = 0.79 mm). 1, RV, external view. 2, carapace, dorsal view. 3, Fu. 4, hemipenis, medial side up. 5, right prehensile palp. 6, left prehensile palp. 7, Mxl palp. 8, forehead with Rake-like organ attached. 9, T2 (scale bars = 0.1 mm).



Figs. 10-15. *Humphreysandona adorea* n. gen., n. sp.; 10-13: holotype (male, L = 0.79 mm). 14: WAM C28219 (female, L = 0.802 mm). 15: allotype (female, L = 0.796 mm). 10, A1. 11, terminal segment on A1 with an aesthetasc. 12, A2. 13, Md. 14, A1 (first segment not shown). 15, T3 (scale bar = 0.1 mm).



Figs. 16-20. *Humphreysandona adorea* n. gen., n. sp.; 16-17, 19-20: allotype (female, L = 0.796 mm). 18: WAM C28219 (female, L = 0.802 mm). 16, Fu. 17, carapace, external view. 18, LV, internal view. 19, A2. 20, T1 (scale bars = 0.1 mm).

completely fused. Basal segment of T3 with d1, d2, dp setae, following one naked; fused segments with medial 'Tf' seta and distal 'Tg' seta (both of same L, about half as long as fused segments); terminal segment with three setae (L ratios 5.7 : 2.25 : 1).

Furca (Fig. 3) with both anterior and posterior setae developed. Posterior claw reduced to pappose seta (reaching 1/3 of anterior claw), anterior one strongly developed and with one strong pappose spine. Anterior claw as long as anterior furcal margin.

Hemipenis (Fig. 4) with extended, square-shaped 'a' lobe, and with sinusoid and inclined dorsal margin; 'b' lobe acutiform; lobe 'h' double-folded and with flat distal margin; 'g' rounded. Zenker's organ with 5+2 rows of spines.

ALLOTYPE (FEMALE, L = 0.796 mm). - Carapace in both lateral (Figs. 17, 18) and dorsal view as in male. L of LV = 0.796 mm; RV = 0.75 mm. Greatest H on both valves equals 58% of L, greatest W same as in male.

A2 (Fig. 19) with three long claws: G1, G2 and G3 (all about 1.3 times as long as first endopodal segments) and three medio-distal setae: z1, z2 and z3 (z1 more claw-like and exceeding distal end of terminal segment; two other minute, not even reaching distal end of penultimate segment); only two t-setae present. Terminal segment with one long GM claw (1.2 times as long as first endopodal segment), and two thin setae: one of which accompanying y3, the other representing claw Gm. L ratios of endopodal segments 7 : 4 : 1.

Apical setae on endopodite T1 (Fig. 20) of almost subequal length. Protopodite of same appendage covered with dense hairs. T1 also with two 'Ta' setae, three setae on exopodite, and 'Tb' and 'Td' setae present.

Genital lobe (Fig. 16) rounded. Anterior furcal claw 0.9 times as long as anterior furcal margin, spine on same claw strongly developed (even stronger than in male); posterior claws reduced into pappose seta, which is slightly longer than in male, but not reaching middle of anterior claw.

Other appendages: A1, Md, Mxl, T2 and T3 (Fig. 15) same as in male.

VARIABILITY. - In one female (WAM C28219) one A1 was 6-segmented (Fig. 14) with divided first and second endopodal segments. This was not noticed on the other A1 nor in other examined specimens; it seems to be a rare variability within the species as it has been noticed in only one out of nine dissected specimens.

ETYMOLOGY. - The name of the species comes from the Latin noun '*adorea*' (f.), meaning glory.

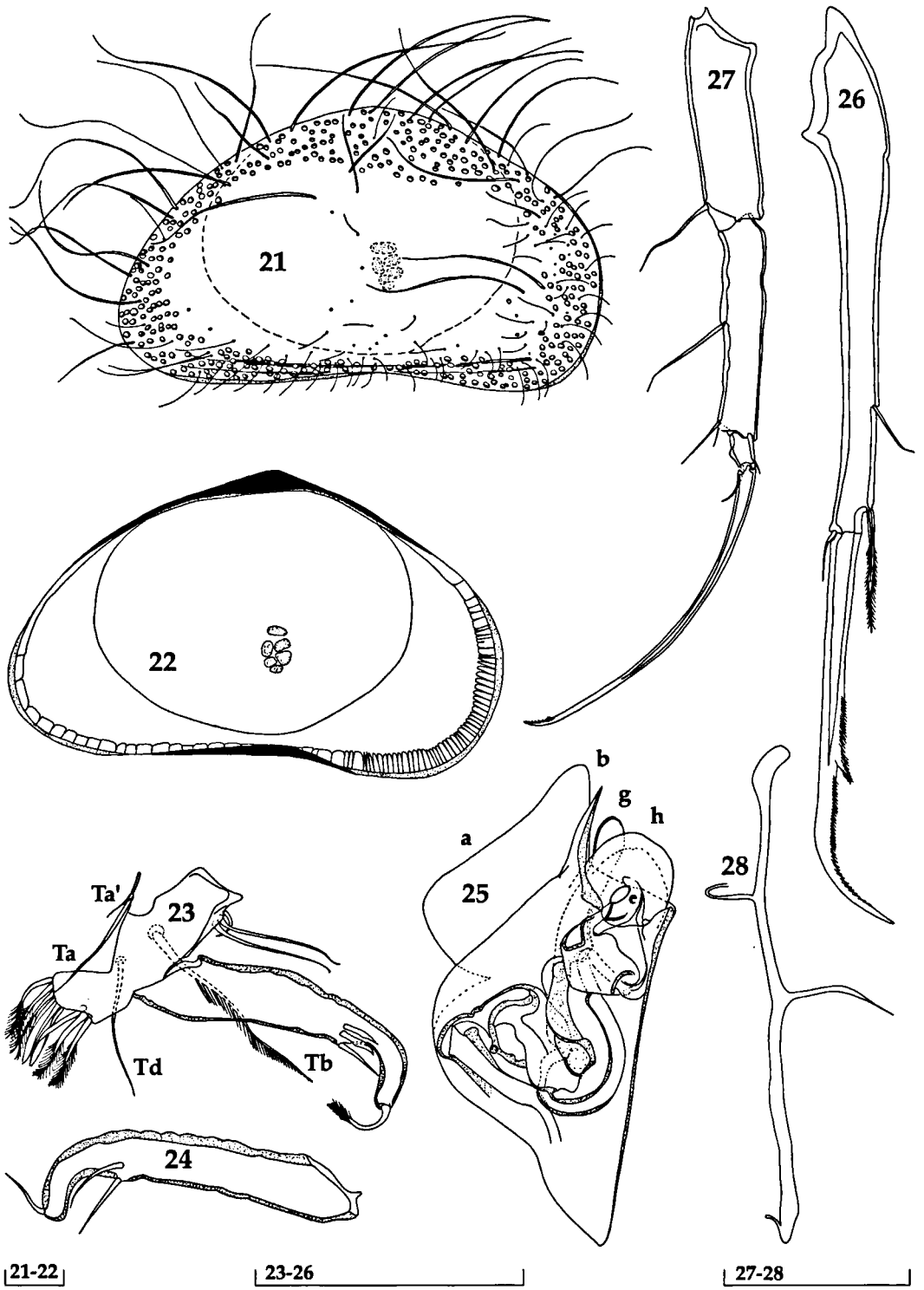
Humphreyscandona fovea n. gen., n. sp.
Figs. 21-34

MATERIAL. - Holotype: male, dissected (WAM C28222), from Old Well in Marrapikurrinyu, Port Hedland, 20°19'32"S 118°37'59"E, 26-X-1996, collector: W. F. Humphreys (BES 4460.1).

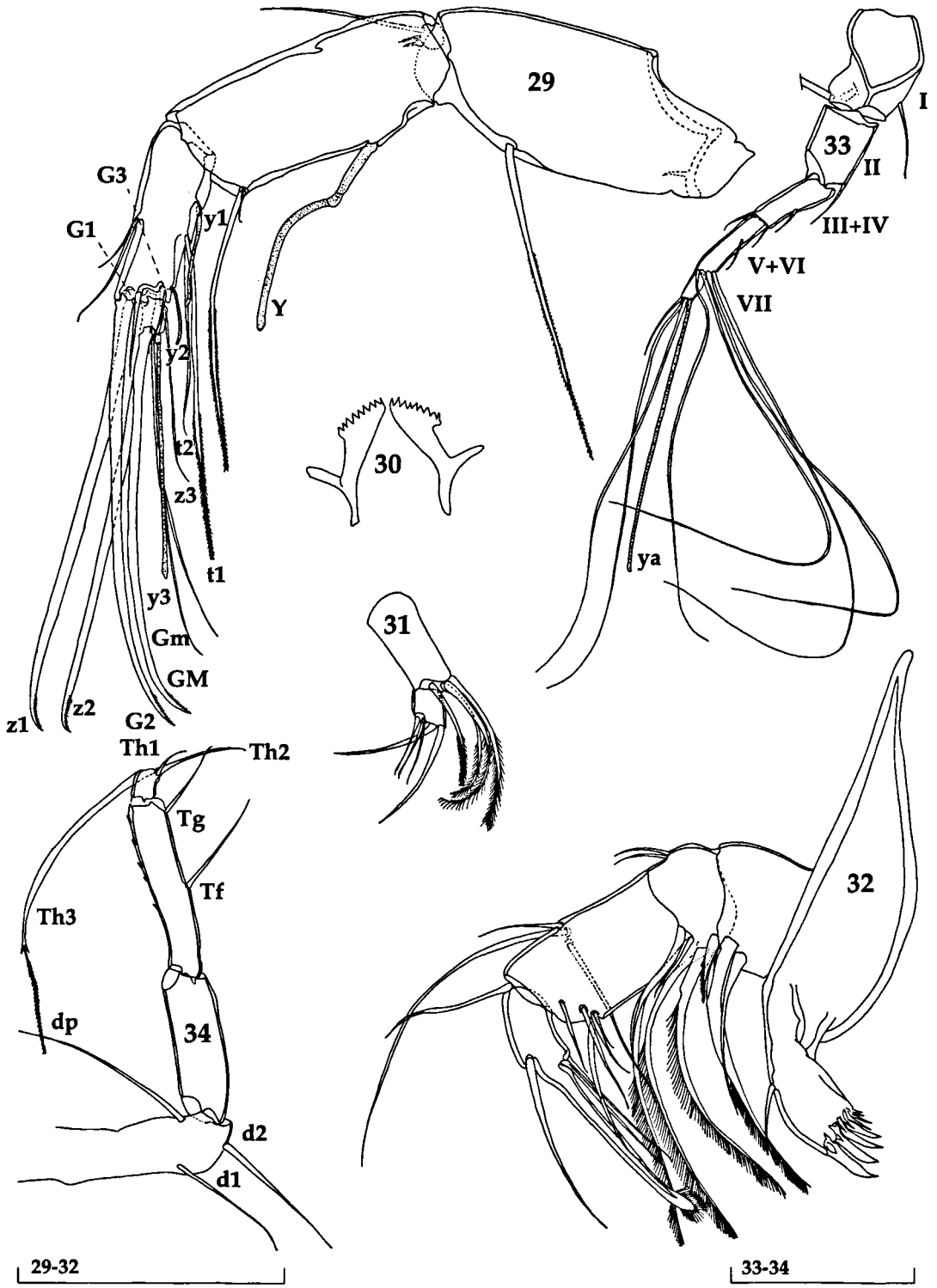
Soft parts of the holotype were mounted on slides in glycerol, while valves are kept on the micropalaeontological slide.

DESCRIPTION OF HOLOTYPE (MALE, L = 0.831 mm). - Carapace triangular in lateral view (Figs. 21, 22). L of LV = 0.831 mm, RV = 0.81 mm. Greatest H on LV = 68%, while on RV = 60% of L. LV dorsally with flange overlapping RV. On both valves greatest H situated around middle. Dorsal margin evenly rounded towards both frontal and caudal margins. Frontal margin clearly wider than caudal one. Ventral margin concave around middle. Valve surfaces covered with long as well as short hairs. Also, surface ornamented ventrally with longitudinal ridges as well as with pits all over the surface, except centrally, where smooth. Selvage peripheral. Marginal zone wide, anteriorly 22%, posteriorly 21% of L. Fused zone relatively wide, with dense marginal pore canals. Dorsal appearance not observed.

A1 (Fig. 33) 5-segmented. First segment with one antero-proximal seta (not shown in Fig. 33), one antero-distal seta and two posterior long ones; second segment with one antero-distal short seta (not reaching middle L of following segment); third segment with short antero-medial seta (hardly reaching distal end of terminal segment) and two short distal setae (not reaching middle of penultimate segment); penultimate segment with one short antero-medial seta (not reaching distal end of same segment), and four long distal setae; terminal segment with one short seta (2 times longer than terminal segment), two long setae and aesthetasc (ya) which is 9.5 times



Figs. 21-28. *Humphreyscandona fovea* n. gen., n. sp., holotype (male, L = 0.831 mm). 21, RV, external view. 22, LV, internal view. 23, right prehensile palp. 24, left prehensile palp. 25, hemipenis, medial side up. 26, Fu. 27, T2. 28, furcal attachment (scale bars = 0.1 mm).



Figs. 29-34. *Humphreyscandona fovea* n. gen., n. sp., holotype (male, L = 0.831 mm). 29, A2. 30, Rake-like organ. 31, Mxl palp. 32, Md. 33, A1. 34, T3 (scale bars = 0.1 mm).

as long as terminal segment. L ratios of three terminal segments 2.3 : 2.4 : 1.

A2 (Fig. 29) 4-segmented without male's bristles. Exopodite plate with two short and one long seta (latter being about 8 times longer). Aesthetasc Y 0.82 times as long as first endopodal segment; aesthetasc y1 reaching distal end of second endopodal segment; y2 slightly exceeding terminal segment; y3 0.9 times as long as first endopodal segment. Penultimate segment with two medial setae on each side of segment: one posterior pappose (t1), other smooth (t2); both anterior smooth. Same segment distally with three long claws: G2, z1 and z2 (all about 1.6 times as long as first endopodal segment), one weak medio-distal claw, representing claw G1 (about twice as long as terminal segment), and two postero-distal setae (one which is slightly longer than terminal segment represents claw G3, the other which is about half as long as terminal claws represents seta z3). Terminal segment with long GM claw (1.4 times as long as first endopodal segments), and two long setae (one accompanying y3, other being claw Gm). L ratios of three endopodal segments 8 : 6 : 1.

Md palp (Fig. 32) 4-segmented. First segment with S1 and S2, alpha and one long smooth seta; second segment with two short setae externally and 3+2 setae internally in bunch. Penultimate segment with three extero-medial setae (one almost reaching distal end of terminal claw, one slightly shorter and one not exceeding distal end of penultimate segment), one gamma seta extero-distally (slightly exceeding distal end of terminal segment), and five intero-medial setae. Terminal segment with one fused and distally pappose claw, one strong seta externally and two fine setae internally. L ratios of three distal segments 1: 2.5.: 1.3.

Mxl palp (Fig. 31) with square-shaped to trapezoidal terminal segment and with five setae/claws observed; penultimate segment with four pappose setae; claws on third endite plumose.

Rake-like organ with nine to 10 teeth respectively (Fig. 30).

Prehensile palps (Figs. 23, 24) almost symmetrical with long fingers. Right prehensile palp (Fig. 23) with three setae. T1 with two 'Ta' setae, 'Tb', 'Td' setae, and three setae in exopodite.

T2 (Fig. 27) 4-segmented, third and fourth segments fused, chitinous membrane externally uninterrupted. Basal segment without any seta; first endopodal segment with one seta which is slightly less than half as long as fused segments; fused segments with one medial seta and two distal setae (medial seta not reaching distal end, one distal reaching distal end of terminal segment, other minute); terminal segment with two setae and claw distally serrated and 1.4 times as long as three distal segments combined.

T3 (Fig. 34) 4-segmented, third and fourth segments being fused. Basal segment with d1, d2 and dp setae; first endopodal segment without any seta; fused segments with 'Tf' seta medially and 'Tg' seta distally (of subequal L, about half as long as fused segment); terminal segment with three setae with L ratios 9.6 : 3 : 1.

Fu (Fig. 26.) with both anterior and posterior setae present (posterior one not reaching distal end); posterior claw reduced to pappose seta, which is about 1/3 of anterior claw; anterior claw strongly curved distally and with strong pappose spine. Same claw as long as anterior furcal margin. Furcal attachment shown in Fig. 28.

Hemipenis (Fig. 25) with extended, square-shaped 'a' lobe (with inclined dorsal margin),'b' lobe sharply pointed, 'g' rounded and higher than 'h', which is also rounded and double-folded. Zenker's organ with 5+2 rows of spines.

FEMALES. - Unknown.

ETYMOLOGY. - From the Latin noun *'fovea'* (f.), meaning pit.

Humphreyscandona pilbarae n. gen., n. sp. Figs. 35-57

MATERIAL. - Holotype: male, dissected (WAM C28223), from Bilanoo Pool (Karaman-Chappuis), Fortescue River, 21°17'43"S, 116°08'27"E, 25-X-1996, collector: W. F. Humphreys (BES 4095).

Additional material: 1 male, dissected (WAM C28224) and 1 juvenile male in alcohol (WAM C28225), from the pool in Fortescue River (B-R), Fortescue River Road Bridge 21°17'52"S 116°08'23"E, 5-VIII-1997, collectors: W. F. Humphreys and S. M. Eberhard (BES 4995); 1 male, dissected (WAM C28226), from large water pool (sample no 9, B-R) in Fortescue River, Fortescue River Road Bridge, 21°17'52"S 116°08'23"E, 5-VIII-1997, collectors: W. F. Humphreys and S. M. Eberhard (BES 4964); 1 female, dis-

sected (WAM C28227); 6 juveniles in alcohol (WAM C28228), from large pool in Fortescue River (sample no 2, B-R), Fortescue River Road Bridge, 21°17'52"S 116°08'23"E, 5-VIII-1997, collector: W. F. Humphreys (BES 1036).

Soft parts and the valves of holotype, 1 male (WAM C28224) and of the female were mounted on slides in Faure's medium. Valves of the other dissected male are kept on micropalaeontological slide, soft parts were mounted on slides in glycerol.

DESCRIPTION OF HOLOTYPE (MALE, L = 0.673 mm). - Carapace reniform in lateral view (Figs. 35, 36). L of LV = 0.673 mm, RV = 0.665 mm. Dorsal margin equally rounded; frontal margin widely rounded and slightly wider than caudal one; ventral margin slightly concave in middle. Greatest H around middle on both valves, equaling 53% of L. Surface of carapace ornamented with longitudinal ridges just on ventral and dorsal parts of carapace, also surface covered with strong hairs. Marginal zone wide, anteriorly about 30%, posteriorly 22% of L. Interior margin inclined in antero-ventral region. Marginal pore canals relatively short, straight and dense. Selvage peripheral. In dorsal view (Fig. 37) LV clearly overlapping RV both on anterior and posterior ends. Greatest W = 30%. Anterior end slightly narrower than posterior one.

A1 (Fig. 49) 5-segmented. First segment with two long posterior setae, one short antero-distally, and one antero-proximally (not shown in Fig. 49); second segment with one short seta (not reaching middle of third segment); third segment with one short antero-medial seta (slightly exceeding distal end of same segment) and two distal setae (both short and not reaching middle of following segment); penultimate segment with short antero-medial seta (almost reaching distal end of terminal segment), three long and one short seta (about 3 times as long as terminal segment); terminal segment with two long setae, one shorter (about 3 times as long as terminal segment), and aesthetasc (ya) which is 9 times as long as terminal segment (Fig. 50). L ratios of three distal segments 2 : 1.2 : 1.

A2 (Figs. 45, 48) 4-segmented and without male's bristles. Exopodite plate with two short and one long seta (latter one being more than 5 times longer). Aesthetasc Y as long as first endopodal segment; y1 exceeding distal end of penultimate segment; y2 exceeds distal end of terminal segment; y3 1.1 times as long as first endopodal segment. Penultimate segment with two medial setae on each side of segment (all smooth, posterior being much longer); three distal claws: G2, z1 and z2 (all about 1.7 times as long as terminal segment); two additional claws (one medial representing reduced G1, being 2.8 times longer than terminal segment, other postero-distally representing reduced claw G3 and just slightly longer than terminal segment); and z3 seta (more than 5 times longer than terminal segment). Terminal segment with one long GM claw (1.5 times as long as first endopodal segment) and just one seta accompanying y3, while Gm not observed. L ratio of three endopodal segments 6.3 : 4 : 1.

Md palp (Fig. 47) 4-segmented. First segment with two plumose, S1 and S2 setae and two smooth setae (short one being alpha); second segment with two short external setae and 3+2 setae internally in bunch. Penultimate segment with three extero-medial setae: one not reaching distal end of same segment, one reaching basis of terminal claw, one reaching half of terminal claw; gamma seta reaching 1/3 of terminal claw. Terminal segment with fused and distally pappose claw, one external seta and two internal ones. L ratios of three distal segments 1 : 3 : 1.44.

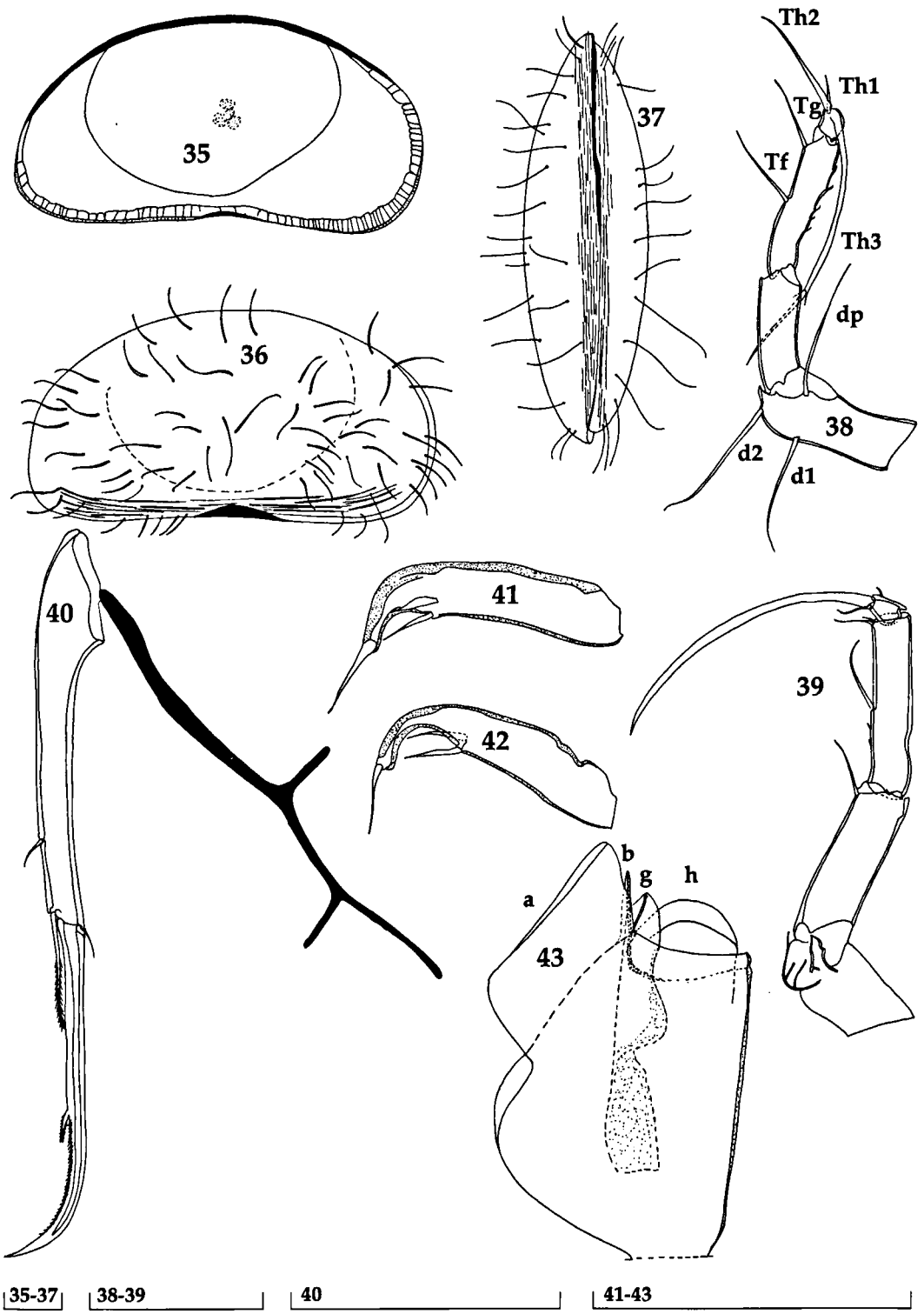
Mxl palp (Fig. 46) with terminal segment square-shaped to trapezoidal, and with two claw-like and three thin setae; third endite of Mxl with two plumose claws.

Rake-like organ (Fig. 44) with eight and nine teeth respectively.

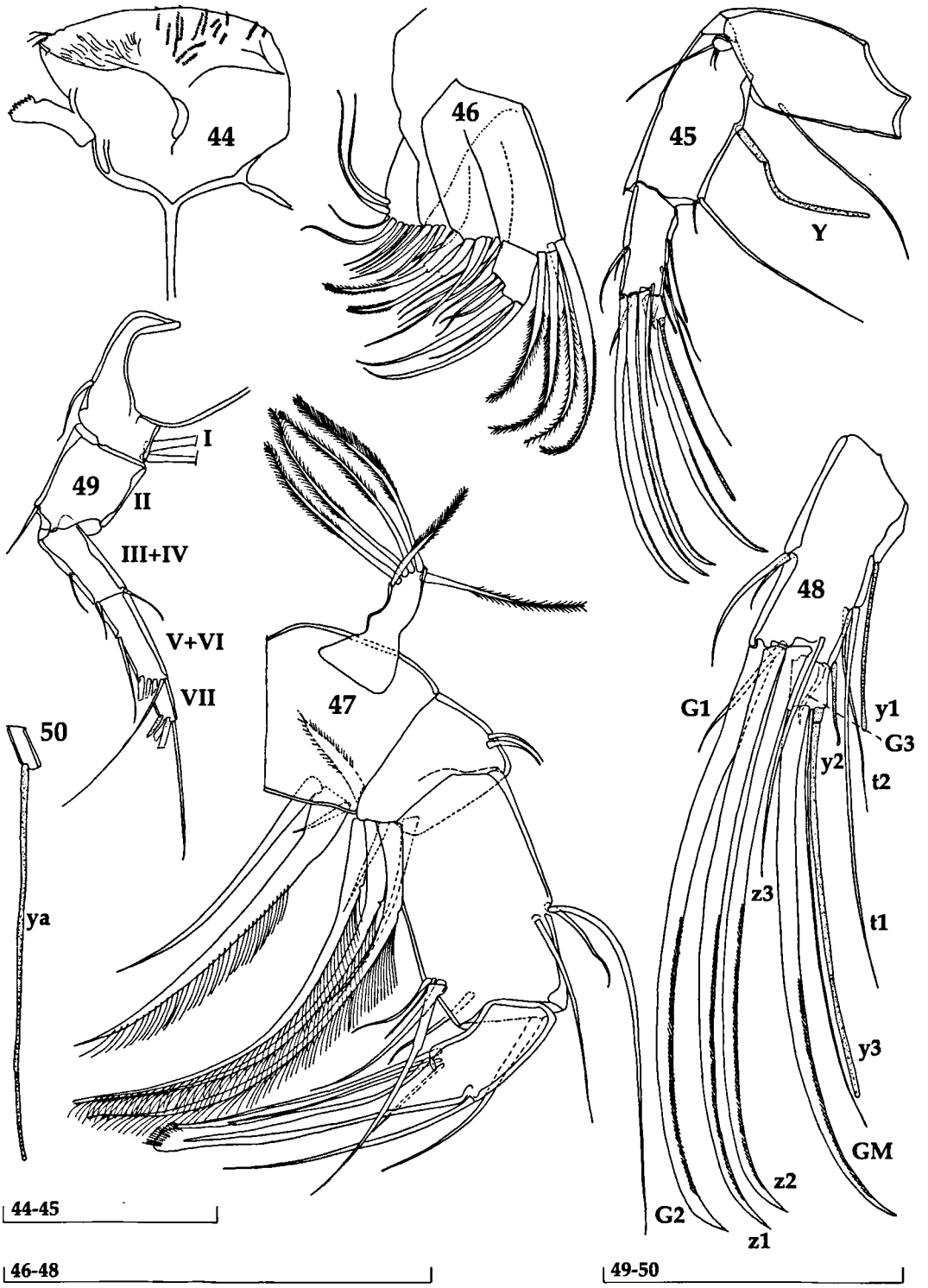
Prehensile palps (Figs. 41 and 42) almost symmetrical and with long setae and fingers.

T2 (Fig. 39) 4-segmented, third and fourth segments being fused and with uninterrupted exterior chitinous membrane. Basal segment without any seta; first endopodal segment with one seta not reaching middle of following segments; fused segments with one medial seta (not reaching distal end of segment), and two distal ones (longer one just reaching distal end of terminal segment, shorter one not even reaching middle of same segment); terminal segment with two short setae and distal claw (1.4 times as long as three terminal segments combined).

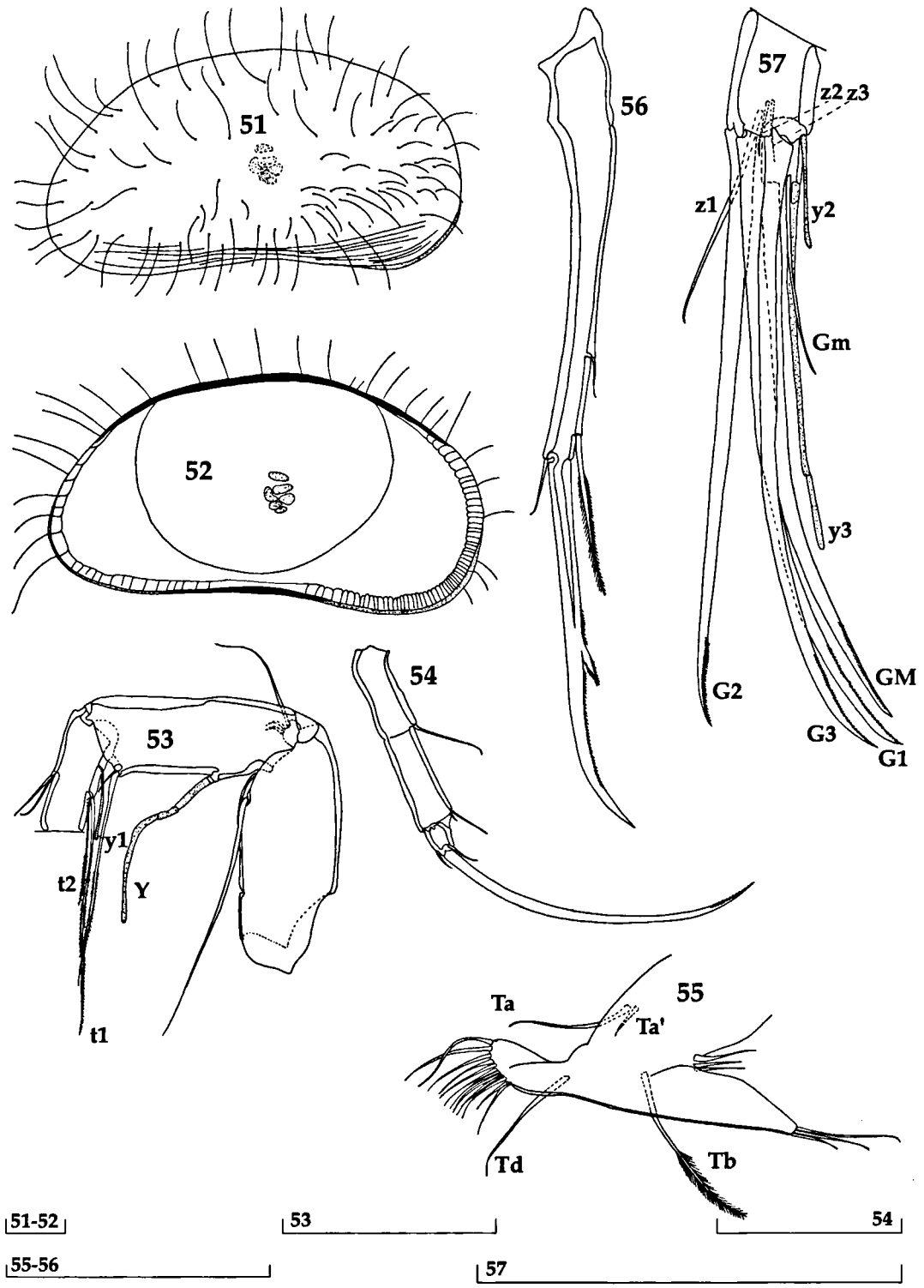
T3 (Fig. 38) 4-segmented, third and fourth segments being fused. Basal segment with d1, d2 and



Figs. 35-43. *Humphreyscandona pilbarae* n. gen., n. sp., holotype (male, L = 0.673 mm). 35, LV, internal view. 36, carapace, external view. 37, carapace, dorsal view. 38, T3. 39, T2. 40, Fu. 41, right prehensile palp. 42, left prehensile palp. 43, hemipenis, lateral side up (scale bars = 0.1 mm).



Figs. 44-50. *Humphreyscandona pilbarae* n. gen., n. sp., holotype (male, L = 0.673 mm). 44, forehead with Rake-like organ attached. 45, A2. 46, Mxl palp with three endites. 47, Md palp. 48, A2, detail. 49, A1. 50, terminal segment of A1 with aesthetasc (scale bars = 0.1 mm).



Figs. 51-57. *Humphreyscandona pilbarae* n. gen., n. sp., WAM C28227 (female, L = 0.73 mm). 51, RV, external view. 52, LV, internal view. 53, A2 (claws and terminal segment missing). 54, T2 (just three distal segments). 55, T1. 56, Fu. 57, A2, detail (scale bars = 0.1 mm).

dp setae; first endopodal segment without any seta; fused segments with 'Tf' seta medially (exceeding distal end of segment) and 'Tg' seta distally (slightly shorter). L ratios of three setae on terminal segment 6.7 : 2.8 : 1.

Furca (Fig. 40) with both anterior and posterior setae developed; posterior claw reduced to pappose seta (equalling about 1/3 of anterior claw); posterior claw well developed and with pappose spine, also same claw 1.2 times as long as anterior furcal margin.

Hemipenis (Fig. 43) with square-shaped lobe 'a', 'b' with very narrow and acutiform sclerotized part, 'g' with slightly pointed distal end, lobe 'h' rounded and double-folded. Zenker's organ with 5+2 rows of spines.

FEMALE (L = 0.73 mm). - Dorsal margin slightly inclined towards posterior end (Figs. 51, 52), also caudal margin much narrower than in male. L of LV = 0.73 mm, RV = 0.684 mm. Greatest H = 56% of L.

Penultimate segment of A2 (Figs. 53, 57) with three long claws (G1, G2 and G3) and three z-setae of which outermost one (z1) strongest and 3.6 times as long as terminal segment. Terminal segment with one long GM claw and, apart from the seta accompanying y3, an additional representing claw Gm (3.1 times as long as terminal segment).

T1 (Fig. 55) with three short setae on distal end of protopodite. T1 with two 'Ta' setae and three setae in exopodite; 'Tb 'and 'Td' setae present.

T2 (Fig. 54) with one division which is not completed and with external chitinous membrane still uninterrupted.

Fu (Fig. 56) also with reduced posterior claw which is almost half as long as anterior one. Genital lobe rounded.

Other characteristics of carapace, and other soft parts same as in male.

ETYMOLOGY. - The name is derived from the region Pilbara (Western Australia) where the species was collected. It is to be treated as a noun in the genitive singular.

Humphreyscandona woutersi n. gen., n. sp.
Figs. 58-81

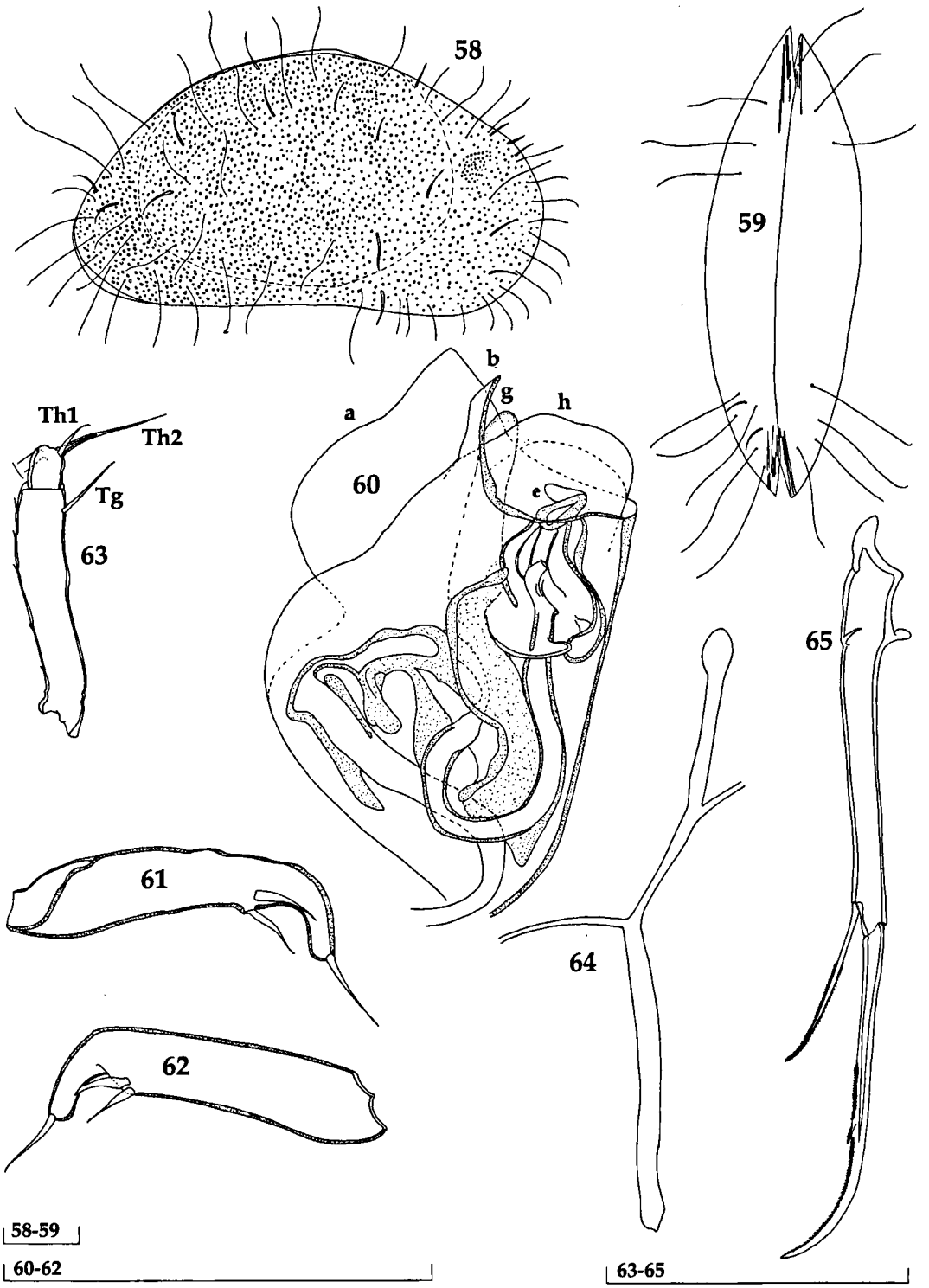
MATERIAL. - Holotype: male, dissected (WAM C28229), from GWMB, 56A, Millstream Aquifer, 21°47'18"S 116°44'23"E, 2-VIII-1997, collectors: W. F. Humphreys and S. M. Eberhard (BES 4922).
Additional material: 1 female, dissected (WAM C28230), from GWMB, 55A, Millstream Aquifer, 21°46'07"S 116°43'35"E, 2-VIII-1997; collectors: W. F. Humphreys and S. M. Eberhard (BES 4923); 1 male, dissected (WAM C28231), from GWMB, 56A, Millstream Aquifer, 21°47'18"S 116°44'23"E, 2-VIII-1997, collectors: W. F. Humphreys and S. M. Eberhard (BES 4926).

Both appendages and soft parts of the holotype and the single female (WAM C28230) were mounted on slides in Faure's medium. Soft parts of the other dissected male were mounted on a slide in glycerol, valves are kept on the micropalaeontological slides.

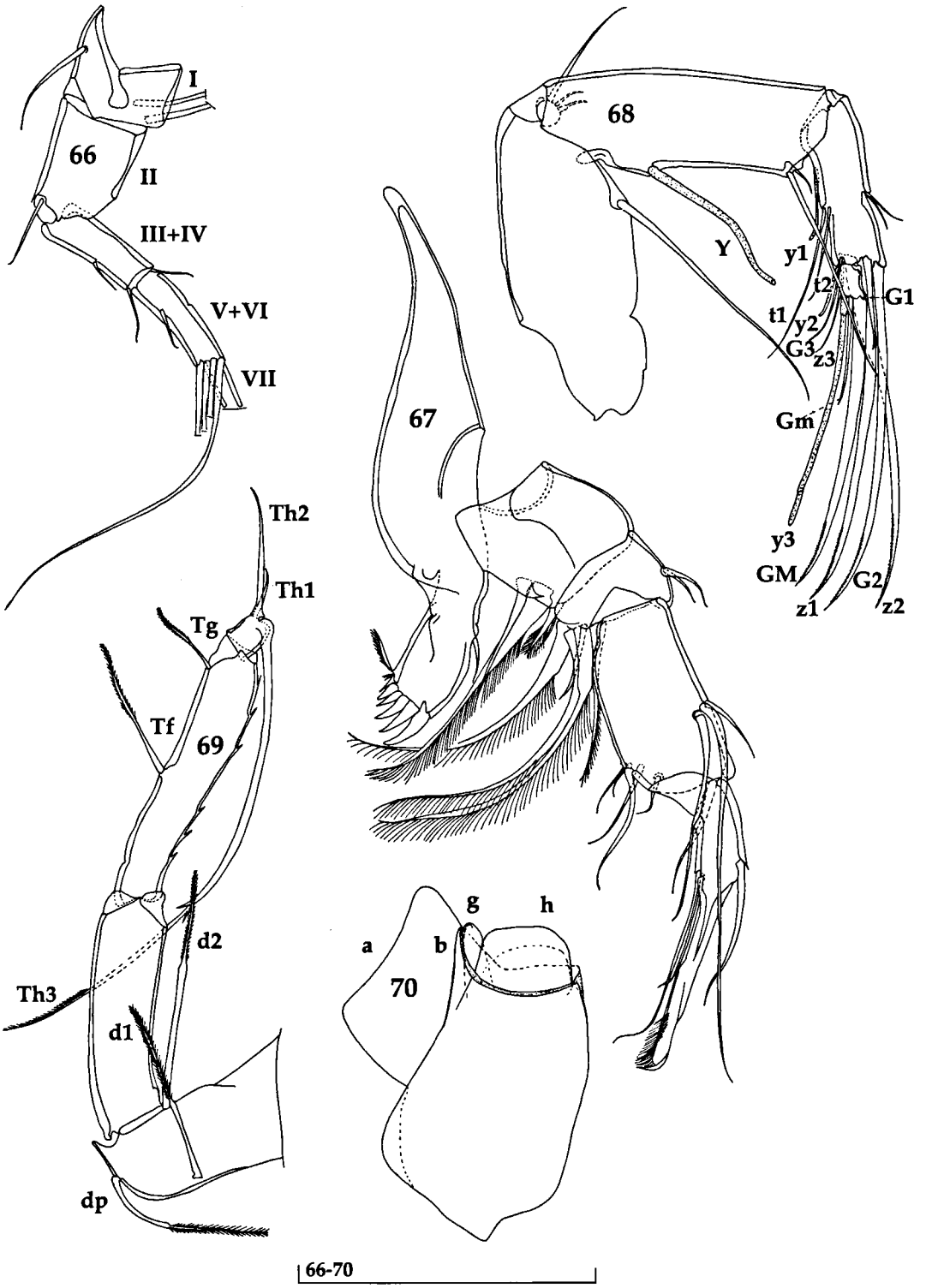
DESCRIPTION OF HOLOTYPE (MALE, L = 0.615 mm). - Carapace laterally subtriangular (Fig. 58). L of LV = 0.615 mm, RV = 0.611 mm. Dorsal margin more inclined towards posterior than towards anterior end; frontal margin wider than caudal one; ventral margin almost straight. Greatest H on both valves equals 57% of H. Valve surface covered with small pits and with two kind of hairs: one short and spine-like, other thin and long. Also, in dorsal view few longitudinal striae visible frontally and caudally. Marginal zone anteriorly 25%, posteriorly 16% of L. Marginal pore canals dense anteriorly, sparse posteriorly. Selvage peripheral on both valves. In dorsal view (Fig. 59), LV weakly overlaps RV on both ends, however more clearly frontally than caudally. Greatest W = 33%. Both caudal and frontal ends pointed.

A1 (Fig. 66) 5-segmented. First segment with one antero-proximal seta (not shown in Fig. 66), one antero-distal and two long posterior ones; second segment with one antero-medial seta (not reaching middle L of following segment); third segment with one short antero-medial seta (hardly reaching distal end of same segment) and two distal setae (hardly reaching middle of following segment); penultimate segment with one antero-medial seta (not reaching distal end of same segment), distally with three long and one shorter seta (little more than seven times longer than terminal segment). Terminal segment with two long and one short seta and aesthetasc (ya) which is 8 times as long as terminal segment. L ratios of three distal segments 2 : 2.2 : 1.

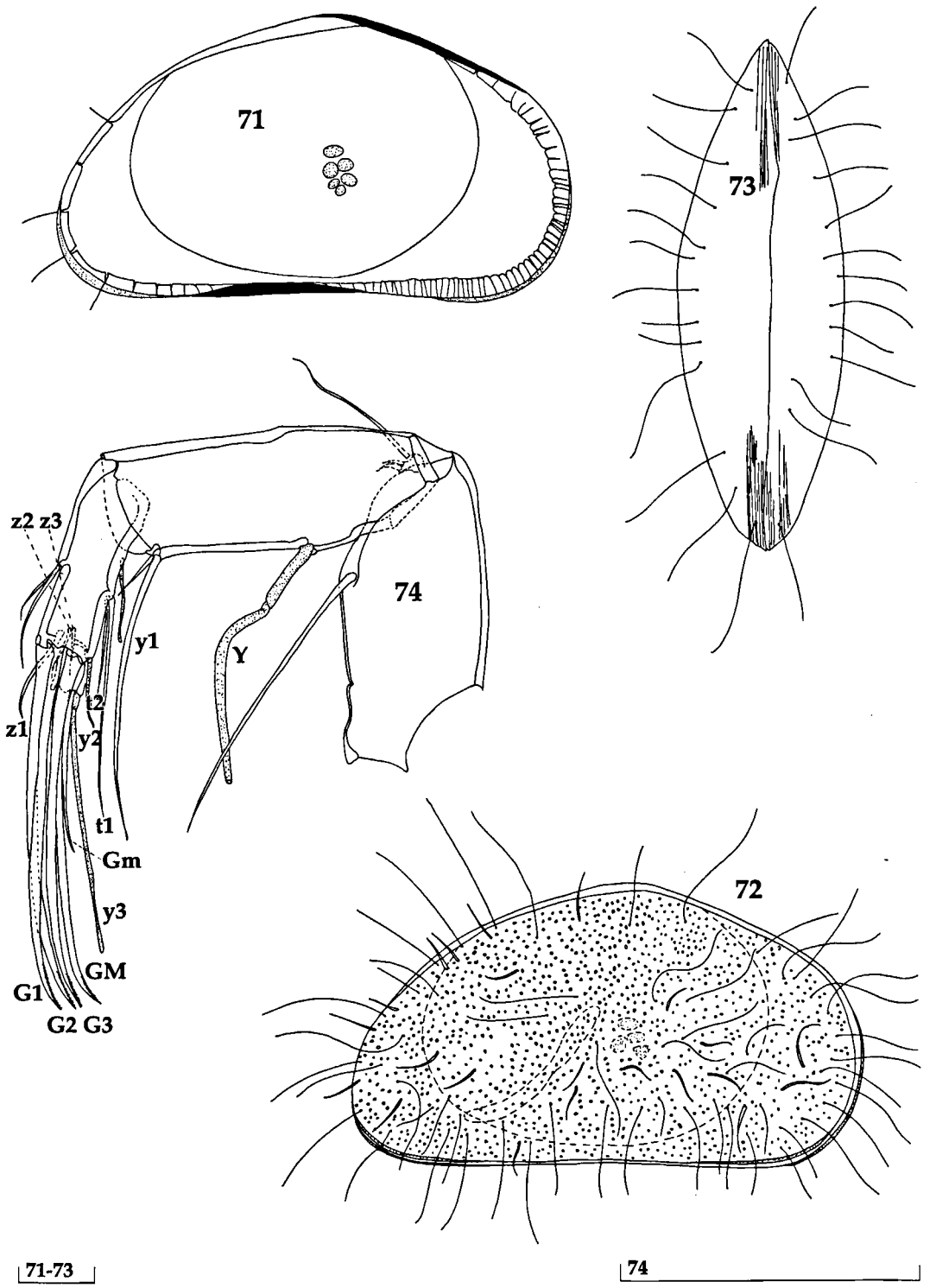
A2 (Fig. 68) 4-segmented and without male's



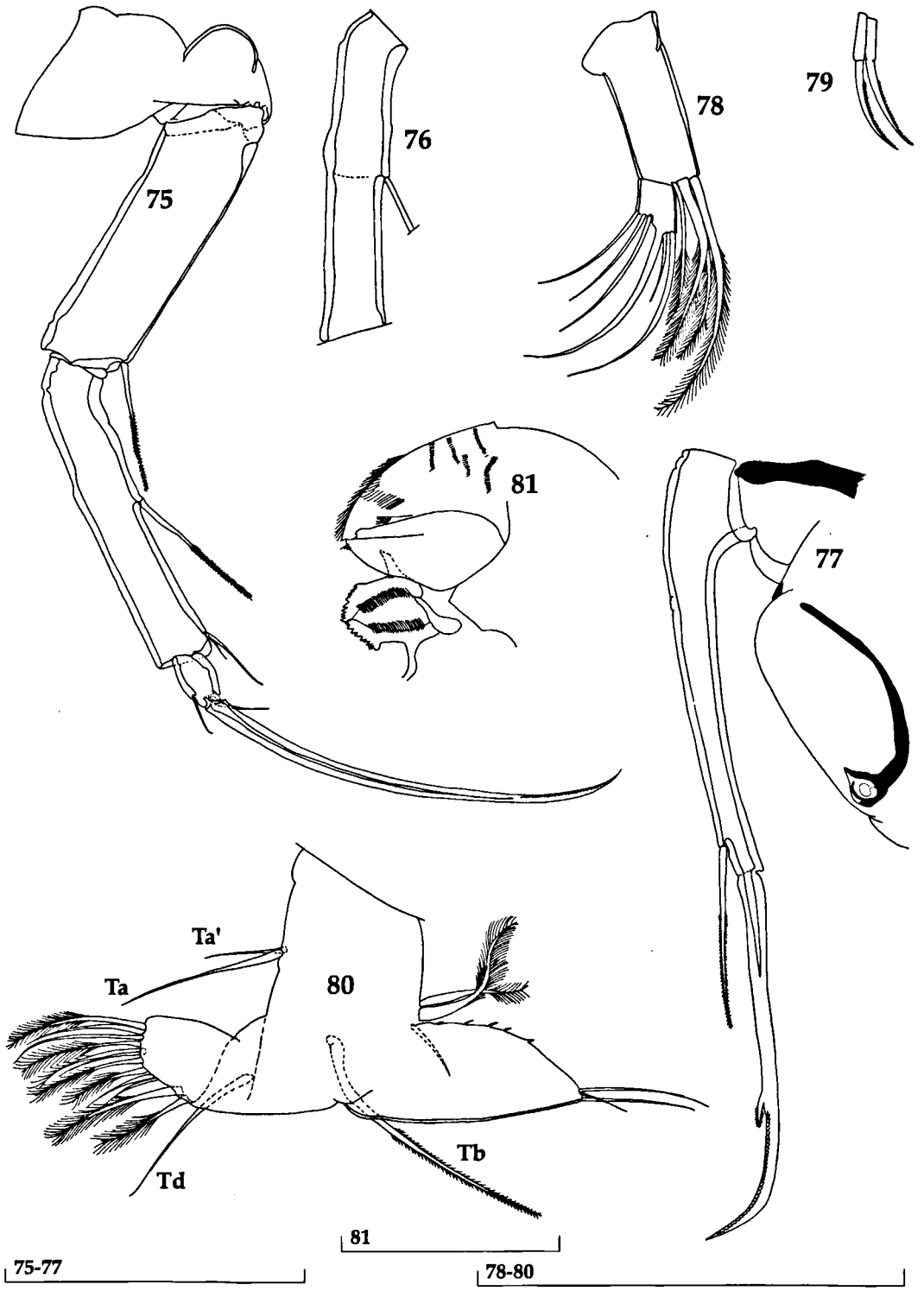
Figs. 58-65. *Humphreyscandona woutersi* n. gen., n. sp., holotype (male, L = 0.615 mm). 58, carapace, external view. 59, carapace, dorsal view. 60, hemipenis, medial side up. 61, right prehensile palp. 62, left prehensile palp. 63, T3, detail. 64, furcal attachment. 65, Fu (scale bars = 0.1 mm).



Figs. 66-70. *Humphreyscandona woutersi* n. gen., n. sp.; 66-69: holotype (male, L = 0.615 mm). 70: WAM C28231 (male, L = 0.645 mm). 66, A1. 67, Md. 68, A2. 69, T3. 70, hemipenis, medial side up (scale bar = 0.1 mm).



Figs. 71-74. *Humphreyscandona woutersi* n. gen., n. sp., WAM C28230 (female, L = 0.679 mm). 71, LV, internal view. 72, carapace, external view. 73, carapace, dorsal view. 74, A2 (scale bars = 0.1 mm).



Figs. 75-81. *Humphreyscandona woutersi* n. gen., n. sp., WAM C28230 (female, L = 0.679 mm). 75, T2. 76, T2, detail. 77, Fu. 78, Mxl palp. 79, Mxl claws. 80, T1. 81, forehead with Rake-like organ attached (scale bars = 0.1 mm).

bristles. Exopodite consists of two short and one long seta (latter one being about 5 times longer). Aesthetasc Y 0.6 times as long as first endopodal segment; y1 not reaching distal end of penultimate segment; y2 1.7 times as long as terminal segment; y3 0.8 times as long as first endopodal segment. Penultimate segment with two medial setae on each side (all smooth, anterior not reaching, while posterior ones exceeding distal end of same segment). Penultimate segment distally with claw G2 and transformed z1 and z2 (all about 1.2 times as long as first endopodal segment); one additional medial claw, being reduced G1 (about twice as long as terminal segment), and two thin postero-distal setae (outermost being z3, inner being reduced G3). Terminal segment with claws GM (about as long as first endopodal segment) and Gm (3.4 times as long as terminal segment) Accompanying seta of y3 not visible. L ratios of endopodal segments 6.2 : 3.5 : 1.

Md palp (Fig. 67) 4-segmented. First segment internally with S1 and S2, and two smooth (short - alpha, and one long) setae. Second segment externally with two small setae, internally with 3+2 setae in bunch. Penultimate segment with three setae externally (two long and one short), gamma seta extero-distally and five intero-distal setae. Terminal segment with fused and distally pappose claw, one strong external seta and two thin internal ones. L ratio of three distal segments 1: 2.6 : 1.25.

Terminal segment of Mxl palp square-shaped to trapezoidal and with two claw-like and three thin setae; claws on third endite plumose.

Rake-like organ with 10 and 11 teeth respectively.

Prehensile palps (Figs. 61, 62) almost symmetrical with long fingers and setae.

T2 4-segmented, third and fourth segments being completely fused and with uninterrupted exterior membrane between them. Basal segment without any seta, first endopodal with one seta not reaching middle of fused segments. Fused segments with one medial seta (reaching distal end of same segment) and two distal setae (one very short, other slightly exceeding distal end of same segment). Terminal segment with two distal setae and claw, which is distally serrated and about 1.2 times as long as three distal segments combined.

T3 (Fig. 69) 4-segmented, third and fourth segments fused. Basal segment with three setae, first endopodal segment without any seta. Fused segments with two setae: medial 'Tf' (slightly exceeding distal end of same segments), and distal 'Tg' seta (exceeding distal end of terminal segment). L ratios of three setae on terminal segment 9.8 : 2.7 : 1.

Fu (Fig. 65) without both anterior and posterior setae. Posterior claw reduced to pappose seta, which is half as long as anterior claw; anterior claw with strong spine and 1.2 times as long as anterior furcal margin.

Hemipenis (Fig. 60) with lobe 'a' square-shaped (with inclined and sinusoid exterior margin); lobe 'b' acutiform; 'g' rounded; lobe 'h' double-folded and with almost flat distal margin. Zenker's organ 5+2 rows of spines.

FEMALE (L = 0.679 mm). - Carapace in lateral view (Figs. 71, 72) subtriangular. L of LV = 0.679 mm, RV = 0.677 mm. Greatest H situated around middle on both valves, equalling 60% of L. Greatest W = 33% (Fig. 73).

Aesthetasc Y on A2 (Fig. 74) equals 84% of first endopodal segment. Penultimate segment of same appendage with long claws G1, G2 and G3 (1.1. times as long as first endopodal segment). Setae z2 and z3 short (not reaching distal end of terminal segment), seta z1 being small claw (about two times as long as terminal segment). Terminal segment with one long GM (as long as first endopodal segment), and one shorter claw - Gm (1/2 as long as first endopodal segment). L ratios of three endopodal segments 7.2 : 3.9 : 1.

T1 (Fig. 80) with three setae on distal end of protopodite of which two of subequal L, while one considerably shorter. T1 with two 'Ta', and three setae on exopodite; 'Tb' and 'Td' setae present.

Genital lobe rounded, Fu (Fig. 77) also without anterior and posterior setae. Anterior claw being 1.14 times as long as furcal margin.

Surface ornamentation, as well as appearance and other details of soft parts (Figs. 75, 78, 79, 81) same as in male.

VARIABILITY. - Few variable features have been noticed in this species. In the holotype male on one T3 the medial seta was absent on the fused

segments (Fig. 63). Also, in males, both 'a' and 'g' lobes can protrude more (Fig. 60) or less (Fig. 70). In the female on one T2 a very weak division on the second and third segments was noticed (Fig. 76), but in any case this division does not interrupt the exterior chitinous membrane between the segments.

ETYMOLOGY. - The species is named after Dr Karel Wouters from the Royal Institute of Natural Science in Belgium, as a friendly acknowledgment for the help he provided during the work on this material. The name is to be treated as a noun in the genitive singular.

Humphreyscandona waldockae n. gen., n. sp.
Figs. 82-99

MATERIAL. - Holotype: male, dissected (WAM C28232), allotype - female, dissected (WAM C28233). Paratypes: 1 male, 1 female and 21 juveniles, all in alcohol (WAM C28234), from Calamina Well, Mulga Downs Station, Fortescue River Valley, 22°11'S 118°28'E, 3-IX-2000, collectors: W. F. Humphreys and J. M. Waldock (BES 8454). Additional material: 1 female, dissected (WAM C28235), 1 male, dissected (WAM C28236); 7 females, 3 males and 24 juveniles, all in alcohol (WAM C28237), from Ebathacalby Well, Fortescue River Valley, 22°14'59"S 118°44'51"E, 25-VII-1997, collectors: W. F. Humphreys and S. M. Eberhard (BES 4849); 2 juveniles in alcohol (WAM C28238), from Yampire Bore, Mulga Downs Station, Fortescue River Valley, 22°15'S 118°34'E, 3-IX-2000, collectors: W. F. Humphreys and J. M. Waldock (BES 8447); 3 juveniles in alcohol (WAM C28239), from the Ebathacalby Well, Mulga Downs Station, Fortescue River Valley, 22°15'S 118°45'E, 2-IX-2000, collectors: W. F. Humphreys and J. M. Waldock (BES 8439).

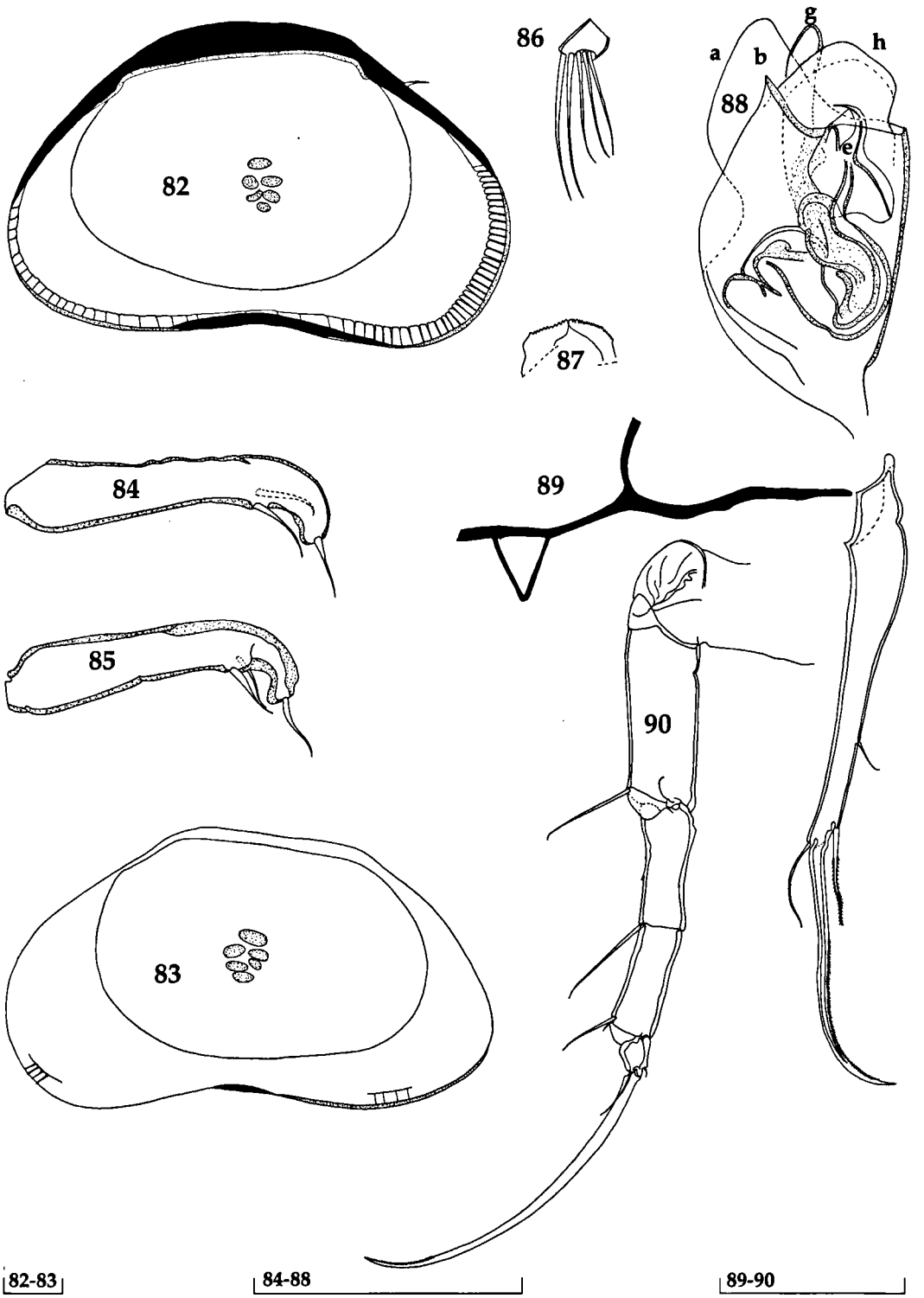
Both soft parts and valves of holotype and allotype were mounted on slides in Faure's medium; just appendages of other dissected specimens were mounted on slides in glycerol, and their valves are kept on the micropalaeontological slides.

DESCRIPTION OF HOLOTYPE (MALE, L = 0.852 mm). - Carapace trapezoidal in lateral view (Fig. 82, 83) with dorsal margin slightly inclined towards posterior end. L of LV = 0.852 mm, RV = 0.821 mm. Both frontal and caudal margins rounded, frontal being clearly wider than caudal one. LV with flange strongly developed dorsally and with greatest H = 65% of total L, while on RV greatest H = 56% of total L. On both valves greatest H situated on first third of carapace. Valve surface strongly ornamented with irregularly shaped pits. Surface mostly with long hairs, LV also dorsally with few spines. Marginal zone anteriorly 23%, posteriorly 20% of L. Marginal pore canals straight and dense. In dorsal view LV overlaps RV on both ends, greatest W = 40% of L, anterior and posterior ends not strongly pointed, but with finely rounded margins.

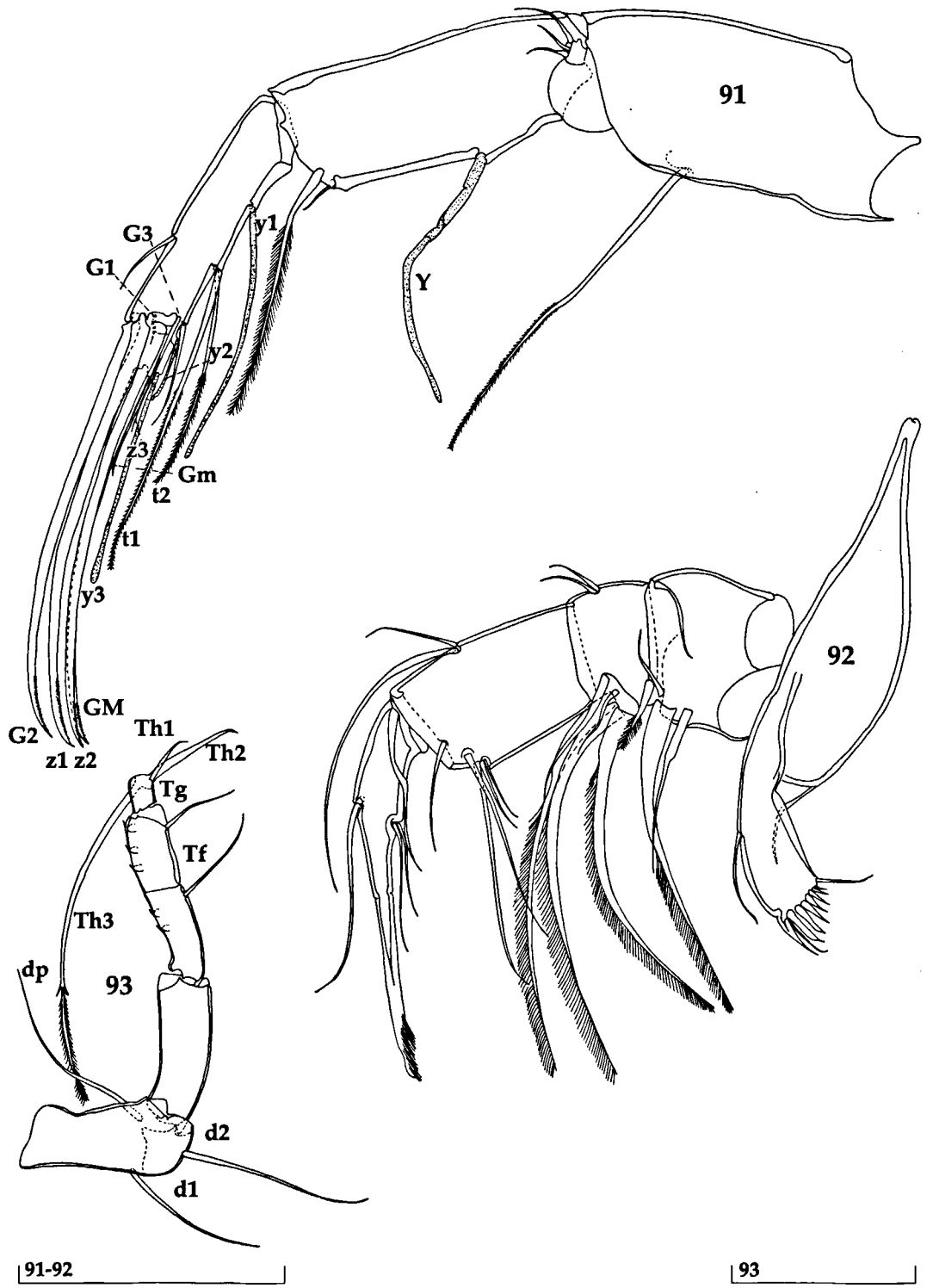
A1 5-segmented. First segment with one antero-proximal seta, one antero-distal and two posterior ones; second segment with one anterior seta (reaching about middle L of following segment); third segment with one antero-medial seta (reaching distal end of same segment), and two distal setae (hardly reaching middle of following segment); penultimate segment with one antero-medial seta (slightly exceeding distal end of same segment), three long and one shorter distal ones (about 5 times as long as terminal segment); terminal segment with two long and one short seta (about 2 times as long as terminal segment), and aesthetasc which is six times as long as terminal segment. L ratios of three distal segments 2.2 : 2.6 : 1.

A2 (Fig. 91) 4-segmented and without male's bristles. Exopodite plate with two short, subequally long setae, and one longer, but less than 2 times. Aesthetasc Y about 0.9 times as long as first endopodal segment; y1 very long and 0.84 times as long as first endopodal segment; y2 slightly exceeds terminal segment; y3 0.7 times as long as first endopodal segment. Penultimate segment with just one antero-medial seta (not reaching distal end of same segment) and two long, pappose postero-medial setae (t1 and t2). Penultimate segment with three long claws (G2, z1 and z2), 1.4 times as long as first endopodal segment; G1 and G3 reduced into fine short setae (G1 just slightly exceeding distal end of penultimate segment, G3 about two times as long as terminal segment); z3 seta-like and about as long as G3. Claw GM on terminal segment well developed (1.2 times as long as first endopodal segment); Gm small and 2.5 times as long as terminal segment. L ratios of three endopodal segments 7 : 5 : 1.

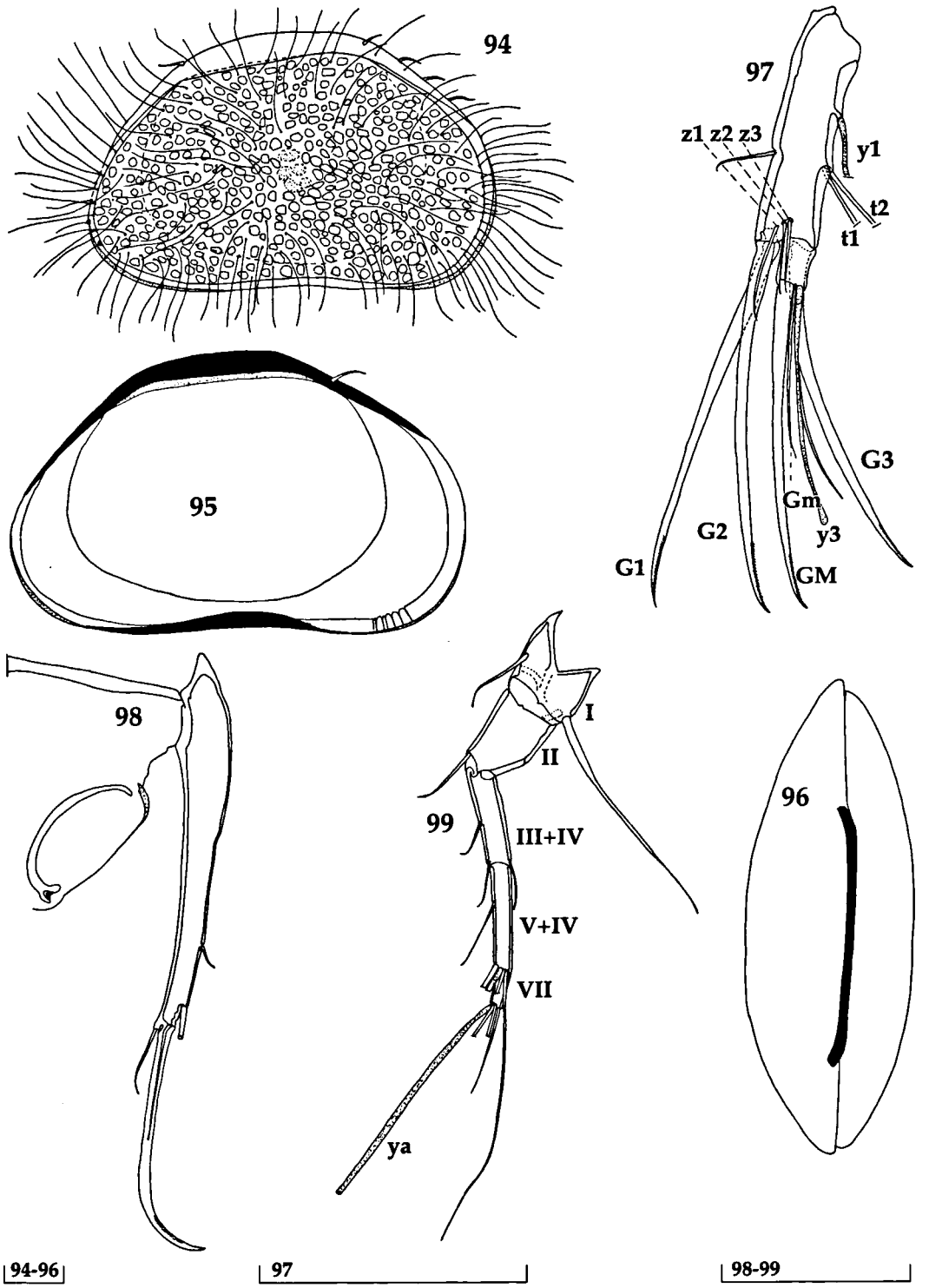
Md (Fig. 92) with 4-segmented palp. First segment with two plumose setae (S1 and S2) and two smooth (alpha and one long additional seta); sec-



Figs. 82-90. *Humphreyscandona waldockae* n. gen., n. sp., holotype (male, L = 0.852 mm). 82, LV, internal view. 83, RV, internal view. 84, left prehensile palp. 85, right prehensile palp. 86, terminal segment of Mxl palp. 87, Rake-like organ. 88, hemipenis, medial side up. 89, Fu. 90, T2 (scale bars = 0.1 mm).



Figs. 91-93. *Humphreyscandona waldockae* n. gen., n. sp., holotype (male, L = 0.852 mm). 91, A2. 92, Md. 93, T3 (scale bars = 0.1 mm).



Figs. 94-99. *Humphreyscandona waldockae* n. gen., n. sp.; 94: WAM C28235 (female, L = 0.692 mm). 95-99: allotype (female, L = 0.747 mm). 94, carapace, external view. 95, LV, internal view. 96, carapace, dorsal view. 97, A2, detail. 98, Fu. 99, A1 (scale bars = 0.1 mm).

ond segment externally with two short setae, internally with 3+2 setae in bunch. Penultimate segment with just two extero-medial setae (one slightly exceeding distal end of same segment, other almost reaching middle of distal claw), one extero-distal seta, and five intero-medial setae. Terminal segment with fused and distally pappose claw, one seta externally and two setae internally. L ratios of three distal segments 1 : 2.3 : 1.2.

Terminal segment of Mxl palp (Fig. 86) small, square-shaped to trapezoidal and with five claws/setae observed.

Rake-like organ with very minute teeth (Fig. 87).

Prehensile palps (Figs. 84, 85) almost symmetrical (fingers quite stocky).

T2 (Fig. 90) 5-segmented, third and fourth segments completely divided. First segment without any seta, second with one seta (reaching middle of following segment), third with one seta (reaching distal end of terminal segment), penultimate with two short setae, distal with two setae and claw, which is distally serrated and 1.2 times as long as three distal segments combined.

T3 (Fig. 93) 5-segmented, third and fourth segments being completely divided. Basal segment with three setae, following segment without any seta, third and fourth with one distal seta each (subequally long and about as long as third segment). L ratio of three setae on terminal segment 6 : 1.8 : 1.

Fu (Fig. 89) with both anterior and posterior setae developed. Posterior claw reduced to pappose seta, and equalling 1/3 of anterior claw, which is well developed and 0.86 times as long as anterior furcal margin.

Hemipenis (Fig. 88) with lobe 'a' less prominent than in other species; 'b' lobe with acutiform chitinous part which is placed more dorsally; 'g' very prominent and with rounded distal margin; lobe 'h' double-folded and with flat distal margin. Zenker's organ with 5+2 rows of spines.

ALLOTYPE (FEMALE, L = 0.747 mm). - Appearance of carapace in both lateral (Figs. 94, 95) and dorsal view (Fig. 96) same as in male. L of LV = 0.747 mm, RV = 0.735 mm. Greatest H on LV = 63% of L, on RV = 55% of L.

Penultimate segment of A2 (Fig. 97) with three long claws (G1, G2, and G3), and three setae (z1, z2, z3), of which z2 and z3 being small and subequally long, while z1 stronger and about twice as long as terminal segment.

Genital lobe (Fig. 98) rounded. Posterior claw reduced to pappose seta (1/3 of anterior claw); anterior claw curved and 0.8 times as long as anterior furcal margin.

On T1 two 'Ta' setae, 'Tb' and 'Td' and three setae in exopodite present.

Carapace ornamentation, as well as appearance of A1 (Fig. 99), other details of A2, Md, Mxl, T2 and T3 same as in male.

ETYMOLOGY. - The species is named after Ms Julliane M. Waldock, from the Western Australian Museum, one of the collectors of the material. The name is to be treated as a noun in the genitive singular.

REMARKS. - The genus *Humphreyscandona* n. gen. can be divided into the following groups of species:

1. *adorea*-group with the species *Humphreyscandona adorea* n. sp., *H. fovea* n. sp., *H. pilbarae* n. sp., and *H. woutersi* n. sp.
2. *waldockae*-group with *Humphreyscandona waldockae* n. sp.

This division is made according to: number of segments both on the second and third thoracopods (four in the *adorea*-, three in the *waldockae*-group); the number of extero-medial setae on the third segment of the mandibular palp (three in the *adorea*-, two in the *waldockae*-group); and the presence of the spine on the anterior furcal claw in the *adorea*-group, absence in the *waldockae*-group. The only representative of the second group is also quite distinct from other species in the genus by the appearance of hemipenis. In *H. waldockae* the lateral lobe ('a') is not as extended as it is in the *adorea*-group, and the chitinous part of lobe 'b' is positioned more dorsally, while in the other representatives of *Humphreyscandona* n. gen. this lobe is more centrally placed. The appearance of the hemipenis is very homogeneous in the *adorea*-group, and differs in a few minor details amongst this species group.

Another unusual, but important feature of *H. waldockae* n. sp. is the appearance of the exopodite on the antenna, where it is a plate with three short setae, while in the other species of the genus

there are two short and one distinctly longer seta. A similar appearance of the antennal exopodite as in *H. waldockae* n. sp. is also noticed in two European genera: *Phreatocandona* Danielopol, 1982 and *Trajancandona* Karanovic, 1999. However, these two genera can be clearly separated from *H. waldockae* n. sp. by other characteristics (see further 'Discussion' at the end of the paper).

Although the above mentioned differences between the two species groups are clear, they are not enough to separate them into different genera. The following common features are phylogenitically more important and do not allow further division: 1, the distribution of setae and number of segments on antennula; 2, the number of external setae on the second segment of mandibular palp, as well as the number of setae intero-medially to intero-distally on the penultimate segment of this appendage; 3, the number of 'a' setae on the first thoracopod; 4, the morphology of the prehensile palps; 5, the reduced posterior furcal claw; 6, the general appearance of the hemipenis.

The species within the *adorea*-group are very homogeneous with the exception of *Humphreyscandona woutersi* n. sp. which, by lacking both anterior and posterior furcal setae, stands apart in this species-group. In all other characteristics *H. woutersi* n. sp. is closely related to the other species of the genus. The absence of posterior furcal seta is an important feature of the following genera: *Candonopsis* Vavra, 1891; *Caribecandona* Broodbakker, 1983; *Danielocandona* Broodbakker, 1983; and *Namibcypris* Martens, 1992. The latter two genera also lack the anterior furcal seta. However, they all have other features that clearly separate them from *H. woutersi* n. sp. (see further 'Discussion' at the end of the paper). The only specimen of *H. fovea* n. sp. observed in the present study has three setae on the right prehensile palp, a feature not noticed in the whole subfamily Candoninae. However, until additional specimens are observed, this characteristic should be taken with caution and as an abnormality.

KEY TO THE SPECIES OF THE GENUS *HUMPHREYSCANDONA* N. GEN. (MALES AND FEMALES)

1a. T2 and T3 5-segmented, Md palp with two setae extero-medially on penultimate segment .... *H. waldockae* n. sp.
b. T2 and T3 4-segmented, Md palp with three setae extero-medially on penultimate segment 2

2a. Both anterior and posterior furcal setae missing .... *H. woutersi* n. sp.
b. Both anterior and posterior furcal setae present 3

3a. Carapace triangular and ornamented with big pits as well as longitudinal ridges ventrally ..... *H. fovea* n. sp.
b. Carapace not triangular and with just longitudinal ridges ventrally 4

4a. Carapace trapezoidal with straight dorsal margin .... *H. adorea* n. sp.
b. Carapace reniform with equally rounded dorsal margin ..... *H. pilbarae* n. sp.

Pilbaracandona n. gen.

TYPE SPECIES. - *Pilbaracandona eberhardi* n. sp.

OTHER SPECIES. - *Pilbaracandona colonia* n. sp.

DIAGNOSIS. - Valves subtriangular, ornamented. Marginal zone wide (anteriorly more than 20% of total length). A1 5-segmented: third and fourth, as well as fifth and sixth segments being fused. Posteriorly on both fused segments, as well as anteriorly on third and fourth segments, chitinous membrane uninterrupted, while one seta present anteriorly on the point of fusion of fifth and sixth segments. Exopodite A2 plate with two short and one distinctly longer seta. Md palp with one seta on outer side of second segment; penultimate segment with three setae intero-medially; terminal segment less than two times as long as wide; terminal claw well sclerotized and fused with same segment. Third endite of Mxl with two plumose claws. One 'Ta' seta and two setae on exopodite of T1 present. T2 5-segmented; basal segment without, subterminal segment with short setae. T3 5-segmented; basal segment with d1, d2 and dp setae, terminal segment with two short (h1 and h2) and one long seta (h3), the latter with two spines on its last third. Fu with posterior claw reduced into one seta, both anterior and posterior setae developed. Hemipenis with lobe 'a' rounded and not extended, 'b' lobe well devel-

oped and with one acutiform, well sclerotised extension which is completely dorsally positioned, 'h' lobe double-folded and not sclerotized; medial lobe 'g' not protruding between lobes, and being flat. Female's genital lobe rounded.

ETYMOLOGY. - The genus is named after the region Pilbara (Western Australia) where the material has been collected. The name is prefixed to the genus name *Candona*, gender feminine.

Pilbaracandona eberhardi n. gen., n. sp.
Figs. 100-120

MATERIAL. - Holotype: male, dissected (WAM C28240), allotype - female, dissected (WAM C28241), from EX 895, Newman Borefield area, 23°19'S 119°52'E, 20-XI-1998, collector: S. M. Eberhard (BES 6387).
Additional material: 1 male, dissected (WAM C28242); 1 juvenile female, dissected (WAM C28243) and 1 juvenile in alcohol (WAM C28244), from WP 120, Newman Borefield area, 23°13'S 119°53'E, 11-XI-1998, collector: S. M. Eberhard (BES 3529); 4 males, dissected (WAM C28245, WAM C28246, WAM C28247, WAM C28248); 1 female, dissected (WAM C28249); 17 males, 24 females and 21 juvenile, all in alcohol (WAM C28250), from W226, Newman Borefield area, 23°15'S 119°54'E, 11-XI-1998, collector: S. M. Eberhard (BES 3524); 1 male, dissected (WAM C28251); 3 females, dissected (WAM 28252, WAM C28253, WAM C28254); 5 males, 18 females and 2 juveniles all in alcohol (WAM C28255), from a bore near W126, Newman Borefield area, 23°15'S 119°53'E, 12-XI-1998, collector: S. M. Eberhard (BES 3577); 1 female in alcohol (WAM C28256), from OB 23, Sample No 46.1, Bore T401, Newman Borefield Area, II-2001, collectors: G. Humphreys, J. Bradbury and K. Armstrong (BES 5590); 1 female, dissected (WAM C28257); 6 males, 10 females and 2 juveniles all in alcohol (WAM C28258), from OB 23, Sample No 45.1, Bore WP 12NR, Newman Borefield area, 23°15'07"S 119°53'37"E, II-2001, collectors: G. Humphreys, J. Bradbury and K. Armstrong (BES 5587).

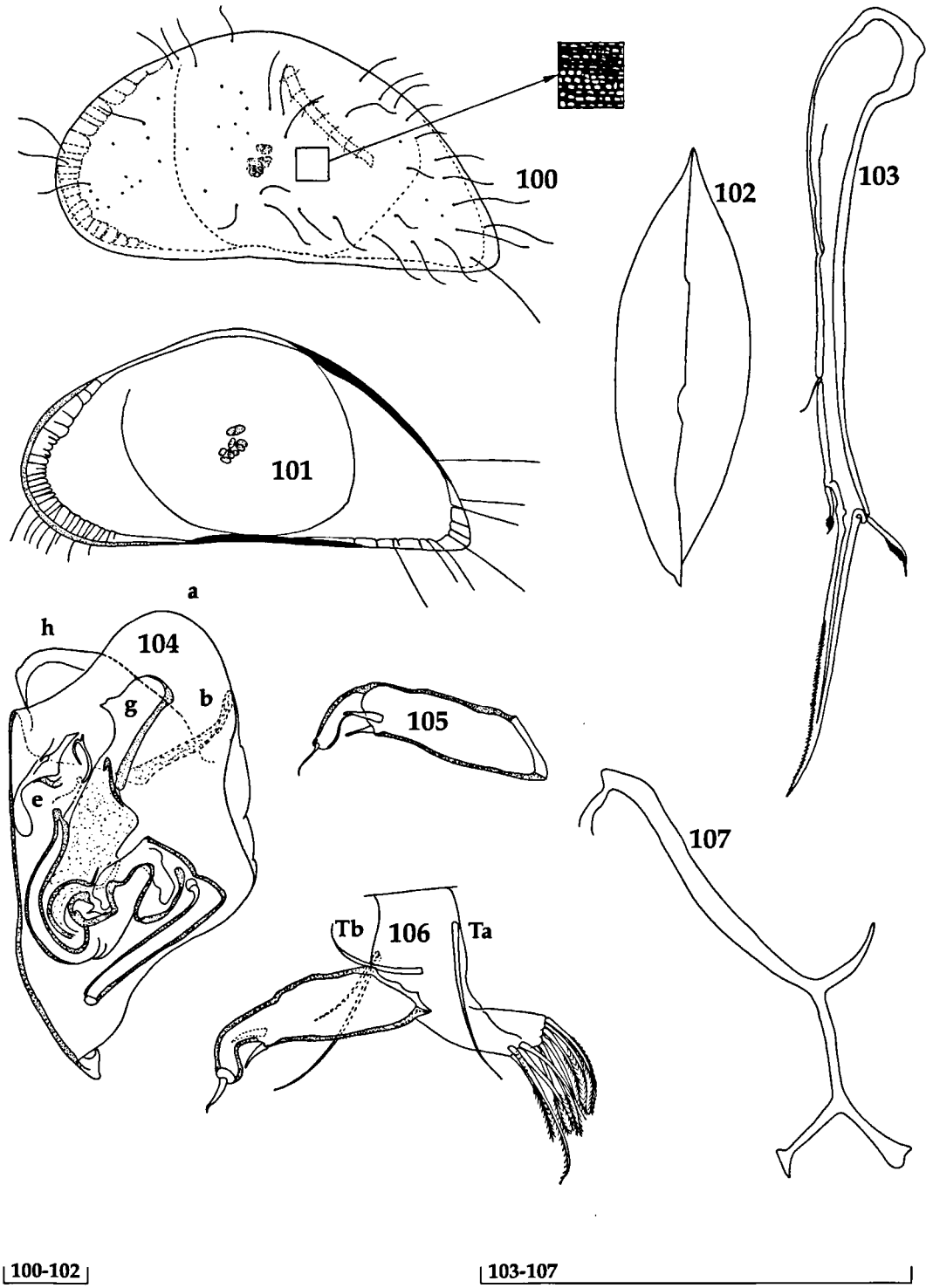
Carapace and soft parts of the holotype, allotype, 2 males (WAM C28242, WAM C28245), and 3 females (WAM C28243, WAM C28249, WAM C28257) were mounted on slides in Faure's medium. Soft parts of the other dissected animals were mounted on slides in glycerol, while their carapaces were preserved in 70% ethyl-alcohol in glass test-tubes.

DESCRIPTION OF HOLOTYPE (MALE, L = 0.527 mm). - Carapace subtriangular in lateral view (Fig. 100, 101). L of LV = 0.527 mm, RV = 0.519 mm. Dorsal margin regularly arched towards anterior margin while inclined towards posterior one. Frontal margin widely rounded, caudal margin distinctly narrower, and almost pointed. Ventral margin almost straight. Greatest H situated around middle on both valves, equalling 50% of L. Valve surface heavily ornamented with longitudinal ridges, which are connected with lateral ridges, together making the appearance of irregular pits. Also, surface covered with long hairs. Marginal zone almost equally wide on both ends and 27% of total L. Marginal pore canals long, unequal in L, some of them branched. Selvage peripheral. In dorsal view (Fig. 102) LV overlaps RV caudally, but not frontally; both ends sharply pointed. Greatest W situated around middle, equalling about 30% of L.

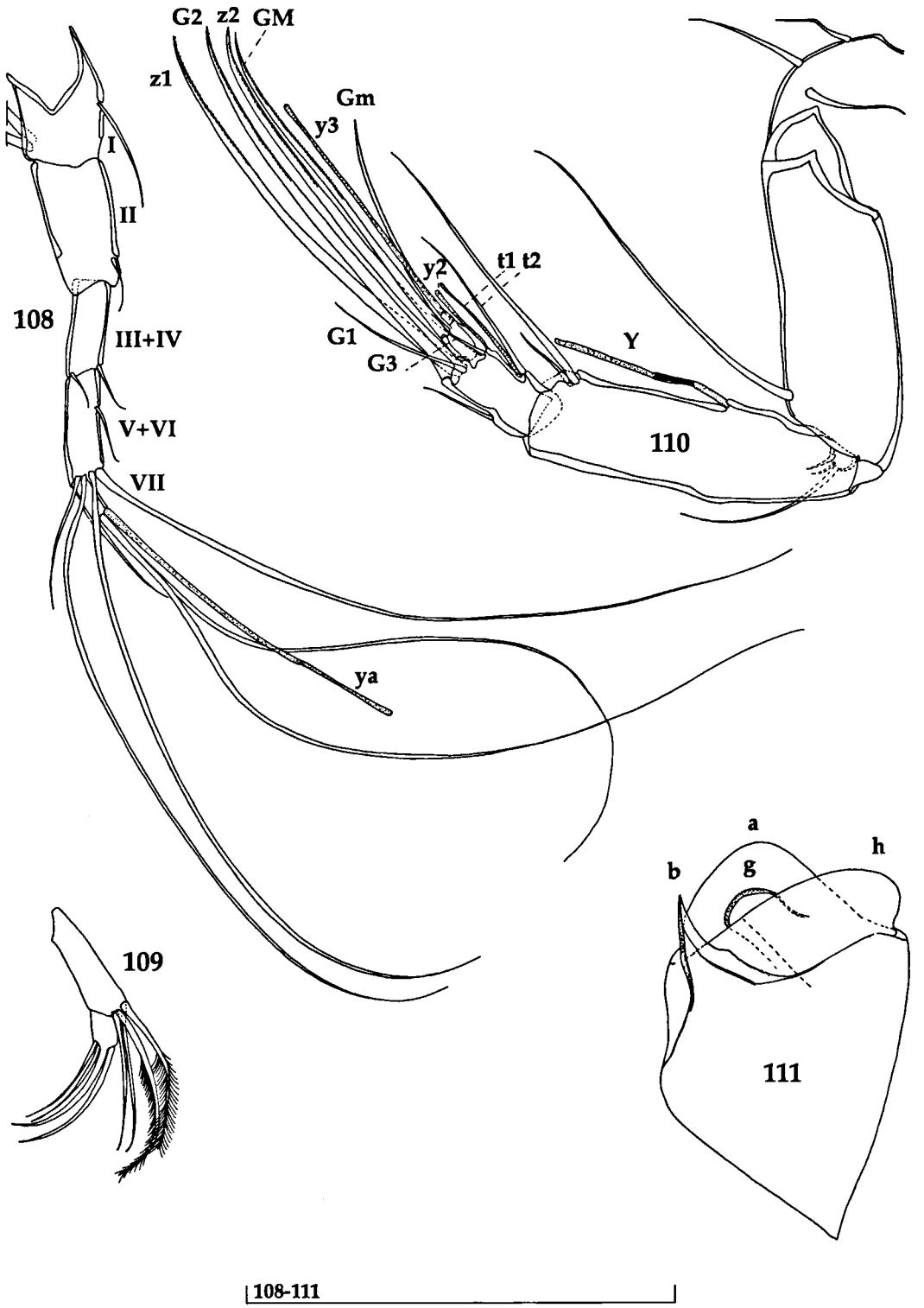
A1 (Fig. 108) 5-segmented. First segment with two long, posterior setae, one short antero-distal, and one antero-proximal (not shown in Fig. 108); second segment with one anterior seta; third segment with two distal setae (hardly reaching middle of penultimate segment); penultimate segment with three long setae and one short (about 3 times as long as terminal segment) distally; terminal segment with two long and one short seta (2.5 times as long as terminal segment), and aesthetasc which is 8.7 times as long as terminal segment. L ratios of three distal segments 2.2 : 2.6 : 1.

A2 (Fig. 110) 4-segmented, without male's bristles. Exopodite consists of two short and one long seta (more than 5 times longer). Aesthetasc Y 0.56 times as long as first endopodal segment; y1 placed much below than usually and exceeding distal end of terminal segment; y2 missing; y3 0.83 times as long as first endopodal segment. Penultimate segment with one antero-medial seta (slightly exceeding distal end of same segment), and two postero-medial setae, one being transformed into sensory seta (exceeding distal end of terminal segment). Three distal claws (G2, z1 and z2), long and about 1.3 times as long as first endopodal segment; G1 seta-like and 3 times as long as terminal segments; G3 also seta-like but shorter (just exceeding distal end of terminal segment); seta z3 missing. GM 1.1, Gm 0.7 times as long as first endopodal segment. L ratios of three endopodal segments 7 : 2 : 1.

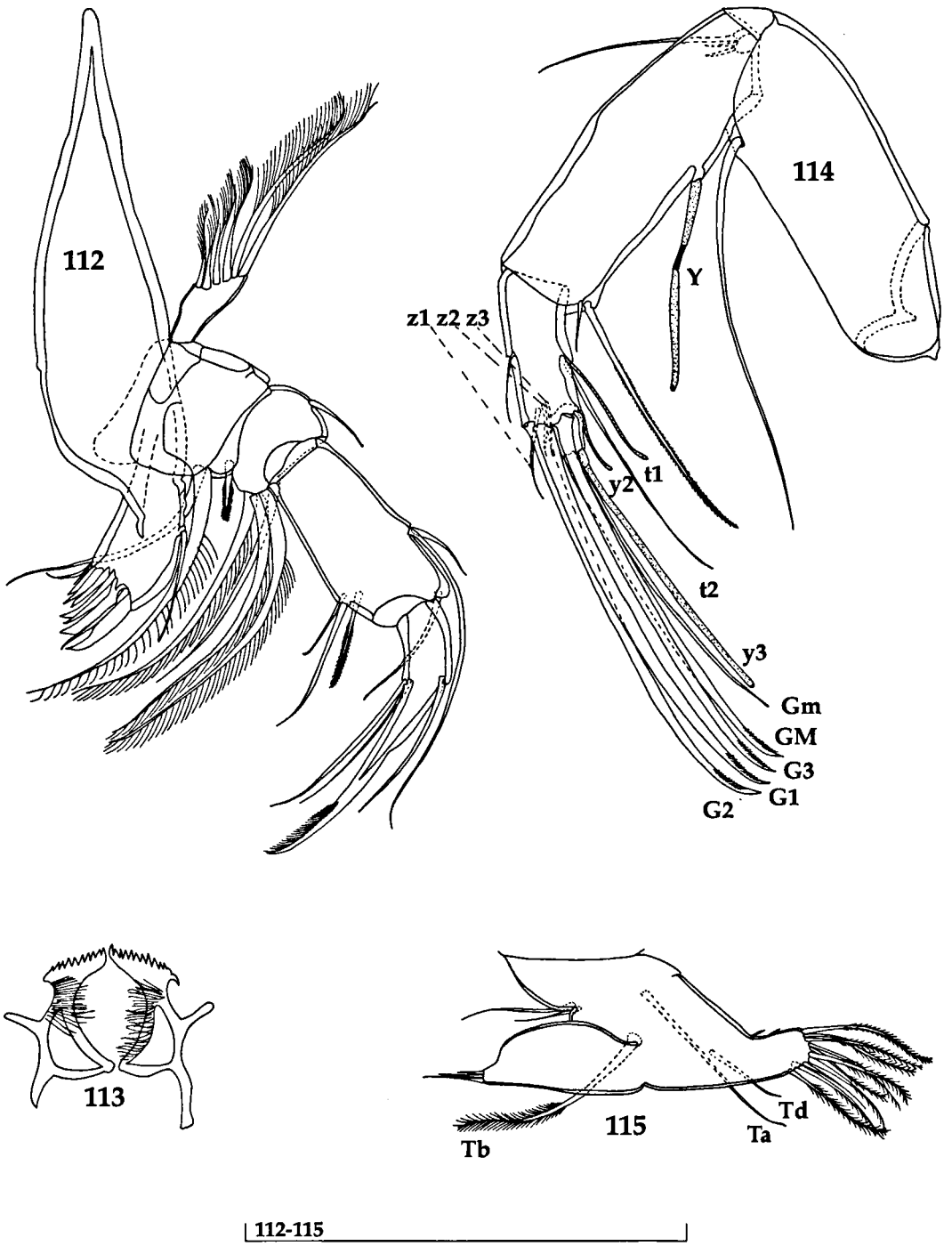
Md palp (Fig. 112) 4-segmented. First segment internally with two plumose S setae, and two smooth (alpha seta not presented in Fig. 112); second segment with one short external seta, and 3+2 setae internally in bunch. Penultimate seg-



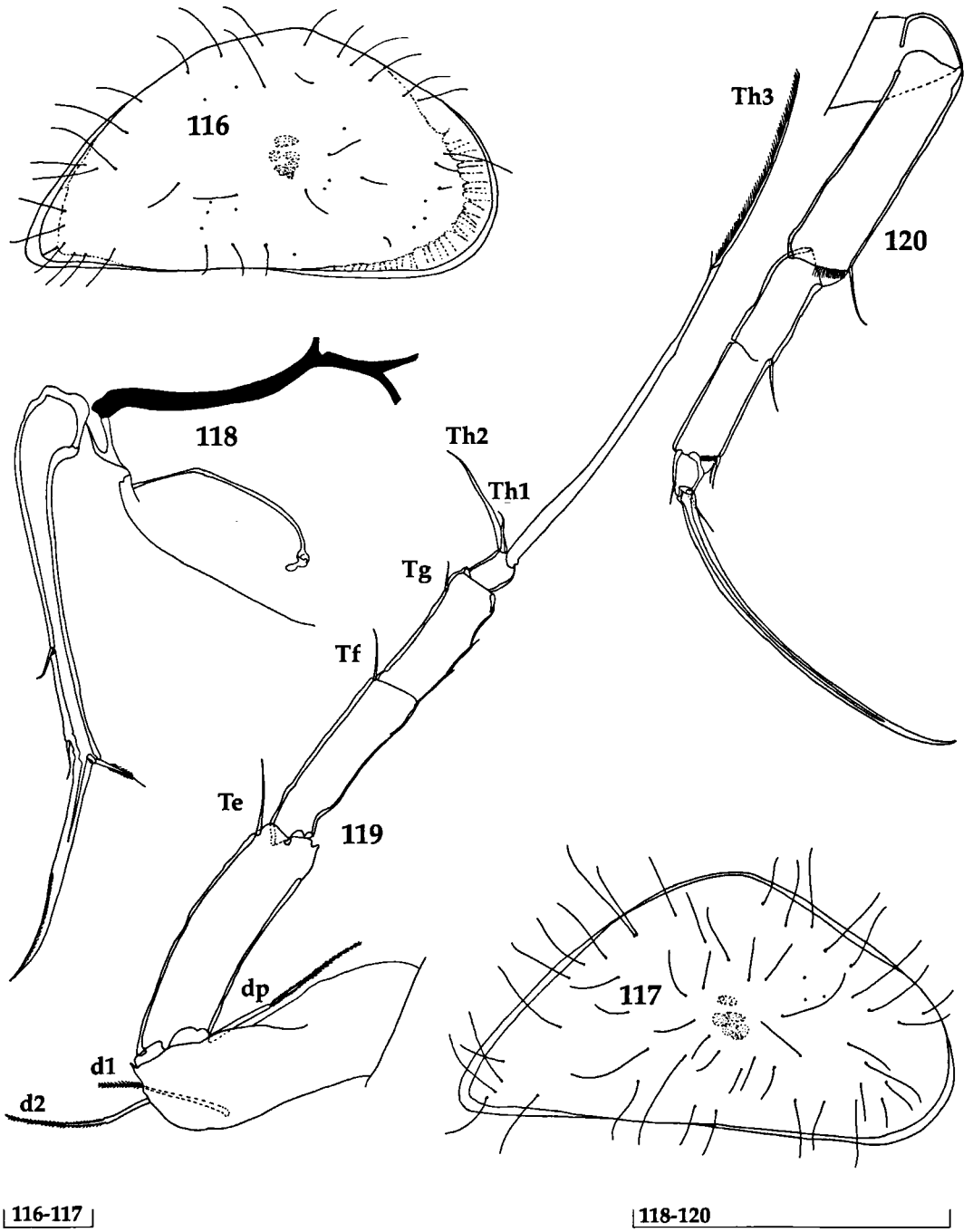
Figs. 100-107. *Pilbaracandona eberhardi* n. gen., n. sp.; 100, 102-107: holotype, male (L = 0.527 mm). 101: WAM C28245 (male, L = 0.528 mm). 100, LV, external view. 101, RV, internal view. 102, carapace, dorsal view. 103, Fu. 104, hemipenis, lateral side up. 105, left prehensile palp. 106, right prehensile palp. 107, furcal attachment (scale bars = 0.1 mm).



Figs. 108-111. *Pilbaracandona eberhardi* n. gen., n. sp.; 108-110: holotype (male, L = 0.527 mm). 111: WAM C28245 (male, L = 0.528 mm). 108, A1. 109, Mxl palp. 110, A2. 111, hemipenis, medial side up (scale bar = 0.1 mm).



Figs. 112-115. *Pilbaracandona eberhardi* n. gen., n. sp.; 112-113: holotype (male, L = 0.527 mm). 114-115: allotype (female, L = 0.523 mm). 112, Md. 113, Rake-like organ. 114, A2. 115, T1 (scale bar = 0.1 mm).



Figs. 116-120. *Pilbaracandona eberhardi* n. gen., n. sp.; 116: 118-120, allotype (female, L = 0.523 mm). 117: WAM C28257 (female, L = 0.552 mm). 116, carapace, external view. 117, carapace, external view. 118, Fu. 119, T3. 120, T2 (scale bars = 0.1 mm).

ment with two extero-medial setae (one just reaching distal end of same segment, other about 6 times longer), gamma seta extero-distally and three intero-medial to intero-distal setae. Terminal segment with fused, distally pappose claw, one seta externally and two setae internally. L ratios of three distal segments 1 : 3 : 1.1.

Terminal segment of Mxl palp (Fig. 109) square-shaped, with four claws/setae observed; claws on third endite plumose.

Rake-like organ (Fig. 113) with 10 and 11 teeth.

Prehensile palps (Figs. 105, 106) with short and stocky fingers and short setae.

T2 5-segmented, third and fourth segment not completely divided, but exterior chitinous margin interrupted. Basal segment naked, first endopodal with one seta not reaching middle of following segment; second endopodal segment with one seta (not reaching middle of following segment); penultimate segment with two very short setae; claw on terminal segment smooth and 1.4 times as long as the three distal segments combined.

T3 5-segmented, second and third endopodal segments divided. Basal segment with three setae; first endopodal segment with 'Te' seta reaching 1/3 of following segment; second endopodal segment with 'Tf' seta also reaching about 1/3 of following segment; penultimate segment with one very short 'Tg' seta distally, which just slightly exceeds distal end of same segment. L ratio of three setae on terminal segment 13.2 : 2.6 : 1.

Fu (Fig. 103) with posterior claw reduced to one pappose seta, which just slightly exceeds basis of anterior claw. Both anterior and posterior setae present: posterior very short (shorter than posterior claw), anterior longer (1.5 times as long as posterior seta). Anterior claw well developed, serrated and 0.8 times as long as anterior furcal margin. Furcal attachment shown in Fig. 107.

Hemipenis (Fig. 104) with 'a' lobe rounded; lobe 'h' double-folded, with flat distal margin; lobe 'b' acutiform and positioned completely dorsally; 'g' flat. Zenker's organ with 5+2 rows of spines.

ALLOTYPE (FEMALE, L = 0.523 mm). - Carapace triangular in lateral view (Fig. 116). L of LV = 0.523 mm, RV = 0.51 mm. Greatest H situated around middle on both valves, and equalling 53% of L. Greatest W also situated around the middle equalling 30% on L.

Claws G1, G2, G3 on penultimate segment of A2 (Fig. 114) subequally L and 1.3 times as long as first endopodal segment. All z setae developed and z1 being strongest and exceeding distal end of terminal segment, while the other two hardly reaching distal end of same segment. Claw GM 1.1, while Gm as long as first endopodal segment. L ratio of three endopodal segments 7 : 3 : 1.

T1 (Fig. 115) with one 'Ta' seta and two setae on exopodite, 'Tb' and 'Td' setae present. Distal end of protopodite with three short setae.

Genital lobe rounded, and without appendages (Fig. 118). Anterior claw reduced and slightly longer than in male, this claw serrated and 0.8 times as long as anterior furcal margin.

Surface ornamentation and other carapace details, as well as appearance of A1, Md, Mxl, T2 (Fig. 120) and T3 (Fig. 119) same as in male.

VARIABILITY. - The appearance of the hemipenis, especially the position and the protuberance of lobe 'b' varies, and can be either as in the holotype (Fig. 104), or as shown in Fig. 111. There is also some variability in the lateral appearance of the female's carapace. It can be with more (Fig. 117) or less (Fig. 116) inclined dorsal margin.

ETYMOLOGY. - The species is named after Mr Stefan M. Eberhard from the 'Caveworks' (Western Australia), who collected the material. The name is to be treated as a noun in the genitive singular.

Pilbaracandona colonia n. gen., n. sp.
Figs. 121-133

MATERIAL. - Holotype: female, dissected (WAM C28259). Paratype: female, dissected (WAM C28260), from OB 23, sample No. 33.2, Bore W262, 23°17'08"S 119°52'02"E, II-2001, collectors: G. Humphreys, J. Bradbury and K. Armstrong (BES 5583).
Additional material: 1 female in alcohol (WAM C28261), from OB 23, Sample No 25.2, Bore T401, II-2001, collectors: G. Humphreys, J. Bradbury and K. Armstrong (BES 5579).

Both soft parts and carapace of dissected specimens were mounted on slides in Faure's medium.

DESCRIPTION OF HOLOTYPE (FEMALE, L = 0.596

mm). - Carapace subtriangular in lateral view (Fig. 121). L of LV = 0.596 mm, RV = 0.579 mm. Greatest H situated on first third on both valves, equalling 43% of total L. Dorsal margin from point of greatest H widely rounded towards anterior end and inclined towards posterior end. Caudal margin extremely narrow, and almost pointed, while anterior one widely rounded. Ventral margin almost straight. Valve surface ornamented with longitudinal ridges, also surface covered with long hairs. Marginal zones very wide, anteriorly 26%, posteriorly 38% of L. Fused zone wide, with long, dense (some branched) marginal pore canals. In dorsal view (Fig. 122) both frontal and caudal ends pointed. Greatest W situated on first third, equalling 23% of L. LV overlapping RV more clearly caudally than frontally.

A1 (Fig. 129) 5-segmented. First segment with one antero-proximal seta (not shown in Fig. 129), one antero-distal, and two posterior setae; second segment with one very short seta; third segment with one short antero-distal seta; penultimate segment with one short antero-medial seta (closer to proximal margin) and four distal setae (three long and one short - slightly exceeding distal end of terminal segment); terminal segment with two long and one short seta and aesthetasc ya which is 9 times as long as terminal segment. L ratios of three distal segments 1.5 : 2.1 : 1.

A2 4-segmented (Fig. 127), exopodite plate with one long and two short setae. The long one being more than 5 times as long as other two setae. Aesthetasc Y 0.64 times as long as first endopodal segment; y1 exceeding distal end of terminal segment as well as y2; y3 as long as first endopodal segment. Penultimate segment with one long, pappose seta postero-medially, and one seta antero-medially which slightly exceeds distal end of same segment. Claws G1, G2 and G3 of subequal L, and 1.2 times as long as first endopodal segment. All z setae visible, but very short. Claw GM 1.2 times as long as first endopodal segment, Gm 4 times as long as terminal segment. L ratios of endopodal segments 8 : 3.5 : 1.

Md palp 4-segmented (Fig. 125). Second segment with one external seta (almost reaching distal end of penultimate segment), and 3+2 setae in bunch. Penultimate segment with two extero-medial setae, one reaching basis of terminal claw, other longer and reaching middle of terminal claw; gamma seta extero-distally, and three setae intero-medially to intero-distally. Terminal segment with one strong seta externally and two thin setae internally. L ratios of three distal segments 1 : 2 : 1.

Distal segment of Mxl palp (Fig. 130) square-shaped with four claws/setae; two claws on third endite plumose.

Rake-like organ (Fig. 131) with nine and 10 teeth.

T1 (Fig. 124) with one 'Ta' seta, two setae in exopodite; 'Tb 'and 'Td' setae present; endopodite with three apical setae of subequal L.

Basal segment of T2 (Fig. 133) with row of short hairs dorsally, but without any seta. First endopodal segment with one distal seta which reaches middle of following segment; second and third segments not completely divided but with clearly interrupted external chitinous membrane. Second endopodal segment with one seta which reaches middle of following segment, while penultimate segment with just one visible, short seta distally. Claw on terminal segment distally serrated and 1.5 times as long as three distal segments combined.

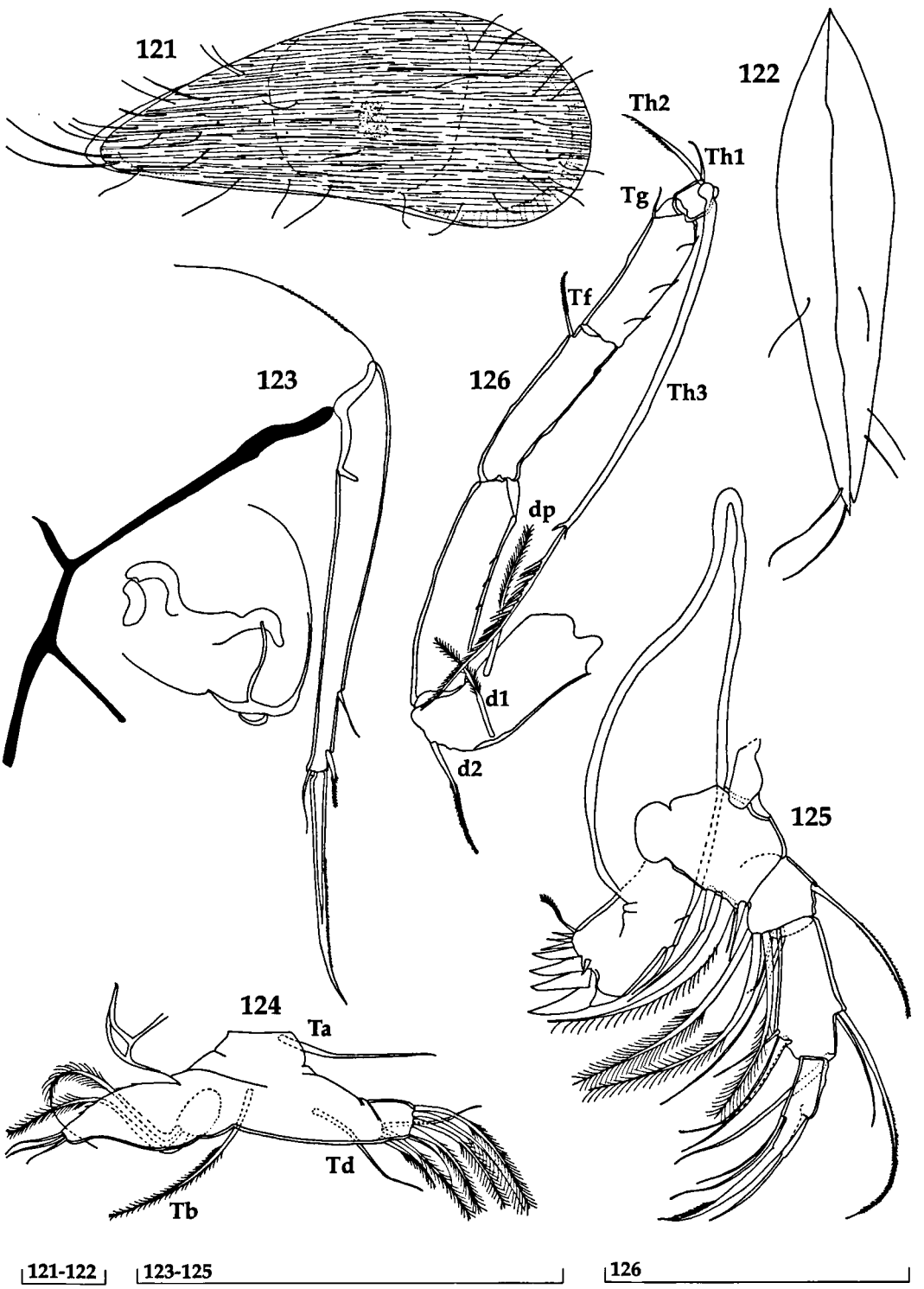
T3 (Fig. 126) 5-segmented. Basal segment with d1, d2 and dp pappose setae, following segment without any seta; second and third endopodal segments with one distal seta each ('Tg' seta on penultimate segment just slightly exceeding distal end of same segment). L ratios of three setae on terminal segment 13 : 2.3 : 1.

Fu (Fig. 123) with both anterior and posterior setae present. Posterior claw reduced in pappose seta (1/4 of anterior claw) while anterior claw well developed, serrated and 0.64 times as long as anterior margin of furcal ramus. Genital lobe rounded and without any appendages. Female being ovigerous.

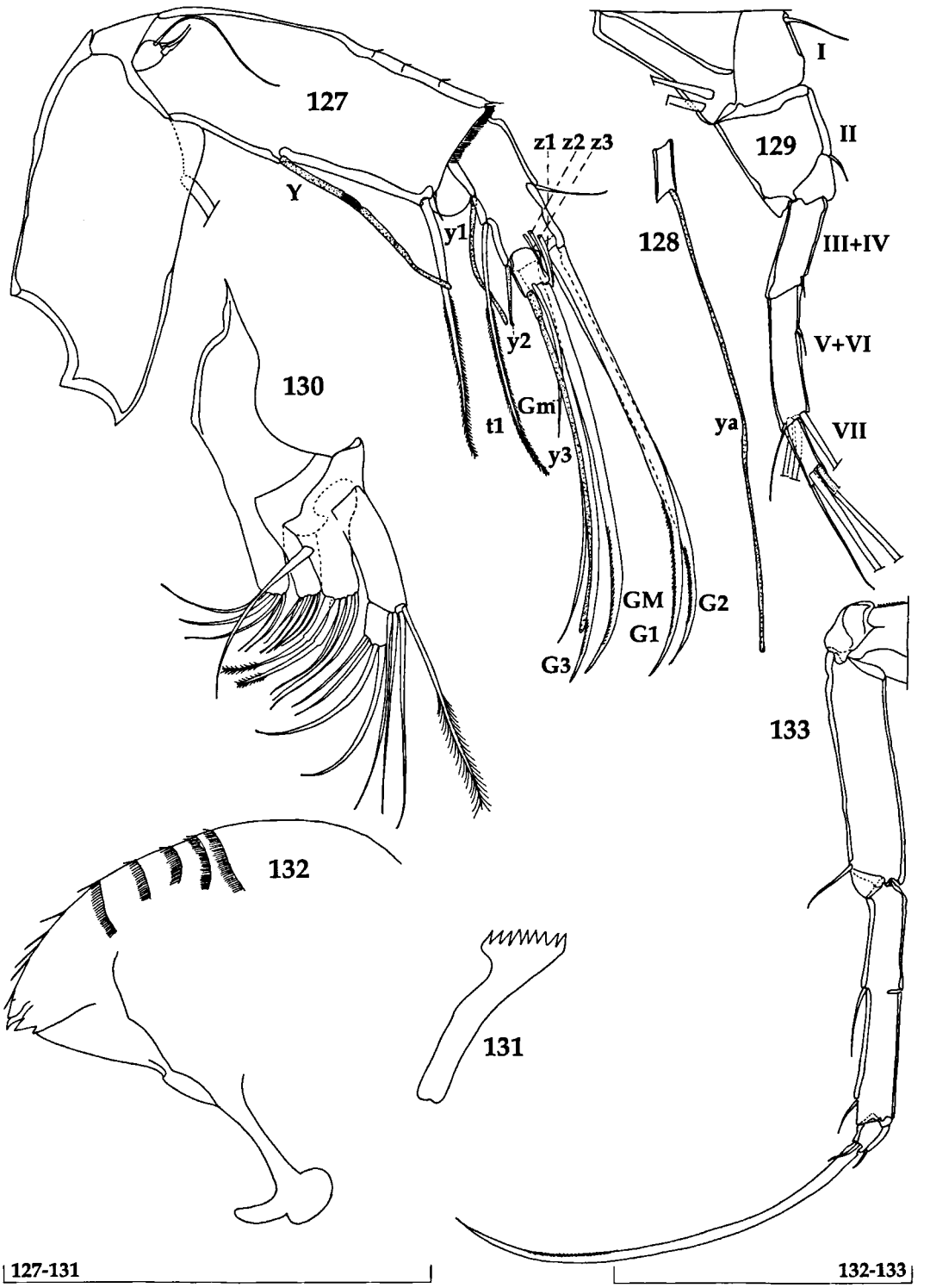
MALES. - Unknown.

ETYMOLOGY. - From the Latin noun '*colonia*' (f.), meaning colony. The name is to be treated as a noun in apposition to the generic name.

REMARKS. - Both species of the genus *Pilbaracandona* n. gen. are very closely related. However, the following differences clearly separate the species:



Figs. 121-126. *Pilbaracandona colonia* n. gen., n. sp., holotype (female, L = 0.596 mm). 121, carapace, lateral view. 122, carapace, dorsal view. 123, Fu. 124, T1. 125, Md. 126, T3 (scale bars = 0.1 mm).



Figs. 127-133. *Pilbaracandona colonia* n. gen., n. sp., holotype, (female, L = 0.596 mm). 127, A2. 128, terminal segment of A1 with aesthetasc. 129, A1. 130, Mxl palp with three endites. 131, Rake-like organ. 132, forehead. 133, T2 (scale bars = 0.1 mm).

1, carapace ornamented with longitudinal and vertical ridges in *Pilbaracandona eberhardi* n. sp., while with just longitudinal ridges in *Pilbaracandona colonia* n. sp.; 2, greatest height in *P. eberhardi* n. sp. equalling about 50%, while in *P. colonia* n. sp. it is 43% of length; 3, carapace more elongated in *P. colonia* n. sp.; 4, external seta on the second segment of mandibular palp short (slightly exceeding distal end of same segment) in *P. eberhardi* n. sp., this seta long (reaching distal end of penultimate segment) in the other species; 5, seta on the first endopodal segment of the third thoracopod present in *P. eberhardi* n. sp., this seta absent in *P. colonia* n. sp. In addition, the type species has one 't' seta transformed into the aesthetasc.

Notacandona n. gen.

TYPE SPECIES. - *Notacandona modesta* n. sp.

OTHER SPECIES. - *Notacandona boultoni* n. sp.

DIAGNOSIS. - Valves triangular, ornamented, marginal zone wide. A1 5-segmented: third and fourth as well as fifth and sixth endopodal segments being fused. Posteriorly chitinous membrane between fused segments uninterrupted, while anteriorly sometimes with one seta on the point of fusion between third and fourth segments. Exopodite A2 plate with two short and one distinctly longer seta. Second segment of Md palp without any seta; penultimate segment with three setae intero-medially; L : W ratio of terminal segment less then 3 : 1, terminal claw not so well sclerotized and fused with same segment. Third endite of Mxl with two smooth claws. One 'Ta' on T1 developed. T2 5-segmented; basal segment without seta; penultimate segment with short seta. T3 5-segmented; basal segment with d1, d2, dp setae; terminal segment with two short (Th1 and Th2) and one long (Th3) seta, the latter with spines on the beginning of its last third. Fu with both claws and setae developed. Hemipenis with lobe 'a' which is square-shaped but not extended dorsally; lobe 'b' with acutiform, well sclerotised extension positioned medially; 'h' double-folded and not sclerotised; 'g' flat and only weakly sclerotised. Female's genital lobe without any extensions.

ETYMOLOGY. - The genus is named after Latin noun '*nota*', meaning sign, prefixed to the genus name *Candona*, gender feminine.

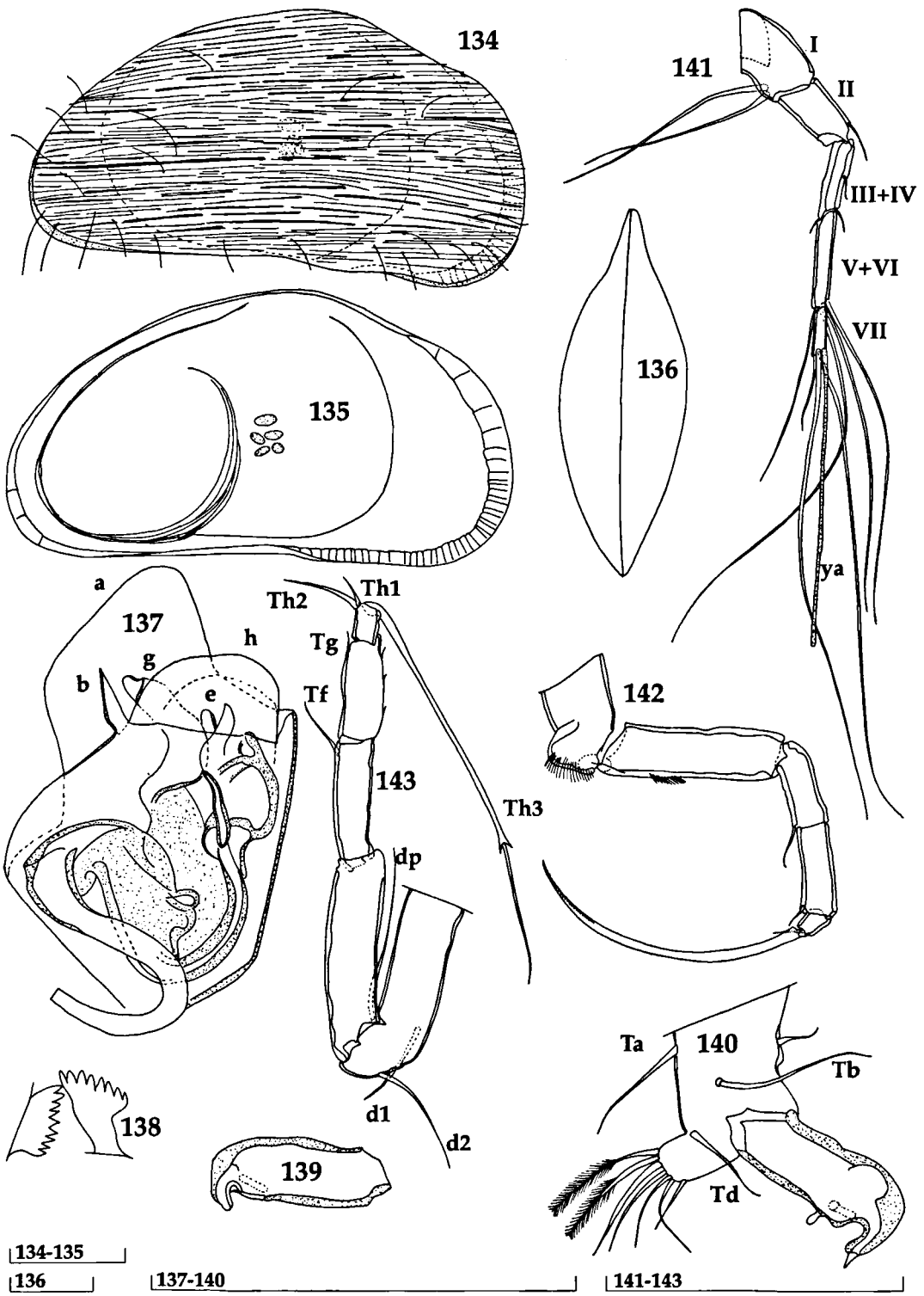
Notacandona modesta n. gen., n. sp.
Figs. 134-152

MATERIAL. - Holotype: male, dissected (WAM C28262). Allotype: female, dissected (WAM C28263). Paratypes: 1 male, dissected (WAM C28264); 1 male and 1 juvenile in alcohol (WAM C28265) from the Weeli Wolli Spring (B-R), 22°55'S 119°11'E, 16-XI-1998, collector: S. M. Eberhard (BES: 3594).

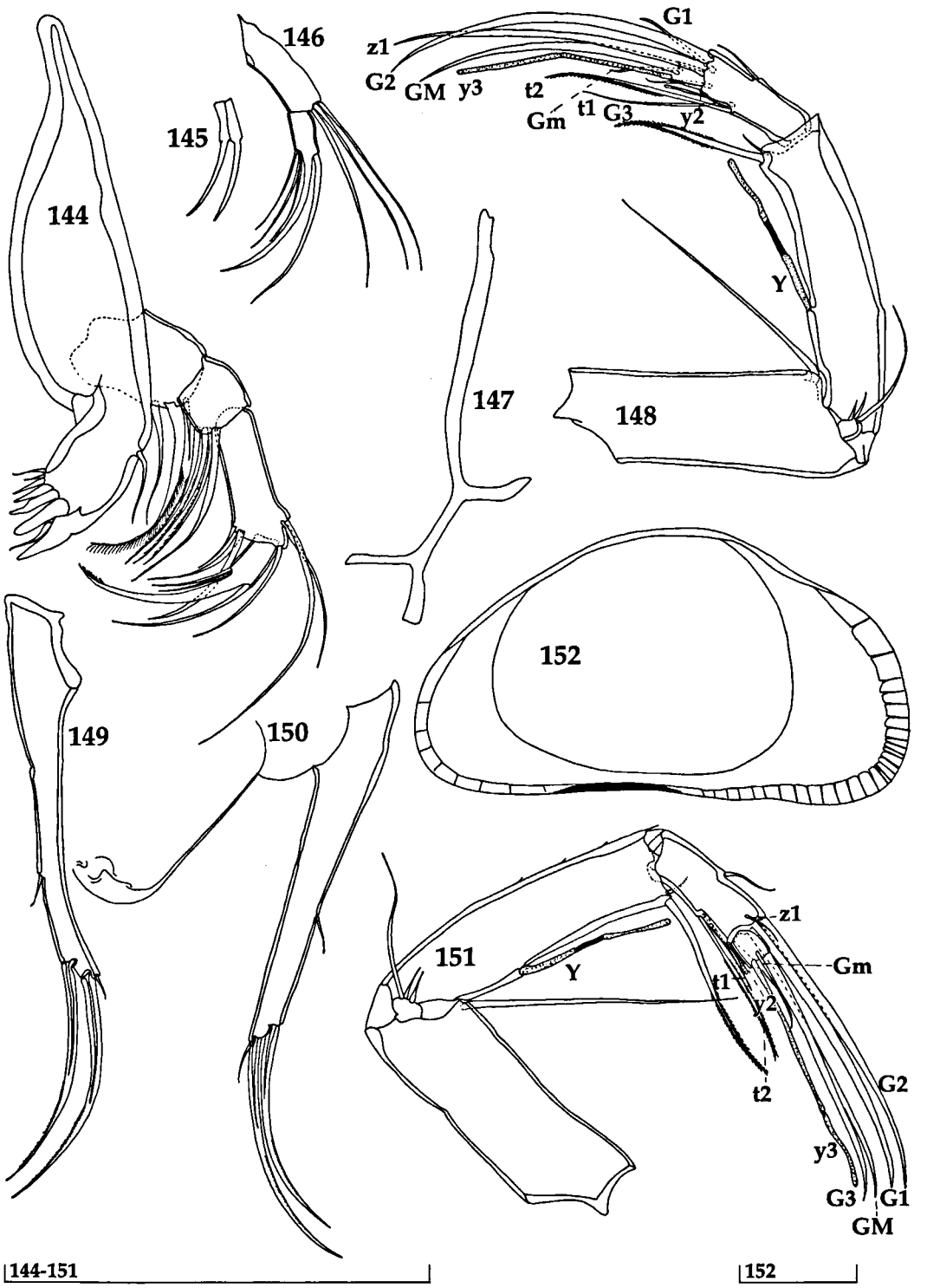
Both soft parts and carapaces of all dissected animals were mounted on slides in Faure's medium.

DESCRIPTION OF HOLOTYPE (MALE, L = 0.431 mm). - Carapace in lateral view (Figs. 134, 135) subtriangular. L of LV = 0.431 mm, RV = 0.421 mm. Greatest H on both valves situated on anterior third of L, equalling 53% of L. From that point dorsal margin sinusoid towards frontal margin and gradually sloping towards posterior one. Both frontal and caudal margins rounded, but caudal being considerably narrower than frontal one. Ventral margin slightly convex in mouth region. Surface completely covered with longitudinal ridges and fine hairs. Marginal zone anteriorly 24%, posteriorly 17% of L. Marginal pore canals dense anteriorly, sparse posteriorly. Selvage visible and developed anteriorly and posteriorly on carapace. In dorsal view (Fig. 136) anterior end cuneiform. LV hardly overlapping RV on both ends. Greatest W not in middle, but rather on anterior third, equalling 35% of L.

A1 (Fig. 141) 5-segmented. First segment with two long posterior setae, one antero-proximal seta (not shown in Fig. 141), but without seta antero-distally. Second segment with one small antero-distal seta (reaching middle L of following segment); third segment with one short antero-medial seta (not reaching distal end of same segment), and two short distal ones (about same L as previous one); penultimate segment distally with three long setae and one shorter (half as long as those long ones); distal segment with three setae: two long and one short (slightly longer than terminal segment), and aesthetasc ya which is 6.5 times as long as terminal segment. L ratios of



Figs. 134-143. *Notacandona modesta* n. gen., n. sp., holotype (male, L = 0.431 mm). 134, RV, external view. 135, LV, internal view (with several spermiducts shown). 136, carapace, dorsal view. 137, hemipenis, medial side up. 138, Rake-like organ. 139, left prehensile palp. 140, right prehensile palp. 141, A1. 142, T2. 143, T3 (scale bars = 0.1 mm).



Figs. 144-152. *Notacandona modesta* n. gen., n. sp.; 144-149: holotype (male, L = 0.431 mm). 150-152: allotype (female, L = 0.417 mm). 144, Md. 145, claws on third endite of Mxl. 146, Mxl palp. 147, furcal attachment. 148, A2. 149, Fu. 150, Fu. 151, A2. 152, LV, internal view (scale bars = 0.1 mm).

three distal segments 1.5 : 2 : 1.

A2 4-segmented and without male's bristles. Exopodite on A2 (Fig. 148) with two short and one long seta (about 4 times longer). Aesthetasc Y 0.57 times as long as first endopodal segment; y1 not developed; y2 slightly exceeding distal end of terminal segment; y3 0.71 times as long as first endopodal segment. Second segment with one anterior seta (reaching distal end) and two posterior setae (t1 and t2), one pappose, other smooth (both setae of subequal L and about 1.5 times as long as second endopodal segment). Penultimate segment with two long claws, one being G2 (outermost), other being transformed z1 seta. Both claws of subequal L and 1.1 times as long as first endopodal segment. G1 reduced into a small claw (3 times as long as terminal segment), G3 being seta about 2 times as long as terminal segment. Setae z2 and z3 missing. GM on terminal segment 0.88 times as long as first endopodal segment, Gm two times as long as terminal segment. L ratios of three endopodal segment 9 : 2.8 : 1.

Md palp (Fig. 144) 4-segmented. First segment internally with four setae (only three shown in Fig. 144). Second segment without any seta externally, while internally with 3+2 setae in bunch (beta seta not shown in Fig. 144, being very small and hardly visible). Following segment with two setae extero-medially (but very close to distal end), one reaching middle of terminal claw, other reaching distal end; gamma seta extero-distally, and three setae intero-distally. Terminal segment with distally pappose claw, fused with segment, one seta externally and two setae internally. L ratios of three distal segments 1 : 2.6 : 1.

Terminal segment of Mxl palp square-shaped to rectangular and with four claws/setae observed (Fig. 146); claws on third endite (Fig. 145) smooth.

Rake-like organ (Fig. 138) with eight and nine teeth.

Prehensile palps (Figs. 139,140) not symmetrical: right being larger than left one. Both palps with short fingers and setae.

T2 (Fig. 142) 5-segmented, third and fourth segments distinctly divided. Basal segment with row of hairs but without any seta; second segment without seta; third and fourth segments with one seta each (both being short). Claw on terminal segment distally serrated and 1.4 times as long as three distal segments combined.

T3 (Fig. 143) 5-segmented. Basal segment with three setae, first endopodal without any seta; 'Tf' seta on second endopodal segment reaching middle of following segment, and 'Tg' seta on penultimate segment just slightly exceeding distal end of penultimate segment. L ratios of three setae on terminal segment 13 : 2.4 : 1.

Fu (Fig. 149) with both claws and both setae present. Claws subequally long, curved and serrated, being 0.8 times as long as anterior furcal margin. Both setae short. Furcal attachment shown in Fig. 147.

Hemipenis (Fig. 137) with small and rounded 'h' lobe, lobe 'a' with inclined dorsal margin. Zenker's organ with 5+2 rows of spines.

ALLOTYPE (FEMALE, L = 0.417 mm). - Carapace of same appearance as in male. L of LV = 0.417 mm, RV = 0.402 mm. Greatest H on both valves equals 54% of L (Fig. 152). Greatest W = 34% of L.

Penultimate segment of A2 with three distal claws (G1, G2 and G3) all subequally long and as long as first endopodal segment (Fig. 151). Only one z seta visible. Aesthetasc y3 slightly longer than in male. L ratios of three endopodal segments 8 : 3.5 : 1.

T1 with one 'Ta' seta, and just one seta visible in exopodite, both 'Tb' and 'Td' setae present. Apically protopodite with three short setae.

Fu (Fig. 150) with posterior claw slightly shorter than in male. Both claws curved and serrated. Anterior being 0.8 times as long as anterior furcal margin. Both setae short, genital lobe rounded.

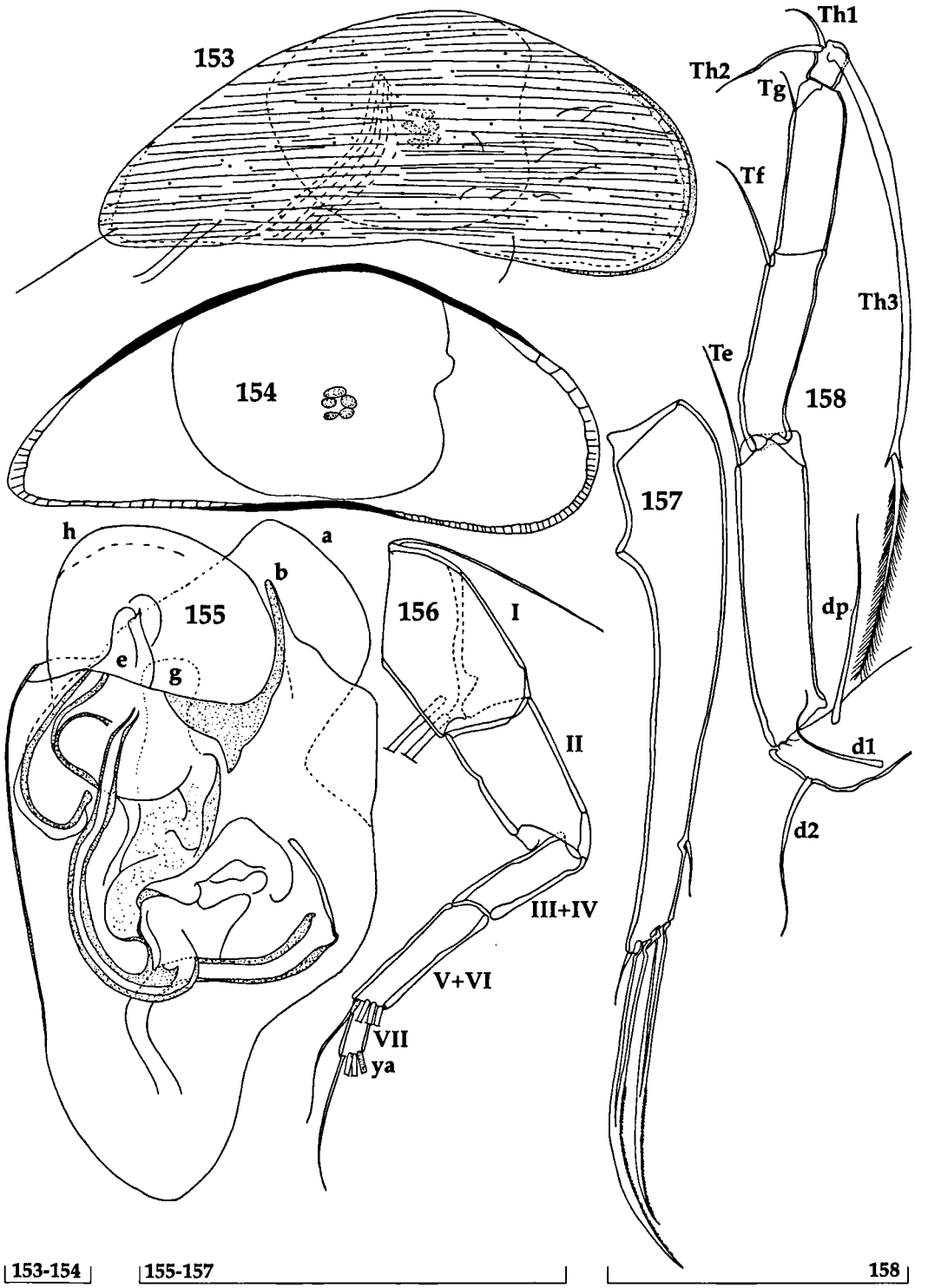
Other characteristics of carapace and soft parts same as in male.

ETYMOLOGY. - The species name is Latin adjective '*modestus*' meaning modest.

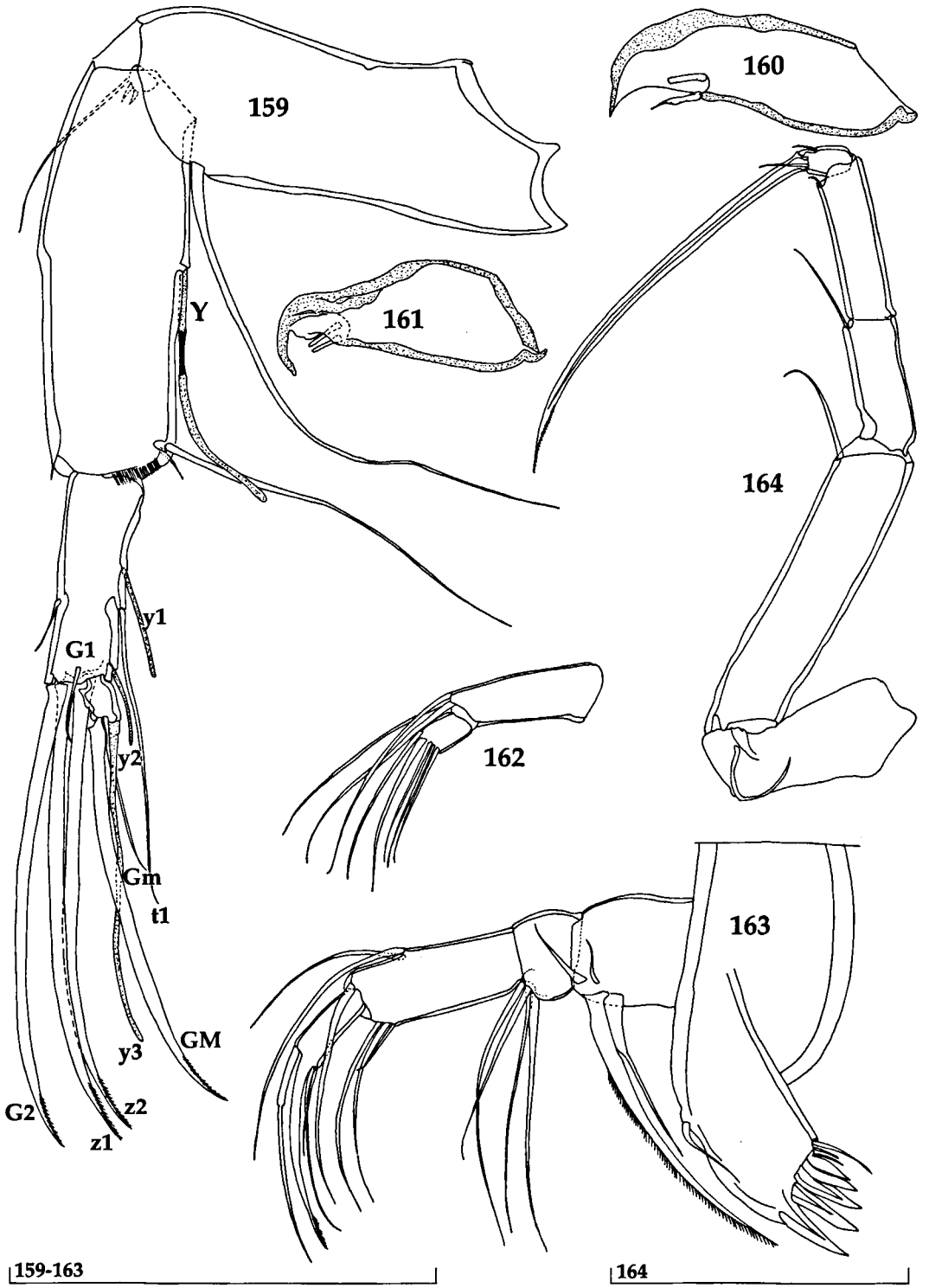
Notacandona boultoni n. gen., n. sp.
Figs. 153-164

MATERIAL. - Holotype: male, dissected (WAM C28266). Paratypes: 1 juvenile, dissected (WAM C28267), 2 juveniles in alcohol (WAM C28268), from the Weeli Wolli Spring (B-R), 22°55'S 119°11'E, 16-XI-1998, collector S. M. Eberhard (BES 3594).

Soft parts of all dissected specimens mounted on slides in



Figs. 153-158. *Notacandona boultoni* n. gen., n. sp., holotype (male, L = 0.7 mm). 153, RV, external view. 154, LV, internal view. 155, hemipenis, medial side up. 156, A1. 157, Fu. 158, T3 (scale bars = 0.1 mm).



Figs. 159-164. *Notacandona boultoni* n. gen., n. sp., holotype (male, L = 0.7 mm). 159, A2. 160, right prehensile palp. 161, left prehensile palp. 162, Mxl palp. 163, Md palp. 164, T2 (scale bars = 0.1 mm).

glycerol, while valves are kept separately in 70% in glass test-tubes.

DESCRIPTION OF HOLOTYPE (MALE, L = 0.7 mm). Carapace in lateral view (Figs. 153, 154) subtriangular. L of LV = 0.7 mm, RV = 0.699 mm. Greatest H slightly in front of middle L on both valves, equalling 46% of L. From that point dorsal margin sloping towards frontal and caudal ends. Frontal margin rounded and clearly wider than caudal one, which is slightly pointed. Ventral margin concave in mouth region. Valve surface covered with longitudinal ridges, and with sparse hairs, which are longer on caudal end. Marginal zone wide, anteriorly 26%, posteriorly 35% of total L. Inner margin anteriorly not equally rounded, but with one dull bulge in eye region. Fused zone narrow, with dense and short marginal pore canals. Selvage peripheral and visible frontally. Greatest W = 28% of L.

A1 (Fig. 156) 5-segmented. First segment with two setae posteriorly and without antero-distal seta (seta shown in Fig. 156 being antero-proximal one). Second and third segments without any seta. Penultimate segment with three long and one short seta (about 2 times as long as terminal segment). Terminal segment with two long and one short seta (about 2 times as long as terminal segment), and aesthetasc 8 times as long as terminal segment. L ratios of three distal segments 2 : 2.5 : 1.

A2 (Fig. 159) 4-segmented and without male's bristles. Exopodite plate with two short and one longer seta (8 times). Aesthetasc Y 0.6 times as long as first endopodal segment; y1 reaching distal end of penultimate segment; y2 exceeding distal end of terminal segment; y3 0.8 times as long as first endopodal segment. Penultimate segment with one seta externally (not reaching distal end of same segment) and one seta internally (1.4 times as long as same segment). Distally three claws (1.1 times as long as first endopodal segment) of which one being G2, the other two transformed setae z1 and z2. G1 reduced into one small and weak claw which slightly exceeds distal end of terminal segment. Claw G3 small, seta-like (not shown in Fig. 159), seta z3 missing. GM as long as first endopodal segment, Gm 4 times as long as terminal segment. L ratios of three endopodal segments 9.1 : 4.6 : 1.

Md palp 4-segmented (Fig. 163). Second segment externally without seta, internally with five setae in bunch (beta seta not shown in Fig. 163, being very small and hardly visible); third segment extero-medially with two setae (one reaching basis of terminal claw, other reaching middle of same claw), gamma seta extero-distally and three setae intero-distally. Terminal segment with fused, and distally pappose claw, one strong seta externally and two thin setae internally. L ratios of three distal claws 1 : 2.8 : 1.3.

Terminal segment on Mxl palp (Fig. 162) square-shaped and with five claws/setae observed.

T1 with one 'Ta' seta, and two setae in exopodite. Prehensile palps not symmetrical, right (Fig. 160) being stronger than left (Fig. 161).

T2 (Fig. 164) 5-segmented, third and fourth segments clearly divided. Basal segment without any seta, first, second and third segments with one seta each, seta on penultimate segment very short.

T3 (Fig. 158) 5-segmented, third and fourth segments completely divided. Basal segment with three setae, first endopodal with 'Te' seta not reaching middle of following segment, second segment with 'Tf' seta which reaches middle of following segment, while 'Tg' on penultimate segment small, just slightly exceeding distal end of same segment. L ratios of three setae on distal end 13 : 2.3 : 1.

Fu (Fig. 157) with both furcal claws developed, as well as both furcal setae. Posterior claw slightly shorter than anterior one, both claws serrated, anterior claw 0.8 times as long as anterior furcal margin.

Hemipenis (Fig. 155), with big and rounded 'h' lobe, 'a' lobe with inclined extero-distal margin, 'b' lobe well developed. Zenker's organ with 5+2 rows of spines.

FEMALES. - Not known.

ETYMOLOGY. - The species is dedicated to Dr Andrew Boulton (University of New England, New South Wales) for his valuable work on the Australian groundwater. The name is to be treated as a noun in the genitive singular.

REMARKS. - *Notacandona modesta* n. sp. and *N. boul-*

toni n. sp. have the same type locality, which is also the only known locality for both species. Although they clearly belong to the same genus, they are actually not very closely related. The most noticeable differential features separating the two species are: 1, posterior margin rounded in *N. modesta* n. sp., elongated in *N. boultoni* n. sp.; 2, dorsal margin sinusoid towards anterior margin in *N. modesta* n. sp., equally sloping in *N. boultoni* n. sp.; 3, fused zone wide in *N. modesta* n. sp., narrow in *N. boultoni* n. sp.; 4, second and third segment on antennula without any seta in *N. boultoni* n. sp., with setae in the other species; 5, penultimate segment on antenna in the male of *N. modesta* n. sp. with just two long claws, in the other species with three long claws; 6, seta on the first endopodal segment of the second thoracopod missing in *N. modesta* n. sp., present in *N. boultoni* n. sp.; 7, first endopodal segment on the third thoracopod without any seta in *N. modesta* n. sp., with one seta in *N. boultoni* n. sp.; 8, lobe 'h' on the hemipenis very small and clearly smaller than lobe 'a' in *N. modesta* n. sp., these lobes of subequal heights in *N. boultoni* n. sp.

DISCUSSION

The three new genera have the following common features: 1, carapace ornamented; 2, antennula 5-segmented; 3, basal segment on the second thoracopod without seta, subterminal segment with one short seta; 4, basal segment of the third thoracopod with three setae, terminal segment with two short and one long seta; 5, lobe 'b' on hemipenis with strongly sclerotized and acutiform part. Despite all those common features there are many differences that clearly separate the three new genera one from another. Those features, as well as common ones, will be discussed here and compared with the same characteristics of other Candoninae genera.

The carapace ornamentation is quite strong in species like *Humphreyscandona waldockae* n. gen., n. sp., as well as in all four species of the other two new genera. In the other new species of *Humphreyscandona* n. gen., the valves are also well ornamented with few striae and/or pits, but not as strongly as in the above mentioned species. The smooth carapace prevails in the subfamily Candoninae over the ornamented one, and this feature has occurred several times in the evolution of the subfamily. Some Tertiary Candoninae genera like *Serbiella* Krstic, 1972, *Lineocypris* Zalannyi, 1929, and *Bakunella* Schneider, 1958 (see Krstic, 1972; Sokac, 1972) have representatives with ornamented valves. Among the Recent Candoninae ornamented valves occur as isolated cases in almost all genera, or as a rule, such as in *Baicalocandona* Mazepova, 1977, a genus endemic to the Lake Baikal (see Mazepova, 1990). Strong carapace ornamentation and triangular or trapezoidal shapes are frequent in groundwater Candoninae (e. g. *Pseudocandona zchokkei* Wolf, 1919). These characteristics are consistent with the ecology of the three new genera. In this sense, valve characteristics like ornamentation and shape, cannot be used to discriminate genera in the subfamily Candoninae.

Although all new genera have a 5-segmented antennula, there are clear differences in the chaetotaxy of this appendage. *Humphreyscandona* n. gen. has an antero-medial seta both on the third and fourth segments, and this genus is the closest towards 6-segmented antennula. One female of the species *H. adorea* n. sp. even has 6-segmented antennula (Fig. 14). This is here presented as a variability, but it clearly shows that the 5-segmented character state originated from a 6-segmented one. According to Smith & Martens (2000), who studied the ontogeny of *Eucypris virens* (Jurine, 1820), fused segments are postulated as "incompletely differentiated podomere". However, the discussion on the homology of fused segments in Cypridoidea is beyond the present paper. In *Pilbaracandona* n. gen., the antero-medial seta is present just on the penultimate segment. In *Notacandona* n. gen., only the type species has an antero-medial seta on the third segment, while *Notacandona boultoni* n. sp., lacks all antero-medial setae. Additionally, both *Notacandona* species lack the antero-distal short seta on the first segment. There are several Candoninae genera with reduced segments on antennula. *Caribecandona* s. str. (Broodbakker, 1983) has a 6-segmented antennula (Brood-bakker, 1983) and in this genus the third and fourth endopodal segments are fused. *Namibcypris* Martens, 1992, and *Terrestricandona* Danielopol & Betsch, 1980 have the same number of segments. In the former genus the fusion is probably between the fourth and fifth segments,

while in the latter one this is not completely clear (see Danielopol & Betsch, 1980), but it seems that the fusion lies between the first and second segments. The genus *Nannocandona* Ekman, 1914 was described to have four segments on antennula (Ekman, 1914), but Marmonier & Danielopol (1988) have found that this appendage consists of five segments and that the fusion is between the third and fourth and between sixth and seventh segments. Five-segmented antennula have been found in two other genera: *Danielocandona* Broodbakker, 1983 and *Meischcandona* Karanovic, 2001. In both genera fusion is between the third and fourth and between the fifth and sixth segments (Broodbakker, 1983; Karanovic, 2001), and this is the same as in all three new Australian genera. All other known Candoninae genera have 7-segmented antennula and just with this feature it is very easy to distinguish them from *Humphreyscandona* n. gen., *Pilbaracandona* n. gen. and *Notacandona* n. gen.

The absence of male sexual bristles is recorded in all three genera (where males are known), but it is not quoted as a generic diagnostic feature as it has been shown several times that within one genus it is possible to have closely related species with or without male's bristles. This is for example the case in *Pseudocandona* Kaufmann, 1900, *Trapezicandona* Schornikov, 1969, and *Trajancandona* Karanovic, 1999. Karanovic (2001) also proposed the unification of species from the genus *Pseudocandona* Kaufmann, 1900, described from Lake Baikal, and of the species from the genus *Baikalocandona* into the latter genus, because the only differential feature was the absence of male bristles in the *Pseudocandona* species from Lake Baikal.

The appearance of the mandibular palp and its chaetotaxy is important in separating the three new genera, as *Humphreyscandona* n. gen. has two setae on the outer side of second segment, *Pilbaracandona* n. gen. has one seta, while in *Notacandona* n. gen. there are no setae. The most common situation in Candoninae is the presence of two external setae. However, genera like *Phreatocandona* Danielopol, 1978, *Danielocandona* Broodbakker, 1983, *Indocandona* Gupta, 1984, *Namibcypris* Martens, 1992 and *Trajancandona* Karanovic, 1999, do not have any seta externally on the second segment of the mandibular palp (see Danielopol, 1982; Broodbakker, 1983; Gupta, 1984; Martens, 1992; Karanovic, 1999). The genus *Nannocandona* has one, while *Terrestricandona* has three setae on that segment (see Marmonier & Danielopol, 1988; Danielopol & Betsch, 1980). Among Candoninae genera only *Candonopsis* Vavra, 1891 has a terminal segment of the mandibular palp clearly elongated and with L : H ratio never less than 3 : 1. In all three new genera, as well as in all other Candoninae this ratio is never more than 2 : 1. There is, however, considerable variation in the type of fusion between the terminal claw and terminal segment, as well as in the level of sclerotization of the same claw between Candoninae, but this analysis is beyond the scope of the present paper. *Humphreyscandona* n. gen. is also easily distinguishable from the other two new genera by having five intero-medial to intero-distal setae on the penultimate segment of the mandibular palp, while the other two genera have three setae only. Also, *Notacandona* n. gen. has clearly more elongated and 'thinner' penultimate segment comparing with *Humphreyscandona* n. gen. and *Pilbaracandona* n. gen.

The terminal segment of the maxillular palp in *Humphreyscandona* n. gen. is more trapezoidal, and although in the other two genera the same segment is more or less square-shaped to elongated, this difference is not so obvious, and cannot be underlined. In other Candoninae the terminal segment is similar with the one in the new genera, with exception of *Danielocandona* and *Namibcypris* where it is very elongated (Broodbakker, 1983; Martens, 1992). In those two genera, as well as in *Trajancandona* and *Meischcandona* this segment bears only three setae (Karanovic, 1999; Karanovic, 2001), while in all other Candoninae there are never less than five. Another interesting characteristic of *Humphreyscandona* n. gen. and *Pilbaracandona* n. gen. but not of *Notacandona* n. gen. is that two claws on the third endite of Mxl are plumose as is also the case in *Namibcypris* and *Danielocandona*. *Notacandona* n. gen. and the other Candoninae have smooth claws.

Only *Humphreyscandona* n. gen. among the new genera has two 'Ta' setae on the protopodite of the first thoracopod, while the other two have one seta. Although it is known that some genera (*Namibcypris* and *Danielocandona*) lack all endopodal

setae (Martens, 1992; Broodbakker, 1983), the chaetotaxy of this appendage in many species of the subfamily Candoninae, but also in many other Cypridoidea, is poorly known due to difficult dissection of this appendage, and because it is hard to summarize the importance of this feature at the generic level.

The division of the third and fourth segments on the second thoracopod is not constant, and while both species of *Notacandona* n. gen. have a completely and clearly 5-segmented second thoracopod, in *Humphreyscandona* n. gen. only *H. waldockae* n. sp. has a 5-segmented second thoracopod (see 'Remarks' *H. waldockae* n. sp.). In *Pilbaracandona* n. gen. this segment is not completely divided, but because the chitinous membrane is interrupted on both external and internal margins, and there is also one horizontal division (which indeed does not run from one side to another) we consider this as a 5-segmented appendage. In the Candoninae these segments are not divided only in *Namibcypris* and *Danielocandona.* The first genus is monospecific while the other has two species: *Danielocandona lieshoute* Broodbakker, 1983 and *D. albida* (Sars, 1901). Sars (1901) poorly described the species *Paracypridospsis albida* Sars, 1901 from Brazil, and later on Martens & Behen (1994) transferred this species into the genus *Danielocandona.* In *D. albida* the number of segments on the second thoracopod is not known. The variation in the number of segments on the second thoracopod within one genus is very rare in the subfamily Candoninae, but *Humphreyscandona* n. gen. is a nice example that this is still possible. The same is true for the number of segments on the third thoracopod; in *Humphreyscandona* n. gen. only *H. waldockae* n. sp. has a 5-segmented third thoracopod as found in the other two new genera. In all other species of *Humphreyscandona* n. gen. this appendage is 4-segmented. The number of segments on the third thoracopod also varies in the other known Candoninae genera (i. e. *Pseudocandona* and *Trapezicandona).* All new species have a short seta on the penultimate segment of the second thoracopod. Only in the genera *Phreatocandona, Danielocandona, Namibcypris* and *Meischcandona* is this seta found to be very long, sometimes exceeding the middle of the terminal claw (see Danielopol, 1978, 1982; Broodbakker, 1983; Martens, 1992; Karanovic, 2001). Also, all three new genera have two short and one long seta on the terminal segment of the third thoracopod which relates them to the genera *Trapezicandona, Cryptocandona* Kaufmann, 1900, *Indocandona, Danielocandona,* and *Meischcandona.* Other Candoninae have two long and one short seta on the same segment. Meisch (1996) made an excellent contribution to the taxonomy of European Candoninae, pointing out the importance of the number of setae on the basal segment of the third thoracopod at the generic level. All new species have three setae on the basal segment.

In *Notacandona* n. gen. both furcal claws are well developed like in the following Candoninae genera: *Candona* Baird, 1835; *Candonopsis* Vavra, 1891; *Paracandona* Hartwig, 1899; *Eucandona* Daday, 1900; *Pseudocandona* Kaufmann, 1900; *Nannocandona* Ekman, 1914; *Cryptocandona* Kaufmann, 1900; *Trapezicanodana* Schornikov, 1969; *Baicalocandona* Mazepova, 1976; *Terrestricandona* Danielopol & Betsch, 1980; *Caribecandona (Cubecandona)* Broodbakker, 1983; *Schellencandona* Meisch, 1996; and *Trajancandona* Karanovic, 1999. The two other new genera have the posterior furcal claw reduced into one seta. This, or a similar type of reduction, is noticed also in *Phreatocandona* Danielopol, 1978, *Caribecandona (Caribecandona)* Broodbakker, 1983, *Indocandona* Gupta, 1984, and *Meischcandona* Karanovic, 2001. *Danielocandona* and *Namibcypris* have stronger reduction, and the furcal ramus is much shorter, with only the anterior claw present and completely fused with the ramus, while the posterior claw is completely missing.

Because some Candoninae genera are known only from females (i. e. *Meischcandona, Phreatocandona, Nannocandona*) it is hard to discuss differences in the morphology of the hemipenis, as well as in the number of spine rows in the Zenker's organ. However, the hemipenis of all three new genera is characterised by the strongly sclerotized and sharply pointed part of the 'b' lobe. In *Humphreyscandona* n. gen. the 'g' lobe furthermore protrudes between the lobes, while in the other new genera it is flat and incorporated between the lobes; in all three new genera the 'h' lobe is double-folded. *Danielocandona* has a double-folded 'b' lobe, while *Caribecandona* has two 'a' lobes. The Zenker's organ in all new genera has 5+2 rows of

spines. This is a more common situation in the Candoninae than 4+2 (in *Schellencandona* Meisch, 1996, *Danielocandona, Trajancandona* and *Baicalocandona*) or 3+2. Zenker's organ with 3+2 rows of spines is found in the genus *Indocandona*, and in two other species: *Candona marimoti* McKenzie, 1972 and *Baicalocandona saxatilis* (Mazepova, 1990). The first species, described from South Korea (McKenzie, 1972) probably belongs to the genus *Pseudocandona.*

In the remarks given for the genus *Humphreyscandona* n. gen. it has been pointed out that one species of the genus has three short setae on the exopodite of the antenna, and another one has a furca without both furcal setae. These features, which are known as generic characteristics of *Phreatocandona* and *Trajancandona* (three short setae on exopodite), as well as *Candonopsis, Caribecandona, Danielocandona* and *Namibcypris* (furca without at least one of the setae) can be considered in the new species as convergences. All three new genera can easily be distinguished from each other by the appearance of the carapace, antennula, mandibular palp, prehensile palps, first thoracopod, furca and hemipenis. According to all features mentioned above, the new genera are also easily distinguishable from other Candoninae. However, the appearance of the carapace, mandibular palp, furca and hemipenis relates them more to tropical and subtropical genera (*Namibcypris, Meischcandona, Caribecandona, Danielocandona* and *Indocandona*) than to the Holarctic ones. The new genera are especially closely related to the African genus *Meischcandona*, which has a trapezoidal valve shape, a 5-segmented antennula, 4-segmented third thoracopod, and a reduced posterior furcal claw. However, this genus has a terminal segment of maxillular palp with one central claw-like seta and two additional thinner ones. With this feature, as well as with the combination of other morphological characteristics, *Meischcandona* can easily be distinguished from all new Australian genera.

Martens (1992) divided the subfamily Candoninae into two tribes: Namibcypridini and Candonini. The first tribe comprises *Danielocandona* and *Namibcypris*, while all other Candoninae belong to the second tribe. The main feature of the former tribe is the strongly reduced furca. As this kind of reduction is found in neither of the new genera, they cannot be included in the Namibcypridini, despite several similar characteristics listed above. The reduced number of the antennular segments, peculiar appearance of hemipenis as well as the chaetotaxy and the number of segments on the second and third thoracopods, exclude the possibility to allocate the new genera even into the tribe Candonini. The subfamily Candoninae, in general, needs a revision which would resolve also a problem of the systematic classification above generic level. This is a part of another, larger project, undertaken by the senior author, and is however beyond the scope of the present paper. Reduction of some segments and setae that are found in the new genera are results of the adaptation to the subterranean environment and the same can be found also in many Holarctic subterranean species. In addition to these reductions, the three new genera are characterized by very long aesthetascs on both antennula and antenna, which can be considered as true adaptations to life in darkness.

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REFERENCES

BRADY, G. S., 1886. Notes on freshwater Entomostraca

from South Australia. Proc. R. Soc. London: 82-93.

BROODBAKKER, N. W., 1983. The subfamily Candoninae (Crustacea, Ostracoda) in the West Indies. Bijdr. Dierk. **53**: 287-326.

BROODBAKKER, N. W. & D. L. DANIELOPOL, 1982. The chaetotaxy of Cypridacea (Crustacea, Ostracoda) limbs: proposal for a descriptive model. Bijdr. Dierk. **52**: 103-120.

CHAPMAN, F., 1914. Notes on Testacea from the Pleisocene marl of Mowbray Swamp, North-West Tasmania. Mem. Nat. Mus. Melb. **5**: 55-61.

CHAPMAN, M. A., 1966. On *Eucypris mytiloides* (Brady), and three new species of *Eucypris* Vavra (Cypridae, Ostracoda) from Australia. Hydrobiologia **27**: 368-378.

DADAY, J., 1910. Untersuchungen über die Süsswasserfauna Deutch-Ost-Afrikas. Zoologica **59**: 1-374.

DANIELOPOL, D. L., 1969. Recherches sur la morphologie de l'organe copulateur mâle chez quelques ostracodes du genre *Candona* Baird (fam. Cyprididae Baird). In: Neale, J. W. (ed.). The taxonomy, morphology and ecology of recent Ostracoda. Oliver & Boyd Ltd., Edinbourgh: 136-153.

DANIELOPOL, D. L., 1978. Über Herkunft und Morphologie der Süsswasser-hypogäischen Candoninae (Crustacea, Ostracoda). Sitz. Osterr. Akad. Wiss. **1**: 1-162.

DANIELOPOL, D. L., 1980. Deux espèces hypogées du genre *Candonopsis* (Ostracoda, Candoninae) du sud de la France et de Cuba. Vie Milieu **30**: 315-323.

DANIELOPOL, D. L., 1982. Three groundwater Candoninae (Ostracoda) from Romania. Int. J. Speleol. **12**: 83-102.

DANIELOPOL, D. L., A. BALTANAS & W. F. HUMPHREYS, 2000. *Danielopolina kornicker*i sp. n. (Ostracoda, Thaumatocypridoidea) from a Western Australian anchialine cave: morphology and evolution. Zool. Scr. **29**: 1-16.

DANIELOPOL, D. L. & J. M. BETSCH, 1980. Ostracodes terrestres de Madagascar: systematique, origine, adaptations. Rev. Ecol. Biol. Sol. **17**: 87-123.

DeDECKKER, P., 1974. *Australocypris*, a new ostracod genus from Australia. Austr. J. Zool. **22**: 91-104.

DeDECKKER, P., 1976. *Trigonocypris* a new ostracod genus from Queensland. Austr. J. Zool. **24**: 145-157.

DeDECKKER, P., 1978. Comparative morphology and review of Mytilocyprinid Ostracods (Family Cypridae). Austr. J. Zool. , Suppl. Ser. **58**: 1-61.

DeDECKKER, P., 1979a. Comparative morphology and review of Australian Notodromatinae Kaufmann, 1900. Senck. biol. **59**: 417-463.

DeDECKKER, P., 1979b. Ostracods from the mound springs area between Strangways and Curdimurka, South Australia. Trans. R. Soc. S. A. **103**: 155-168.

DeDECKKER, P., 1981a. Taxonomy and ecological notes of some ostracods from Australian inland waters. Trans. R. Soc. S. A. **105**: 91-138.

DeDECKKER, P., 1981b. Taxonomic notes on some Australian ostracods with description of new species. Zool. Scr. **10**: 37-55.

DeDECKKER, P., 1981c. On *Notiocypridopsis frigogena* (Graf). Stereo-Atlas of Ostracod Shells **8**: 101-106.

DeDECKKER, P., 1982a. On *Caboncypris nunkeri* DeDeckker gen. et sp. nov. Stereo-Atlas of Ostracod Shells **9**: 125-132.

DeDECKKER, P., 1982b. Ostracods from Australian inland waters, notes on taxonomy and ecology. Proc. R. Soc. Vic. **93**: 43-85.

DeDECKKER, P., 1982c. Non-marine ostracods from Quaternary profiles at Pulbena and Mowbray Swamps, Tasmania. Austr. J. Paleont. **6**: 249-274.

DeDECKKER, P., 1983. Terrestrial ostracods in Australia. In: Lowry, J. K. (ed.). Paper from the conference of the biology and evolution of Crustacea. Austr. Mus. Mem. **18**: 87-100.

DeDECKKER, P. & K. G. McKENZIE, 1981. *Bennelongia*, a new cypridid ostracod genus from Australasia. Trans. R. Soc. S. A. **105**: 53-58.

EKMAN, S., 1914. Beitrage zur Kenntnis der schwedichen Süsswasser-Ostracoden. Zool. Bidr., Uppsalla **3**: 1-36.

GUPTA, L. P., 1984. *Indocandona krishnakanti*, gen. et sp. nov. (Crustacea: Ostracoda: Candonidae) from subterranean waters of Bihar, India. Rec. Zool. Surv. Ind. **81**: 291-298.

HENRY, M., 1919. On some Australian freshwater Copepoda and Ostracoda. J. R. Soc. N. S. W. **53**: 29-48.

HENRY, M., 1923. A monograph of the freshwater Entomostraca of New South Wales. Proc. Linn. Soc. N. S. W. **48**: 267-185.

HUMPHREYS, W. F., 1999. Relict stygofaunas living in sea salt, karst and calcrete habitatas in arid northwestern Australia contain many ancient lineages. In: Ponder, W. & D. Lunney (eds). The other 99%. The conservation and biodiversity of Invertebrates. Trans. R. Zool. Soc. N. S. W.: 219-227.

HUMPHREYS, W. F., 2000. Karst wetlands biodiversity and continuity through major change: an example from arid tropical Western Australia. In: Gopal, B., W. J. Junk & J. A. Davis (eds). Biodiversity in wetlands: assessment, function and conservation. Backhuys Publ. Leiden, The Netherlands **1**: 227-258.

HUMPHREYS, W. F., 2001. Groundwater calcrete aquifers in the Australian arid zone: the context to an unfolding plethora of stygal biodiversity. In: Humphreys, W. F. & M. S. Harvey (eds). Subterranean biology in Australia 2000. Rec. W. A. Mus., Suppl. **64**.: 63-83.

HUSSAINY, S. U., 1969a. A new species of *Gomphocythere* (Limnocytheridae, Ostracoda) from Australia. Proc. R. Soc. Vic., New Ser. **82**: 299-303.

HUSSAINY, S. U., 1969b. Description of male of *Candonocypris assimilis* G. O. Sars 1894 (Cypridae, Ostracoda). Proc. R. Soc. Vic., New Ser. **82**: 305-307.

KARANOVIC, I., 1999. A new genus and two new species of Candoninae (Crustacea, Ostracoda) from Montenegro (SE Europe). Mém. Biospéol. **26**: 47-57.

KARANOVIC, I., 2001. *Meischcandona* gen. nov. from Africa, and a key to the genera of the subfamily Candoninae (Crustacea, Ostracoda). Bull. Inst. R. Sci. Nat. Belg. **71**: 93-99.

KING, R. L., 1855. On Australian Entomostracans. Pap. Proc. R. Soc. Tas. **3**: 56-75.

KLIE, W., 1932. Die Ostracoden der deutschen limnologischen Sunda Expedition. Arch. Hyrdobiol. **11**: 447-501.

KRSTIC, N., 1972. Rod *Candona* (Ostracoda) iz kongerijskih slojeva juznog dela Panonskog basena. Srpska Akad. Nauka i Umetn., Poseb. Izd. **39**: 291-298.

MARMONIER, P. & D. L. DANIELOPOL, 1988. Découverte de *Nannocandona faba* Ekman (Ostracoda, Candoninae) en basse Autriche. Son origine et son adaptation au milieu interstitiel. Vie Milieu **38** (1): 35-48.

MARTENS, K., 1987. Homology and functional morphology of the sexual dimorphism in the antenna of *Sclerocypris* Sars, 1924 (Crustacea, Ostracoda, Megalocypridinae). Bijdr. Dierk. **57**: 183-190.

MARTENS, K., 1992. On *Namibcypris costata* n. gen., n. sp. (Crustacea, Ostracoda, Candoninae) from a spring in Northern Namibia, with the description of a new tribe and a discussion on the classification of the Podocopina. Stygologia **7**: 27-42.

MARTENS, K., 1998. General morphology of non-marine ostracods. In: Martens, K. (ed.). Sex and parthenogenesis: evolutionary ecology of reproductive modes in non-marine ostracods. Bakhuys Publ. Leiden, The Netherlands: 57-75.

MARTENS, K. & F. BEHEN, 1994. A checklist of the recent non-marine Ostracods (Crustacea, Ostracoda) from the inland waters of South America and adjacent islands. Trav. sci. Mus. nation. hist. nat. Luxemb. **22**: 1-81.

MARTENS, K. & G. ROSSETTI, 2002. On the Darwinuloidae (Crustacea, Ostracoda) from Oceania, with the description of *Vestalenula matildae* sp. nov. Invertebr. Syst. **16**: 195-208.

MAZEPOVA, G. F., 1990. Rakushkovie rachki (Ostracoda) Baikala. Akad. Nauk SSSR: 1-472.

MEISCH, C., 1996. Contribution to the taxonomy of *Pseudocandona* and four related genera, with the description of *Schellencandona* nov. gen., a list of the Candoninae genera, and a key to the European genera of the subfamily (Crustacea, Ostracoda). Bull. Soc. Nat. Luxemb. **97**: 211-237.

McKENZIE, K. G., 1966a. *Mytilocypris*, a new ostracode genus from Tasmania. Pap. Proc. R. Soc. Tas. **100**: 27-30.

McKENZIE, K. G., 1966b. Freshwater Ostracoda from North-Western Australia. Aust. J. Mar. freshw. Res. **17**: 259-279.

McKENZIE, K. G., 1968. A new species of *Paracypria* (Ostracoda, Cyprididae) from Victoria, Australia. Zool. Anz. **180**: 384-389.

McKENZIE, K. G., 1972. Results of the speleological survey in South Korea 1966. Bull. Nat. Sci. Mus., Tokyo **15**: 155-166.

McKENZIE, K. G., 1978. Ostracoda (Crustacea: Podocopida) from Southern Australian Salt Lakes, with the description of *Retycypris* new genus. Trans. R. Soc. S. A. **102**: 175-190.

SARS, G. O., 1889. Freshwater Ostracoda and Copepoda, raised from dried Australian mud. Christ. Vid.-Selsk. Forh. **3**: 1-73.

SARS, G. O., 1894. Contribution to the knowledge of the fresh water Entomostraca of New Zealand as shown by artificial hatching from dried mud. Skrif. Vidensk.-Selsk., Mathem.-Naturvid. **5**: 1-62.

SARS, G. O., 1896a. On some West-Australian Entomostraca raised from dried sand. Arch. Math. Naturv. B. **19**: 1-35.

SARS, G. O. 1896b. On fresh-water Entomostraca from the neighbourhood of Sydney, partly raised from dried mud. Arch. Math. Naturv. B. **28**: 1-81.

SARS, G. O., 1901. Contribution to the knowledge of the fresh-water Entomostraca of South America. As shown by artificial hatching from dried material. Arch. Math. Naturv. B. **24**: 1-52.

SMITH, R. J. & MARTENS, K., 2000. The ontogeny of the cypridid ostracod *Eucypris virens* (Jurine, 1820) (Crustacea, Ostracoda). Hydrobiologia **419**: 31-63.

SOKAC, A., 1972. Pannonian and Pontian Ostracode fauna of Mt. Medvednica. Paleontol. Jugosl. **11**: 1-149.

VAVRA, V., 1897. Susswasser-Ostracoden Deutsch-Ost-Afrikas. In: Mobius, K. (ed.). Die Tierwelt Ost-Afrikas und der Nachbergebiete **4**: 2-28.

WATTS, C. H. S. & W. F. HUMPHREYS, in press. A new genus and six new species of Dytiscidae (Coleoptera) from underground waters in the Yilgarn paleodrainage system of Western Australia. Rec. S. A. Mus.

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