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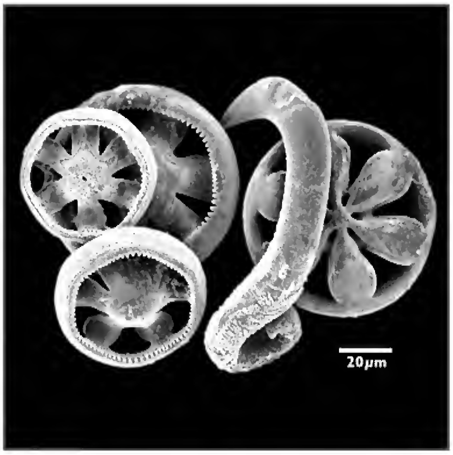

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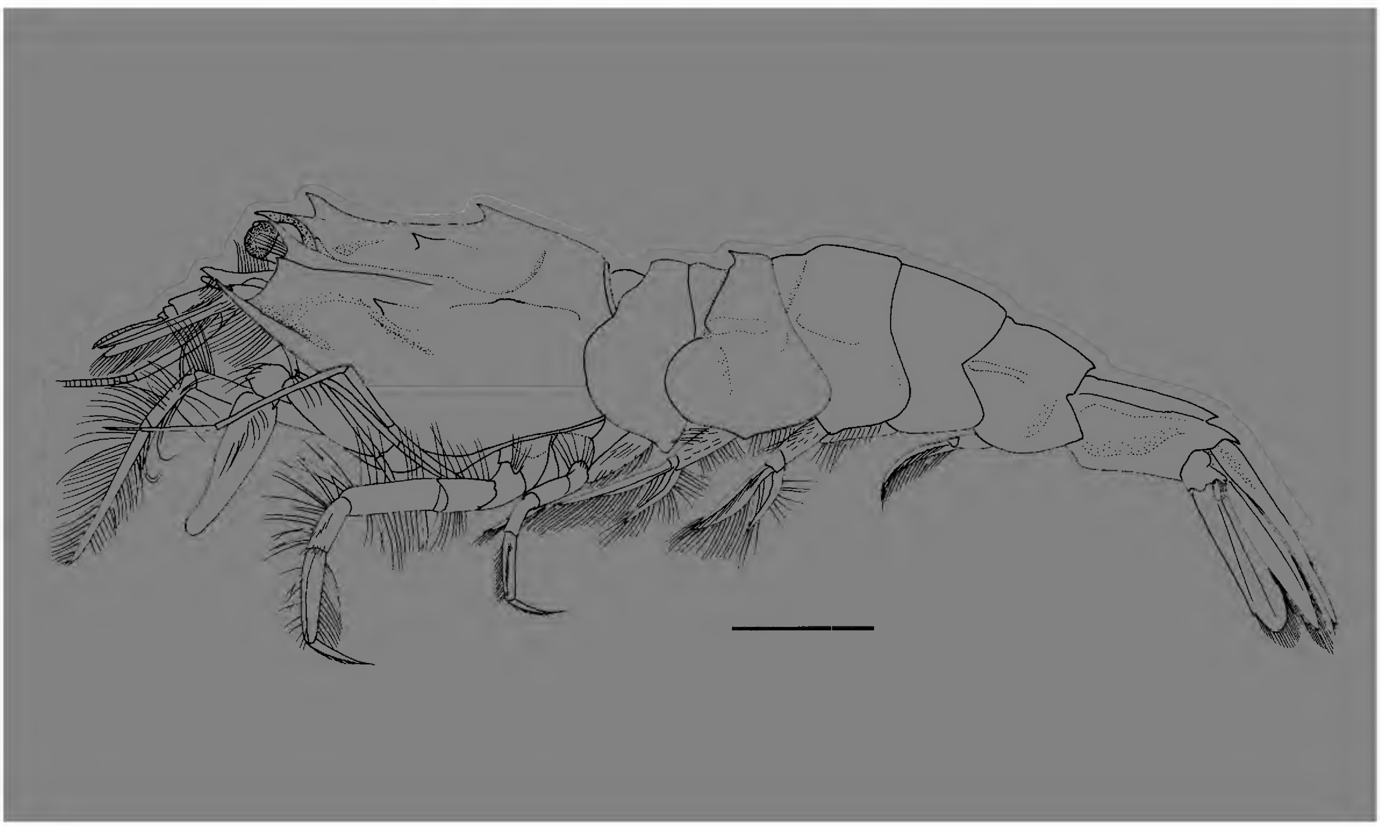

Cover images

Front top left: Enhanced colour photo of preserved specimen of *Taeniogyrus australianus* (Stimpson, 1855), showing wheel cluster papillae (large) and hook clusters (small) (27 mm long; Australia, Sydney Harbour, 1968; AM J16377).
Front top right: SEM image for specimen of *Taeniogyrus australianus* (Stimpson, 1855) (Long Reef, Collaroy, Sydney; RBINS IG 31 459 ex AM J20086).
Front lower: *Metacrangon spinidorsalis* sp. nov., holotype, female (cl 10.4 mm), WAM C45115, entire animal in lateral view. Scale bar = 5 mm. Described by Tomoyuki Komai and Joanne Taylor.
Back top left: *Hydrobiosella nandawar* sp. nov., lateral view. Described by David I. Cartwright.
Back top right: A new cucumberfish of the genus *Paralaupus* (family Paraulopidae) from the Tasman Sea, described in this issue by Martin Gomon.
Back lower: Osteichthyan lower jaw. G*yroptychius* specimen NRM PZ P1409.

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MELBOURNE AUSTRALIA

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Museum Victoria, formerly known as the Museum of Victoria, was formed in 1983 by the merger of the National Museum of Victoria (established in 1854) and the Science Museum of Victoria (established in 1870). Museum Victoria undertakes research in order to contribute to a deeper understanding and appreciation of the origins, diversity and development of Australia's natural, cultural and scientific heritage, and applies this knowledge for the benefit of society.

Memoirs of Museum Victoria (formerly known as Memoirs *of the National Museum of Victoria* until 1983) is the museum's scientific journal and advances the museum's objectives by publishing papers on original research in the natural sciences pertinent to Victoria and/or the museum's collection. It is published annually, on 31 December.

From Volume 58 (2000) *Memoirs of Museum Victoria* is available in a .pdf file format on the museum's website **http://museumvictoria.com.au/About/Books-and-Journals/Journals/Memoirs-of-Museum-Victoria**. Individual papers may be downloaded free of charge. It is also available as a printed edition by subscription or institutional exchange, and inquiries should be directed to the Librarian, Museum Victoria, GPO Box 666, Melbourne, Victoria 3001, Australia or by email **library@museum.vic.gov.au**.

Deadline for submission of papers

Final manuscripts (prior to papers being refereed) and accompanying illustrations must be submitted to the editor **no later than 1 August**. Earlier submission is encouraged.

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Papers must be submitted to the editor in final manuscript form as a **word document file only** and double line spaced. Any accompanying images or drawings must be submitted separately and NOT embedded within the text.

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An outline of the required **format and style guide** is supplied here; however, authors should also refer to the previous edition of *Memoirs of Museum Victoria* for a more in-depth guide.

Papers should be arranged as follows:

title (including higher classification of zoological taxa)
authors' name and address (postal and email)
abstract
key words
contents (only if the paper is extensive)
introduction
main text
acknowledgements
references
index (only if extensive)
tables within the text

- Author's **email addresses** in contact details should be in brackets.
- Primary **headings** are in bold and left justified; secondary headings in italics and left justified. *Italics* in the text should otherwise be restricted to generic and specific names. **Paragraphs** are indented. **Measurements** must be in the metric system (SI units).
- **Abbreviation** of River and Island/s: Use R for River, I for Island and Is. for Islands.
- For **numbers, use numerals except** when used in text narrative when they should be spelt out, but only up to and including the number ten. Numerals should also be spelt out when used as follows: first, second, third, fourth, tenth, twentieth and so on.
- The word **Figure** should be spelt out when used below a genus name in the body of the text and in the Figure caption. However, when figures are referred to within the text do not spell out and instead use fig. or figs.
- **Captions** to illustrations must be submitted separately at the end of the manuscript and should follow this example:

  Figure 1. *Storthyngurella hirsuta* sp. nov., male, holotype: a, b, dorsal and lateral views of body; c, d, frontal and lateral views of cephalon.
- **References** should be listed alphabetically at the end of the manuscript. Journal and book titles must be in full and italicised, with the year of publication, edition, page number, publisher and city of publication in roman. Authors should follow this example:

  Paulin, C.D. 1986. A new genus and species of morid fish from shallow coastal waters of southern Australia. Memoirs of Museum Victoria 47: 201–206.

  Last, P.R., and Stevens, J.D. 1994. *Sharks and rays of Australia*. CSIRO Publishing: Melbourne. 513 pp.

  Wilson, B.R., and Allen, G.R. 1987. Major components and distribution of marine fauna. Pp. 43–68 in: Dyne, G.R. and Watson, D.W. (eds), *Fauna of Australia Volume 1A General articles*. Australian Government Publishing Service: Canberra.
- **Reference citations** should use the following style:

  Paulin, 1986; Last and Stevens, 1994; Smith et al., 1990.
- In **taxonomic** papers, synonymies should be of the form: taxon, author, year, pages, figures. A period and dash must separate taxon and author except in the case of reference to the original description, e.g. *Leontocaris* Stebbing, 1905: 98–99.—Barnard, 1950: 699.
- **Supplementary information** (extended lists of material examined, databases, etc) should be submitted separately and with the final manuscript to be forwarded to referees. The Editorial Board encourages use of supplementary information to minimise the cost of printing as long as the requirements of the International Code of Zoological Nomenclature are met in the printed paper.

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Studies of Australian *Hydrobiosella* Tillyard: a review of the Australian species of the *Hydrobiosella bispina* Kimmins group (Trichoptera: Philopotamidae)

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Abstract

Cartwright, D.I. 2010. Studies of Australian *Hydrobiosella* Tillyard: a review of the Australian species of the *Hydrobiosella bispina* Kimmins group (Trichoptera: Philopotamidae). *Memoirs of Museum Victoria* 67: 1–13.

Descriptions and keys are provided for males of 12 philopotamid caddis fly species in the genus *Hydrobiosella* Tillyard, *H. bispina* group. Among these are ten new species from Australia: *Hydrobiosella bilga*, *H. dugarang*, *H. gurara*, *H. moorda*, *H. mundagurra*, *H. nandawar*, *H. thurawal*, *H. unispina*, *H. woonoongoora* and *H. yokunna*. Females of six of the species are also described. Group separation is based on male genitalic characteristics, the key features for the *H. bispina* group being inferior appendages with an elongate terminal segment, fringed ventrally by a row of dark setae, and nearly all species with paired, hooked lateral processes on segment ten. Of the 12 species treated here, all are endemic to the east coast region of the Australian mainland.

Keywords Trichoptera, caddis flies, Philopotamidae, Hydrobiosella, Australia

Introduction

Records of *Hydrobiosella* Tillyard in Australia are relatively recent; the genus was first described in 1924 for a New Zealand species, *H. stenocerca* Tillyard. Only in 1953 were the first Australian species recognised in the genus, with the transfer of the southern Western Australian species *H. michaelseni* (Ulmer 1908) from *Dolophilus* and description of *H. arcuata* Kimmins from southeastern Queensland, *H. bispina* Kimmins from New South Wales, and *H. cognata* Kimmins, *H. tasmanica* Mosely and *H. waddama* Mosely all from Tasmania (in Mosely and Kimmins, 1953). Subsequently, the following species were added: *H. letti* Korboot (1964) from New South Wales, *H. armata* Jacquemart (1965), *H. anasina*, *H. cerula*, *H. corinna*, *H. orba* and *H. sagitta* all from Tasmania (Neboiss, 1977), and *H. amblyopia* Neboiss (1982) from southern Western Australia. Neboiss (2003) added six more Tasmanian species, *H. anatolica*, *H. disrupta*, *H. otaria*, *H. propinqua*, *H. scalaris* and *H. tahunense*, bringing the total Australian species of *Hydrobiosella* to 20.

Ross (1956) recognised *Hydrobiosella* as a subgenus of *Sortosa* Navas, but during his work on Tasmanian caddis flies, Neboiss (1977) reinstated it to full species status. At the same time, he placed the Tasmanian species in three groups — the *H. corinna* group and the *H. tasmanica* group each with four species; and *H. waddama* with only one species. In 2003, Neboiss added a further six species to the *H. tasmanica* group, bringing the Tasmanian *Hydrobiosella* total to 15 species. Although the Tasmanian *Hydrobiosella* have been well studied, until now, little effort has been expended on the mainland Australian members of the genus — only five species are presently recorded. Among them, two in the group are being studied here: *H. arcuata* and *H. bispina*, and one of the new species described below was cited in a checklist as *Hydrobiosella* sp. nov. PT-2029 (Walker et al., 1995).

Henderson (1983), in his systematic study of New Zealand philopotamids, discussed the wider relationships between New Caledonian and Australian *Hydrobiosella* species. He found that synapomorphies of the New Zealand species of *Hydrobiosella* are not consistent in the known Australian species, thus concluding that the Australian species cannot be placed as a monophyletic group in his classification. Finally, he commented ‘too little is known at present for a full understanding of the relationships of this family’, especially ‘the lack of detailed information on the Australian and South American fauna …’ This present revision is the first of a series in which all the Australian *Hydrobiosella* groups will be revised. Once key characters of the different groups are identified, relationships of the Australian groups with other philopotamid groups, particularly species in New Zealand and New Caledonia, can be assessed.

In this taxonomic revision of the Australian *Hydrobiosella bispina* group, about 250 male and female specimens were examined and referred to 12 species. The most common species, *H. woonoongoora*, represented about 34% of the total specimens examined, *H. unispina* about 22% and *H. bispina* about 21%. Six of the 12 species are known from fewer than five specimens. The 12 species, including the ten new species, were collected from southern and eastern Australia. All except two species (from northeastern Queensland) are from the Bassian region, which is suggestive of a 'southern' origin, a thesis supported by the fact that the genus is known only from Australia, New Zealand and New Caledonia.

Methods and abbreviations

Among *Hydrobiosella* species — size, body and wing colour can be useful characters, but are variable. Colour can be a useful character in live or freshly preserved material but, with time, it often fades in alcohol. All the *H. bispina* group specimens were stored in alcohol, and many for over 20 years. Most of the material studied was on loan from Museum Victoria and made available by Dr Arturs Neboiss. Depositories for specimens are abbreviated as follows: Museum Victoria, Melbourne (NMV), Australian National Insect Collection, Canberra (ANIC) and the Natural History Museum, London (BMNH). All specimens mentioned in the text, including types, are lodged in the NMV unless stated otherwise.

Males of each species are readily distinguished by genitalic features, but often require clearing of the abdomen in potassium hydroxide. Females were paired with respective males on the basis of similarities in size and colouration, and on locality.

Figured specimens are identified by the notebook numbers of Dr Arturs Neboiss (prefix PT-) or the author (prefix CT-). Terminology generally follows that of Neboiss (1977, 1982), Blahnik (2005) and Holzenthal et al. (2007). However, past authors have used a variety of names for the same structures as outlined by Muñoz-Quesada and Holzenthal (2008, p. 8). For example, in this study, 'harpago' is used instead of apical or terminal segment of the inferior appendages, and 'preanal appendage' is used instead of superior appendage or cercus. Abbreviations for genitalic parts are indicated on selected figures. Typically, setae or spines are illustrated only on the right side of the figure (as viewed) to enable a better depiction of the underlying structures. Length and width measurements generally refer to the maximum length divided by maximum width.

Descriptions

Hydrobiosella Tillyard

Hydrobiosella Tillyard 1924: 288; Mosely and Kimmins 1953: 387; Neboiss 1977: 45.

Type species. *Hydrobiosella stenocerca* Tillyard by monotypy.

Generic descriptions are given by Tillyard (1924: 288), Mosely and Kimmins (1953: 387) and Neboiss (1977: 45).

Key to males of known Australian groups (or ungrouped species) of *Hydrobiosella* Tillyard

1. Phallus without pair of parameres (Neboiss 1986, figs pp. 99; *H. amblyopia*, 101; *H. armata*, *H. tasmanica*, 102; *H. orba*, *H. corinna*) 2
– Phallus with pair of parameres (Neboiss 1986, figs pp. 99; *H. michaelseni*, *H. waddama*, 101; *H. letti*, 102; *H. bispina*, 103; *H. arcuata*) 4
2. Preanal appendages present, usually small (Neboiss 1977, figs 204–211; Neboiss 1986, figs p. 102 *H. orba*, *H. corinna*; Neboiss 2003, figs 8a–h); Tas .. *H. corinna* group
– Preanal appendages absent (Neboiss 1986, figs pp. 99 *H. amblyopia*, 101 *H. armata*, *H. tasmanica*) 3
3. Phallus apically with downward projecting spine(s) (Neboiss 1977, figs 216–221, 225, 226; Neboiss 1986, figs p. 101 *H. armata*, *H. tasmanica*; Neboiss 2003, figs 10a–g, 11a–g, 12a–f); Tas .... *H. tasmanica* group
– Phallus apically without downward projecting spine(s) (Neboiss 1982, fig. 12; Neboiss 1986, figs p. 99 *H. amblyopia*); S-WA .... *H. amblyopia* (ungrouped)
4. Inferior appendages with harpago with dark row of setae forming fringe along ventral margin (figs 2–4; Neboiss 1986, figs pp. 102 *H.bispina*, 103 *H. arcuata*); E-Vic, E-NSW, E-Qld .... *Hydrobiosella bispina* group
– Inferior appendages with harpago without dark row of setae forming fringe along ventral margin (Neboiss 1986, figs pp. 99 *H. michaelseni*, *H. waddama*, 101 *H. letti*) 5
5. Parameres elongate and sinusoidal, attached ventrally to base of phallus (Neboiss 1977, fig. 233; Neboiss 1986, figs p. 99 *H. waddama*; Neboiss 2003, figs 12g, h); Tas, SE Aust. .... *H. waddama* (group — only one species described)
– Parameres not elongate and sinusoidal, not attached ventrally to base of phallus (Neboiss 1982, figs 9, 10; Neboiss 1986, figs pp. 99 *H. michaelseni*, 101 *H. letti*) 6
6. Parameres curved strongly and crossed (Neboiss 1982, figs 9, 10; Neboiss 1986, figs p. 99 *H. michaelseni*); S-WA .... *H. michaelseni* (ungrouped)
– Parameres not curved strongly and crossed (Neboiss 1986, figs p. 101 *H. letti*); CE-NSW ... *H. letti* (ungrouped)

Hydrobiosella bispina group

Diagnosis. Key features of males in the group are inferior appendages with the harpago elongate, often angled near middle, with a dark row of setae forming a fringe along ventral margin; segment X with a pair of lateral lobes, which usually end in small hooks.

Description. Head and nota dorsally brown to dark brown with setal warts and scutellum pale, abdomen brownish dorsally and ventrally, paler laterally; wings light brown to brown. Medium sized adults. Forewing length, males: 5.9–8.8 mm; females: 6.1–8.7 mm; forewing length about 2.9–3.0 times maximum width, wing venation similar to the type species *H. stenocerca*, R1 simple, forks 1, 2, 3, 4 and 5 present; forks 1 and 2 sessile; fork 2 with nygma, about 1.6–1.7 times length fork 1; fork 3 shorter, length 0.6–0.7 times length fork 2, fork 3 length about

2.0 times length footstalk, cross-veins r–m and m contiguous or nearly meeting at fork 3; fork 4 similar length to fork 3, fork length about 4 times length footstalk; fork 5 very long, length between 1.7–1.8 times length fork 4; discoidal cell closed, length about 4.5 times maximum width. Hind wing length about 2.5–2.6 times maximum width, with forks 1, 2, 3 and 5 present; fork 1 usually sessile, occasionally with very short footstalk; fork 2 sessile, nygma present, fork 2 length between 1.3–1.4 times fork 1 length; fork 3 length about 0.5–0.6 times fork 2 length, fork 3 similar length to footstalk; fork 5 very long, length between 2.1–2.2 times length fork 3; discoidal cell closed, length between 4.5 times maximum width; with three anal veins (fig. 1).

Male. Segment IX usually with a small rounded notch medially on ventrodistal margin (figs 7, 13), rarely without (figs 10, 19). Preanal appendages absent. Segment X mainly sclerotised with a central pale, mostly membranous mesal lobe, with one or two pairs of short hairs subapically (figs 5–6); with a pair of more pigmented lateral lobes, which usually end in small hooks (figs 8–9). Phallus generally tube-like, slightly dilated subapically, with a pair of slender, straight or slightly curved parameres arising from the phallus basolaterally (figs 2–3, 5–6). Inferior appendages two segmented, in lateral view, basal segment robust, harpago more slender, straight to sharply angled near middle (figs 3, 6).

Female. Genitalia typical of genus, sometimes with a small projection, which can be diagnostic, on sternite VIII mesodistally (figs 38–49).

Larva. Confirmed larvae are unknown, although *Hydrobiosella* spp AV8 and AV15 (Cartwright, 1997) almost certainly belong to this group. *Hydrobiosella* sp. AV8 larvae have been recorded mainly in riffle habitats from small to medium streams 2–13 m wide at low to moderate altitudes between 70–1200 m (Suter et al. 2006). These larvae have the forecoxa with two sclerotised processes on the anterior margin and the anterior margin of the frontoclypeus convex.

Remarks. The 12 species in this group are known from eastern mainland Australia, ranging from northeastern Queensland to eastern Victoria (latitudinal range 16°35'–37°18'S). Females of only six species have been associated.

Key to males of species of the Australian *Hydrobiosella bispina* group

1. Inferior appendages with harpago straight or with ventral margin forming a weakly obtuse angle (figs 3, 6) 2
– Inferior appendages with harpago neither straight nor with ventral margin forming a weakly obtuse angle, but forming almost a right angle (figs 21, 24, 36) 7
2. Segment X with a dorsal spine (Fig. 3); NE-Qld .... *H. unispina*
– Segment X without a dorsal spine (figs 6, 9) 3
3. Segment X without subapical, lateral pair of hooks (figs 5–6); CE-NSW .... *H. gurara*
– Segment X with subapical, lateral pair of hooks (figs 8–9, 11–12) 4
4. Segment X in dorsal view with apex rounded, slightly bulbous and dorsoventrally flattened (figs 8–9); NE-NSW .... *H. nandawar*
– Segment X in dorsal view with apex not rounded and dorsoventrally flattened, slender and laterally compressed (figs 11–12, 14–15) 5
5. Segment X with robust subapical, lateral pair of hooks, apex slender in lateral view (figs 11–12); NE-Qld .... *H. dugarang*
– Segment X without robust subapical, lateral pair of hooks, apex not slender in lateral view (figs 14–15, 17–18) 6
6. Inferior appendages with harpago dilated slightly in apical half (fig. 15); E-Vic .... *H. bilga*
– Inferior appendages with harpago not dilated slightly in apical half (fig. 18); C-Qld .... *H. mundagurra*
7. Parameres very long, reaching tip of inferior appendages (figs 20–21); E-NSW .... *H. bispina*
– Parameres not very long, not reaching tip of inferior appendages (figs 23–24) 8
8. Inferior appendages with harpago curved strongly in distal half so apex is pointing downwards (fig. 24); SE-Qld .... *H. arcuata*
– Inferior appendages with harpago not curved strongly in distal half so apex is pointing posteriorly (figs 27, 30) 9
9. Segment X in dorsal view with apex tapered gradually, not constricted sub-apically (fig. 26); CE-NSW .... *H. moorda*
– Segment X in dorsal view with apex not tapered gradually, constricted subapically (figs 29, 32) 10
10. Segment X in lateral view with apex slightly bulbous, not curved downwards; subapical, lateral pair of hooks directed outwards (figs 29–30); SE-Qld .... *H. woonoongoora*
– Segment X in lateral view with apex not slightly bulbous, curved slightly downwards; subapical, lateral pair of hooks directed downwards (figs 32–33, 35–36) 11
11. Inferior appendages with basal segment tapered strongly distally; harpago not dilated slightly in distal half (fig. 33); CE-NSW .... *H. thurawal*
– Inferior appendages with basal segment not tapered strongly distally; harpago dilated slightly in distal half (fig. 36); CE-NSW .... *H. yokunna*

Hydrobiosella unispina sp. nov.

Figures 2–4, 38–39

Holotype. Male, Queensland, Mt Spec State forest, Camp Ck trib., 18°57'S, 146°10'E, 760 m, 11 Jun 1994, A. L. Sheldon (NMV, T- 20893).

Paratypes. Queensland. 1 male (specimen PT-2029 figured), Mt

Spec, at light, 11 May 1975, R. Storey and D. Hancock; the following sites all Mt Spec State forest, 18°57'S, 146°10'E, A. L. Sheldon; 1 male, Birthday Ck above weir, 820 m, 6 Dec 1993; 1 male, Camp Ck proper, 760 m, 11 Jun 1994; 1 male, 1 female (specimen CT-635 figured), Camp Ck trib., 760 m, 15 May 1994; 1 male, same site, 5 Dec 1993; 1 male, 1 female, same site, 15 Mar 1994; 1 male, same site, 12 Dec 1993; 2 males, 1 female, same site, 6 Jul 1994, 1 male, same site, 6 Nov 1993; 1 male, same site, 23 Apr 1994; 2 males, same site, 21 Nov 1993; 1 male, same site, 20 Dec 1993; 1 male, same site, 15 Oct 1993; 1 male, same site, 4 Mar 1994 (NMV).

Other material examined. Queensland. 1 female, Upper Little Mossman R., Mt Lewis, 10 Dec 1974, M. S. Moulds; 1 male, 'top of the range', 19 Butler Drive, Kuranda, 335 m, 16°48'S, 145°38'E, 1–15 Feb 2007, D. C. F. Rentz (ANIC); the following sites all Mt Spec State forest, 18°57'S, 146°10'E, A. L. Sheldon: 1 male, 3 females, unnamed ck, Paluma Dam Rd, 860 m, 17 Jan 1994; 1 male, same site, 11 Jun 1994; 1 male, same site, 6 Jul 1994; 1 male, unnamed ck 'cascade', 920 m, 17 May 1994; 2 males, 'Confusion' Ck, trib. to unnamed ck, Paluma Res., 17 May 1994; 2 females, Birthday Ck above weir, 820 m, 20 Dec 1993; 2 males, 1 female, same site, 22 Oct 1993; 1 male, same site, 6 Nov 1993; 2 females, same site, 13 Nov 1993; 1 female, same site, 21 Nov 1993; 1 male, Birthday Ck below falls, 760 m, 11 Jun 1994; 1 male, Birthday Ck, Iron Cabin, 790 m, 12 Feb 1994; 1 male, Birthday Ck, 870 m, 16 Jan 1994; 2 males, 1 female, same site, 31 Oct 1993; 2 males, Williams Ck trib., 745 m, 13 Nov 1993; 2 males, same site, 15 May 1994; 1 female, Camp Ck trib., 760 m, 13 Dec 1993; 1 female, Echo Ck trib., 735 m, 7 Nov 1993 (NMV).

Diagnosis. *Hydrobiosella unispina* can be separated from other species in the group by the dorsal spine on segment X and segment IX produced into a triangular point medially on distal margin.

Description. Wings similar to those of *H. arcuata* (fig. 1), length of forewing: male 6.7–8.0 mm, female 7.2–8.7 mm.

Male. Segment IX without a noticeable notch on mesodistal margin, instead produced into a triangular point (fig. 4). Segment X with mesal lobe broadbased, dorsoventrally compressed in distal two-thirds, with a mesodorsal spine (figs 2–3); in dorsal view, subtriangular or tongue shaped, tapered distally, length about 2.3 times maximum width, with a pair of lateral lobes, without projecting hooks (fig. 2); in lateral view slender, downcurved in distal two-thirds (fig. 3). Inferior appendages in lateral view, with basal segment subrectangular, length about 1.8–1.9 times maximum width; harpago nearly as long as basal segment, more slender, length about 3.5 times width, weakly (obtusely) angled near middle (fig. 3).

Female. Genitalia typical of genus, with a small triangular projection on sternite VIII mesodistally (figs 38–39).

Etymology. *Unispina* — Latin for 'one spine' (spine on tergum X).

Remarks. *Hydrobiosella unispina* is a common species and has been collected mainly from the Mt Spec area of northeastern Queensland (latitudinal range 16°35'–18°57'S).

Hydrobiosella gurara sp. nov.

Figures 5–7

Holotype. Male (specimen CT-577 figured), New South Wales, Jerusalem Falls near Karuah (about 32°39'S, 151°57'E), 6 Dec 1988, G. Theischinger (NMV, T-20913).

Diagnosis. *Hydrobiosella gurara* can be separated from other species in the group by the absence of lateral subapical hooks on segment X and from *H. unispina* by the absence of a dorsal spine on segment X.

Description. Wings similar to those of *H. arcuata* (fig. 1), length of forewing: male 6.5 mm.

Male. Segment IX with a deep notch on mesodistal margin (fig. 7). Segment X with robust mesal lobe, broadbased, with a pair of pigmented lateral lobes, without hooks (figs 5–6); in dorsal view subtriangular, tapered slightly distally with a rounded apex (fig. 5). Phallus robust (fig. 6). Inferior appendages in lateral view, with basal segment subquadrate, length about 1.5 times maximum width; harpago longer than basal segment, length about 1.3–1.4 times length basal segment, slender, length about 5.5 times width, narrowed and weakly (obtusely) angled near middle, slightly dilated in apical third (fig. 6).

Female. Unknown.

Etymology. *Gurara* — Australian Aboriginal (New South Wales) word for 'long' or 'tall' (harpago on inferior appendages).

Remarks. The holotype male is the only specimen of *Hydrobiosella gurara* collected from the type locality in central-eastern New South Wales (latitude 32°39'S).

Hydrobiosella nandawar sp. nov.

Figures 8–10

Holotype. Male, New South Wales, Mt Kaputar, 30°16'S, 150°10'E, 3 Jan 1986, G. Theischinger (NMV, T-20914)

Paratype. New South Wales. 1 male (specimen CT-428 figured), Mt Kaputar Nat. Pk, Dawson Springs, 9 Oct 1973, A. Neboiss (NMV).

Diagnosis. *Hydrobiosella nandawar* can be separated from other species in the group by the rounded, slightly bulbous and dorsoventrally flattened apex on segment X.

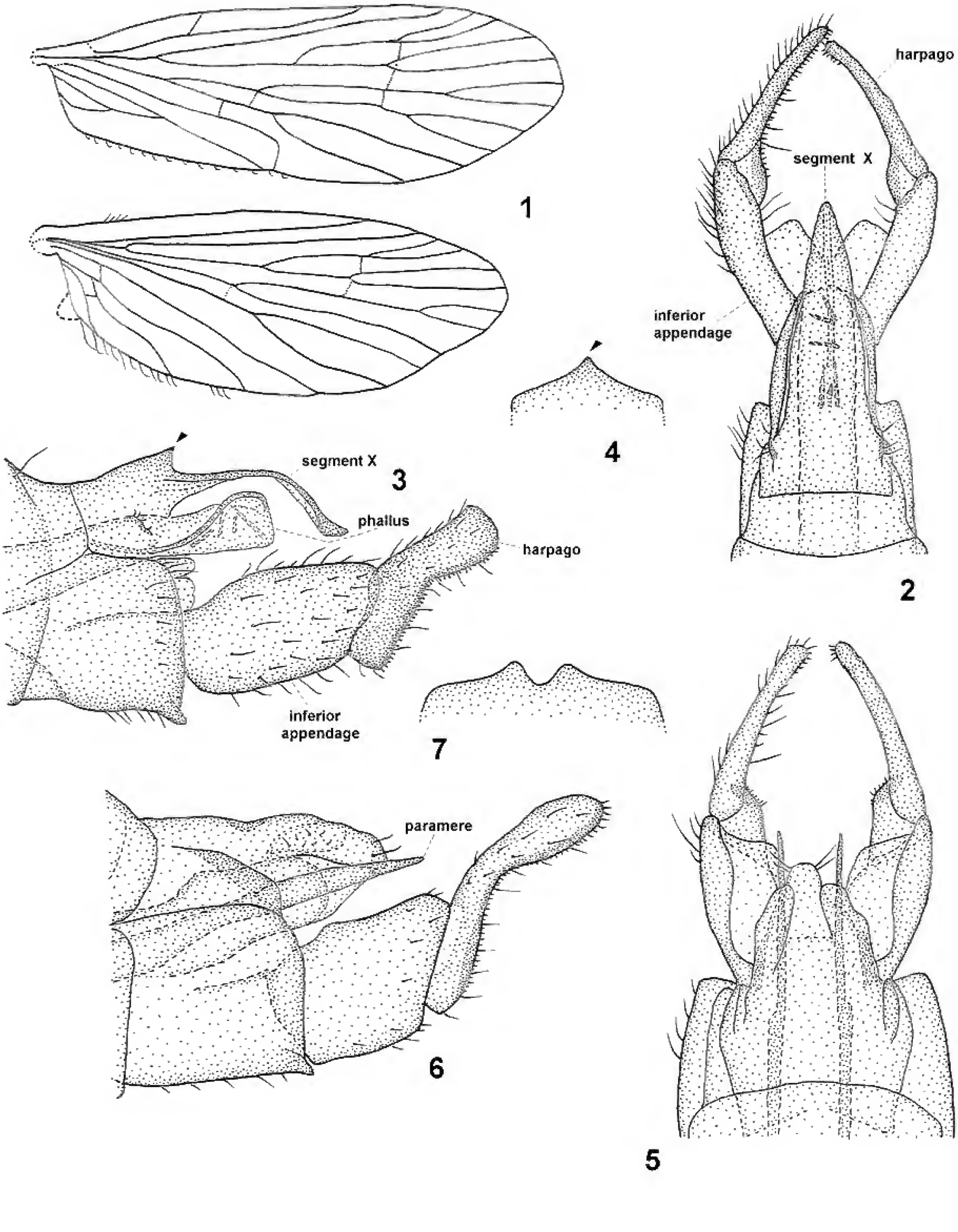
Description. Wings similar to those of *H.arcuata* (fig. 1), length of forewing: male 7.6–8.0 mm.

Male. Segment IX without a noticeable notch medially on distal margin (fig. 10). Segment X mesal lobe with distal third slightly dorsoventrally compressed (figs 8–9); in lateral view, distal third slender, straight (fig. 9); in dorsal view, distal third narrowed subapically, slightly bulbous and rounded apically (fig. 8), with a pair of pigmented lateral lobes, which terminate in small, slightly downward projecting hooks (figs 8–9). Inferior appendages in lateral view, with basal segment length about twice maximum width, broadest in basal third, tapered slightly distally; harpago shorter than basal segment, length about 0.8 times length basal segment, slender, length about 4.5 times width, weakly (obtusely) angled near middle (fig. 9).

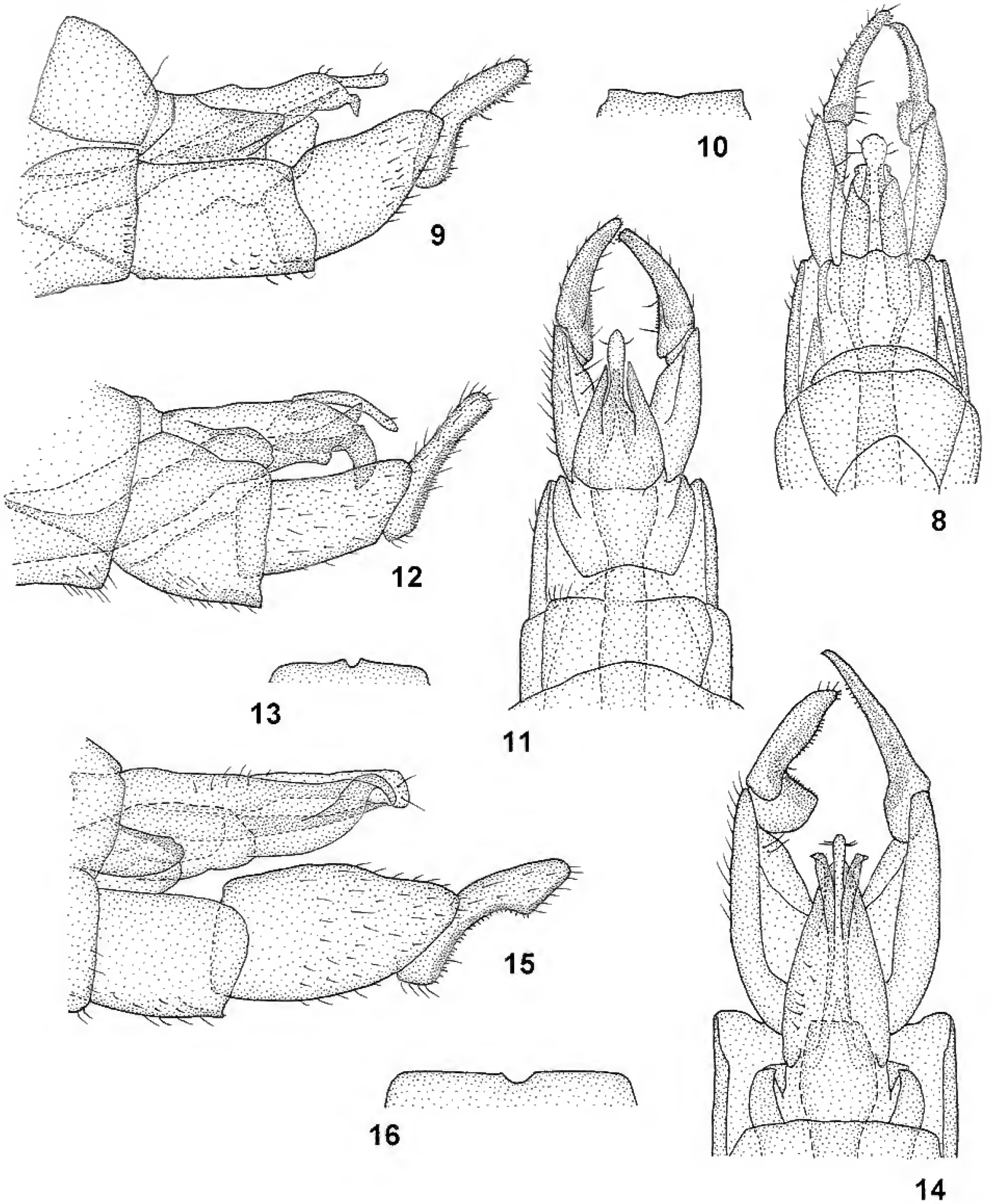
Female. Unknown.

Etymology. *Nandawar* – Australian Aboriginal name for 'Mt Kaputar' (type locality).

Remarks. Two male specimens of *Hydrobiosella nandawar* have been collected from the Mt Kaputar National Park in northeastern New South Wales (latitude 30°16'S).



Figures 1–7. *Hydrobiosella* spp.; 1, *Hydrobiosella arcuata* Kimmins, wings; 2–7, *Hydrobiosella* spp., male genitalia in dorsal, lateral and part ventral views; 2–4, *Hydrobiosella unispina* sp. nov.; 2, dorsal; 3, lateral; 4, ventral, mesodistal margin of segment IX; 5–7, *Hydrobiosella gurara* sp. nov.; 5, dorsal; 6, lateral; 7, ventral, mesodistal margin of segment IX.



Figures 8–16. *Hydrobiosella* spp. male genitalia in dorsal, lateral and part ventral views; 8–10, *Hydrobiosella nandawar* sp. nov.; 8, dorsal; 9, lateral; 10, ventral, mesodistal margin of segment IX; 11–13, *Hydrobiosella dugerang* sp. nov.; 11, dorsal; 12, lateral; 13, ventral, mesodistal margin of segment IX; 14–16, *Hydrobiosella bilga* sp. nov.; 14, dorsal; 15, lateral; 16, ventral, mesodistal margin of segment IX.

Hydrobiosella dugarang sp. nov.

Figures 11–13

Holotype. Male (specimen CT-560 figured), Queensland, Dalrymple Ck near Eungella, 21°02'S, 148°43'E, 3 Apr 1993, G. Theischinger (NMV, T-20915).

Diagnosis. *Hydrobiosella dugarang* can be separated from other species in the group by the robust subapical, lateral pair of hooks and slender apex, both on segment X in lateral view.

Description. Wings similar to those of *H.arcuata* (fig. 1), length of forewing: male 6.2 mm.

Male. Segment IX with a small notch medially on distal margin (fig. 13). Segment X with slender mesal lobe (figs 11–12); in lateral view, slightly downcurved apically (fig. 12); in dorsal view, slender, not narrowed subapically (fig. 11), with a pair of more pigmented lateral lobes, which terminate in robust, downward projecting hooks (figs 11–12). Inferior appendages in lateral view, with basal segment length about twice maximum width, broadest in basal half, tapered slightly distally; harpago about same length as basal segment, slender, straight, length about 5.7–5.9 times width (fig. 12).

Female. Unknown.

Etymology. *Dugarang* — Australian Aboriginal word for 'straight' (inferior appendages).

Remarks. The male holotype is the only known specimen of *Hydrobiosella dugarang* from the type locality in northeastern Queensland (latitude 21°02'S).

Hydrobiosella bilga sp. nov.

Figures 14–16

Holotype. Male, New South Wales, Nungatta Ck, Yambula State Forest (about 37°08'S, 149°29'E), 16–17 Feb 2000, J. Miller (ANIC).

Paratypes. New South Wales. 6 males, collected with holotype (ANIC). Victoria. 1 male (specimen CT-571 figured), Beehive Ck, 30 km N of Cann River, (about 37°18'S, 149°12'E), 21 Mar 1977, A. Neboiss (NMV).

Diagnosis. *Hydrobiosella bilga* can be separated from other species in the group by the combination of the slightly dilated apices and weakly obtuse angle on ventral margin of the harpago and the pair of subapical hooks on segment X.

Description. Wings similar to those of *H.arcuata* (fig. 1), length of forewing: male 7.3–8.4 mm. Forewing fork 2 long, length fork 2 about 1.5 times length of fork 1; length fork 3 about 1.9 times length footstalk; fork 4 length about 7 times length footstalk. Hind wing fork 1 sessile; fork 3 length about twice length of footstalk.

Male. Segment IX with a small shallow notch medially on distal margin (fig. 16). Segment X mesal lobe with a pair of short hairs/bristles subapically, slightly laterally compressed; in dorsal view slender, not narrowed subapically (fig. 14), with a pair of more pigmented lateral lobes, which terminate in small, slender, slightly outward and downward projecting hooks (figs 14–15). Inferior appendages in lateral view, with basal segment length about 1.8 times maximum width, broad basally, tapered slightly distally; harpago more slender, straight with slightly convex ventral margin, slightly dilated in apical third (fig. 15).

Female. Unknown.

Etymology. *Bilga* — Australian Aboriginal word for 'bee's nest' (type locality — Beehive Creek).

Remarks. Eight male specimens of *Hydrobiosella bilga* have been collected from the two localities in southeastern New South Wales and eastern Victoria (latitudinal range 37°08'–37°18'S).

Hydrobiosella mundagurra sp. nov.

Figures 17–19, 40–41

Holotype. Male, Queensland, Carnarvon Gorge Nat. Pk, 25°15'S, 148°24'E, 12 Nov 1990, G. Theischinger (NMV, T-20917).

Paratypes. Queensland. 5 males (specimen CT-575 figured), 15 females (specimen CT-607 figured), collected with holotype (NMV).

Other material examined. Queensland. 16 females, collected with holotype (NMV).

Diagnosis. *Hydrobiosella mundagurra* can be separated from other species in the group by the combination of harpago, which is straight and not dilated in distal half, and segment X with slender lateral pair of hooks and slender apex in dorsal view.

Description. Wings similar to those of *H. arcuata* (fig. 1), length of forewing: male 5.9–6.7 mm, female 6.5–8.7 mm. Forewing fork 2 long, length fork 2 about 1.5 times length of fork 1; fork 3 length about 1.6 times length footstalk; fork 4 length about 4.6 times length footstalk. Hind wing fork 1 with short footstalk; fork 3 length about 1.9 times length of footstalk.

Male. Segment IX without a noticeable notch medially on distal margin (fig. 19). Segment X mesal lobe with a pair of short hairs/bristles subapically, slightly laterally compressed; in dorsal view slender, not narrowed subapically (Fig. 17), with a pair of more pigmented lateral lobes, which terminate in small, slender, slightly outward and downward projecting hooks (figs 17–18). Inferior appendages in lateral view, with basal segment length about 1.9 times maximum width, broad basally, tapered slightly distally; harpago more slender, nearly straight (fig. 18).

Female. Genitalia typical of genus, with a small rounded projection on sternite VIII mesodistally (figs 40–41).

Etymology. *Mundagurra* — named for the Australian Aboriginal dreaming rainbow serpent believed to have created Carnarvon Gorge.

Remarks. Six males and many females of *Hydrobiosella mundagurra* have been collected from the type locality in central-eastern Queensland (latitude 25°15'S).

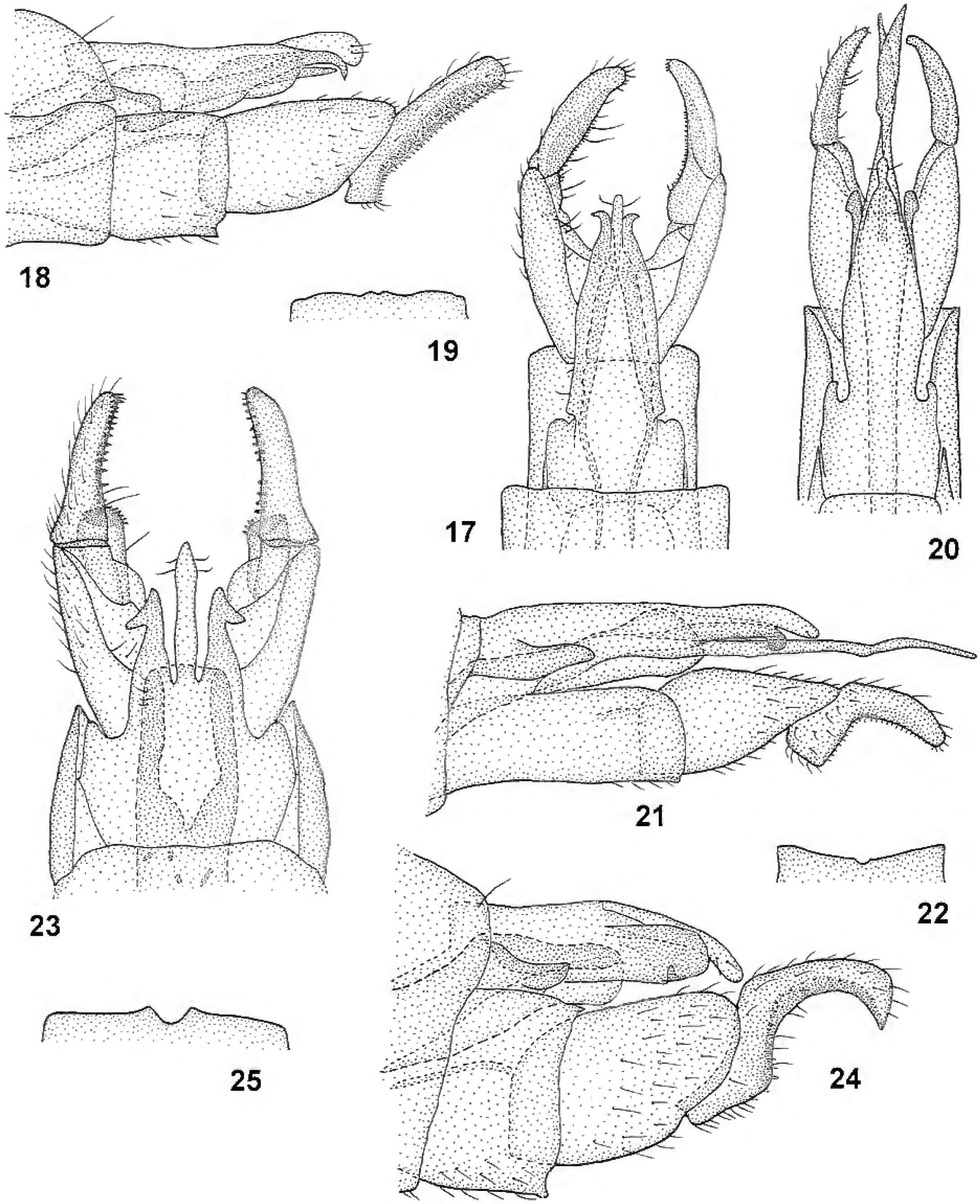
Hydrobiosella bispina Kimmins

Figures 20–22, 42–43

Hydrobiosella bispina Kimmins in Mosely and Kimmins, 1953: 394, fig. 270.—Neboiss, 1986: 102.

Type material (not seen). Holotype. Male, New South Wales, Stanwell Park, 23 Apr 1916, R. J. Tillyard (BMNH).

Paratype (not seen). New South Wales. 1 male, collected with holotype (BMNH).



Figures 17–25. *Hydrobiosella* spp. male genitalia in dorsal, lateral and part ventral views; 17–19, *Hydrobiosella mundagurra* sp. nov.; 17, dorsal; 18, lateral; 19, ventral, mesodistal margin of segment IX; 20–22, *Hydrobiosella bispina* Kimmins.; 20, dorsal; 21, lateral; 22, ventral, mesodistal margin of segment IX; 23–25, *Hydrobiosella arcuata* Kimmins; 23, dorsal; 24, lateral; 25, ventral, mesodistal margin of segment IX.

Material examined. New South Wales. 3 males, 6 females, Wilson R., Wilson R. Reserve, 11 Feb 2008, R. St Clair; 1 male, Wilson R., Bobs Ridge Rd, 31°15'S, 152°31'E, 4 Dec 2007, A. Glaister, J. Dean and R. St Clair; 1 male (specimen PT-579 figured), Tubrabucca, Barrington Tops, 15 Nov 1953, A. Neboiss (NMV); 2 males, 16 females, Dilgry R., Banksia camp ground, 31°53'S, 151°32'E, 2 Dec 2007, A. Glaister, J. Dean and R. St Clair; 3 males, 4 females, Gloucester R., Gloucester R. camping area, 32°03'S, 151°41'E, 1 Dec 2007, A. Glaister, J. Dean and R. St Clair; 1 male, 1 female (specimen CT-605 figured), Gloucester Tops, el. 1280 m, Malaise, 19 Nov to 4 Dec 1988, D. Bickle; 3 males, 1 female, Gloucester Tops, 32°04'S, 151°34'E, el. 1300 m, 2–3 Dec 1988, Theischinger and Mueller; 1 male, 1 female, Jerusalem Falls near Karuah, 6 Dec 1988, G. Theischinger; 1 male, 1 female, Wilson R. near Bellangry, 5 Dec 1988, G. Theischinger; 1 male, Wollomi Brook, The Basin, Olney State Forest, 33°06'S, 151°14'E, 26 Nov 2007, A. Glaister, J. Dean and R. St Clair (NMV).

Diagnosis. *Hydrobiosella bispina* can be separated from other species in the group by the very long parameres, which reach the tip of the inferior appendages.

Description. (Revised after Kimmins in Mosely and Kimmins, 1953.) Wings similar to those of *H.arcuata* (fig. 1), length of forewing: male 6.3–8.3 mm, female 7.2–8.6 mm. Forewing fork 2 long, length fork 2 about 1.5 times length of fork 1; length fork 3 about twice length footstalk; fork 4 length about 8 times length footstalk. Hind wing fork 1 sessile; fork 3 length about 1.5 times length of footstalk.

Male. Segment IX with small, shallow notch medially on distal margin (fig. 22). Segment X with a slender mesal lobe, with a pair of short hairs/bristles subapically, in lateral view slightly downturned distally (fig. 21); in dorsal view slightly narrowed subapically (fig. 20); with a pair of pigmented lateral lobes, which end in small, slightly downward and outward projecting rounded hooks (figs 20–21). Phallus generally slender, slightly dilated subapically; with a pair of very slender and elongate parameres arising from the phallus near the apex (fig. 21). Inferior appendages in lateral view, with basal segment length about twice maximum width, broadest near middle, tapered strongly distally; harpago more slender, with ventral margin sharply angled at about 90 degrees near middle, tapered slightly distally (fig. 21).

Female. Genitalia typical of genus, with a small, shallow, triangular projection on sternite VIII mesodistally (figs 42–43).

Remarks. Males and females of *Hydrobiosella bispina* have been collected from nine sites in addition to the type locality, all in eastern New South Wales (latitudinal range 31°15'–33°06'S).

Kimmins' (in Mosely and Kimmins 1953) and Neboiss' (1986) figures have been redrawn to allow direct comparisons and to accompany the description that is revised in light of new interpretations of *Hydrobiosella* genitalic structures.

Hydrobiosella arcuata Kimmins

Figures 1, 23–25, 44–45

Hydrobiosella arcuata Kimmins in Mosely and Kimmins, 1953: 397, fig. 271. —Neboiss, 1986: 103.

Type material (not seen). Holotype. Male, Queensland, Montville, 3 Oct 1912, R. J. Tillyard (BMNH).

Material examined. Queensland. 1 male, Booloumba Ck, 8 km SW Kenilworth, 26°39'S, 152°39'E, 12 Dec 1984, G. Theischinger; 1 male (specimen CT-573 figured), Booloumba Ck, Mary R. catchment, 26°41'S, 152°37'E, 26 Oct 1993, collector unknown; 1 male, 1 female, Branch Ck, Brisbane R. catchment, 26°52'S, 152°41'E, 26 Apr 1993; collector unknown; 1 male, 2 females (specimen CT-603 figured), Stony Ck, Brisbane R. catchment, 26°52'S, 152°43'E, 18 Aug 1992; collector unknown (NMV).

Diagnosis. *Hydrobiosella arcuata* can be separated from other species in the group by the shape of the harpago, where the ventral margin is curved or arched strongly so that the apex points downwards.

Description. (Revised after Kimmins in Mosely and Kimmins, 1953). Wings similar to other species in the group (fig. 1), length of forewing: male 6.3–7.3 mm, female 6.1–8.0 mm. Forewing fork 2 long, length fork 2 about 1.6 times length of fork 1; length fork 3 about twice length footstalk; fork 4 length about 4.5 times length footstalk. Hind wing fork 1 sessile or with very short footstalk; fork 3 length about 1.0–1.3 times length of footstalk.

Male. Segment IX with shallow notch medially on distal margin in between a pair of small knobs (fig. 25). Segment X with a slender mesal lobe, with a pair of short hairs/bristles subapically, in lateral view slightly downturned distally (fig. 24); in dorsal view not narrowed subapically (fig. 23), with a pair of more pigmented lateral lobes, which terminate in small, slightly backward and outward projecting hooks (figs 23–24). Phallus truncate apically, with a pair of robust parameres arising from the phallus subapically (fig. 24). Inferior appendages in lateral view, with basal segment length about 1.7 times maximum width, broad basally, rounded distally; harpago more slender, with ventral margin sharply angled near middle, curved in distal half with downward pointing acute apex (fig. 24).

Female. Genitalia typical of genus, with a small, shallow, rounded projection on sternite VIII mesodistally (figs 44–45).

Remarks. Males and females of *Hydrobiosella arcuata* have been collected from five sites in addition to the type locality, all in southeastern Queensland (latitudinal range 26°39'–26°52'S).

Kimmins' (in Mosely and Kimmins 1953) and Neboiss' (1986) figures have been redrawn to allow direct comparisons and to accompany the description that is revised in light of new interpretations of *Hydrobiosella* genitalic structures.

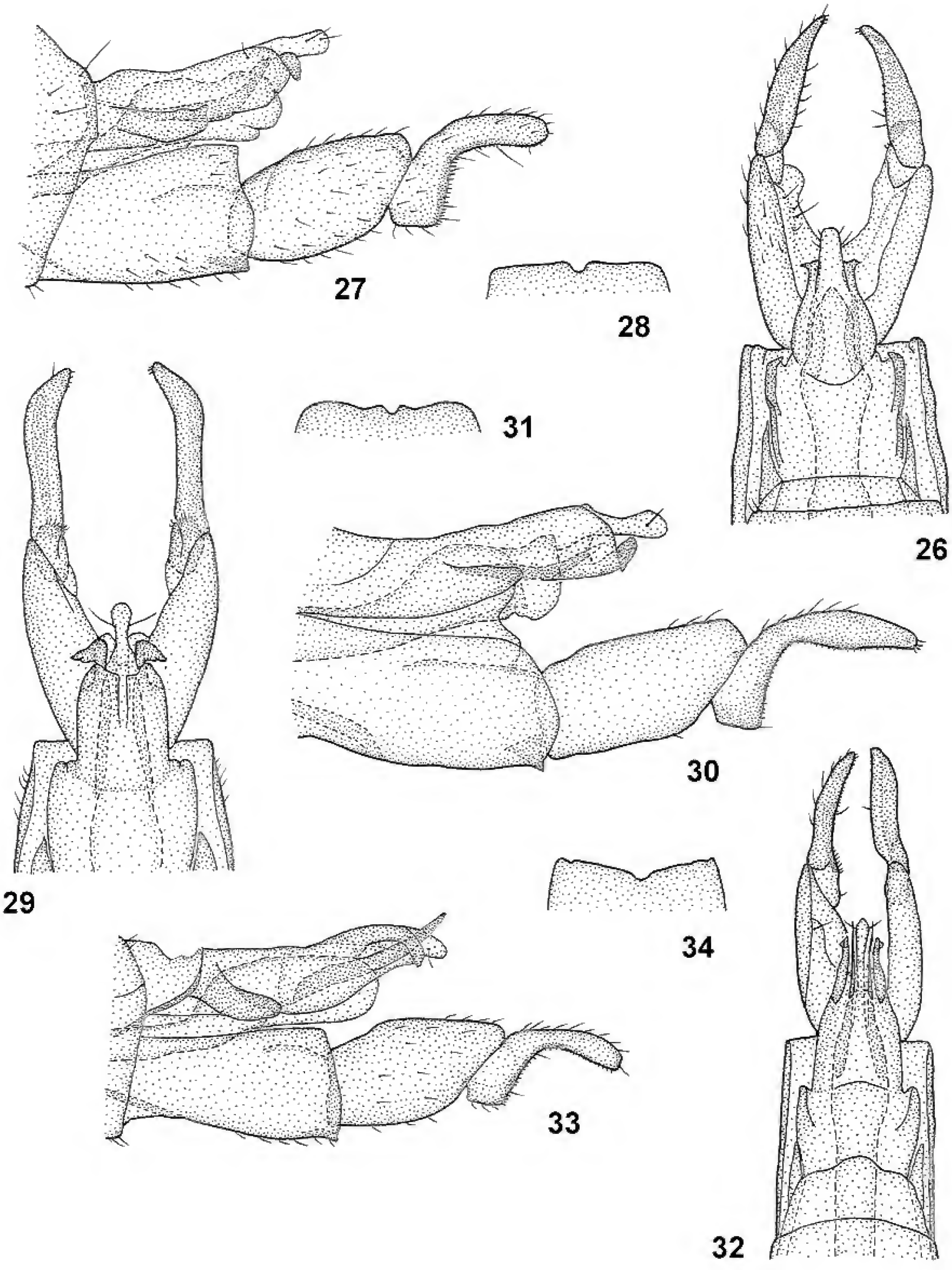
Hydrobiosella moorda sp. nov.

Figures 26–28

Holotype. Male, New South Wales, (about 33°41'S, 150°17'E), Pulpit Hill Ck, Megalong Valley, 8 Oct 1985, A. Neboiss (NMV, T-20938).

Paratypes. New South Wales. 2 males (specimen PT-1421 figured), collected with holotype (NMV).

Diagnosis. *Hydrobiosella moorda* can be separated from other species in the group by the combination of segment X in dorsal view with a robust, gradually tapered apex, not constricted subapically, and the ventral margin of the harpago sharply angled at about 90 degrees near middle with apex pointing posteriorly.



Figures 26–34. *Hydrobiosella* spp. male genitalia in dorsal, lateral and part ventral views; 26–28, *Hydrobiosella moorda* sp. nov.; 26, dorsal; 27, lateral; 28, ventral, mesodistal margin of segment IX; 29–31, *Hydrobiosella woonoongoora* sp. nov.; 29, dorsal; 30, lateral; 31, ventral, mesodistal margin of segment IX; 32–34, *Hydrobiosella thurawal* sp. nov.; 32, dorsal; 33, lateral; 34, ventral, mesodistal margin of segment IX.

Description. Wings similar to those of *H.arcuata* (fig. 1), length of forewing: male 8.0–8.8 mm. Forewing fork 2 long, length fork 2 about 1.5 times length of fork 1; length fork 3 about 1.5 times length footstalk; fork 4 length about 5.3 times length footstalk. Hind wing fork 1 sessile; fork 3 length about 1.3–1.4 times length of footstalk.

Male. Segment IX with a small shallow notch medially on distal margin (fig. 28). Segment X with a robust mesal lobe, with a pair of short hairs/bristles subapically, in lateral view not downturned distally (fig. 27); in dorsal view, tapered slightly distally, not narrowed subapically (fig. 26); with a pair of more pigmented lateral lobes that end in small, slightly downward and outward projecting hooks (figs 26–27). Inferior appendages in lateral view, with basal segment length about 1.9 times maximum width, broadest near middle, rounded distally; harpago more slender, ventral margin sharply angled at about 90 degrees near middle (fig. 27).

Female. Unknown.

Etymology. Moorda — Australian Aboriginal word for 'blue mountain' (type locality — Blue Mountains).

Remarks. Three male specimens of *Hydrobiosella moorda* have been collected from the type locality in central-eastern New South Wales (latitude 33°41'S).

Hydrobiosella woonoongoora sp. nov.

Figures 29–31, 46, 47

Holotype. Male, New South Wales, Upper Crystal Ck at Crystal Ck rainforest retreat, 28°15'S, 153°18'E, 25 Dec 2006, A. Wells (ANIC).

Paratypes. New South Wales. 20 males, 16 females (specimen CT-636 figured), collected with holotype (ANIC). Queensland. 4 males (specimen CT-567 figured) Coomera Ck, Lamington Nat. Pk, 8 Feb 1961, F. A. Perkins (NMV).

Other material examined. New South Wales. 12 males, collected with holotype (ANIC); 1 male, 4 females, same site and collector, 26 Dec 2006 (ANIC); 1 male, 1 female, same site and collector, 24 Dec 2006 (ANIC). Queensland. 4 females, Coomera Ck, Lamington Nat. Pk, 8 Feb 1961, F. A. Perkins; 4 males, 1 female, Lamington Nat. Pk, 28 Jan 1963, G. Monteith; 1 male, 1 female, Lamington Nat. Pk, 27 May 1959, collector unknown; 1 male (damaged), Binna Burra, 22 May 1964, B. Genn (NMV); 1 male, 1 female, Binna Burra, Lamington Nat. Pk, 750 m, 28°11'S, 153°11'E, 10 Nov 1988, E. S. Nielsen and M. Horak (ANIC); 4 males, 3 females, Binna Burra, 28°12'S, 153°11'E, Lamington Nat. Pk, 3–10 Nov 1984, E. D. Edwards; 1 male, 'Gwingamma', 6 km SW of Tallebudgera, 28°11'S, 153°23'E, 18–23 Apr 1994, Malaise trap, Rentz, Lee, Upton (ANIC); 2 males, Redwood Park, Toowoomba, 27°35'S, 151°59'E, 8 Nov 1988, E. S. Nielsen and M. Horak (ANIC).

Diagnosis. Hydrobiosella woonoongoora can be separated from other species in the group by small differences in segment X; the mesal lobe in has a slightly bulbous apex and the lateral lobes have apical hooks directed outwards.

Description. Head, body and wings brownish, some specimens paler. Wings similar to those of *H.arcuata* (fig. 1), length of forewing: male 6.4–8.1 mm, female 6.6–8.2 mm. Forewing fork 2 long, length fork 2 about 1.6 times length of fork 1; length fork 3 about 1.9 times length footstalk; fork 4 length about 4.6–5.4 times length footstalk. Hind wing fork 1 with very short footstalk; fork 3 length about twice length of footstalk.

Male. Segment IX with small shallow notch medially on distal margin (fig. 31). Segment X with mesal lobe slightly bulbous apically, with a pair of short hairs/bristles subapically, in lateral view not downturned distally (fig. 30); in dorsal view, narrowed slightly subapically (fig. 29), with a pair of pigmented lateral lobes, which terminate in small, outward projecting hooks (figs 29–30). Inferior appendages in lateral view, with basal segment length about twice width, broad basally, rounded distally; harpago more slender, with ventral margin sharply angled at about 90 degrees near middle, very slightly dilated in apical third (fig. 30).

Female. Genitalia typical of genus, with a small, rounded projection on sternite VIII mesodistally (figs 46–47).

Etymology. Woonoongoora — Australian Aboriginal word for the Lamington National Park ranges (type locality — Lamington National Park).

Remarks. Many male and female specimens of *Hydrobiosella woonoongoora* have been collected from five sites near the type locality in northeastern New South Wales and southeastern Queensland (latitudinal range 27°35'–28°15'S).

Hydrobiosella thurawal sp. nov.

Figures 32–34, 48–49

Holotype. Male, New South Wales, Minnamurra Falls (about 34°38'S, 150°44'E), ?12 Aug 1967, N. Hynes and joint collector unknown (NMV, T-20945).

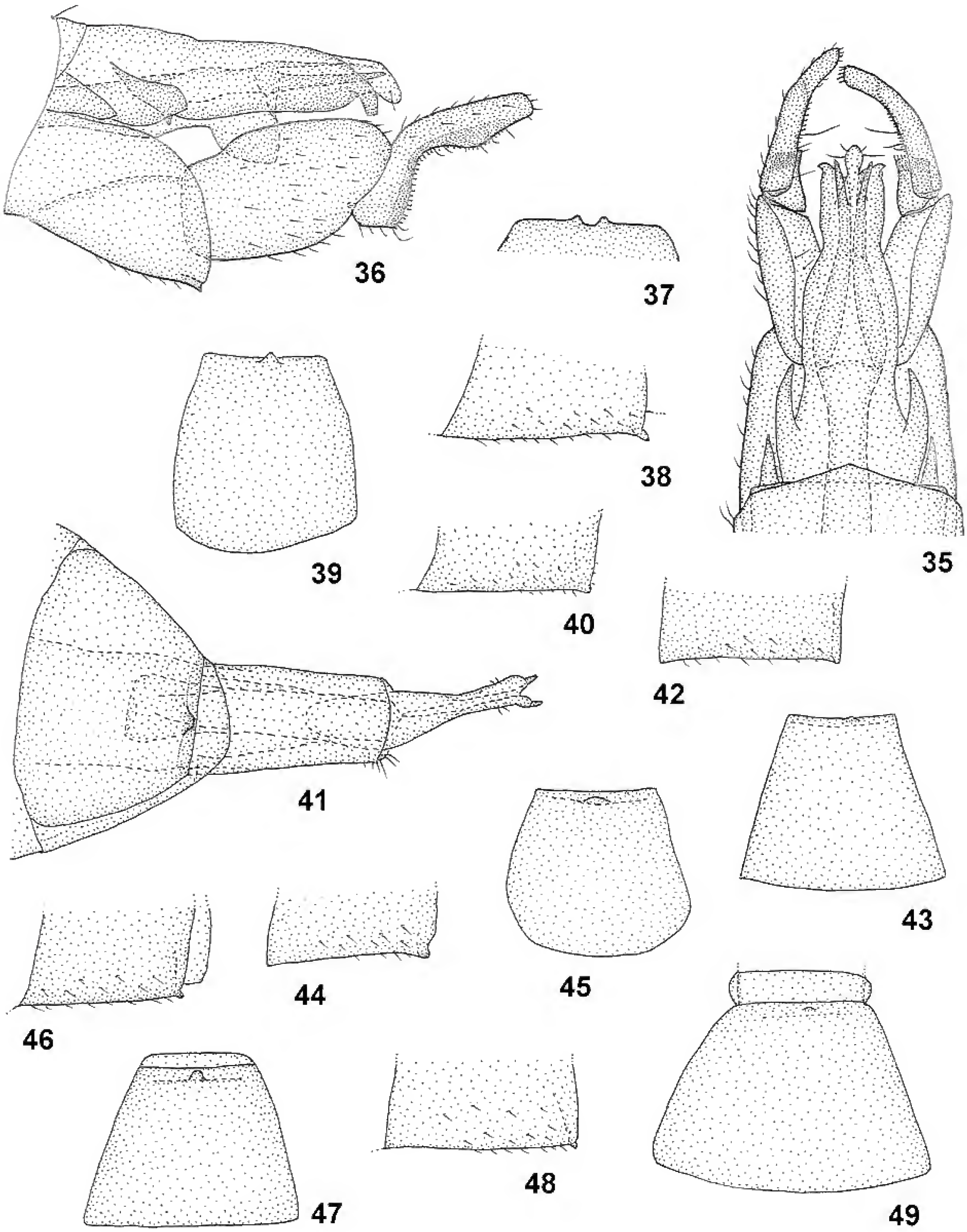
Paratype. New South Wales. 1 male (specimen PT-580 figured), 1 female (specimen CT-604 figured), Minnamurra Falls, W of Kiama, 25 Mar 1973, A. Neboiss (NMV).

Diagnosis. Hydrobiosella thurawal can be separated from other species in the group by small differences in segment X and the inferior appendages; segment X in lateral view, with apex not bulbous, curved slightly downwards; lateral lobes with apical hooks directed downwards and not outwards; inferior appendages with basal segment tapered strongly distally; harpago with ventral margin sharply angled at about 90 degrees, not dilated in distal half.

Description. Wings similar to those of *H.arcuata* (Fig. 1), length of forewing: male 6.9–8.5 mm, female 8.7 mm. Forewing fork 2 long, length fork 2 about 1.6 times length of fork 1; length fork 3 about twice length footstalk; fork 4 length about 5.8 times length footstalk. Hind wing fork 1 with very short footstalk; fork 3 length about 2.4 times length of footstalk.

Male. Segment IX with small, shallow notch medially on distal margin (fig. 34). Segment X mesal lobe, with a pair of short hairs/bristles subapically, in lateral view slightly downturned distally (fig. 33); in dorsal view, narrowed subapically, very slightly bulbous apically (fig. 32), with a pair of pigmented lateral lobes, which terminate in small, downward projecting hooks (figs 32–33). Inferior appendages in lateral view, with basal segment length about 1.8 times maximum width, broadest near middle, tapered distally, harpago more slender, ventral margin sharply angled at about 90 degrees near middle (fig. 33).

Female. Genitalia typical of genus, with a small, shallow projection on sternite VIII mesodistally (figs 48–49).



Figures 35–49. *Hydrobiosella* spp.; 35–37, *Hydrobiosella yokunna* sp. nov. male genitalia in dorsal, lateral and part ventral views; 35, dorsal; 36, lateral; 37, ventral, mesodistal margin of segment IX; 38–49, *Hydrobiosella* spp. female genitalia (part segment VIII) in lateral and (segment VIII) ventral view; 38–39, *Hydrobiosella unispina* sp. nov.; 38, lateral; 39, ventral; 40–41, *Hydrobiosella mundagurra* sp. nov.; 40, lateral; 41, female genitalia, ventral; 42–43, *Hydrobiosella bispina* Kimmins; 42, lateral; 43, ventral; 44–45, *Hydrobiosella arcuata* Kimmins; 44, lateral; 45, ventral; 46–47, *Hydrobiosella woonoongoora* sp. nov.; 46, lateral; 47, ventral; 48–49, *Hydrobiosella thurawal* sp. nov.; 48, lateral; 49, ventral.

Etymology. *Thurawal* — Australian Aboriginal name for the area around the type locality.

Remarks. Two males and one female specimen of *Hydrobiosella thurawal* have been collected from the type locality in central-eastern New South Wales (latitude 34°38'S).

Hydrobiosella yokunna sp. nov.

Figures 35–37

Holotype. Male (specimen CT-574 figured), New South Wales, Tuckers Knob, Orara West State Forest, 29°41'S, 152°48'E, 22 Nov 1990, G. Theischinger (NMV, T-20948).

Diagnosis. *Hydrobiosella yokunna* can be separated from other species in the group by small differences in segment X and the inferior appendages; segment X in lateral view, with apex not bulbous, curved slightly downwards; lateral lobes with apical hooks directed downwards and not outwards; inferior appendages with basal segment not tapered strongly distally; harpago with ventral margin sharply angled at about 90 degrees, dilated slightly in distal half.

Description. Wings similar to those of *H.arcuata* (fig. 1), length of forewing: male 6.9–8.5 mm. Forewing fork 2 long, length fork 2 about 1.5 times length of fork 1; length fork 3 about 1.5 times length footstalk; fork 4 length about 7.8 times length footstalk. Hind wing fork 1 with very short footstalk; fork 3 length about 1.2 times length of footstalk.

Male. Sternite IX with shallow notch medially on distal margin in between a pair of small knobs (fig. 37). Tergum X mesal lobe, with a pair of short hairs/bristles subapically, in lateral view slightly downturned distally (fig. 36); in dorsal view, narrowed subapically, slightly bulbous apically (fig. 35); with a pair of pigmented lateral lobes, which terminate in small, downward projecting hooks with slightly truncate apices (figs 35–36). Inferior appendages in lateral view, with basal segment length about 1.7 times maximum width, broadest near middle, rounded distally; harpago more slender, narrowed and with ventral margin angled at about 90 degrees near middle, slightly dilated in apical third (fig. 36).

Female. Unknown.

Etymology. *Yokunna* — Australian Aboriginal word for 'crooked' or 'bent' (terminal segment of inferior appendages).

Remarks. The holotype male is the only specimen of *Hydrobiosella yokunna* collected from the type locality in central-eastern New South Wales (latitude 29°41'S).

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A new species of *Paraulopus* (Aulopiformes: Paraulopidae) from seamounts of the Tasman Sea

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Abstract Gomon, M.F. 2010. A new species of *Paraulopus* (Aulopiformes: Paraulopidae) from seamounts of the Tasman Sea. *Memoirs of Museum Victoria* 67: 15–18.

A new species of the *Paraulopus nigripinnis* species complex of the family Paraulopidae is described from four specimens taken on seamounts and rises in the western, central and eastern parts of the Tasman Sea between 30° and 35°S. It is distinguishable from other members of the complex in having 8–9 anal fin rays; 19 pectoral fin rays; 48 vertebrae; 19–24 predorsal scales; 5.5 scales above the lateral line; a large pelvic fin (length 22.8–28.4% SL), distal margin of pelvic fin deeply concave, separating the fin into inner and outer lobes, with the inner lobe much shorter than the outer (the ratio of the lengths of the outer to the inner is 1.7–2.1); two prominent, broad brown bands on the side of the body posterior to the dorsal fin; a broad black marginal stripe covering the distal third of the dorsal fin, with a distinct broad white submarginal stripe; a white marginal band and a black submarginal band on the distal third of the upper lobe of the caudal fin; a black marginal band on the ventral lobe of the caudal fin; and the buccal cavity almost entirely black.

Keywords Paraulopidae, *Paraulopus*, sp. nov., Tasman Sea

Introduction

Scrutiny of museum specimens referrable to the recently described genus *Paraulopus* (Sato and Nakabo, 2002a) has revealed a surprising diversity in Australian and New Zealand waters (Sato and Nakabo, 2002b; Gomon and Sato, 2004; Sato *et al*., 2010). Members of this Indo-West Pacific genus are separable into two complexes: the Northern Hemisphere and tropical *Paraulopus oblongus* complex, and a *Paraulopus nigripinnis* complex — so far known only from cool tropical and temperate Australasian localities. Species of the latter were distinguished by Sato *et al*. (2010). Species in the Tasman Sea separating Australia and New Zealand usually occur, at least in part, at deep-shelf or upper-slope depths of one of the two countries. Several specimens of a previously undescribed species in the *P. nigripinnis* complex, first collected near Lord Howe Island, are known from seamounts and rises in the Tasman Sea, but apparently do not occur in Australian continental waters, and so far have not been taken within New Zealand's Exclusive Economic Zone. A description of that species is presented here.

Materials and methods

Terminology and methodology mostly follow Sato *et al*. (2010). The pelvic fin in species with a deeply concave distal margin are separated into distinct inner and outer lobes; the lengths of the lobes are measured from the base of the first pelvic fin ray to the tip of the longest ray of each lobe. Institutional codes are those of Leviton *et al*. (1985).

Paraulopus balteatus sp. nov. Banded cucumberfish

Figure 1; table 1

Material examined. Holotype: AMS I.44606-001 (320), Tasman Sea, Australia, New South Wales, Browns Mount off Botany Bay 34°02'S, 151°39'E (estimated), 430 m, 17 June 2008, drop line, FV *Blue Eye*, collected by Jurgen Konrad and retained by Pascal Geraghty, Department of Primary Industries, NSW Fisheries.

Paratypes: NMNZ P. 10455 (246), Three Kings Ridge, 30°45.00'S, 173°57.00'E, 537–677 m, 6 July 1962, RV Tui, beam trawl; NMNZ P. 35686 (278), Lord Howe Rise, 34°09.20'S, 162°51.80'E, 365–793 m, 16 September 1998, FV Arrow; NMV A22071 (305), Lord Howe Rise, 33°38'S–33°38'S, 162°21'E–162°28'E, 300–750 m, 22 March 2001, demersal trawl, Ken Smith, MAFRI.

Diagnosis. Anal fin rays 8–9; pectoral fin rays 19; vertebrae 48; predorsal scales 19–24; scales above lateral line 5.5; pelvic fin large, length 22.8–28.4% SL, larger in males than females, inner lobe much shorter than outer lobe, ratio of lengths of outer lobe to inner 1.7–2.1; sides with two prominent broad brown bands posterior to dorsal fin; broad black marginal stripe covering distal third of dorsal fin with distinct broad white submarginal stripe; distal third of upper lobe of caudal fin with white marginal band and black submarginal band and ventral lobe with black marginal band; buccal cavity pigmented black forward to jaws; males with black anal fin margin anteriorly and distally, anal fin of females lacking dark margins.

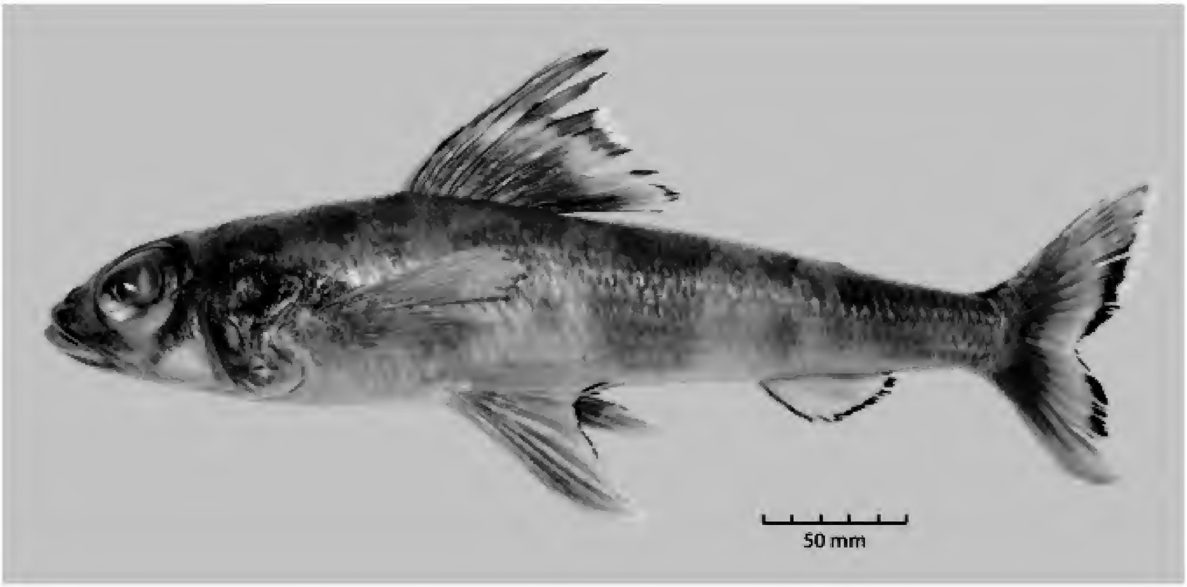

Figure 1. *Paraulopus balteatus* sp. nov., holotype, AMS I.44606-001, 320 mm SL, male, Tasman Sea, Australia, New South Wales, Browns Mount off Botany Bay 34°02'S, 151°39'E (est.), 430 m, photo by S. Humphreys (AMS).

Description. Dorsal fin rays 11; anal fin rays 9; caudal fin rays 1+8+1+9+8+1+8+1; pectoral fin rays 19; pelvic fin rays 9; vertebrae 19+29; lateral line scales 48–49; scales above lateral line 5.5; scales below lateral line 3.5; predorsal scales 19–24; gill rakers 8–9+18–20 = 27–28. (See table 1 for morphometric values).

Cigar-shaped body, tapering evenly to narrow caudal peduncle; anus about midway between pelvic-fin base and anal-fin origin. Head bluntly pointed, rather cylindrical, not depressed; dorsal outline of head and nape nearly straight in lateral profile; snout short. Nostrils ovoid, positioned midway between eye and tip of snout, subdivided by transverse flap of skin. Superocular ridge on either side above central half of eye. Eye large, positioned dorsolaterally, on dorsal profile of head. Posterior edge of preopercle smooth, curved at angle. Mouth terminal; dorsoposterior corner of maxilla below centre of eye. Teeth on jaws fine, in broad strip extending anteriorly onto lateral surfaces of premaxilla and dentary, tapering to narrow strip posteriorly. Vomerine teeth fine, in narrow transverse band, continuous with posteriorly tapering band of teeth on exposed edge of palatine; hyoid teeth fine, in ovoid patch on each side, axis angled anteromesially at anterolateral corner of tongue; teeth on lateral periphery slightly enlarged. Gill rakers on upper arm of first arch short; those on lower limb moderately long and slender, with one or two rudimentary rakers at both dorsal and ventral ends of arch.

Scales large, cycloid. Predorsal scales extending forward to vertical through posterior extent of eye. Cheek scales large, covering cheek and preopercle, in about three poorly defined rows. Lateral line positioned midlaterally on side, anterior end slightly elevated.

Dorsal fin moderately tall with short base, second ray longest but only slightly longer than first, subsequent rays decreasing in length; first two rays unbranched, subsequent rays branched; vertical through origin of fin closer to origin of pelvic fin than origin of pectoral fin; adipose fin small but obvious, positioned just in advance of vertical through posterior end of anal fin base. Anal fin short based, of moderate height, first ray shortest, length of subsequent rays subequal, first two unbranched, others branched; anal fin origin closer to base of tail than to origin of pelvic fin. Caudal fin distinctly forked, upper lobe slightly longer than lower. Posterior tip of pectoral fin reaching beyond origin of pelvic fin but not to vertical through centre of longest ray; fourth ray longest; first ray simple, others branched. Posterior tip of depressed pelvic fin reaching about halfway between pelvic fin origin and anal fin origin; posterior margin distinctly concave; inner ray distinctly shorter than fin length; first ray unbranched, others branched; tip of outer lobe of pelvic fin expanded into a fleshy, pad-like structure.

A large species, largest specimen examined 320 mm SL.

Pigmentation in alcohol. Body dusky dorsally, underside pale, with two broad brown bands encircling body except ventrally, first posterior to dorsal fin, second posterior to anal fin, and several broad brown blotches dorsally on side, one below posterior half of dorsal fin, second between bands (third just prior to caudal fin in paratypes). Snout, dorsal part of cheek and operculum very dark. Buccal lining of mouth black; tongue black with white tip and lateral margins. Dorsal fin dark brown basally with broad black marginal stripe occupying distal half (to third) of fin anteriorly, and broad white submarginal stripe. Adipose fin dusky. Anal fin white with narrow black margin anteriorly and distally in males; entirely white in females. Caudal fin dark basally with broad pale vertical intermediate

Table 1. Selected proportional measurements and counts for types of *Paraulopus balteatus* sp. nov.

	Holotype	Paratypes (*n* = 3)	
		Range	Mean ± SD
Standard length (mm)	320	246–305	
% SL			
Body depth	21.6	17.8–19.7	18.7±1.0
Body width	18.3	15.8–21.5	17.9±3.2
Head length	30.0	30.6–32.6	31.5±1.0
Caudal peduncle depth	8.1	5.8–7.6	6.9±0.9
Caudal peduncle length	19.6	20.2–21.8	20.8±0.8
Predorsal length	37.8	39.2–40.0	39.7±0.4
Preanal length	75.0	71.6–74.4	73.3±1.5
Prepectoral length	30.4	31.3–32.9	31.9±0.9
Prepelvic length	42.5	40.7–43.6	41.8±1.6
Preanus length	55.0	56.1–59.3	58.0±1.7
Pelvic fin origin to anus	15.2	16.4–19.1	17.6±1.4
Anus to anal fin origin	18.5	15.6–16.2	16.0±0.3
Dorsal fin base	15.1	12.8–15.0	14.1±1.1
Dorsal fin height	24.9	21.7–28.3	25.7±3.6
Dorsal fin last ray		8.0–17.0	12.5±6.4
Anal fin base	7.6	6.7–8.3	7.4±0.8
Anal fin height	7.5	5.9–9.7	8.4±2.2
Pectoral fin length	22.0	20.8–21.6	21.2±0.4
Pelvic fin length	26.5	22.8–28.4	26.2±3.0
Pelvic fin inner lobe length	15.1	12.6–14.9	13.8±1.2
Interpelvic width	15.0	13.3–16.1	14.2±1.6
% HL			
Head depth	57.8	49.7–53.1	51.8±1.8
Orbit diameter	34.9	36.1–38.8	37.7±1.4
Postorbital length	43.2	38.0–40.5	39.3±1.3
Head width	55.9	55.8–57.0	56.5±0.6
Interorbital width	10.9	9.5–11.0	10.2±0.8
Upper jaw length	44.5	43.1–43.8	43.5±0.4
Snout length	26.0	23.2–26.6	24.7±1.8
Adipose fin length	5.7	6.2–7.4	6.6±0.7
% pelvic fin length			
Pelvic fin inner lobe length	57.0	48.7–55.4	52.7±3.6

Meristic values	**Holotype**	**Range**
Dorsal-fin rays	11	11
Anal-fin rays	9	8–9
Pectoral-fin rays	19	19
Pelvic-fin rays	9	9
Gill rakers	8 + 19 = 27	8–9 + 18–20 = 27–28
Pored lateral-line scales	47	48–49
Scales above lateral line	5.5	5.5
Scales below lateral line	3.5	3.5
Predorsal scales	24	19–21
Vertebrae	19 + 29	19 + 29

HL = head length; SD = standard deviation; SL = standard length band and narrow white marginal band with black submarginal band on upper lobe and narrow black marginal band on dorsal two-thirds of lower lobe. Pectoral fin dusky. Pelvic fin rather dark with white margin on distal edge and distally along anterior edge; fine black distal edge (in males only).

Fresh colour. Body bluish-grey above with pearlescent white underside and iridescent blue sheen; bands and blotches brownish. Black markings on fins intensely so; other dark areas (described above) greyish. Pectoral and outer parts of pelvic fins shaded yellow.

Etymology. The name *balteatus*, from the Latin for 'belted or banded', in reference to the distinctive broad brown bands on the sides of the body in this species.

Distribution. Known only from the Tasman Sea at 30–35°S, from Browns Mount southeast of Botany Bay, New South Wales, to the Three Kings Ridge just north of the northern boundary of New Zealand's EEZ, in depths no shallower than 300 m and no greater than 800 m.

Comments. This species was initially confused with *Paraulopus okamurai* (Sato and Nakabo, 2002b), a closely related congener that occurs in the same area. It attains a similarly large size and has equally distinctive black-and-white-patterned dorsal and caudal fins. The pattern of the fins in *P. okamurai* is the basis for its New Zealand vernacular name, 'magpie cucumberfish'. The two are separable by details of the fin patterns, as well as the presence in the new species of prominent broad brown bands on the side of the body of adults (versus, at most, much smaller brown blotches midlaterally and a smaller brownish saddle behind the adipose fin), 8–9 anal fin rays (versus 9–11 rays, rarely 9), 19 pectoral fin rays (versus 16–17), and an entirely black interior of the mouth, except for the tongue, which has white at the tip and along the lateral edges (versus entirely pale). The same characteristics also separate *P. balteatus* from most other species in the complex. Its pectoral fin count overlaps only with *P. novaeseelandiae* (Sato and Nakabo, 2002b), which rarely has 19 rays; only *P. melanostomus* (Sato *et al*., 2010) has the buccal cavity completely lined with black, although the throat of some of the others is darkly pigmented. Many of the species, especially at a small size, have brownish spots or small blotches along the side, often horizontally aligned midlaterally, and like *P. novaeseelandiae* have a brownish saddle under or behind the adipose fin. None of those blotches, however, are expanded to broad bands that nearly encircle the side as in *P. balteatus*. The new species also has among the largest pelvic fins of the genus, the length of which is only matched by *P. longianalis* (Sato *et al*., 2010), and to some extent *P. novaeseelandiae*, but the inner lobe of the pelvic fin in *P. balteatus* is much shorter relative to the outer lobe than in the others (length of outer lobe relative to inner lobe 1.7–2.1 versus 1.3–1.7).

As in most other members of the *P. nigripinnis* complex, sexual dimorphism is quite apparent in this species, involving the size and colouration of the pelvic fins and pigmentation of the dorsal and anal fins. Males have a larger pelvic fin (length 26.5–28.4% SL, versus 22.8% SL in females), and the pigmentation of these fins is much darker in males with a fine black margin distally. Males also have a fine black margin anteriorly and distally on the anal fin that is missing in females, while the dorsal fin has a fine, stark white distal margin that does not appear to feature in females.

Despite the recent increase of collecting in central latitudes of the Tasman Sea, this species is known only from four large specimens, one of which was taken on hook and line. Its absence from trawl collections may infer a preference by the species for a hard-bottom habitat, which is usually avoided by trawl fishers. The fact that *P. nigripinnis, P. novaeseelandiae* and *P. okamurai* have also been taken with hook and line (Roberts, 1997, 2004; Stewart, 2006; Struthers, National Museum of New Zealand, pers. comm., March 2010) suggests that species of this genus are carnivorous. Individuals probably rest on their substantial pelvic fins waiting for potential prey to come to them — a behaviour common to a number of other members of the order.

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Taxonomic revision of the genus *Ratabulus* (Teleostei: Platycephalidae), with descriptions of two new species from Australia

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Abstract

Gomon, M.F. and Imamura, H. 2010. Taxonomic revision of the genus *Ratabulus* (Teleostei: Platycephalidae), with descriptions of two new species from Australia. *Memoirs of Museum Victoria* 67: 19–33.

The platycephlid genus *Ratabulus* Jordan and Hubbs, 1925 is reviewed taxonomically. The genus is defined by the long, slender canines on its upper jaw, palatine and vomer, the presence of a small free spine between the two dorsal fins, the iris lappet broad and simple dorsally, the suborbital ridge with numerous spines, the suborbitals and preopercle lacking sensory tubes in the cheek region, and lateral line scales with only a single pore posteriorly. Although the genus has been regarded as comprising only a single species, *Ratabulus diversidens* (McCulloch, 1914), this study presents descriptions of four: *R. megacephalus* (Tanaka, 1917) in southern Japan to the South China Sea, *R. diversidens* in eastern Australia, *R. fulviguttatus* sp. nov. in northwestern Australia and *R. ventralis* sp. nov. in northeastern Australia. *R. megacephalus*, having been regarded as a junior synonym of *R. diversidens*, is easily separable from that species in having more anteroventrally slanted oblique scale rows above the lateral line (94–112 versus 80–93). *R. fulviguttatus* sp. nov. is similar to *R. megacephalus* in having small dark spots dorsally on the body, but differs from it in having a shorter snout (30.4–34.8% HL versus 31.2–35.7% HL), longer pelvic fin (20.9–25.7% SL versus 19.5–23.1% SL), and a pale brown head and body (versus dark brown). Although *R. ventralis* sp. nov. resembles *R. diversidens* in having the nasal bone with tubercles, the former is distinguished from the latter and *R. megacephalus* by its longer pectoral fin (15.8–18.6% SL versus 13.9–17.0% SL). *R. diversidens* also differs from its three congeners in having larger brownish spots on the pelvic fin.

Keywords *Ratabulus*, revision, *Ratabulus fulviguttatus* sp. nov., *Ratabulus ventralis* sp. nov.

Introduction

Jordan and Hubbs (1925) proposed the genus *Ratabulus* for *Thysanophrys megacephalus* Tanaka, 1917 (the spelling *Rutabulus* also appeared in this publication, as described below), based on its possession of characters, such as canine-like upper jaw teeth. Matsubara and Ochiai (1955) redefined the genus using a greater variety of characters, including osteology, as seen in the configuration of the urohyal and pelvic bones. *Insidiator diversidens*, described by McCulloch in 1914, was subsequently referred to this genus (e.g. Sainsbury et al., 1985; Paxton et al., 1989; Hoese et al., 2006). Knapp (1999) synonymised *R. megacephalus* with *R. diversidens*, but some authors did not agree (e.g. Nakabo, 2002; Hoese et al., 2006). After examining specimens collected from the West Pacific Ocean and Australia in detail, we concluded that the genus comprises four species, including the northwest Pacific *R. megacephalus*, two new species from northwestern, and northeastern Australia, as well as *R. diversidens*, confined to southeastern Australia. We provide descriptions for all four and a key to distinguish between them.

Materials and methods

Counts and measurements were made according to Hubbs and Lagler (1958), and were routinely taken from the left side, except for gill rakers that were counted on the right side. A small detached spine at the origin of the first dorsal fin and another between the dorsal fins are expressed by separating the values with a '+', and were not included in the length of the first dorsal fin base. Pectoral fin counts follow the formula:

$$\begin{array}{c}\text{dorsal unbranched}\\+\\\text{intermediate branched}\\+\\\text{ventral unbranched rays}\end{array} = \text{total rays.}$$

The number of oblique scale rows above the lateral line is the number of diagonally angled scale rows slanting downward and forward (anteroventrally), or downward and backward (posteroventrally), which was counted just above the lateral line. Measurements of less than 100 mm were made with calipers to the nearest 0.1 mm; those 100 mm or more were recorded to an accuracy of three significant figures. Terminology of head spines follows Knapp et al. (2000). Institutional acronyms are from Eschmeyer (1998), except for Hokkaido University Museum, Hakodate (HUMZ) and National Museum of Nature and Science, Tokyo (NSMT). Standard and head lengths are abbreviated as SL and HL, respectively. In species descriptions, meristic and morphometric data for primary types are presented first, followed by the range in secondary or nontype material enclosed by parentheses where variations that deviate from the primary type value were observed. Color comparisons between species are based on preserved specimens. Collection localities of the four species of *Ratabulus* are shown in fig. 1.

Genus *Ratabulus*

(Figures 2–8)

Ratabulus Jordan and Hubbs, 1925: 286 (original description, type species: *Thysanophrys megacephalus* Tanaka, 1917).

Rutabulus Jordan and Hubbs, 1925: 93 (incorrect original spelling and unavailable name; see 'Remarks').

Diagnosis. A genus of Platycephalidae with I + VII to IX + 0 or I-10 to 12 dorsal fin rays (usually I + VIII + I-12); 11 or 12 anal fin rays (usually 12); 18–21 pectoral fin rays (usually 19 or 20); 52–56 pored lateral line scales; 1 + 5 to 8 gill rakers (usually 1 + 6 or 7); body depressed and elongate, mostly covered with ctenoid scales, some cycloid scales on undersurface; head flattened; postorbital region, opercle, interorbit and nape scaled; upper surface of eye without papillae or flaps; iris lappet usually broad and simple dorsally; interorbit moderately narrow and slightly concave; posterior margin of orbit lacking distinct pit; interopercular flap absent; moderate to long and slender canines on upper jaw, palatine, and in two separate patches on vomer; tooth band on upper jaw without distinct notch; lip margins without papillae; suborbital and preopercular sensory tubes absent on cheek; pored lateral line scales with a single exterior opening posteriorly; first dorsal fin originating slightly posterior to opercular margin; pectoral fin rounded posteriorly, its posterodorsal corner weakly pointed; innermost pelvic fin ray unbranched, others branched; fourth pelvic fin ray longest; and posterior margin of caudal fin slightly oblique, upper lobe longer.

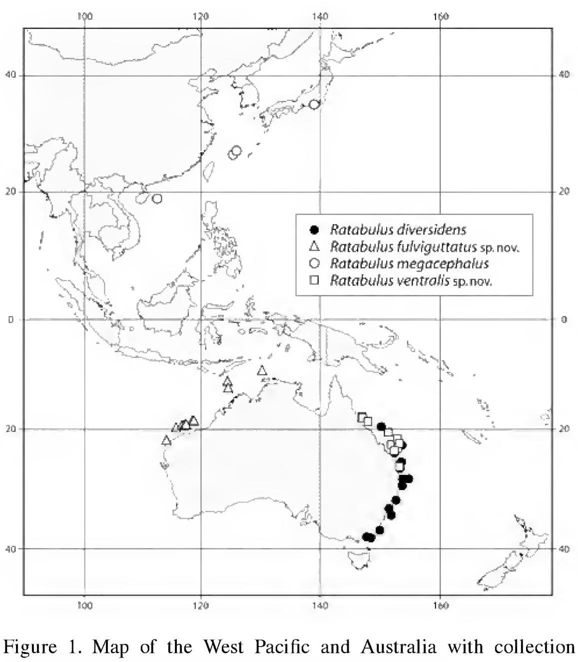

Figure 1. Map of the West Pacific and Australia with collection localities for specimens of four species of *Ratabulus*.

Remarks. The genus *Ratabulus* includes the following four species: *R. diversidens* from eastern Australia, *R. megacephalus* from the Northwest Pacific, *R. fulviguttatus* sp. nov. from northwestern Australia and *R. ventralis* sp. nov. from northeastern Australia. *Ratabulus* can be easily distinguished from other genera of Platycephalidae in usually having one small free spine between the dorsal fins, iris lappet usually broad and simple dorsally, suborbital ridge with many small to large spines, moderate to long and slender canines on the upper jaw, palatine and in two separate patches on the vomer, no sensory tubes from the suborbitals and preopercle in the cheek region, and pored lateral line scales with one posterior exterior opening.

Although Jordan and Hubbs (1925: 286) proposed the name *Ratabulus* for this genus, *Rutabulus* appeared in the list of new genera on an earlier page (96) of the same publication. As no-one has dealt with this discrepancy, we, as first revisers, consider *Ratabulus* to be the correct spelling, since it has been used by most subsequent authors (e.g. Matsubara and Ochiai, 1955; Paxton et al., 1989; Shao and Chen, 1993; Imamura, 1996; Kim et al., 2005; Knapp, 1999; Hoese et al., 2006). *Rutabulus*, therefore, is regarded as an incorrect spelling and an unavailable name (ICZN, 1999: Arts. 24.2.3, 32.4).

Key species of *Ratabulus*

1 Anteroventrally slanted oblique scale rows above lateral line 80–93; dorsal surface of head with large and pale to dark-brown spots of irregular shapes; pelvic fin with large brown spots .... *R. diversidens*

— Anteroventrally slanted oblique scale rows above lateral line 91–113; dorsal surface of head with small, round, brown spots; pelvic fin with small brown spots 2

2 Nasal bone with tubercles (fig. 4d); pelvic fin 19.5–25.7% SL; dorsal surface of body without spots .... *R. ventralis* sp.nov.

— Nasal bone without tubercles (figs 4b–c); pelvic fin 25.3–28.2% SL; dorsal surface of body with brownish or dark-brownish spots 3

3 Snout 30.4–34.8% HL; dorsal surface of head and body pale brown .... *R. fulviguttatus* sp. nov.

— Snout 31.2–35.7% HL; dorsal surface of head and body dark brown .... *R. megacephalus*

Table 1. Selected proportional measurements for specimens and types of four species of *Ratabulus* spp.

	R. diversidens			***R. megacephalus***	***R. fulviguttatus* sp. nov.**		***R. ventralis* sp. nov.**	
	Lectotype	Paralectotypes	Non-types	Non-types	Holotype	Paratypes	Holotype	Paratypes
	AMS E.2103	(n=2)	(n=23)	(n=23)	CSIRO H4031-79	(n=16)	CSIRO H6116-02	(n=11)
Standard length (mm)	**232**	**212, 245**	**54.4–391**	**83.4–344**	**262**	**140–266**	**304**	**172–328**
% Standard length								
Head length	38.0	36.5–39.3	36.5–41.0	37.3–41.8	39.2	37.6–42.0	37.7	38.4–41.2
Snout length	11.8	11.4–11.6	11.5–13.2	11.8–14.4	11.9	11.4–13.8	11.8	12.2–13.1
Orbital diameter	8.5	7.9–10.1	7.4–10.8	7.4–9.6	8.1	7.8–9.1	7.7	7.6–9.1
Interorbital width	2.7	3.0, [2]	1.8–3.7	2.0–3.0	2.4	2.1–2.7	2.7	2.4–3.1
Upper jaw length	13.8	13.4–14.2	13.0–15.4	13.5–16.0	14.1	13.6–15.3	13.3	13.8–15.3
Lower jaw length	20.5	19.9–21.1	19.9–23.5	20.2–25.1	21.8	21.2–23.6	20.7	21.4–22.9
Caudal peduncle depth	4.1	3.9–4.2	3.7–4.4	4.0–4.9	4.0	4.0–4.8	4.5	3.9–4.7
Caudal peduncle length	9.7	9.7–9.8	8.8–10.5	10.5–12.6	10.8	9.5–11.9	9.9	9.3–10.8
Predorsal length	38.6	37.7–40.5	37.7–40.8	39.0–42.1	40.1	39.0–43.2	39.4	39.3–42.0
First dorsal fin base length	17.8	17.7–18.8	16.8–19.2	13.8–18.1	18.8	17.3–19.5	18.6	15.2–19.6
Second dorsal fin base length	23.2	21.8–24.4	21.8–24.4	22.1–24.9	21.4	21.2–24.1	23.6	21.7–23.8
Length of first spine of first dorsal fin	1.1	1.0–1.1	0.7–1.6	0.7–2.1	0.7	0.5–1.4	1	0.8–1.6
Length of second spine of first dorsal fin	1	13.7–15.0	11.8–15.0	11.0–15.3	13.1	11.1–14.3	14.0	12.3–15.0
Length of first ray of second dorsal fin	10.6	10.7[2]	8.5–11.8	8.8–15.2	10.7	9.8–11.7	10.0	10.3–11.8
Anal fin base length	28.3	28.6–29.8	27.9–30.6	25.0–28.9	26.1	24.8–28.2	26.6	25.2–27.6
Length of first anal fin ray	6.4	6.1[2]	5.4–7.1	5.2–8.6	5.7	5.2–6.6	5.4	5.6–6.4
Pectoral fin length	14.3	14.1–14.5	13.9–15.8	13.9–17.0	16.3	14.6–16.5	17.3	15.8–18.6
Pelvic fin length	24.8	23.9–24.7	22.1–28.5	19.5–23.1	23.3	20.9–25.7	27.2	25.3–28.2
Caudal fin length	17.7	3	16.4–21.0	16.6–19.1	16.7	16.1–19.9	16.7	16.7–18.7
% Head length								
Snout length	31.0	29.5–31.1	29.5–32.3	31.2–35.7	30.4	30.4–34.8	31.3	30.9–32.4
Orbital diameter	22.3	21.6–25.6	19.7–26.5	19.2–22.8	20.6	19.8–22.4	20.5	19.3–22.4
Interorbital width	7.1	8.3[2]	4.5–9.7	5.1–7.8	6.1	5.0–6.9	7.2	6.0–8.0
Upper jaw length	36.4	36.0–36.8	34.2–38.4	34.5–38.4	36.0	35.1–37.4	35.2	35.1–37.1
Lower jaw length	53.9	53.8–54.5	53.6–57.4	53.3–60.1	55.7	55.7–58.5	54.9	54.4–56.4

[1] broken

[2] broken in smaller specimen

[3] broken in both specimens

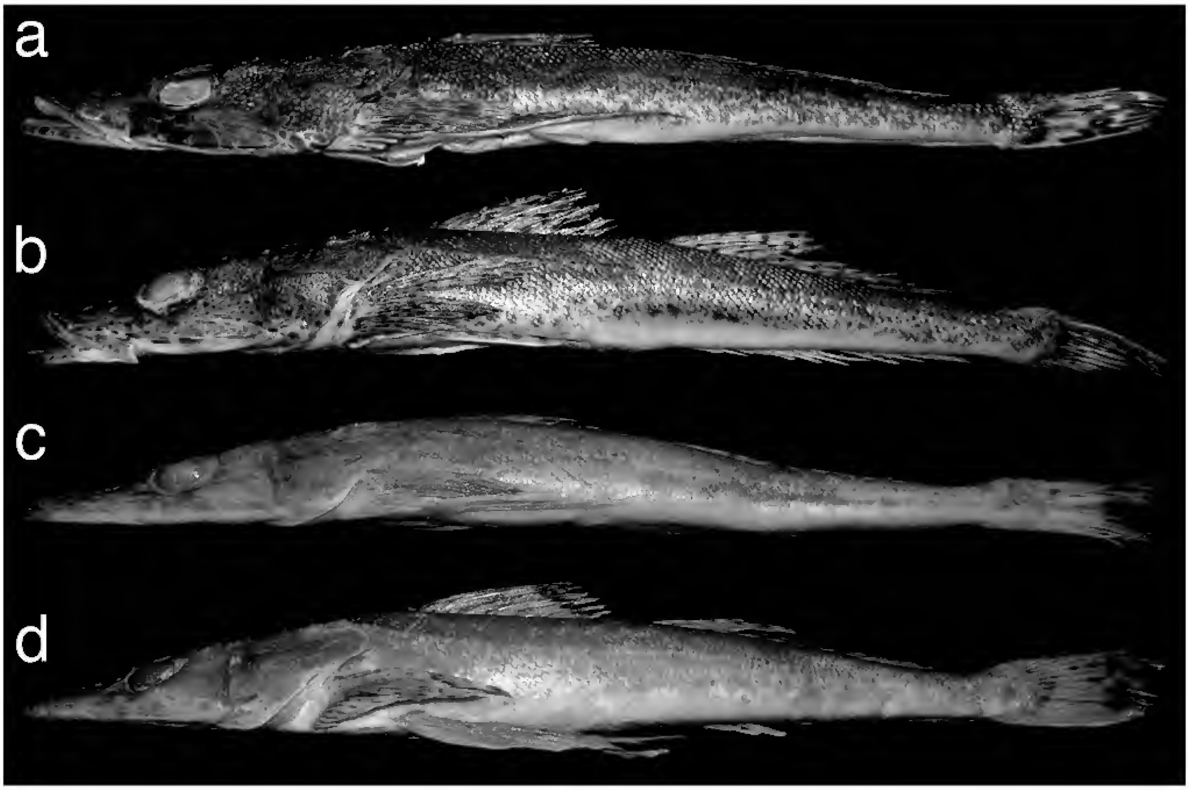

Figure 2. Lateral views of four species of *Ratabulus*: a, *R. diversidens*, AMS I.40494-001, 391 mm SL; b, *R. megacephalus*, HUMZ 200048, 344 mm SL; c, *R. fulviguttatus* sp. nov., CSIRO H4031-79, holotype, 262 mm SL; d, *R. ventralis* sp. nov., CSIRO H6116-02, holotype, 304 mm SL.

Ratabulus diversidens (McCulloch, 1914)

English name: Freespine flathead

(Figures 2a, 3a, 4a, 5a, 6a, 7, 8a)

Insidiator diversidens McCulloch, 1914: 148, fig. 13, pl. 31-fig. 1 (original description, type locality: 11 km northeast of Port Stephens Lighthouse, New South Wales, Australia); McCulloch, 1929: 403 (list and distribution, New South Wales, Australia)

Ratabulus diversidens: Paxton et al., 1989: 470 (list and distribution, Queensland to off Sydney, New South Wales, Australia) (in part); Knapp, 1999: 2410, unnumbered fig. (description, eastern Australia) (in part); Hoese et al., 2006: 944 (list and distribution, Queensland to off Sydney, New South Wales, Australia) (in part).

Lectotype (designated here). AMS E.2103, 232 mm SL, 11 km northeast of Port Stephens Lighthouse, New South Wales, 87 m, 10 November 1910, FIS Endeavour.

Paralectotypes. Two specimens. AMS E.1566, 212 mm SL and AMS I.11254, 245 mm SL, collected with lectotype.

Nontypes. Twenty-three specimens (54.4–391 mm SL) eastern Australia. AMS I.15523-010, 190 mm SL, off Brisbane, Queensland (26°31'S, 153°28'E), 137 m, 26 July 1968; AMS I.23993-003, 205 mm SL, Ballina-Tweed Heads, New South Wales (28°13'S, 153°52'E), 201 m, 17 August 1978, FRV *Kapala*; AMS I.25097-007, 2: 118–140 mm SL, east of Brunswick Heads, New South Wales (28°24'S, 153°51'E), 155–174 m, 3 June 1978, FRV *Kapala*; AMS I.25804-019, 278 mm SL, just north of Townsville, Queensland (17°51'S, 147°01'E), 260 m, 9 January 1986, RV *Soela*; AMS I.31332-001, 370 mm SL, off Wollongong, New South Wales (34°25'S, 152°00'E), 18–109 m, February 1991; AMS I.39088-001, 369 mm SL, 5–6 km offshore, North Head, New South Wales (33°17'S, 151°35'E), 65 m, 31 January 1999; AMS I.40494-001, 391 mm SL, off Crowdy Head, New South Wales (31°51'S, 152°45'E), 60–70 m, 2000; AMS I.45084-009, 2 of 5: 182–230 mm SL, northeast of Arrawarra Headland, New South Wales (29°30'S, 153°48'E), 7 May 1971, FRV *Kapala*; CSIRO H630-29, 273 mm SL, south of Saumarez Reef, Queensland (22°36'S, 153°50'E), 345–350 m depth, 17 November 1985, FRV *Soela*; CSIRO H630-30, 308 mm SL, collaboration with CSIRO H630-29; CSIRO H698-22, 295 mm SL, east of Bowen, Marian Plateau, Queensland (19°29.2'S, 150°16.5'E – 19°29.8'S, 150°17.8'E), 324–328 m, 15 November 1985, FRV *Soela*; CSIRO H4268-01, 204 mm SL, east of Pambula, New South Wales (36°54'S, 149°58'E – 36°55'S, 149°57'E), 42–43 m, 28 April 1996, FRV *Southern Surveyor*; NMV A15248, 290 mm SL, off Lakes Entrance, Victoria (38°07'S, 147°45'E), January 1995; NMV A15249, 283 mm SL, collaboration with NMV A15248; NMV A19471, 349 mm SL, off Lakes Entrance, Victoria (38°17'52²S, 148°33'34²E), 90–156 m, 22 October 1997; QM I.2117, 313 mm SL, east of Tweed Heads, New South Wales (28°12'S, 154°54'E), 235 m, 27 July 1982;

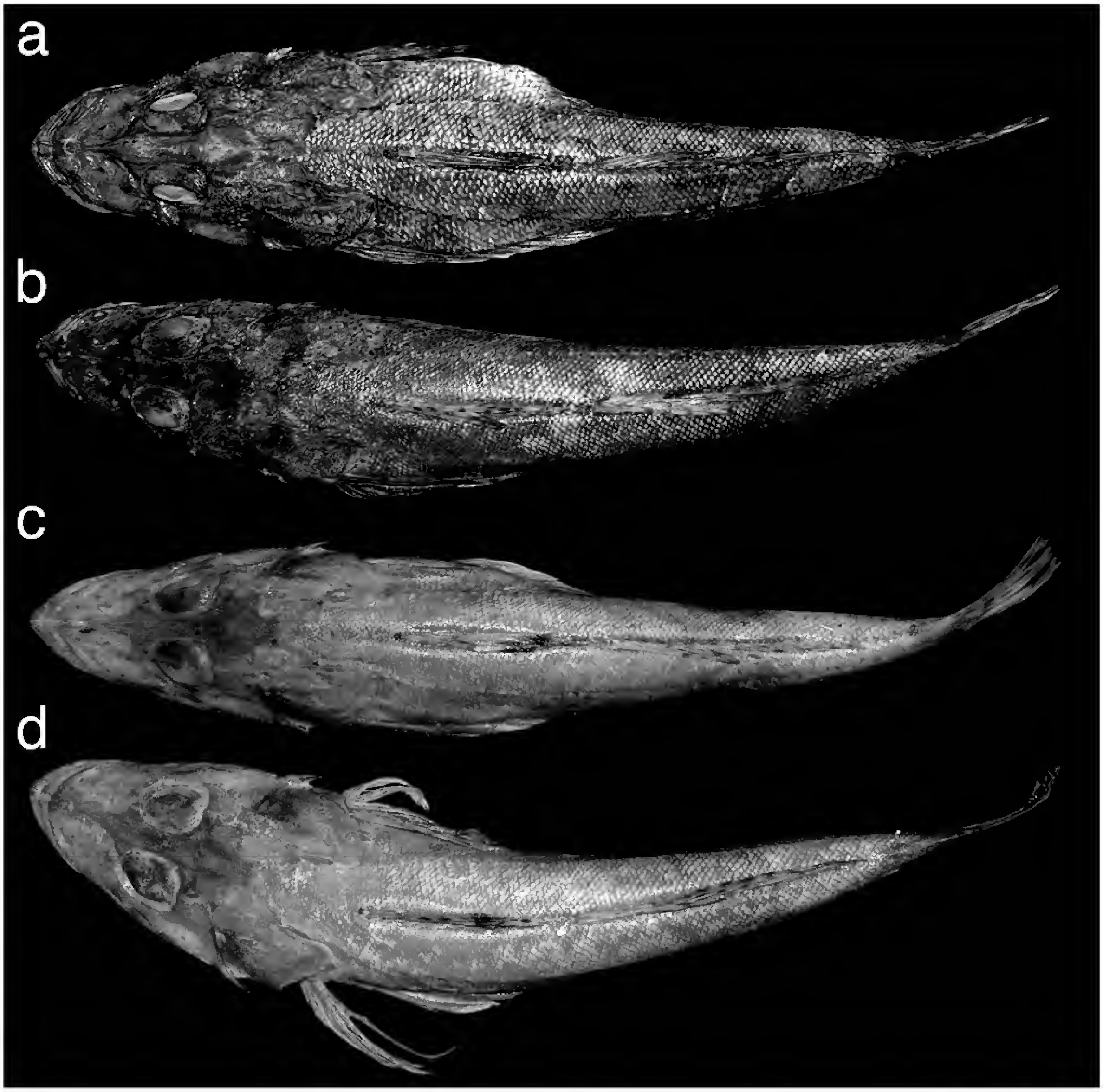

Figure 3. Dorsal views of four species of *Ratabulus*: a, *R. diversidens*, AMS I.40494-001, 391 mm SL; b, *R. megacephalus*, HUMZ 200048, 344 mm SL; c, *R. fulviguttatus* sp. nov., CSIRO H4031-79, holotype, 262 mm SL; d, *R. ventralis* sp. nov., CSIRO H6116-02, holotype, 304 mm SL.

QM I.18698, 215 mm SL, Queensland (25°27'S, 153°46'E – 25°17'S, 153°43'E), 183–230 m, 14 September 1980; QM I.18813, 2: 203–252 mm SL, Queensland (23°50'S, 152°36'E – 23°46'S, 152°32'E), 238–274 m, 23 September 1980; QM I.26624, 274 mm SL, east of Fraser Island, Queensland (26°S, 153.3°E), 30 m, 16 May 1990; QM I.34240, 2: 54.4–144 mm SL, southeast of Cape Moreton, Queensland (28°12'S, 154°54'E), 235 m, 27 July 1982.

Diagnosis. A species of *Ratabulus* with 80–93 anteroventrally slanted oblique scale rows above lateral line; snout length 29.5–32.3% HL, slightly decreasing proportionally with growth; pectoral fin length 13.9–15.8% SL; pelvic fin length 22.1–28.5% SL; nasal bone with tubercles in larger specimens; dorsal surface of head with large, pale to dark-brown irregularly shaped spots, body without spots dorsally; pelvic fin with large brown spots.

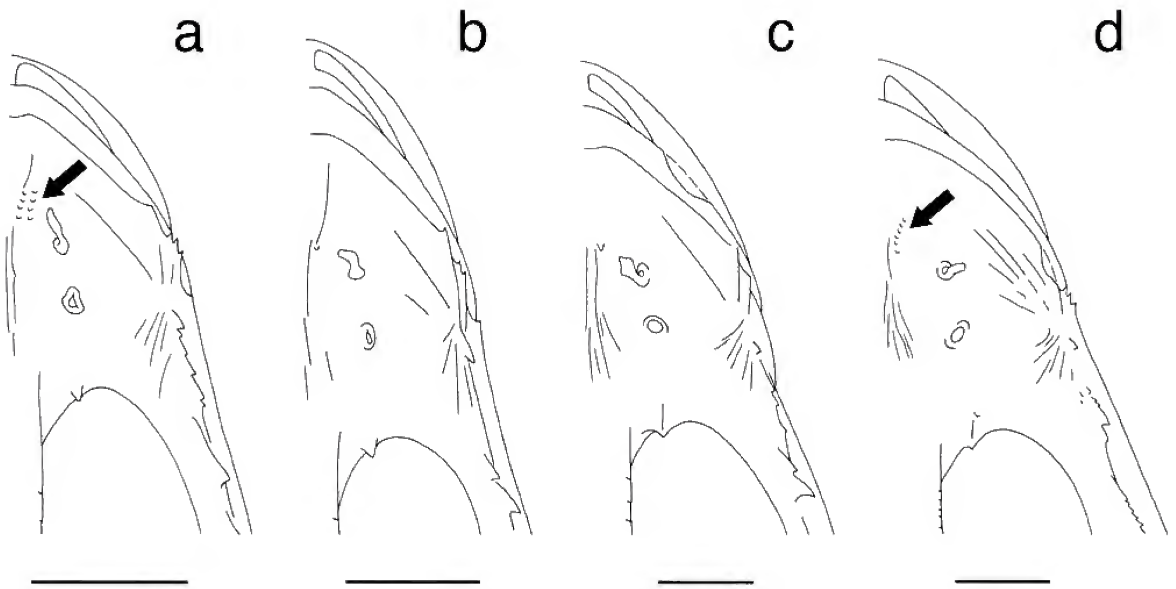

Figure 4. Dorsal views of anterior head region in four species of *Ratabulus*: a, *R. diversidens*, AMS I.11523-010, 190 mm SL; b, *R. megacephalus*, BSKU 87405, 216 mm SL; c, *R. fulviguttatus* sp. nov., CSIRO H4031-79, holotype, 262 mm SL; d, *R. ventralis* sp. nov., CSIRO H6116-02, holotype, 304 mm SL. Arrows show tubercles on nasal bone. Scale bar = 10 mm.

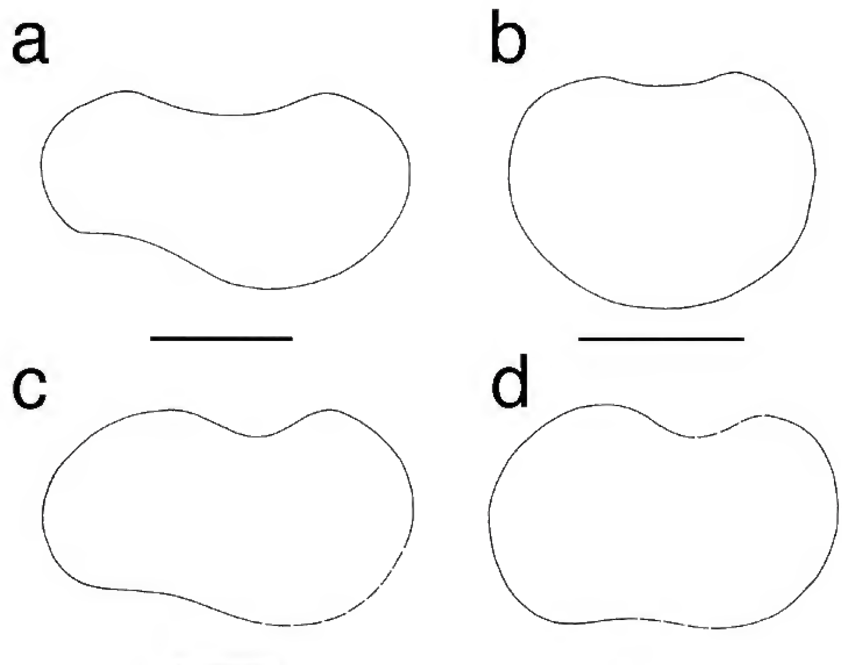

Figure 5. Iris lappet (left eye) of four species of *Ratabulus*: a, *R. diversidens*, AMS I.45084-009, 230 mm SL; b, *R. megacephalus*, BSKU 87405, 216 mm SL; c, *R. fulviguttatus* sp. nov., CSIRO H4031-79, holotype, 262 mm SL; d, *R. ventralis* sp. nov., CSIRO H6116-02, holotype, 304 mm SL. Scale bar = 3 mm.

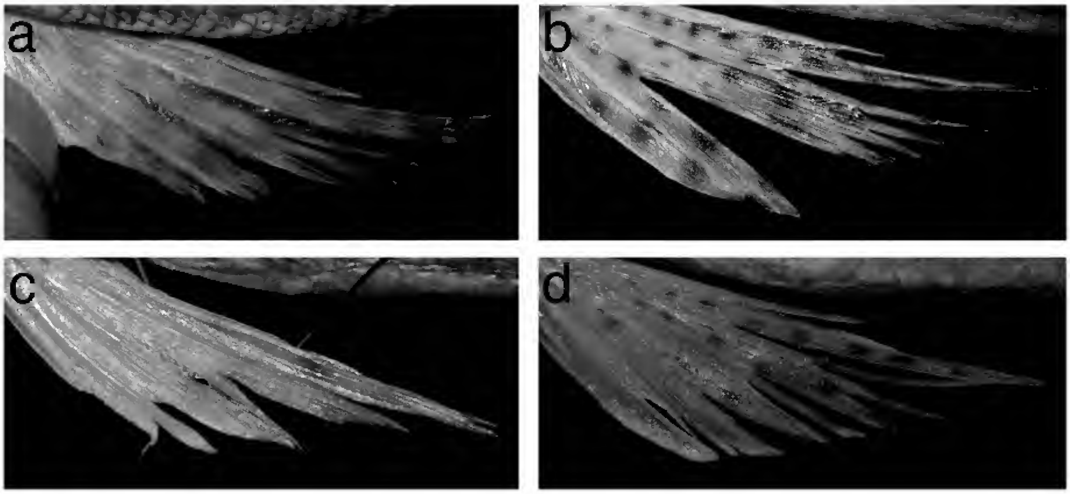

Figure 6. Dorsolateral view of pelvic fin in four species of *Ratabulus*: a, *R. diversidens*, CSIRO H630-29, 273 mm SL; b, *R. megacephalus*, HUMZ 200048, 344 mm SL; d, *R. fulviguttatus* sp. nov., CSIRO H4031-79, holotype, 262 mm SL; d, *R. ventralis* sp. nov., CSIRO H6116-02, holotype, 304 mm SL.

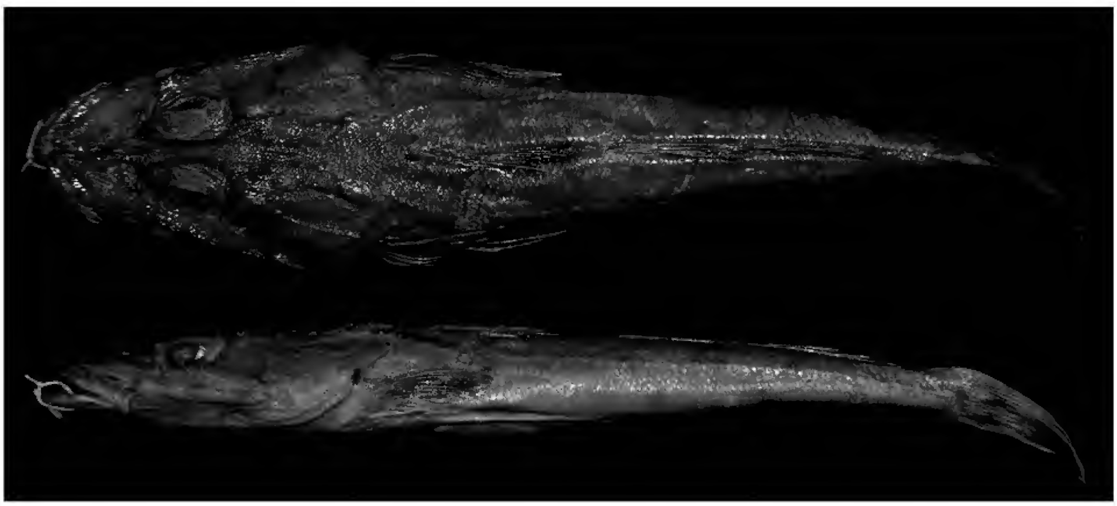

Figure 7. Dorsal (upper) and lateral (lower) views of *Ratabulus diversidens*, AMS E.2103, lectotype, 232 mm SL, 11 km northeast of Port Stephens Lighthouse, New South Wales.

Description. Dorsal fin rays I+VIII+I-11 (I+VIII+I-10 or 11, 10 in one); anal fin rays 12; branched caudal fin rays 12 (11–13, usually 12 or 13, smallest specimen with 11 rays); pectoral fin rays 2 + 10 + 8 = 20 (2 or 3 + 10 – 12 + 6 to 8 = 19 or 20); pelvic fin rays I, 5; scales in lateral line 54 (53 or 54), anterior 6 (3–7) scales with spine; posteroventrally slanted oblique scale rows above lateral line 75 (71–78); anteroventrally slanted oblique scale rows above lateral line 84 (80–93); gill rakers 1 + 6 = 7 (1 + 5–8 = 6–9).

See table 1 for selected proportional measurements. Head length 2.6 (2.4–2.7) in SL. Snout rather robust, its length 3.2 in HL (3.1–3.3 in HL, ratio as % HL slightly decreasing proportionally with growth) (fig. 9). Iris lappet broad and simple dorsally, absent ventrally (rarely absent dorsally, and usually broad and simple ventrally) (fig. 5a). Interorbital width 14.1 (10.3–22.2) in HL. Nasal bone without distinct spines, but with tubercles (smallest specimen, 54.4 mm SL, with single spine

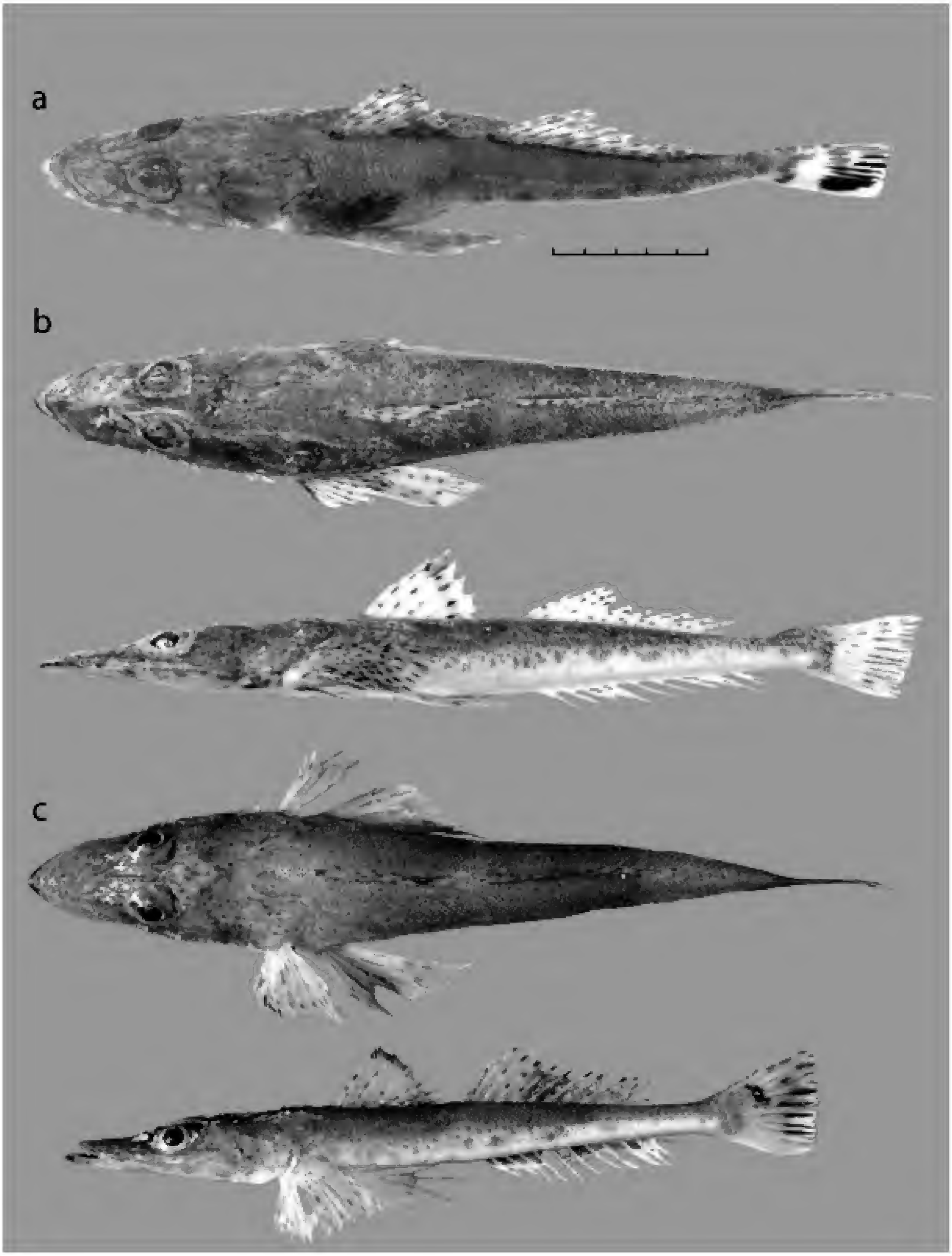

Figure 8. Three species of *Ratabulus*: a, *R. diversidens*, off Newcastle, New South Wales (33°08'S, 151°56'E), 125–130 m, 7 September 1978, specimen discarded, scale bar = 5 cm, photo by K. Graham; b, *R. megacephalus*, HUMZ 199844, 264 mm SL, East China Sea (26°35.68'N, 125°04.57'E – 26°36.73'N, 125°05.78'E), 192–186 m, 5 May 2007, photo by Hokkaido University; c, *R. fulviguttatus* sp. nov., upper specimen CSIRO H1505-15, 189 mm SL, lower specimen H1505-06, 219 mm SL, north of Nickol Bay, Western Australia (19°07'S, 117°06'E – 19°07'S, 117°04'E), 177–184 m depth, 5 October 1988, FRV *Soela*, photo by CSIRO.

and without tubercles) (fig. 4a). Lachrymal with four (2–7) anterolaterally directed spines. Single (rarely two) preocular spine in front of eye, its base with tubercles (with small spines, or without small spines and tubercles in several specimens). Suborbital ridge roughly serrated by many small to large spines; anteriormost (preorbital) spine small (rarely absent). Supraorbital ridge serrated, except anteriorly. Single postocular spine present. Pterotic with serrated ridge ending in strong spine. Parietal with single spine, followed posteriorly by three small spines on left side and four on right (by 1–5 spines). Supratemporal with serrated ridge (with serrated or smooth ridge) ending in spine. Posttemporal with two spines on left side and one on right (with 1–4 spines, usually one). Preopercle with three (two or three) spines; uppermost longest, not reaching posterior margin of opercle, bearing two small spines on left side and one on right on base laterally (usually one). Ridge of lower opercular spine smooth on left side and serrated on right. Posterior end of maxilla below anterior margin of eye (just beyond it in several specimens). Anterior part of upper jaw with conical teeth (short canines in several specimens) anteriorly, followed by long, slender canines; middle and posterior parts of upper jaw with villiform teeth, but innermost row with small, slender conical teeth. Lower jaw with narrow tooth band containing small conical teeth anteriorly, becoming smaller posteriorly, followed by villiform teeth at end of jaw; innermost row conical (conical teeth to moderately long canines). Palatine with moderately broad tooth band; anterior part of palatine with short canines laterally and moderately long canines mesially (moderate to long and slender canines mesially); posterior part of palatine with small conical teeth. Vomer with about four (about three or four) tooth rows centrally; anterior part of vomer with small conical teeth, middle and posterior parts with moderate to long and slender canines. Posterior margin of caudal fin mostly straight (rarely slightly concave); caudal fin length 5.6 (4.8–6.1) in SL. Pectoral fin length 7.0 (6.3–7.2) in SL. Posterior tip of pelvic fin reaching second (first to third) anal fin ray; pelvic fin length 4.0 (3.5–4.5) in SL.

Color in alcohol (lectotype, fig. 7). Head and body mostly faded. First dorsal fin with dark brown submarginal stripe; second dorsal with scattered small dark brown spots. Caudal fin with five longitudinal black stripes along fin membranes posteriorly. Upper part of pectoral fin with about two dark brown bands. Pelvic fin with large dark-brown spots posteriorly.

Other specimens with head and body pale to dark-brown dorsally, pale yellow ventrally; dorsal surface of head with large irregular pale to dark-brown spots; body without spots, but sometimes with several narrow dark-brown bands dorsally, side with longitudinal stripe formed by continuous gray spots below lateral line. First dorsal fin with dark brown to black submarginal stripe, base clear anteriorly, with scattered small dark brown to black spots; second dorsal with dark brown spots. Anal fin pale or with melanophores along rays. Caudal fin with 4–6 narrow black longitudinal stripes posteriorly; lower stripes tending to merge in some specimens; upper part of fin with several brown spots. Pectoral fin with small dark-brown spots tending to form bands. Pelvic fin with large brown spots (fig. 6a).

Color when fresh based on photograph (fig. 8a). Similar to those in alcohol.

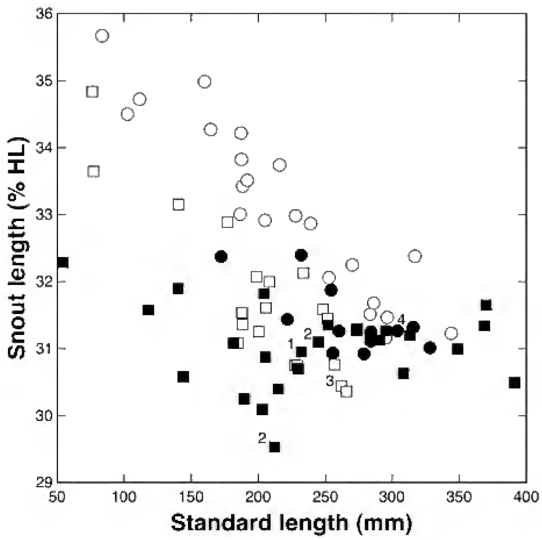

Figure 9. Comparison of snout length (% HL) with standard length (mm) in specimens examined of four species of *Ratabulus*; solid square, *R. diversidens*; open circle, *R. megacephalus*; open square, *R. fulviguttatus* sp. nov.; solid circle, *R. ventralis* sp. nov.; 1, lectotype of *R. diversidens*; 2, two paralectotypes of *R. diversidens*; 3, holotype of *R. fulviguttatus*; 4, holotype of *R. ventralis*.

Distribution. Eastern Australia from Townsville, Queensland (17°51'S) to Lakes Entrance, Victoria (38°17'52²S), recorded at depths of at least 30–345 m (McCulloch, 1914; Paxton et al., 1989) (fig. 1).

Remarks. *Ratabulus diversidens* is easily separable from *R. megacephalus* and *R. fulviguttatus* in having 80–93 anteroventrally slanted oblique scale rows above the lateral line (versus 94–112 in *R. megacephalus* and 99–113 in *R. fulviguttatus*), the snout length 29.5–32.3% HL, becoming slightly shorter proportionally with growth (versus 31.2–35.7% HL in *R. megacephalus* and 30.4–34.8% HL in *R. fulviguttatus*) (fig. 9), nasal bone with tubercles in larger specimens (versus lacking tubercles in *R. megacephalus* and *R. fulviguttatus*) (fig. 4), the dorsal surface of the head with large, irregularly shaped, pale to dark-brown spots, the body without spots dorsally (versus dorsal surface of head and body with small, round, pale or dark-brown spots in *R. megacephalus* and *R. fulviguttatus*) (fig. 3). *R. diversidens* resembles *R. ventralis* in having tubercles on the nasal bone, but differs from it in having a shorter pectoral fin (13.9–15.8% SL in *R. diversidens* versus 15.8–18.6% SL in *R. ventralis*) (fig. 10) and large, irregular spots on the head (versus a head with small, round, brown spots in *R. ventralis*) (fig. 3). This species can be separated from the other three by the large brown spots on its pelvic fin (versus having small spots) (fig. 6).

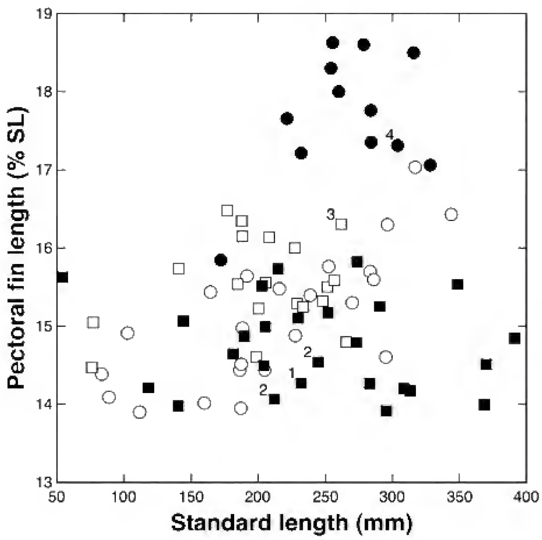

Figure 10. Comparison of pectoral fin length (% SL) with standard length (mm) in specimens examined of four species of *Ratabulus*; solid square, *R. diversidens*; open circle, *R. megacephalus*; open square, *R. fulviguttatus* sp. nov.; solid circle, *R. ventralis* sp. nov.; 1, lectotype of *R. diversidens*; 2, two paralectotypes of *R. diversidens*; 3, holotype of *R. fulviguttatus*; 4, holotype of *R. ventralis*.

McCulloch (1914) recorded the collection locality of the type specimens of *R. diversidens* as 'seven miles S. 21°W. off Port Stephens Lighthouse, New South Wales', but data with the specimens indicate they were captured 11 km northeast of Port Stephens Lighthouse (S. Reader, pers. comm., 16 May 2006).

Ratabulus megacephalus (Tanaka, 1917)

Japanese name: Haname-gochi

(Figures 2b, 3b, 4b, 5b, 6b, 8b)

Thysanophrys megacephalus Tanaka, 1917: 11 (original description, fish market in Tokyo); Tanaka, 1931: 37 (list, Japan); Kamohara, 1952: 70 (list, Kochi, Japan).

Thysanophrys (*Ratabulus*) *megacephalus*: Kamohara, 1964: 77 (list, Kochi).

Ratabulus megacephalus: Jordan and Hubbs, 1925: 287 (English translation of original description published in Japanese); Okada and Matsubara, 1938: 334 (key and distribution, Tokyo to Kagoshima, Japan); Mori, 1952: 159 (list and distribution, Tongyeong, southern South Korea); Matsubara and Ochiai, 1955: 95, pl. 3 (description, southern Japan and East China Sea); Matsubara, 1955: 1122 (key, short description and distribution, Tokyo Bay, south from Kasumi, Hyogo Prefecture, Korea and East China Sea); Anonymous, 1962: 926, fig. 730 (description, Hainan Island, South China Sea); Ochiai, 1984: 322, pl. 289-E (short description and distribution, southern Japan to East China Sea); Yatou, 1985: 599, 729, pl. 371 (description and distribution, Okinawa Trough); Shao and Chen, 1987: 86, fig. 20 (short description, Taiwan); Shao and Chen, 1993: 258, pl. 65-4 (short description, Taiwan); Imamura, 1996: 207, fig. 62 (list); Imamura, 1997: 220, fig. 5 in 221 page (short description); Lee and Joo, 1998: 220, fig. 4 (description, Pusan); Knapp, 2000: 608 (list, South China Sea); Nakabo, 2002: 618, unnumbered figs (pictorial key and limited meristic values, Pacific coast of southern Japan and East China Sea); Shinohara et al., 2001: 318 (list, Tosa Bay, Japan); Youn, 2002: 259, 570, unnumbered fig. (pictorial key, Tongyeong, southern South Korea); Kim et al., 2005: 237, unnumbered fig. (short description, Tongyeong, southern South Korea).

Ratabulus diversidens (nec McCulloch, 1914): Knapp, 1999: 2410 (description, East and South China seas and northern Philippines) (in part).

Nontypes (location of holotype unknown, Eschmeyer et al., 1998). Twenty-three specimens (83.4–344 mm SL), Northwest Pacific. BSKU 9503, 186 mm SL, fish market, Mimase, Kochi Prefecture, 1 December 1950; BSKU 36141, 192 mm SL, fish market, Mimase, Kochi Prefecture, 9 December 1981; BSKU 36270, 228 mm SL, fish market, Mimase, Kochi Prefecture, 26 January 1982; BSKU 51453, 205 mm SL, fish market, Mimase, Kochi Prefecture, 9 April 2000; BSKU 52257, 160 mm SL, Irino fishing port, Hata-gun, Kochi Prefecture, 10 August 2000; BSKU 54460, 252 mm SL, fish market, Mimase, Kochi Prefecture, 24 November 2000; BSKU 59497, 83.4 mm SL, Irino fishing port, Hata-gun, Kochi Prefecture, 18 March 2002; BSKU 63578, 188 mm SL, Saga fishing port, Hata-gun, Kochi Prefecture, 20 November 2002; BSKU 73629, 88.7 mm SL, Irino fishing port, Hata-gun, Kochi Prefecture, 5 April 2002; BSKU 85012, 164 mm SL, Tosa Bay, Kochi Prefecture, 125 m depth, 30 September 1997, R/V *Kotaka-maru*; BSKU 87405, 216 mm SL, fish market, Mimase, Kochi Prefecture, 30 March 2000; FAKU 12168, 270 mm SL, East China Sea, February 1949, K. Matsubara and R. Ishiyama; FAKU 14957, 14959–14960, 3: 283–295 mm SL, Maisaka, Shizuoka Prefecture; HUMZ 37397, 111 mm SL, no collection data (perhaps Kochi Prefecture); HUMZ 49396, 187 mm SL, fish market, Mimase, Kochi Prefecture, 15 November 1975; HUMZ 49470, 187 mm SL, fish market, Mimase, Kochi Prefecture, 17 November 1975; HUMZ 200048, 344 mm SL, East China Sea (27°06.31'N, 125°47.32'E – 27°06.11'N, 125°46.24'E), 192–186 m, 2 June 2007; HUMZ 200050, 296 mm SL, collaboration with HUMZ 200048; NSMT-P 828, 103 mm SL, Enoura, Izu Peninsula, Shizuoka Prefecture (35°03'N, 138°54'E); USNM 329510, 239 mm SL, South China Sea (19°06'30"N, 112°23'E), 203–218 m, 22 July 1958; USNM 383571, 370 mm SL, fish market, Bolinao, Luzon, Philippines, 7–9 October 1995.

Other material. One specimen. HUMZ 199844, 264 mm SL, East China Sea (26°35.68'N, 125°04.57'E – 26°36.73'N, 125°05.78'E), 192–186 m, 5 May 2007 (used for description of color when fresh).

Diagnosis. A species of *Ratabulus* with 94–112 anteroventrally slanted oblique scale rows above lateral line; snout length 31.2–35.7% HL, markedly decreasing in length proportionally with growth; pectoral fin length 13.9–17.0% SL; pelvic fin length 19.5–23.1% SL; nasal bone without tubercles; dorsal surface of head and body dark brown, with small, round, dark-brown spots; and pelvic fin with small brown to black spots.

Description. Dorsal fin rays I + VIII + I-11 or 12 or I + IX + 0-11 (I + IX + 0-11 in one, I + VIII + I-12 in one); anal fin rays 12; pectoral fin rays two or three (usually two) + 9–11 + 6–8 = 19 or 20; pelvic fin rays I, 5; branched caudal fin rays 12 or 13; scales in lateral line 53–55, anterior three or four scales with spine; posteroventrally slanted oblique scale rows above lateral line 71–78; anteroventrally slanted oblique scale rows above lateral line 94–112; gill rakers 1 + 6–8 = 7–9.

See table 1 for selected proportional measurements. Head length 2.4–2.7 in SL. Snout rather long, its length 2.8–3.2 in HL, ratio as %HL markedly decreasing proportionally with growth (fig. 9). Iris lappet broad and simple dorsally and absent ventrally (fig. 5b). Interorbital width 12.8–19.6 in HL. Nasal bone with 0–2 spines, and without tubercles (fig. 4b). Lachrymal with 2–4 spines directed anterolaterally. Preocular spine in front of eye, its base without spines or tubercles. Suborbital ridge with many small to large spines; anteriormost (preorbital) spine usually present. Supraorbital ridge serrated medially and posteriorly or just posteriorly. Postocular spine present. Pterotic ridge with 1–3 spines. Parietal with single spine, followed posteriorly by 0–2 additional spines. Supratemporal usually with a spine, rarely with two. Posttemporal with one or two spines. Preopercle with twp or three spines; uppermost longest, not reaching posterior margin of opercle, bearing one small spine on base laterally. Ridge of lower opercular spine without serrations. Posterior end of maxilla below anterior margin of eye or just posterior to it. Anterior part of upper jaw with conical or small canine teeth in front of long, slender canines, followed by villiform teeth, innermost row with small, slender conical teeth. Lower jaw with narrow band of small conical teeth anteriorly, smallest teeth posteriorly, followed by villiform teeth, innermost a row of moderately long canines. Palatine with moderately broad tooth band; those anterolaterally canines of short to moderate length with moderate to long and slender canines mesially; posterior part of palatine with small conical teeth. Vomer with about 2–5 tooth rows medially; anterior teeth conical or short canines, those medially and posteriorly slender canines of moderate length. Posterior margin of caudal fin mostly straight, slightly concave or slightly rounded in some; caudal fin length 5.2–6.0. Pectoral fin length 5.9–7.2 in SL. Posterior tip of pelvic fin not reaching anal fin origin; pelvic fin length 4.3–5.1 in SL.

Color in alcohol. Head and body dark brown dorsally, pale yellowish ventrally. Dorsal surfaces of head and body with small, round, dark-brown spots; body usually without bands dorsally, but occasionally with indistinct darker bands; longitudinal stripe formed by continuous series of gray spots on side below lateral line. First dorsal fin with dark brown to black submarginal stripe, base clear anteriorly with scattered small dark-brown to black spots; second dorsal with brown to black spots. Anal fin with melanophores along rays. Caudal fin with 5–9 narrow longitudinal black stripes posteriorly; several dark-brown to black spots anteriorly and dorsally. Pectoral and pelvic fins with small dark-brown to black spots (fig. 6b).

Color when fresh from photographs of HUMZ 199844 (fig. 8b). Similar to those in alcohol.

Distribution. East and South China seas, and Northwest Pacific, including southern Japan, Korea, Taiwan, Hainan Island and northern Philippines, at depths of 192–218 m (Anonymous, 1962; Ochiai, 1984; Shao and Chen, 1987, 1993; Knapp, 1999; Kim et al., 2005) (fig. 1).

Remarks. *R. megacephalus* is most similar to *R. fulviguttatus* in having the nasal bone devoid of tubercles (versus tubercles present in *R. diversidens* and *R. ventralis*) (fig. 4) and the dorsal surface of the body with small, round spots (versus without spots) (fig. 2). *R. megacephalus* differs from *R. fulviguttatus* in having a proportionally longer snout (31.2–35.7% HL in *R. megacephalus* versus 30.4–34.8% HL in *R. fulviguttatus*) and shorter pectoral fins (13.9–17.0% SL compared to 14.6–16.5% SL) (figs 9–10) at comparable sizes, and the dorsal surface of the head and body dark brown (versus pale brown) (fig. 2). *R. megacephalus* is also separable from *R. ventralis* in having shorter pectoral fins (13.9–17.0% SL versus 15.8–18.6% SL) and pelvic fins (19.5–23.1% SL versus 25.3–28.2% SL) (figs 10–11).

Sadovy and Cornish (2000) reported *Ratabulus megacephalus* from Hong Kong, but their photograph depicts a specimen of *Inegocia ochiaii* Imamura, 2010, previously known incorrectly as '*Inegocia guttata*' (e.g. Matsubara and Ochiai, 1955; Ochiai, 1984), a species that has an interopercular flap, and a long and branched iris lappet.

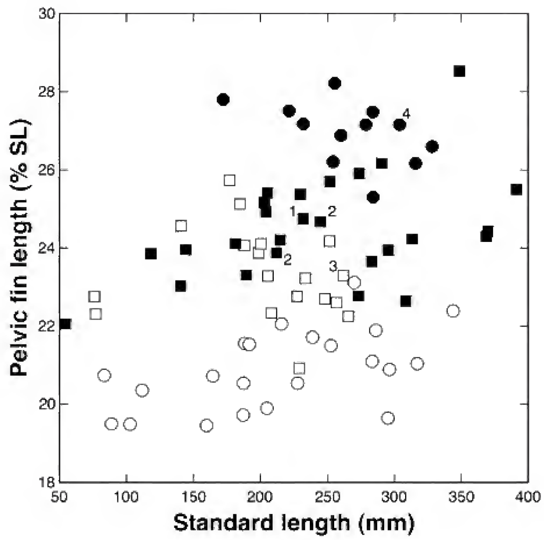

Figure 11. Comparison of pelvic fin length (% SL) with standard length (mm) in specimens examined of four species of *Ratabulus*; solid square, *R. diversidens*; open circle, *R. megacephalus*; open square, *R. fulviguttatus* sp. nov.; solid circle, *R. ventralis* sp. nov.; 1, lectotype of *R. diversidens*; 2, two paralectotypes of *R. diversidens*; 3, holotype of *R. fulviguttatus*; 4, holotype of *R. ventralis*.

Ratabulus fulviguttatus sp. nov.

English name: Orangefreckled flathead

(Figures 2c, 3c, 4c, 5c, 6c, 8c)

Ratabulus diversidens (nec McCulloch, 1914): Gloerfelt-Tarp and Kailola, 1984: 123, unnumbered fig. (short description, northwestern Australia); Sainsbury et al., 1985: 114, unnumbered fig. (description, northwestern Australia); Paxton et al., 1989: 470 (list and distribution, Northwestern Shelf, Australia) (in part); Knapp, 1999: 2410 (description, Northwestern Shelf and Timor Sea) (in part); Hutchins, 2001: 28 (list, Western Australia); Hoese et al., 2006: 944 (list and distribution, off North West Cape to off Port Hedland, Western Australia) (in part).

Holotype. CSIRO H4031-79, 262 mm SL, north of Cape Lambert, Western Australia (18°57'S, 117°14'E), 248 m, 30 August 1995, FRV *Southern Surveyor*.

Paratypes. 16 specimens (140-266 mm SL), from northwestern Australia. AMS I.21621-006, 206 mm SL, northwest shelf, Western Australia (11°49'S, 124°17'E), 195–200 m, 10 June 1979; AMS I.22805-013, 3: 177–188 mm SL, 170 km north of Port Hedland, Western Australia (18°28'S, 118°15'E), 150–156 m, 28 March 1982, FRV *Soela*; AMS I.22807-023, 3: 188–227 mm SL, 175 km north of Port Hedland, Western Australia (18°32'S, 118°17'E), 200–204 m, 2 April 1982, FRV *Soela*; AMS I.22828-012, 3: 248–265 mm SL, 190 km north of Port Hedland, Western Australia (19°01'S, 117°12'E), 200–202 m, 14 April 1982, FRV *Soela*; CSIRO CA3624 (voucher of Sainsbury et al., 1985), 233 mm SL, northwest of Nichol Bay, Western Australia (19°15'S, 116°40'E), 172 m, 25 January 1983, FRV *Soela*; CSIRO CA4091, 229 mm SL, north of Bathurst Island, Arafura Sea, Northern Territory (10°02'S, 130°01'E), 216 m, 8 July 1980; CSIRO H1035-23, 251 mm SL, north of Dampier Archipelago, Western Australia (19°08'S, 116°54'E), 196 m, 24 October 1996, FRV *Soela*; CSIRO H1512-04, 140 mm SL, north of Monte Bello Islands, Western Australia (19°39'S, 115°36'E), 180 m, 11 October 1988, FRV *Soela*; CSIRO H4031-79, 262 mm SL, north of Cape Lambert, Western Australia (18°57'S, 117°14'E), 248 m, 30 August 1995, FRV *Southern Surveyor*; CSIRO H4631-03, 198 mm SL, north of Dampier Archipelago, Western Australia (19°11'S, 116°35'E), 196 m, 11 August 1997, FRV *Southern Surveyor*; WAM P.32204-001, 208 mm SL, Western Australia, Timor Sea (12°57'S, 124°20'E), 8 June 1979.

Nontypes. Two specimens. WAM P.9351-001, 76.0 mm SL, Western Australia (21°49'S, 113°56'E), 121–126 m, 1 February 1964; WAM P. 9352-001, 77.1 mm SL, coll. with WAM P.9351-001.

Other material. Two specimens. CSIRO H1505-06, 219 mm SL, north of Nickol Bay, Western Australia (19°07'S, 117°06'E – 19°07'S, 117°04'E), 177–184 m, 5 October 1988, FRV *Soela*; CSIRO H1505-06, 189 mm SL, collected with CSIRO H1505-06 (used for description of color when fresh).

Diagnosis. A species of *Ratabulus* with 99–113 anteroventrally slanted oblique scale rows above lateral line; snout length 30.4–34.8% HL, markedly decreasing proportionally with growth; pectoral fin length 14.6–16.5% SL; pelvic fin length 20.9–25.7% SL; nasal bone without tubercles; dorsal surface of head and body pale brown, with small, round brown spots; and pelvic fin with small brown spots.

Description. Dorsal fin rays I + VIII + I-11 (I + VII to IX + I-11 or 12, VII in one and IX in one, 12 in one); anal fin rays 12 (11 or 12, 11 in one); pectoral fin rays 2 + 12 + 6 = 20 (1 or 2 + 9–12 + 6–8 = 19–21, usually 20); pelvic fin rays I, 5; branched caudal fin rays 13; scales in lateral line 56 (54–56), anterior three (three or four) scales with spine; posteroventrally slanted oblique scale rows above lateral line 80 (71–80); anteroventrally slanted oblique scale rows above lateral line 107 (99–113); gill rakers 1 + 7 = 8 (1 + 6–8 = 7–9, usually 7).

See table 1 for selected proportional measurements. Head length 2.6 (2.4–2.7) in SL. Snout rather slender, its length 3.3 (3.0–3.3) in HL, markedly decreasing proportionally with growth (fig. 9). Iris lappet broad and simple both dorsally and ventrally (fig. 5c). Interorbital width 16.3 (14.5–20.0) in HL. Nasal bone with small spine, but without tubercles (fig. 4C). Two spines on lachrymal of right side, three on left, spines directed anterolaterally. Single preocular spine in front of eye, its base without spines or tubercles (with tubercle on left side of one paratype, CSIRO H4631-03). Suborbital ridge with many small to large spines, anteriormost (preorbital) distinct. Supraorbital ridge serrated except anteriorly. Single postocular spine present. Pterotic with one spine (one to four spines). Parietal with single spine, without accompanied spines posteriorly (followed by one or two spines in several paratypes). Supratemporal with one spine (two to three spines in several paratypes). Posttemporal with one spine. Preopercle with two spines (three in several paratypes); upper longer, not reaching posterior margin of opercle, bearing one small spine on base laterally (rarely two spines or spines absent). Ridge of lower opercular spine without serrations. Posterior end of maxilla below anterior margin of pupil (not reaching to anterior margin of pupil in several paratypes). Anterior part of upper jaw with short canines at front, followed by long and slender canines posteriorly; middle and posterior parts of upper jaw with villiform teeth, innermost row comprising small, slender, conical teeth. Lower jaw with two tooth rows (one to about three rows); outer row with moderately long conical teeth anteriorly, and two rows of villiform teeth anterolaterally (outer one to two rows of villiform teeth, or small to moderately long conical teeth), teeth becoming smaller posteriorly, teeth villiform posteriorly; inner row with conical teeth (canines of small to moderate size in several paratypes). Palatine with moderately broad tooth band; anterior part of palatine with canines of moderate length (long canines in several paratypes) laterally, and long and slender canines mesially; posterior part of palatine with small to moderately long conical teeth. Vomer with about three tooth rows medially (with two to four rows), small canines anteriorly (canines of moderate length in several paratypes), followed by long, slender canines. Posterior margin of caudal fin slightly concave (mostly straight in several paratypes); fin length 6.0 (5.0–6.2) in SL. Pectoral fin length 6.1 (6.1–6.8) in SL. Posterior tip of pelvic fin not reaching anal fin origin (just reaching anal fin origin or just beyond it in several paratypes); pelvic fin length 4.3 (3.9–4.5) in SL.

Color in alcohol. Head and body pale brown dorsally, pale yellowish ventrally; dorsal surface of head and body with small, round, brown spots, but no bands; lateral side of body below lateral line with pale purple longitudinal stripe (or stripe formed by continuous series of purple spots). First dorsal fin with one dark grayish submarginal stripe, basal area clear anteriorly with scattered small dark-brown spots; second dorsal fin with brown (or dark brown) spots. Anal fin pale. Caudal fin with many black longitudinal narrow stripes and spots posteriorly; upper part of fin with several brown spots. Pectoral fin slightly dusky, with small brown spots. Pelvic fin mostly faded on left side, with few small indistinct brown spots on right (with several small distinct brown spots in several paratypes) (fig. 6c).

Color when fresh from photographs of CSIRO H505-15 and H505-16 (fig. 8c). Head and body with small, round, reddish brown and brown spots dorsally. Body with two broad brown bands dorsally. Other colors similar to those in alcohol.

Distribution. Northwestern Australia, from North West Cape, Western Australia (21°49'S) to Bathurst Island, Northern Territory (10°02'S), at depths of at least 126–248 m (Sainsbury et al., 1985; Paxton et al., 1989) (fig. 1).

Etymology. The specific name *fulviguttatus*, from the Latin word meaning 'orange or brown spots', refers to this species' characteristic spots on the head and body.

Remarks. *R. fulviguttatus* differs from *R. ventralis* in having the nasal bone without tubercles (versus with tubercles) (fig. 4), shorter pelvic fins (20.9–25.7% SL versus 25.3–28.2% SL) (fig. 11), and body with small, round, brown spots (versus without spots) (fig. 2). It is easily separable from *R. diversidens*, with which it has been confused, by the small, round, brown spots scattered over the dorsal surface of the head and body (versus without spots). The spots in *R. fulviguttatus* are reddish and/or brown when fresh, which explains the Australian standard name. The character is clearly evident in colour photos and description provided by Gloerfelt-Tarp and Kailola (1984) and Sainsbury et al. (1985).

Ratabulus ventralis sp. nov.

New English name: Longfin flathead

(Figures 2d, 3d, 4d, 5d, 6d)

Ratabulus diversidens (nec McCulloch, 1914): Paxton et al., 1989: 470 (list and distribution, off Brisbane) (in part); Knapp, 1999: 2410 (description, Coral Sea) (in part); Hoese et al., 2006: 944 (list and distribution, off Brisbane) (in part).

Holotype. CSIRO H6116-02, 304 mm SL, east of Townsville, Queensland (18°39.3'S, 148°03.4'E – 18°36.4'S, 147°59.5'E), 244–248 m, 8 December 1985, FRV *Soela*.

Paratypes. Eleven specimens (172–328 mm SL) from Queensland, northeastern Australia. AMS I.25804-019, 278 mm SL, just north of Townsville (17°51'S, 147°01'E), 260 m, 9 January 1986, FRV *Soela*; AMS I.25823-002, 328 mm SL, north of Townsville (17°58'S, 147°02'E), 260 m, 16 January 1986, FRV *Soela*; AMS I.25832-007-006, 284 mm SL, north of Townsville (17°58'S, 147°03'E), 260 m, 19 January 1986, FRV *Soela*; CSIRO H690-03, 232 mm SL, Swain Reefs (21°31'S, 152°58'E), 247 m, 20 November 1985, FRV *Soela*; QM I.18546, 284 mm SL, off Swain Reefs (22.54°S, 152.12°E – 22.59°S, 152.12°E), 347–384 m, 3 October 1980; QM I.19276, 255 mm SL, east of Capricorn Group (23.11°S, 153.00°E – 23.01°S, 152.55°E), 366–392 m, 20 September 1980; QM I.20934, 254 mm SL, east of Swain Reefs (22.03°S, 153.05°E), 170 m, 28 August 1983; QM I.20939, 316 mm SL, east of Bunker Group (23.59°S, 152.51°E), 340 m, 27 August 1983; QM I.21624, 221 mm SL, southeast of Swain Reefs (22.4°S, 153.35°E), 310 m, 6 September 1983; QM I.23088, 260 mm SL, off Swain Reefs (20.49°S, 151.52°E), 288 m, 20 September 1986; QM I.34327, 172 mm SL, east of Noosa (26.25°S, 153.4°E), 119–120 m, 19 July 2002.

Diagnosis. A species of *Ratabulus* with 91–104 anteroventrally slanted oblique scale rows above lateral line; snout length 30.9–32.4% HL, markedly decreasing proportionally with growth; pectoral fin length 15.8–18.6% SL; pelvic fin length 26.2–28.2% SL; nasal bone with tubercles; dorsal surface of head with small, round, brown spots, body without dark spots; pelvic fin with small brown spots.

Description. Dorsal fin rays I + VIII + I-11 (I + VII or VIII + I-11, or I + IX + 0-11, VII in one, IX in one); anal fin rays 12; pectoral fin rays 2 + 11 + 7 = 20 (2 + 10 or 11 + 6–9 = 19–21); pelvic fin rays I, 5; branched caudal fin rays 13 (12 or 13); scales in lateral line 55 (52–55), anterior four (3–5) scales with spine; posteroventrally slanted oblique scale rows above lateral line 83 (71–76); anteroventrally slanted oblique scale rows above lateral line 98 (91–104); gill rakers 1 + 7 = 8 (1 + 7 or 8 = 8 or 9).

See table 1 for selected proportional measurements. Head length 2.7 (2.4–2.6) in SL. Snout rather robust, its length 3.2 in HL (3.1–3.2 in HL, slightly decreasing proportionally with growth, fig. 9). Iris lappet broad and simple both dorsally and ventrally (fig. 5d). Interorbital width 13.9 (12.5–16.7) in HL. Nasal bone without distinct spines, but with tubercles (fig. 4d). Lachrymal with three anterolaterally directed spines on left side, right side partly damaged (2–5, with short serrations posterior to spines in some paratypes). Single preocular spine in front of eye, its base with tubercles (with small spines in several paratypes). Suborbital ridge roughly serrated by many small to large spines; anteriormost (preorbital) spine small. Supraorbital ridge serrated except anteriorly. Single postocular spine present. Pterotic with serrated ridge ending in strong spine. Parietal with single spine, lacking spines posteriorly (with small spines or tubercles in many paratypes). Supratemporal with smooth ridge (with serrated ridge in many paratypes) ending in spine. Posttemporal with one spine (usually with 1–3, rarely with serrated ridge ending in one spine). Preopercle with two (two or three) spines; upper longer, not reaching posterior margin of opercle, with one small spine on base laterally. Ridge of lower opercular spine without serrations (with weak serrations or with spine in some paratypes). Posterior end of maxilla reaching just beyond anterior margin of eye. Front of upper jaw with short canines (with conical teeth in some paratypes) anteriorly, followed by long and slender canines; middle and posterior parts of jaw with villiform teeth, one or two inner rows (innermost row) having small, slender conical teeth. Lower jaw with narrow tooth band of small conical teeth anteriorly, teeth smaller posteriorly, followed by villiform teeth; innermost row with short to moderately long (short to long and slender) canines. Palatine with moderately broad tooth band; anterior part with moderately long (short to moderately long) canines laterally, and long, slender (moderately long to long and slender) canines mesially; posterior part with moderately long to long conical teeth. Vomer with about three (about 3–5) tooth rows medially; short canines anteriorly, followed by long, slender canines. Posterior margin of caudal fin slightly concave (mostly straight in some paratypes); caudal fin length 6.0 (5.3–6.0) in SL. Pectoral fin length 5.8 (5.4–6.3) in SL. Posterior tip of pelvic fin reaching second (third to fourth) anal fin ray; pelvic fin length 3.7 (3.5–3.8) in SL.

Color in alcohol. Head and body pale brown dorsally, pale yellowish ventrally; dorsal surface of head with small, round, brown spots; body without spots and bands dorsally; side below lateral line with one pale grayish longitudinal stripe (grayish stripe formed by continuous series of spots in some paratypes). First dorsal fin with one blackish submarginal stripe, base clear anteriorly with small scattered black spots; second dorsal fin with brown (dark brown in some paratypes) spots. Anal fin pale. Caudal fin with several black longitudinal narrow stripes and spots posteriorly; upper part of caudal fin with several brown spots. Pectoral and pelvic fins with small brown spots (fig. 6d).

Distribution. Northeastern Australia from Townsville (17°51'S) to Noosa, Queensland (26.25°S), at depths of at least 120–366 m (fig. 1).

Etymology. The specific name *ventralis* from Latin, meaning 'of the belly', refers to this species' characteristic long pelvic fin.

Remarks. *R. ventralis* is most similar to *R. diversidens*, from which it can be distinguished as discussed in 'Remarks' in the above treatment of the latter. This species is poorly represented in museum collections and has been mostly overlooked in the literature. It has been considered by authors, which have treated specimens, as simply northern records of *R. diversidens*.

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Upper Devonian osteichthyan remains from the Genoa River, Victoria, Australia

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Abstract

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The Genoa River Trackway site in the Upper Devonian Combyingbar Formation represents one of the earliest records of tetrapods (land vertebrates) from Australia. However, the osteichthyan assemblage from the site is poorly known compared to other Devonian tetrapod localities. New information from a tetrapodomorph fish lower jaw possibly indicates the first record of a tristichopterid from the Genoa River Beds. The specimen shares a posteroventral embayment in the profile of lower jaw with *Eusthenopteron foordi*, *Platycephalichthys bischoffi*, and Moroccan tristichopterid material, as well an isolated specimen of the 'osteolepidid' *Gyroptychius*. Polyplocodont and dendrodont teeth are also described from the Genoa River, with the latter indicating the presence of a large, porolepiform taxon. The antiarch placoderm *Remigolepis* represents the most abundant fossil fish taxon recorded from the Genoa River. The possible presence of phyllolepid placoderm material may support previous suggestions of a pre-Famennian age for the Genoa River Beds.

Keywords tristichopterid, Tetrapodomorpha, Genoa River, Devonian, polyplocodont, dendrodont

Introduction

The fine-grained sandstone of the Genoa River Beds (=Combyingbar Formation [Vandenberg *et al*., 1992]) along the Genoa River, southeastern Victoria, is renowned for preserving the first record of Devonian tetrapods from Australia and Gondwana (Warren and Wakefield, 1972). Discovered by Norman A. Wakefield in 1971, this material was described as three distinct tetrapod trackways by Warren and Wakefield (1972) and Clack (1997), with subsequent work focusing mainly on the two better preserved footprint sets, believed to be distinct in form (Clack, 2002; Young, 2006; 2007). Biostratigraphic and lithological indicators summarised by Young (2006) suggested a Frasnian age for the locality, but did not describe any fossils to support this. Dunn (1897), Hall (1959) and Douglass (1974) recorded Upper Devonian plant material from the Genoa River, with the strata broadly corresponding to the Merrimbula Group of the New South Wales south coast (Lewis *et al*., 1994), more specifically, lithofacies 1–3 of the Early to Mid-Frasnian, Twofold Bay Formation (Simpson *et al*., 1997; Young, 2007). The age of the Genoa River trackways are notable for being '…probably contemporary with *Obruchevichthys* and *Elginerpeton*' (Clack, 2002; p. 92), previously considered to be the oldest known tetrapods (Ahlberg, 1995). However, the recent discovery of a tetrapod trackway site from the Eifelian Northern Holy Cross Mountains, Poland (Niedźwiedzki *et al*., 2010) is significantly older than this aforementioned material.

In contrast to the importance of the Genoa site, none of the vertebrate assemblage has been described. Such details have been published regarding the fauna from Northern Hemisphere tetrapod localities, such as those from East Greenland (summarised by Blom *et al*., 2007). The record of the Devonian fish fauna from the Genoa River includes the placoderm taxa *Bothriolepis*, *Remigolepis* and *Groenlandaspis* (Young, 1988) and a phyllolepid taxon (recorded in the field notes of Anne Warren [Anne Warren, La Trobe University, pers. comm., 2009]). Isolated 'crossopterygian skull elements' have also been reported from the site (Young, 1988; p. 192), along with bone elements and scales from the porolepiform fish *Holoptychius* (Young, 1993), although this record has since been questioned (Young, 2007). A large, poorly preserved partial lower jaw of an 'osteolepiform' fish was identified by Ahlberg and Clack (1998), based on a broad distribution of denticles on the prearticular and a posterodorsally directed glenoid surface of the articular. New descriptive work on this specimen, NMV P198470, is presented here following further preparation. Several similarities to tristichopterid specimens from the Frasnian of Canada, Russia and the Famennian of Tafilalt, Morocco, are suggested. Two distinct sarcopterygian fish tooth morphologies from the Genoa River fauna are also described in detail for the first time. This includes a small polyplocodont tooth and a large dendrodont tusk. The former morphology is known from tetrapodomorph fishes and lower tetrapods, while the latter is unique to the Porolepiformes

(Schultze, 1970). A list is presented of the fossil fish specimens collected from the Genoa River and stored in Museum Victoria. The biostratigraphic implications of the Genoa River fauna are discussed, including the possible presence of phyllolepid material.

Material and methods

The aforementioned specimens were collected in 1973 by Ian Stewart on a field trip led by James W. Warren along the bank of the Genoa River, Victoria, Australia. Preliminary work on the jaw (NMV P198470) was carried out by Alec L. Panchen and Anne Warren, but was never published (Anne Warren, La Trobe University pers. comm., 2009). Manual surface preparation was undertaken by Per E. Ahlberg and Jennifer A. Clack (Ahlberg and Clack, 1998), with bone material being dissolved in hydrochloric acid by T.H in 2008. A black latex peel of the specimen was then dusted with sublimate of ammonium chloride and photographed with a Nikon D80 camera using a Nikon DX 18–135 mm lens. The polyplocodont (NMV P229479) and dendrodont (NMV P229477) teeth were sectioned by Ian Stewart, and photographed with a Leica DFC500 camera using a Leica M205C microscope. Anatomical terminology follows that of Jeffery (2003).

Institutional abbreviations

NMV, Museum Victoria, Melbourne; MNHN, Muséum national d'Histoire naturelle, Paris, France; NRM, Naturhistoriska riksmuseet (Natural History Museum of Sweden).

Systematic descriptions

Superclass Osteichthyes Huxley, 1880

Class Sarcopterygii Romer, 1955

Horizon. Combyingbar Formation (Vandenberg *et al*., 1992)

Order Tetrapodomorpha Ahlberg, 1991

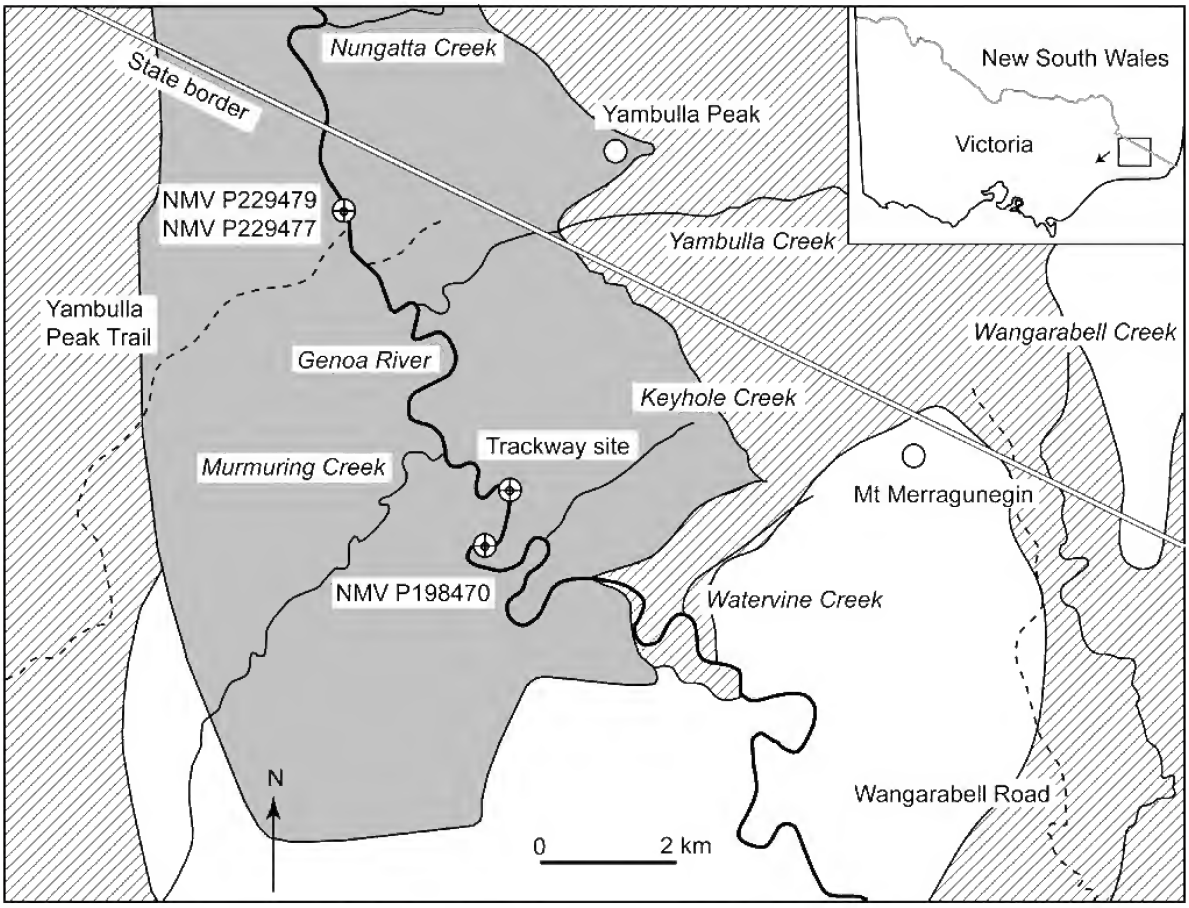

Figure 1. Geological map of Genoa River area, Genoa, Victoria, Australia (modified from Marsden, 1976; Simpson et al., 1997); grey = Late Devonian, Combyingbar Formation; diagonal lines = Early Devonian, Maramingo Granite; white = Ordovician slate, sandstone.

tetrapodomorph gen. et sp. indet.

Large incomplete lower jaw (Ahlberg and Clack, 1998; p. 35)

Poorly preserved lower jaw; belonged to an osteolepiform fish (Young, 2006; p. 413)

Poorly preserved osteolepiform sarcopterygian lower jaw (Young, 2007; p. 1003)

Referred specimen. NMV P198470, an incomplete lower jaw, including infradentaries, prearticular, articular, and possible dentary and coronoid elements.

Locality. Along the Genoa River, between the branches of Murmuring Creek and Keyhole Creek (fig. 1).

Description. Only the lingual surface of NMV P198470 is preserved (figs 2a–b), consisting of an elongate, relatively narrow, posterior half of a lower jaw. It measures 18 cm long from the preserved anterior to the posterior tip of the articular, and 5 cm deep from the level of the infradentaries to the dorsal margin of the dentary. Parts of the dorsal and ventral margins are incomplete, most notably the dorsal area anterior to the articular. Most of the surface of the jaw is covered by the prearticular (fig. 2b), which anteriorly carries small patches of denticles (fig. 2b) near the dorsal margin. These patches are replaced posteriorly by a roughened surface of bone, which is marked with a conspicuous crescent-shaped contour (fig. 2b) towards the posterior margin of the prearticular.

Posterior to the prearticular is the articular (fig. 2b), which displays a posterodorsally directed, concave glenoid surface. It is bordered anterodorsally and posteroventrally by two rounded prongs, with the former being preceded by a prominent concave dip in the preserved dorsal margin of the jaw. This could possibly represent the inner margin of the adductor fossa (fig. 2b).

Anterior to this region, the dorsal margin of the jaw is represented by two strips of bone: the dentary (fig. 2b), which is preserved anteriorly, and a presumed coronoid (fig. 2b), represented by a posteriorly positioned ledge that sits lingual to the dentary. Both the dentary and the coronoid are incompletely preserved.

Although the ventral margin of the lower jaw is incomplete anteriorly, a small slither of bone positioned labially to the prearticular may represent the third infradentary (fig. 2b). It is followed by a small break, and then by a similar bone, possibly the fourth infradentary (fig. 2b). This bone is bordered dorsally by a narrow groove, which rises transversely to delineate the margin of the prearticular from a region of exposed meckelian bone (fig. 2b). A small depression is present in this area, ventral to the glenoid surface of the articular. This may represent the opening for the ramus mandibularis of n. facialis (fig. 2b). The posteroventral outline of the jaw shows a distinct concave, step-like margin towards the articular (fig. 2b).

Comparisons to other taxa. Affinities of NMV P198470 to various osteichthyan clades can be eliminated quickly through comparisons of lower jaw gross morphology. NMV P198470 differs from Devonian 'palaeoniscid' fishes such as '*Mimia*' and *Moythomasia* (Gardiner, 1984) (fig. 2c) in lacking a dorsally directed glenoid fossa on the articular (and also the latter by the absence of a double prearticular); Devonian actinistians, such as *Miguashaia* (Forey *et al*., 2000) (fig. 2d) and *Styloichthys* (Friedman, 2007) by lacking a ventral mandibular flange protruding below the level of the infradentaries and the 'sympletic' articulation at the posterior of the jaw; Devonian dipnoans, such as *Chirodipterus* and *Rhinodipterus* (Jarvik, 1967) by having a prearticular, coronoid series and lacking a principle tooth plate; and porolepiforms, such as *Holoptychius* (Jarvik, 1972) (fig. 2e) by lacking a rounded posteroventral margin and large dorsoventral depth. Among tetrapodomorphs, NMV P198470 differs from rhizodontids by lacking an unossified articular and other meckelian elements (Jeffery, 2003) (fig. 2f); Devonian tetrapods, such as *Ventastega* (Ahlberg and Clack, 1998) (fig. 2g) by lacking an articular situated posterodorsally to the dentary tooth row; and most 'osteolepidids', such as *Ectosteorhachis* (Thomson, 1964) (fig. 2h) in having a gentle, transverse posteroventral outline towards the articular.

NMV P198470 is comparable to *Platycephalichthys bischoffi* (Vorobyeva, 1962: plates XVI-XVII) and some specimens of *Eusthenopteron foordi* (fig. 2i; Jarvik, 1980: fig. 125), in which the posteroventral margin of the lower jaw displays a concave profile. This embayment is also present in the unnamed tristichopterid specimen MNHN n° MCD 42 from Tafilalt, Morocco (Lelièvre and Janvier, 1986) (fig. 2k), which also shares the acute crescent shaped contour on the posterior region of the prearticular (fig. 2k). Among the lower jaw morphology of other tristichopterids, a posteroventral concave profile is absent from *Eusthenopteron säve-söderberghi* (Vorobyeva, 1962: plate I), *E. kurshi* (Zupiņš, 2008), *Jarvikina wenjukowi* (Vorobyeva, 1962: plate XXVIII), *Eusthenodon wängsjöi* (Jarvik, 1952) and *Tristichopterus* (Traquair, 1875). A posteroventral embayment is also present in the lower jaw of *Gyroptychius* specimen NRM PZ P1409 (fig. 2j), although this element is preserved in labial view.

tetrapodomorph gen. et sp. indet.

Referred specimen. NMV P229479, small parabasally sectioned, polyplocodont tooth.

Locality. Along the Genoa River, approximately 30–50 m upstream from the Yambulla Peak Track (fig. 1).

Description. The specimen, represented by a single tooth (figs 3a–c), measures approximately 1.5 cm from the apex to the preserved parabasal section, and is 8 mm in diameter. Several loose plications (fig. 3a) are present at the base of the external surface. These extend approximately one-third of the total height of the tooth, and are replaced apically by a smooth layer of enamel. The pulp cavity (fig. 3b) is visible in parabasal section, and seems to be free from osteodentine. It is surrounded by loose, simple folds of orthodentine (figs 3b–c), which appear to be interrupted intermediately by bone (fig. 3c).

Comparisons with other taxa. Tooth morphology of NMV P229479 closely matches that of polyplocodont teeth in having a free pulp cavity, simple orthodentine folds and bone of attachment extending between folds (Schultze, 1970: fig. 1a). This morphology is present in rhizodontids, *Megalichthys*, *Eusthenopteron* and *Tristichopterus* (Schultze, 1970). However, the lingual surface of NMV P229479 differs from that of rhizodontids, such as *Barameda* (Holland *et al*., 2007) in lacking fine, raised striae on the enamel.

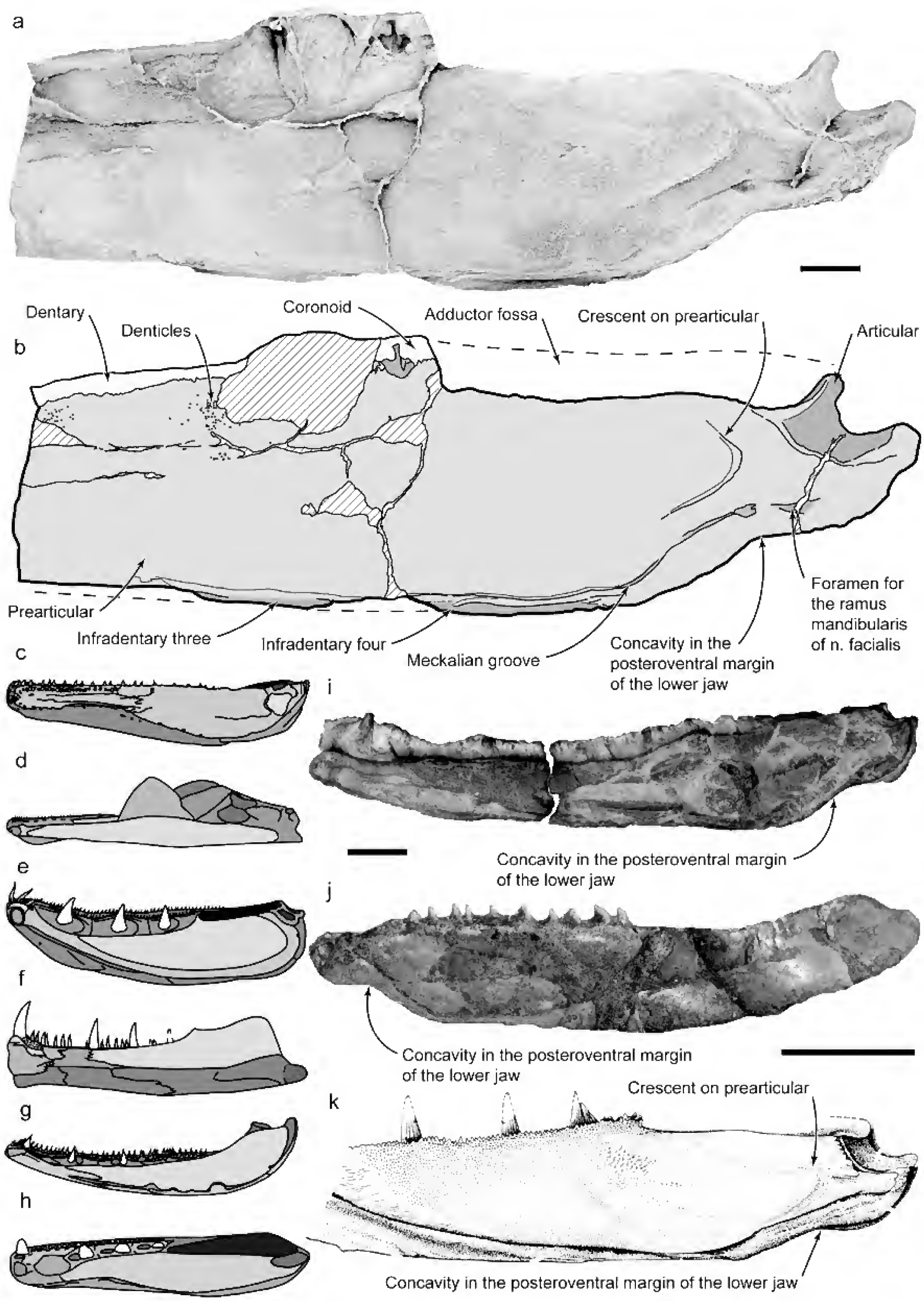

Figure 2. Osteichthyan lower jaws; a, photograph of possible tristichopterid NMV P198470; b, interpretive drawing of NMV P198470; c, *Moythomasia* (modified from Gardiner, 1984); d, *Miguashaia* (modified from Forey et al., 2000); e, *Holoptychius* (modified from Jarvik, 1972); f, *Rhizodus* (modified from Jeffery, 2003); g, *Ventastega* (modified from Ahlberg and Clack, 1998); h, *Ectosteorhachis* (modified from Thomson, 1964); i, *Eusthenopteron* specimen NRM PZ P35; j, *Gyroptychius* specimen NRM PZ P1409; k, tristichopterid specimen MNHN n° MCD 42 (modified from Lelièvre and Janvier, 1986). Scale = 1 cm; scale not included for c–h; all jaws excluding j are in lingual view; j is in labial view.

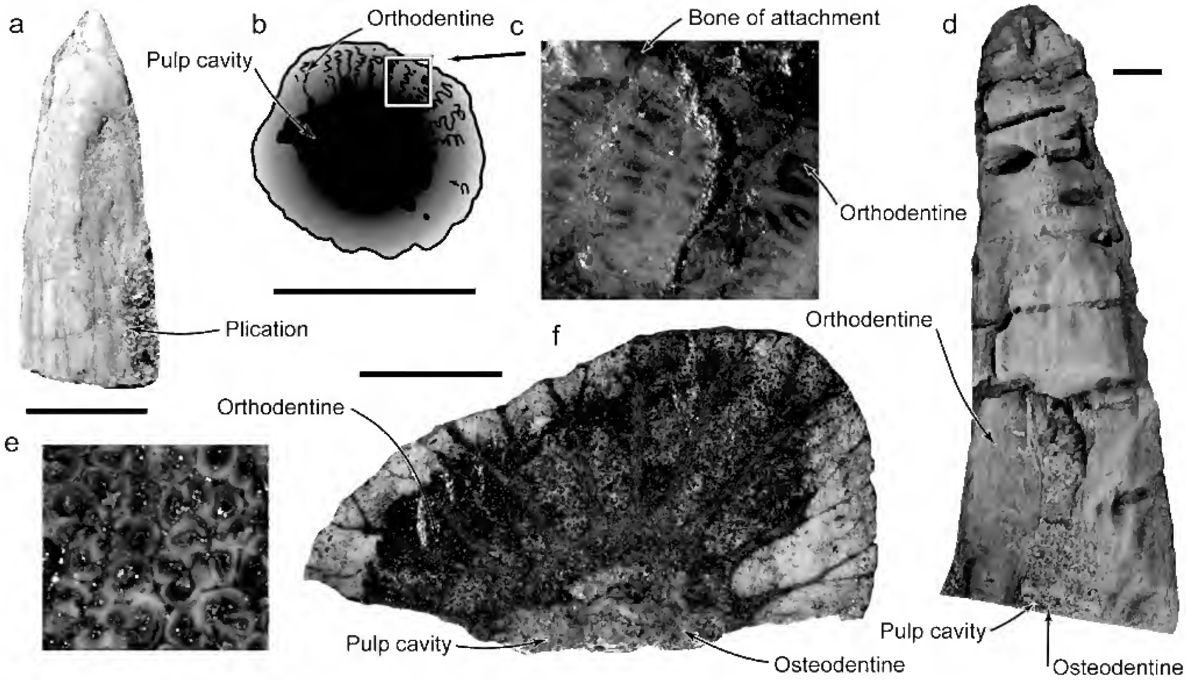

Figure 3. Tooth morphologies of tetrapodomorph fishes; a, labial view of polyplocodont tooth, NMV P229479; b, stylised drawing showing complete parabasal section of NMV P229479; c, orthodentine folding of NMV P229479 in parabasal section; d, vertical section of dendrodont tooth, NMV P229477; e, orthodentine folding of NMV P229477; f, parabasal section of NMV P229477. Scale = 5 mm; scale not included for c, e.

Order Porolepiformes Jarvik, 1942

? porolepiform gen. et sp. indet.

Referred specimen. NMV P229477, a large, vertically and parabasally sectioned dendrodont tooth element.

Locality. Along the Genoa River, approximately 30–50 m upstream from the Yambulla Peak Track (fig. 1).

Description. Specimen NMV P229477 is represented by a large fang (figs 3d–f), being approximately 6 cm in height, although parts of the base may not have been collected. The external surface is badly damaged, preserving no plications, with the proximal end sectioned vertically, exposing the pulp cavity (figs 3d–f). The width of the pulp cavity varies, being approximately half the total width of the specimen (total width = 2.2 cm) towards the proximal end, to be only one-fifth of the total diameter approaching the apex. Inside the pulp cavity is a granular column of bone, probably representing osteodentine (figs 3d, f). Lateral to the pulp cavity are wide expanses of orthodentine (figs 3d–f), which are marked with fine, densely packed lines, representing folding. This intense folding is more apparent in parabasal section, and appears darker and tighter towards the pulp cavity (fig. 3e). Several regions of orthodentine are interrupted by channels of osteodentine emanating from the pulp cavity (fig. 3f). In some instances, these channels appear to bifurcate and narrow as they approach the outer surface of the tooth.

Comparisons with other taxa. The combination of complicated folded orthodentine and a pulp cavity filled with osteodentine in NMV P229477 closely matches the description of dendrodont tooth morphology from porolepiform fishes, such as *Porolepis* (Schultze, 1970) and *Laccognathus* (Schultze, 1969). There is no intrusion of outside bone of attachment between the folds of orthodentine, in contrast to eusthenodont teeth (Schultze, 1970).

Discussion

Of the osteichthyan remains from the Genoa River Beds, the lower jaw of NMV P198470 may offer a link to tristichopterid taxa from outside East Gondwana in having a posteroventral embayment in the profile of the lower jaw. This particular feature is present in the *Eusthenopteron*-like tristichopterid material from Famennien of Morocco (Lelièvre and Janvier, 1986), and some specimens of *Eusthenopteron foordi* from the Frasnian of Miguasha, Quebec, Canada (e.g. NRM PZ P35 from the Swedish Museum of Natural History). *Eusthenopteron* is considered among the more primitive members of the Tristichopteridae, along with the Scottish Givetian taxon, *Tristichopterus* (Ahlberg and Johanson, 1997). A possible relationship between these taxa and NMV P198470 is surprising, because the record of tristichopterids in Australia otherwise consists of mandageriids. This includes *Cabonnichthys* Ahlberg and Johanson, 1997 and *Mandageria* Johanson and Ahlberg, 1997 from the Fransian Mandagery Formation of Canowindra, New South Wales; *Eusthenodon* from the Famennian of the Hunter Formation of Grenfell, New South Wales (Johanson, 2004); and the Worange Point Formation, south of Eden, New South Wales (Ahlberg *et al*., 2001). *Eusthenodon* was initially described from the Famennian of East Greenland (Jarvik, 1952). However, the assignment of the Eden tristichopterid within *Eusthenodon* has been questioned by Young (2008), placing it with the Canowindra tristichopterids in a possibly endemic Gondwanan subfamily — the Madageriidae — based on the presence of accessory vomers on the palate. The only other notable Australian taxon previously linked with the Tristichopteridae is *Marsdenichthys* Long, 1985 from the Givetian of Mt. Howitt, Victoria. This taxon has also been associated with the Rhizodopsidae (Long, 1999), although new material described by Holland *et al*. (2010) shows no affinities to this clade or the Tristichopteridae. In addition, the lower jaw of *Marsdenichthys* (Holland *et al*., 2010: fig. 2) lacks the posteroventral embayment of NMV P198470 and some tristichopterid taxa. However, evaluating the distribution of the posteroventral lower jaw concavity seen in NMV P198470 throughout the Tristichopteridae requires caution, because the area is either not well preserved or described as the Madageriidae (e.g. Young *et al*., 1992; Ahlberg and Johanson, 1997; Johanson and Ahlberg, 1997) and *Langlieria* (Clément, 2002); and appears absent from *Eusthenodon wängsjöi* (Jarvik, 1952), *Jarvikina* (Vorobyeva, 1962), the European species of *Eusthenopteron* (e.g. Vorobyeva, 1962; Zupiņš, 2008) and the basal *Tristichopterus* (Traquair, 1875). A poorly developed posteroventral lower jaw concavity also appears in *E. foordi* specimen P.2197 (Jarvik, 1996: fig. 19), although the relevant area in this specimen is possibly crushed. Outside the Tristichopteridae, a posteroventral embayment is also present in the lower jaw of *Platycephalichthys* from the Frasnian of Russia (Vorobyeva, 1962). However, this taxon, which was previously associated with tristichopterids, shares some affinities with 'elpistostegid' fishes, such as *Panderichthys* (Coates and Friedman, in press), and thus may occupy a more crownward phylogenetic position. It is also worth noting that a concave posteroventral profile marks the lower jaw of the cosmine-covered 'osteolepidid' *Gyroptychius* specimen, NRM PZ P1409. Although no cosmine was recorded on the scant labial surface material of NMV P198470 (before preparation), the presence of a posteroventral notch in the jaws of both specimens is potentially significant, as *Gyroptychius* is the sister taxon to the Tristichopteridae in Ahlberg and Johanson (1998) and shares a number of other characters with the group, including vomers with long posterior processes, an elongate ethmosphenoid block, and a trifurcate tail. However, the lower jaws of several specimens of *G. agssizi* (Jarvik, 1948: fig. 74), *G. milleri* (Jarvik, 1948: fig. 80) and *G. groenlandicus* (Jarvik, 1950: fig. 21) have rounded posteroventral profiles. Thus, posteroventral jaw morphology may vary within *Gyroptychius*. Alternatively, this region may be damaged in NRM PZ P1409 and may not represent a shared character between *Gyroptychius* and the Tristichopteridae. Furthermore, *Spodichthys* from the Frasnian of East Greenland has been shown to be the immediate sister taxon to the Tristichopteridae (Snitting, 2008), subsequent to the analysis of Ahlberg and Johanson (1998). This taxon displays a rounded posteroventral lower jaw profile (Snitting, 2008: fig. 7). Thus, it appears unlikely that concave posteroventral mandible morphology was present in *Gyroptychius*, was lost in *Spodichthys* and *Tristichopterus*, and then re-evolved at the node containing *Eusthenopteron*.

The phylogenetic relationships of the polyplocodont tooth NMV P229479 are difficult to discern, based on the widespread prevalence of similar tooth morphology throughout several tetrapodomorph groups, including rhizodontids, megalichthyids, tristichopterids, 'elpistostegids' and early tetrapods (Schultze, 1970). Based on relative size and spatial proximity to each other, it is possible that the lower jaw of NMV P198470 and NMV P229479 are attributable to the same form, although several other Palaeozoic fish sites are known to contain multiple tetrapodomorph fish genera (e.g. Mt. Howitt, Holland *et al*., 2010). Thus, isolated elements such as these must be interpreted with caution, because they may belong to different taxa.

The use of polyplocodont and eusthendont tooth morphologies as phylogenetic indicators may help clarify the relationships of advanced tristichopterids. In the cladistical analysis of Clément *et al*. (2009), *Eusthenodon* and *Langlieria* are grouped in an apical clade with *Mandageria* and *Cabonnichthys*. However, the former two taxa are described as having eusthenodont teeth (Schultze, 1970; Clément, 2002), while polyplocodont teeth are recorded from the later (Ahlberg and Johanson, 1997; Johanson and Ahlberg, 1997). It would be of great interest to determine the tooth morphology of the Eden tristichopterid to compare with the Northern Hemisphere specimens of *Eusthenodon* and the tristichopterids from Canowindra, to ascertain phylogenetic information. Curiously, the use of eusthenodont tooth morphology as a character is not included in the phylogenetic analysis of Ahlberg and Johanson (1997) or Johanson and Ahlberg (1997), with *Eusthenodon* coded with *Mandageria* and *Cabonnichthys* as having polyplocodont teeth. It is not stated in the relative literature whether the teeth of *Mandageria* (Johanson and Ahlberg, 1997) and *Cabonnichthys* (Ahlberg and Johanson, 1997) have been sectioned or are only known from natural moulds, as in other tetrapodomorph fishes from Canowindra, such as *Gooloogongia* (Johanson and Ahlberg, 2001). Among other tetrapodomorph fishes, eusthenodont teeth have also been described from *Platycephalichthys* (Vorobyeva, 1959) and *Litoptychus* (Schultze and Chorn, 1998). This latter form, known from the Frasnian of Colorado, United States of America (Schultze and Chorn, 1998), is placed as the sister taxon to the Megalichthyidae in Coates and Friedman (in press).

The identification of NMV P229477 as a dendrodont tooth confirms the record of porolepiform taxa among the Genoa River fauna. In overall proportions, NMV P229477 is slightly larger than the vomerine fang of *Barameda decipiens* from the Carboniferous of Mansfield, Victoria (Holland *et al*., 2007), a taxon probably 3–4 m in total body length (pers. obs., 2010). As some specimens of the cosmopolitan porolepiform *Holoptychius* exceed 2.5 m in length (Long, 1995), it is not unreasonable to suggest a very large body size for NMV P229477, possibly among the largest recorded for porolepiform fishes.

Of the faunal assemblage recorded from the Genoa River Beds (table 1), the most common taxon represented in the collections of Museum Victoria is the antiarch placoderm, *Remigolepis*, with up to eight registered specimens. Several large incomplete antiarch plates collected from the Genoa River (ANU 3269–3272) are also stored in the Research School of Earth Sciences, Australian National University (Gavin Young, ANU pers. comm., 2010). High occurrences of *Remigolepis* have been noted from the Upper Famennian tetrapod sites of Ningxia, China and East Greenland (Lebedev, 2004). Further similarities between the fossils localities of the Genoa River and East Greenland also occur in the presence of other taxa. As with the Genoa River Beds, the faunal assemblage of the Aina Dal Formation of East Greenland includes *Remigolepis* and *Bothriolepis*, as well as phyllolepid, tristichopterid, porolepiform and tetrapod material (Blom *et al*., 2007). The remains of *Groenlandaspis*, also reported from the Genoa River, are possibly present in the younger Harder Bjerg Formation of East Greenland (Blom *et al*., 2007). Plates attributed to *Groenlandaspis* from the Genoa River (e.g. NMV P186587) show evenly spaced, fine tubercles, similar to the condition in regularly ornamented specimens of *Groenlandaspis* (e.g. Daeschler *et al*., 2003: figs 2, 4). As stated by Young (2006), this material contradicts spurious reports of a smooth, unornamented form of *Groenlandaspis* from the Genoa River by Young (1993), which had been used previously to equate the age of the Genoa River Beds to that of the Famennian Worange Point Formation.

Of the sarcopterygian material collected from the Genoa River, the rounded scales of specimen NMV P230291 are not characteristic of the genus *Holoptychius*, reported from the area by Young (1993). The abovementioned sarcopterygian scales stored in Museum Victoria are marked with fine radiating ridges on the exposed external surface, similar to those preserved in some rhizodontids (e.g. Holland *et al*. 2007: fig. 4) and non-madageriids tristichopterids (e.g. Jarvik, 1952: fig. 30c). This pattern is distinct from the lateral scales of *Holoptychius*, in which the exposed external surface bares much thicker, broadly separated, radiating lines (Cloutier and Schultze, 1996: fig 11a). Aside from the examples described in this paper, several other sarcopterygian teeth have been collected from the Genoa River. Although varying in size and shape, it is difficult to discern the affinities of these specimens without obtaining detailed cross-sections. These specimens include NMV P229478, a partial jaw with several teeth. In contrast to the possible tristichopterid jaw NMV P198470, the incomplete nature of NMV P229478 does not allow detailed comparisons with known sarcopterygian forms.

Table 1. List of Museum Victoria specimens collected from the Genoa River.

Museum number	taxon	material
NMV P229529	*Remigolepis*	Plate
NMV P229545	*Remigolepis*	Plate
NMV P230039	*Remigolepis*	Plates and scales
NMV P230040	*Remigolepis*	Plate
NMV P230041	*Remigolepis*	Plate
NMV P229544	*Remigolepis*	Plates, shoulder joint
NMV P186587	*Groenlandaspis*	Plate
NMV P186582	*Groenlandaspis* and *Remigolepis*	Plate impressions
NMV P230038	*Bothriolepis*, *Remigolepis* and ?phyllolepid	Plate impressions
NMV P230683	Placoderm indet.	Plate
nMV P230682	Placoderm indet.	Plate
NMV P229476	Placoderm indet.	Plate
nMV P230042	Sarcopterygian indet.	Tooth
nMV P230043	Sarcopterygian indet.	Tooth
nMV P229478	Sarcopterygian indet.	Partial jaw and teeth
nMV P230291	Sarcopterygian indet.	Scales
nMV P229477	Porolepiform indet.	Tusk
nMV P229479	Tetrapodomorph indet.	Tooth
nMV P198470	Tetrapodomorph indet.	Jaw
nMV P41321	Tetrapod indet.	Trackways 1 and 2
nMV P41322	Tetrapod indet.	Trackway 3

In regards to the age of the Genoa River Beds, the potential record of phyllolepid material is compelling as a biostratigraphic indicator. This record consists of elements observed in the field by Anne Warren (pers comm., La Trobe University, 2009), as well as the impression of a plate on specimen NMV P230038 (table 1), a large block red sandstone. This material is of great importance, as the record of phyllolepids from Australia extends to Givetian and Frasnian fossil sites (Young, 2005), in contrast to the Famennian range for the group from Euramerican localities (e.g. Blom *et al*., 2007). This record could support an earlier, possibly Frasnian, age for the Genoa River localities, as suggested by Young (2006). It should be noted that although five phyllolepid genera have been described from the pre-Famennian sites in Australia (listed in Young, 2010), indeterminate phyllolepid material has also been reported from other Famennian sites in East Gondwana (Young, 2005: fig. 4). Furthermore, the possible impression of a phyllolepid plate on NMV P230038 consists of a small, incomplete region of parallel ridged ornament. This region could alternatively be interpreted as the parallel, laterally running ridges marking the anterior ventrolateral plate of *Remigolepis* (e.g. Johanson, 1997: fig 12e). Nevertheless, the report of phyllolepid plates in the field (Anne Warren, pers comm., 2009) possibly provides significant new information regarding the age of the Genoa River Beds. Of the other placoderm taxa reported from the Genoa River, *Bothriolepis, Remigolepis*, and *Groenlandaspis* have been recorded from both Frasnian (e.g. Canowindra; Young, 2008) and Famennian (e.g. Grenfell; Johanson, 1997) fossils sites from Australia.

The possibly Frasnian age of the Genoa River Beds does not contradict current ideas regarding the occurrence and dispersal of tristichopterid and porolepiform fishes throughout the early Late Devonian. Such hypotheses include the origin of the Tristichopteridae in Euramerica, based on the presence of the stem taxon *Spodichthys* and the earliest member of the group *Tristichopterus* in the Northern Hemisphere (Snitting, 2008). The discovery of NMV P198470 from the Genoa River may support the dispersal of the group to Gondwana as early or before the Early–Mid Frasnian, rather than at the Frasnian–Famennian boundary. This scenario is possibly contradicted by the presence of tristichopterid material from the Givetian Bunga Beds, on the south coast of New South Wales (Young, 2007; 2008). However, this material, including scales and an isolated cleithrum, does not include any known tristichopterid synapomorphies, and should be regarded with caution.

The age of porolepiform material from other East Gondwana sites far exceeds that of NMV P229477. This includes elements from the Pragian–Eifelian Dulcie Sandstone and Cravens Peak Beds of Central Australia (Young and Goujet, 2003). This East Gondwanan record appears as old as the earliest porolepiform taxa from the Northern Hemisphere, such as *Porolepis* (Jarvik, 1972).

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Three new species of the crangonid genus *Metacrangon* Zarenkov (Crustacea: Decapoda: Caridea) from Australia

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Abstract

Komai, T. & Taylor, J. 2010. Three new species of the crangonid genus *Metacrangon* Zarenkov (Crustacea: Decapoda: Caridea) from Australia. *Memoirs of Museum Victoria* 67: 45–59.

Examination of collections from waters off southern Australia resulted in significant findings of three new species of the crangonid genus *Metacrangon* Zarenkov, 1965: *M. australis* sp. nov. from the Southern Ocean off Tasmania, west of Maquarie Island; *M. poorei* sp. nov. from the Tasman Sea; and *M. spinidorsalis* sp. nov. from waters off southwestern Western Australia and the Tasman Sea. The two former species are morphologically similar to *M. variabilis* (Rathbun, 1902) from the north Pacific and *M. proxima* Kim, 2005 from Japan. The third is referred to the informal *M. jacqueti* (A. Milne-Edwards, 1881) species group. Differentiating characters of these three new species are discussed and a key to their identification is provided.

Keywords

Crustacea, Decapoda, Caridea, Crangonidae, *Metacrangon*, new species, key, Australia, Victoria, Western Australia, Tasmania, Macquarie Island

Introduction

The crangonid shrimp genus *Metacrangon* Zarenkov, 1965 is rather diverse, with 26 named species and one subspecies (De Grave *et al*., 2009; Komai and Komatsu, 2009; Komai, in press). It is characterised by the shallowly depressed gastric region of the carapace, the usual presence of a pair of submedian teeth on the carapace, the laterally flared pleuron of the sixth abdominal somite, and the second pleopod with an appendix masculina being much shorter than the endopod (Zarenkov, 1965; Butler, 1980; Kim and Hayashi, 2003; Kim, 2005). Christoffersen (1988) supported the monophyly of the genus. Many of these 27 taxa are rare, reported from limited geographic locations that are often confined to or near their type localities. Although species of *Metacrangon* are well represented in the north Pacific Ocean, no species of the genus have been described from Australia. Poore (2004) reported that unidentified species were known to occur on the southeastern shelf off eastern Tasmania at around 500–600 m depth, but to date, these have remained undescribed. A nominal new species from southwestern Australia was also recently reported by Poore *et al*. (2008) from sampling cruises off the continental margin of Western Australia onboard the FRV *Southern Surveyor* in 2005, mounted by CSIRO Marine and Atmospheric Research (CMAR) and Museum Victoria (project entitled 'Mapping benthic ecosystems on the deep continental shelf and slope in Australia's southwest region').

This present study was initiated to describe the new species from southwestern Australia reported by Poore *et al*. (2008), but our examination of the *Metacrangon* specimens lodged in Museum Victoria, referred to by Poore (2004), confirmed two further species, both new to science. In this paper, these three new species are described and illustrated: *M. australis* sp. nov. from waters southeast of Tasmania off Macquarie Island; *M. spinidorsalis* sp. nov. (= *Metacrangon* sp. Poore, 2004 and *Metacrangon* sp. MoV 5423 Poore *et al*., 2008) from southwestern Australia and the Tasman Sea; and *M. poorei* sp. nov. from the Tasman Sea. These three species occur in rather high latitudinal areas.

The examined material remains in Museum Victoria, Melbourne (MV) and the Western Australian Museum, Perth (WAM). The abbreviation 'sp. MoV' refers to the unique Museum Victoria number allocated to new or undetermined taxa (and is not the same as sp. nov., which refers to a new species). The measurement provided is of the postorbital carapace length (cl) measured from the level of the posterior margin of the orbit to the midpoint of the posterodorsal margin. In order to avoid unnecessary repetition, only *M. spinidorsalis* is fully described and differential descriptions are given for the other two new species.

Taxonomic account

Metacrangon australis sp. nov.

Figures 1–3

Material examined. Holotype: Australia, Tasmania, southwestern Pacific west of Macquarie Island (54°42.42'S, 158°45.12'E – 54°41.36'S, 158°43.12'E), 700–900 m, 22–23 Jan 1999, FRV *Southern Surveyor*, epibenthic sled (stn SS01/99/65), NMV J60424 (1 female, cl 13.1 mm).

Paratypes: same data as holotype, NMV J61200 (2 females, cl 9.9, 12.1 mm).

Description. Body (fig. 1) moderately robust. Rostrum (figs 2a–b) narrowly triangular with acute apex in dorsal view, directed forward or slightly ascending, about 0.20 times as long as carapace; dorsal surface with middorsal carina in proximal half; lateral margin slightly convex in lateral view, merging into orbital margin; midventral carina distinct, ventral margin nearly straight in lateral view. Carapace (figs 1, 2a) very slightly widened anteriorly, longer than wide postorbitally; surface covered with very short setae; dorsal midline with two moderately small, subequal teeth; anterior (epigastric) tooth arising at 0.10 of carapace length, posterior (cardiac) tooth broken off, arising at 0.75–0.80 of carapace length; submedian and hepatic teeth moderately small; antennal tooth moderately strong, directed forward in dorsal view, weakly ascending (same degree as rostrum) in lateral view, acuminate, falling short of rostral tip; orbital cleft absent; anterolateral margin between antennal and branchiostegal teeth sinuous with obtuse lobule (holotype) or with tiny denticle (paratypes) inferior to base of antennal tooth; branchiostegal tooth moderately strong, very slightly diverging anteriorly in dorsal view and strongly ascending in lateral view, distinctly overreaching dorsodistal margin of antennal basicerite; pterygostomial tooth small, visible in lateral view; postorbital carina clearly delimited, accompanied by longitudinal suture; weak epibranchial carina present.

Thoracic sternites depressed; fifth sternite with small, forwardly directed median tooth, otherwise unarmed.

Abdomen (figs 1, 2c) moderately sculptured; first to fifth somites with sharply delimited, crested middorsal carina, anterior end of middorsal carina on second somite produced anteriorly. Pleuron of anterior four somites rounded marginally. Fifth somite with posterodorsal margin slightly produced medially; posterolateral margin unarmed; pleuron with posteroventral angle rounded, ventral margin gently convex. Sixth somite 1.6 times longer than wide, with distinct, slightly curved submedian carinae, not reaching posterodorsal margin; dorsolateral carina distinct, reaching to posterodorsal margin; posterodorsal margin produced, distinctly bilobed; pleuron flared laterally, with small posteroventral tooth; posterolateral process moderately strong, directed posteriorly, terminating in sharp tooth. Telson (figs 2c–d) tapering distally to acute apex, with three pairs of minute dorsolateral spines, anteriormost pair located at posterior 0.35; three pairs of spiniform setae posterior to third pair of dorsolateral spines.

Eye (figs 2a–b) as long as wide; cornea as wide as eyestalk, darkly pigmented, corneal width 0.13–0.15 of carapace length; eyestalk with small, papilla-like dorsal tubercle.

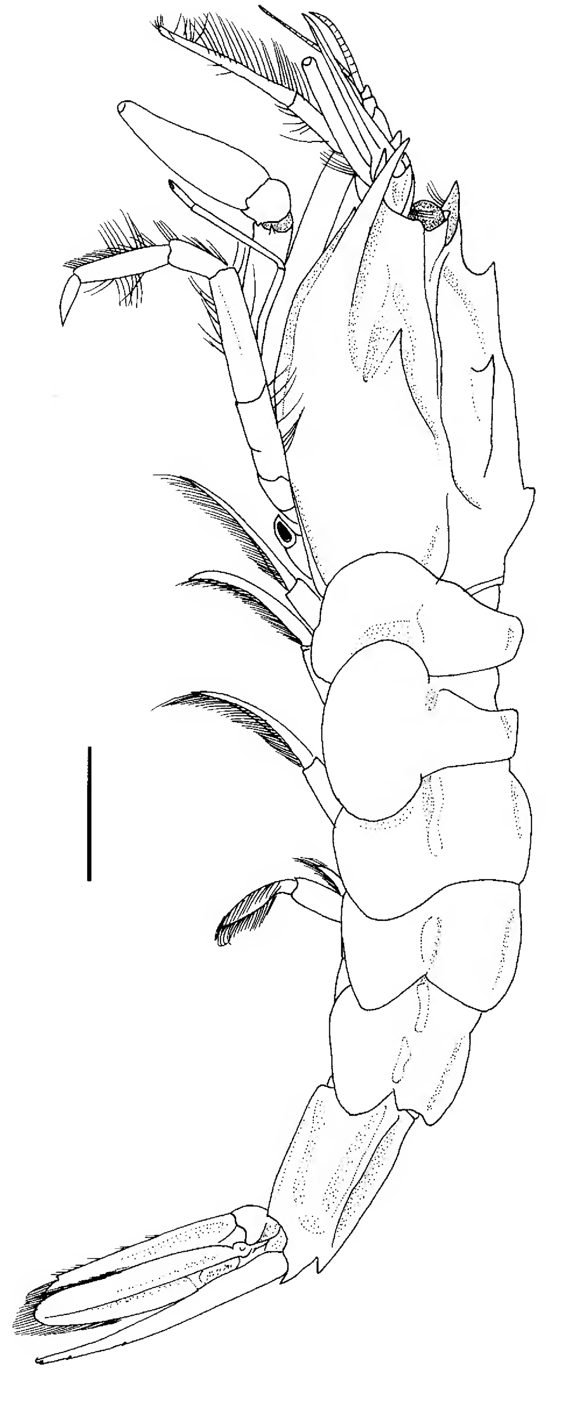

Figure 1. *Metacrangon australis* sp. nov., holotype, female (cl 13.1 mm), NMV J60424, entire animal in lateral view (left fifth pereopod lost). Scale bar = 5 mm.

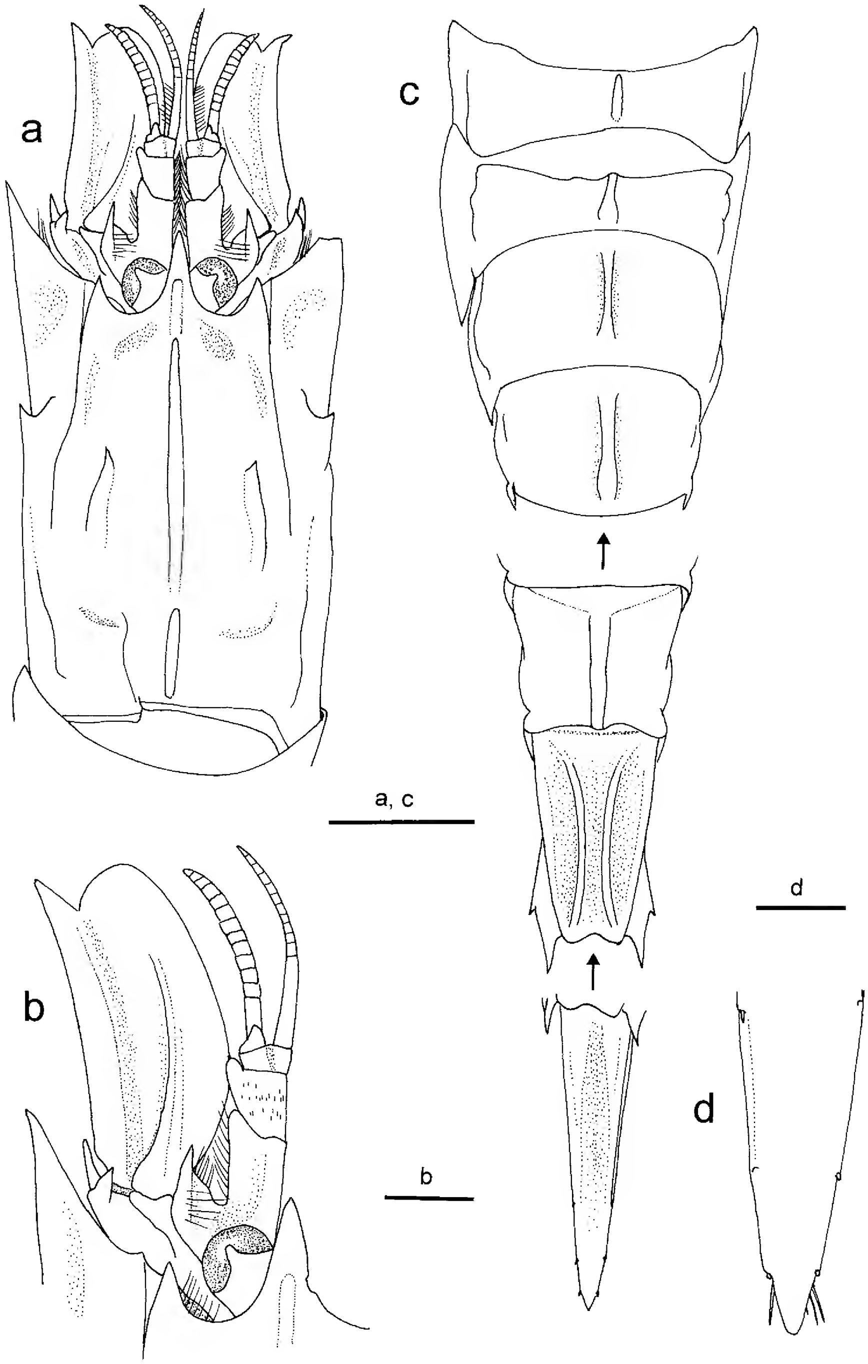

Figure 2. *Metacrangon australis* sp. nov., holotype, female (cl 13.1 mm), NMV J60424: a, carapace and cephalic appendages, dorsal view (setae partially omitted); b, anterior part of carapace (left side) and left cephalic appendages, dorsal view; c, abdomen, dorsal view; d, posterior part of telson, dorsal view. Scale bars = 5 mm for a and c; 2 mm for b; 1 mm for d.

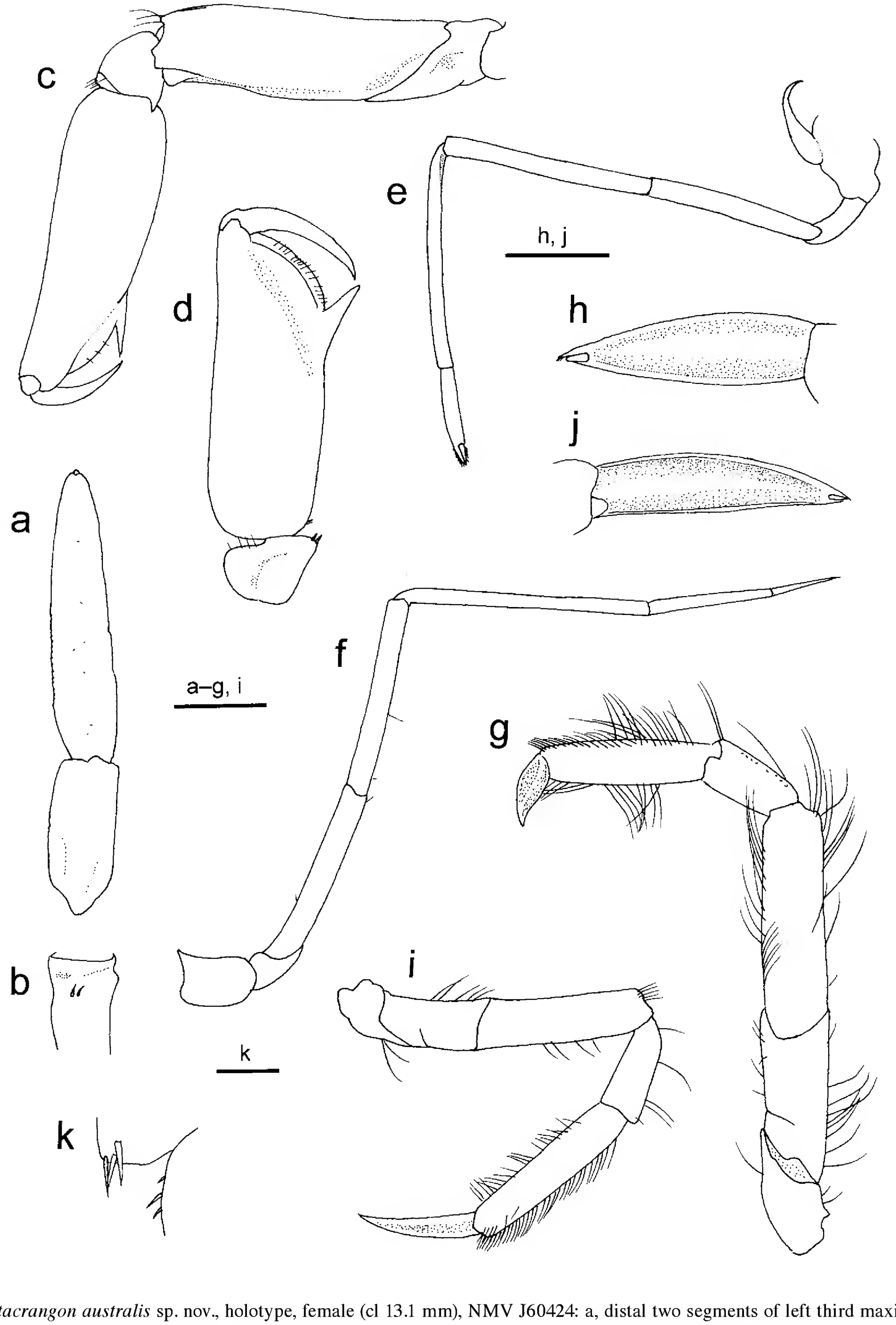

Figure 3. *Metacrangon australis* sp. nov., holotype, female (cl 13.1 mm), NMV J60424: a, distal two segments of left third maxilliped, dorsal (extensor) view (setae omitted); b, distal part of antepenultimate segment of left third maxilliped, ventral view; c, left first pereopod, lateral view; d, same, subchela and carpus, dorsal (extensor) view; e, left second pereopod, lateral view; f, right third pereopod, lateral view; g, left fourth pereopod, lateral view; h, same, dactylus, flexor view; i, right fifth pereopod, lateral view; j, same, dactylus, flexor view; k, posterolateral tooth of left uropodal exopod, dorsal view (setae omitted). Scale bars = 2 mm for a–g and i; 1 mm for h and j; 0.5 mm for k.

Antennular peduncle (figs 2a–b) moderately stout, reaching midlength of antennal scale. First segment with prominent, blunt distolateral process directed dorsally; distomesial margin unarmed; stylocerite falling far short of distolateral process of first segment, terminating in slender, sharp tooth, lateral margin gently convex. Second segment widened distally, slightly longer than wide, with prominent, blunt distolateral process. Third segment much wider than long. Outer flagellum consisting of 13 articles.

Antennal basicerite (figs 2a–b) stout, with acutely pointed dorsodistal lateral angle and long ventrolateral tooth distinctly overreaching dorsodistal lateral angle. Antennal scale (figs 2a–b) 0.50–0.55 times as long as carapace and about 2.3 times longer than wide; lateral margin weakly concave; distolateral tooth moderately broad, slightly overreaching rounded lamella.

Third maxilliped (fig. 3a) relatively stout, overreaching antennal scale by full length of ultimate segment; ultimate segment about 4.5 times longer than wide; penultimate segment about 2.3 times longer than wide; antepenultimate segment with two subequal spiniform setae subdistally (fig. 3b).

First pereopod (fig. 3c) moderately stout, slightly overreaching antennal scale; palm (fig. 3d) 2.9 times longer than wide, not widened proximally or distally; lateral and mesial margins faintly sinuous; thumb relatively long; carpus with small ventrolateral tooth, otherwise unarmed on distolateral margin; merus with small dorsodistal tooth, ventral margin sinuous, crested. Second pereopod with dactylus about 0.3 times as long as palm (fig. 3e); length ratio of chela to ischium 1:2.3:2.2:1.8. Third pereopod (fig. 3f) slender; length ratio of dactylus to ischium 1:1.8:3.8:2.8:2.8. Fourth pereopod (fig. 3g) relatively stout, reaching nearly distal margin of antennal scale; dactylus (fig. 3H) elongate subovate, spatulate, about 0.5 times as long as propodus, margins naked; dactylus–propodus articulation about 60°; propodus about 4.0 times longer than wide; propodus–carpus combined distinctly shorter than merus–ischium combined. Fifth pereopod (fig. 3i) shorter than fourth pereopod; dactylus (fig. 3j) spatulate, subequal in length to dactylus of fourth pereopod, about 0.7 times as long as propodus.

Uropodal exopod with blunt posterolateral tooth and with three spiniform setae (fig. 3k).

Colouration. Not known.

Distribution. Known only from the type locality in the Southern Ocean southeast of Tasmania, west of Macquarie Island, at depths of 700–900 m.

Remarks. *Metacrangon australis* is somewhat similar to *M. proxima*, *M. variabilis* and *M. poorei* sp. nov. in the general disposition of carapacial teeth and the carination of the abdomen, but it is quite unique within the genus in having the combination of the following characters: the rostrum is narrowly triangular and distinctly overreaches the distal corneal margins; the carapace has two middorsal teeth, of them the anterior tooth is distinctly postrostral and the posterior (cardiac) tooth arises at 0.75–0.80 of the carapace length; the lateral margin of the rostrum merges into the orbital margin, thus no cleft is defined; the first to fifth abdominal somites bear sharp, crested middorsal carina; and the anterior three pleura are rounded marginally. Of particular note is the lack of an orbital cleft, an uncommon trait previously known only in *M. knoxi* (Yaldwyn, 1960) (see Komai, 1997). *M. knoxi* is referred to the *M. jacqueti* (A. Milne-Edwards, 1881) species group (Komai, 1997) and is readily distinguished from *M. australis* by the anterior middorsal tooth on the carapace that arises at the midlength of the rostrum and the presence of a ventral tooth on each first to third abdominal pleuron.

Etymology. Named '*australis*', Latin meaning 'southern', alluding to the type locality of this new species, representing the southernmost locality of the genus.

Metacrangon poorei sp. nov.

Figures 4, 5

Material examined. Holotype: Australia, off southeastern Victoria, (39°53.76'S, 149°03.39'E), 1608 m, 28 Apr 2000, FRV *Southern Surveyor*, epibenthic sled, (stn SS01/00/246), NMV J52069 (1 female, cl 8.1 mm).

Description. Based on holotype female. Body (figs 4a–e) moderately robust. Rostrum (figs 4a–b, 5a) triangular with acute apex in dorsal view, strongly ascending (angle against horizontal plane of carapace about 45°), 0.20 times as long as carapace; dorsal surface with low, but clearly delimited middorsal carina; lateral margin faintly sinuous in lateral view, merging into postorbital region of carapace; midventral carina distinct, ventral margin sinuous in lateral view. Carapace (figs 4a–b) not widened posteriorly, longer than wide postorbitally; dorsal midline with two moderately small teeth; anterior (epigastric) tooth arising at 0.18 of carapace length, posterior (cardiac) tooth broken off, arising at 0.68 of carapace length; submedian and hepatic teeth moderately small; antennal tooth moderately strong, directed forward in dorsal view, strongly ascending (same degree as rostrum) in lateral view, acuminate, falling slightly short of rostral apex; orbital cleft distinct; anterolateral margin between antennal and branchiostegal teeth concave, unarmed; branchiostegal tooth moderately strong, directed forward in dorsal view, strongly ascending in lateral view, reaching dorsodistal margin of antennal basicerite; pterygostomial tooth small, clearly visible in lateral view; postorbital carina clearly delimited, accompanied by longitudinal suture; epibranchial carina weakly absent.

Fifth to eighth thoracic sternites each with distinct median keel: on fifth, spiniform, directed forward; on sixth, terminating anteriorly in tiny tooth; on seventh, angulated anteriorly; and on eighth, rounded.

Abdomen (figs 4c–e) slightly sculptured, surface sparsely punctate; first somite with trace of middorsal carina, second to fourth somites with rather broad, clearly delimited middorsal carina. Pleuron of anterior four somites rounded marginally. Fifth somite with low, rather broad, clearly delimited middorsal carina; posterodorsal margin faintly produced medially; posterolateral margin unarmed; pleuron with posteroventral angle rounded, ventral margin gently convex. Sixth somite 1.7 times longer than wide, with distinct, slightly curved submedian carinae, not reaching posterodorsal margin;

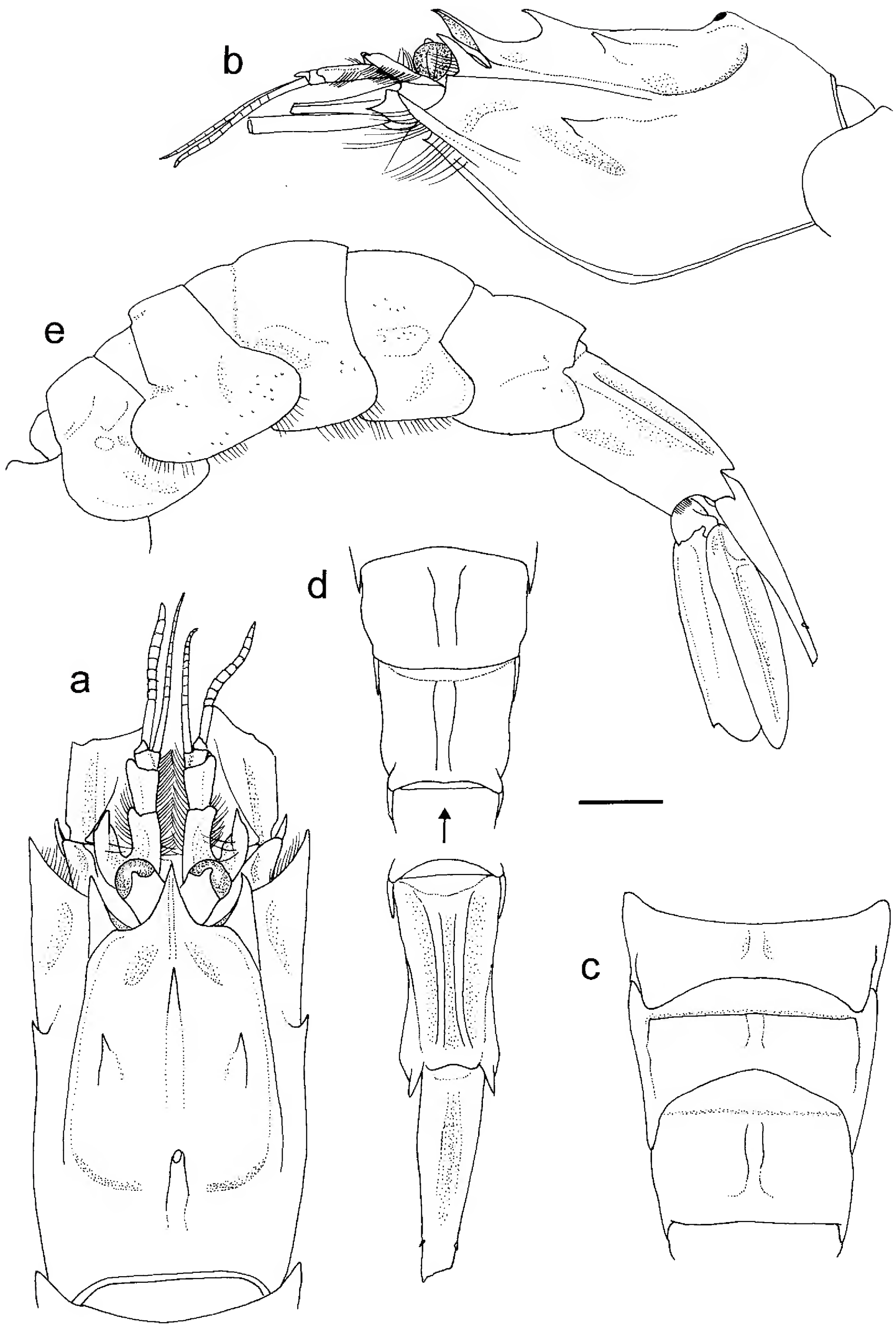

Figure 4. *Metacrangon poorei* sp. nov., holotype, female (cl 8.1 mm), NMV J52069: a, carapace and cephalic appendages, dorsal view; b, same, lateral view; c, first to third abdominal somites, dorsal view; d, fourth abdominal somite to telson, dorsal view; e, entire abdomen, lateral view. Scale bar = 2 mm.

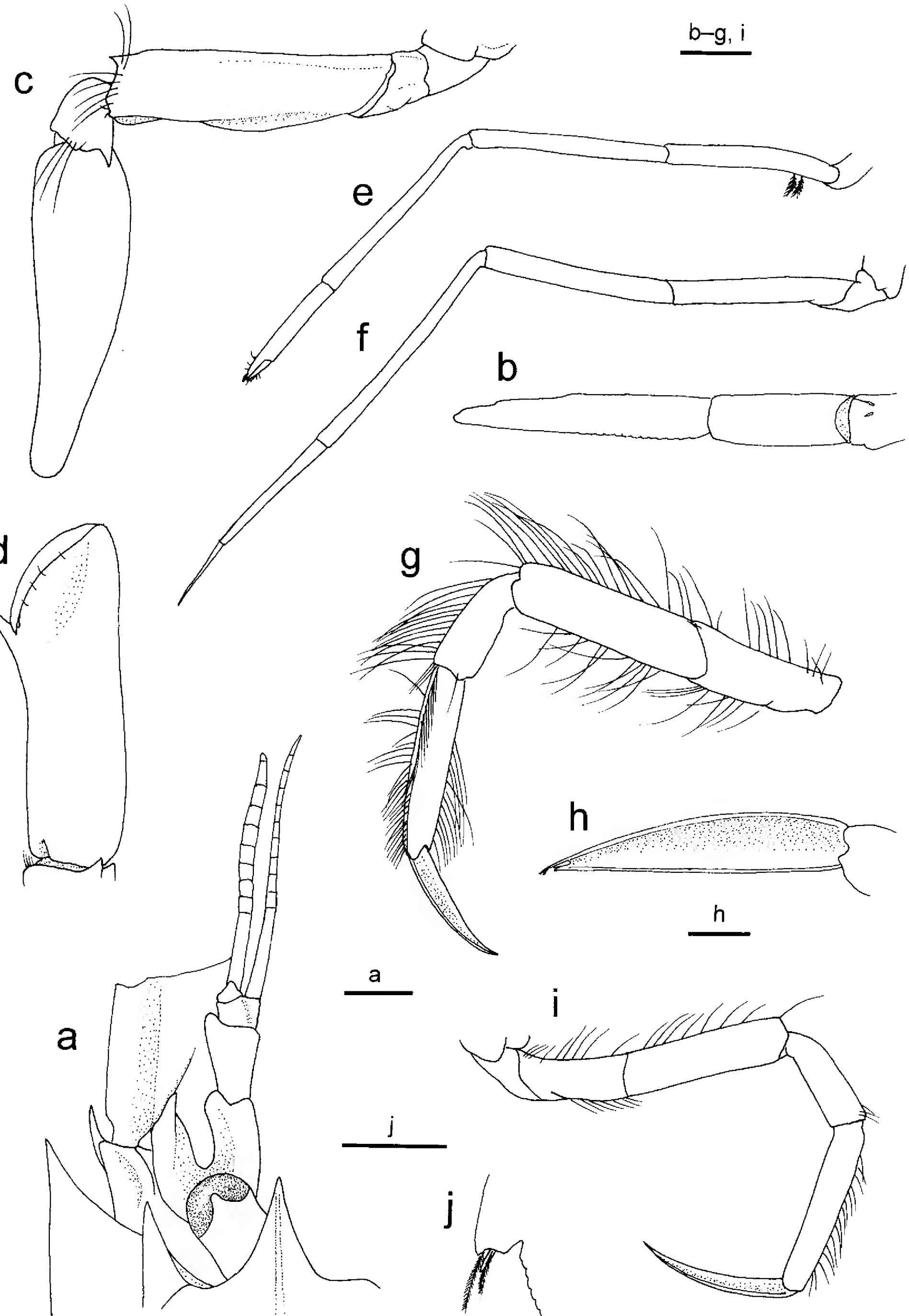

Figure 5. *Metacrangon poorei* sp. nov., holotype, female (cl 8.1 mm), NMV J52069: a, anterior part of carapace (left side) and left cephalic appendages, dorsal view; b, distal two segments and distal part of antepenultimate segment of left third maxilliped, ventral (flexor) view; c, left first pereopod, lateral view; d, same, subchela, flexor view; e, left second pereopod, lateral view; f, left third pereopod, lateral view; g, left fourth pereopod, lateral view; h, same, dactylus, flexor view; i, right fifth pereopod, lateral view; j, posterolateral tooth of left uropodal exopod, dorsal view. Scale bars = 1 mm for a–g and i; 0.5 mm for h and j.

dorsolateral carina distinct, reaching to posterodorsal margin; posterodorsal margin produced, weakly bilobed; pleuron flared laterally, posteroventral tooth small; posterolateral process moderately strong, directed slightly laterally, terminating in sharp tooth. Telson (fig. 4d) damaged, but one pair of dorsolateral spines still preserved.

Eye (figs 4a, 5a) slightly longer than wide; cornea as wide as proximal part of eyestalk, darkly pigmented, corneal width 0.17 of carapace length; eyestalk with small, papilla-like dorsal tubercle.

Antennular peduncle (figs 4a, 5a) moderately stout. First segment with prominent, blunt distolateral process directed dorsally; distomesial margin unarmed; stylocerite just reaching tip of distolateral process, subacutely pointed, lateral margin gently convex. Second segment slightly widened distally, distinctly longer than wide, with prominent, blunt distolateral process. Third segment wider than long. Outer flagellum consisting of 10–11 articles.

Antennal basicerite (fig. 5a) stout, with rounded dorsodistal lateral angle and long ventrolateral tooth distinctly overreaching dorsodistal lateral angle. Antennal scale damaged (fig. 5a).

Third maxilliped (fig. 5b) relatively slender, overreaching antennal scale by 0.6 length of ultimate segment; ultimate segment gradually tapering distally, 6.0 times longer than wide; penultimate segment about 2.7 times longer than wide; antepenultimate segment with two unequal spiniform setae subdistally.

First pereopod (figs 5c–d) moderately stout; palm 3.5 times longer than wide, not widened proximally or distally; lateral and mesial margins faintly sinuous; thumb moderately broad; carpus with small ventrolateral tooth, otherwise unarmed on lateral margin; merus with small dorsodistal tooth, ventral margin sinuous, crested. Second pereopod (fig. 5e) with dactylus about 0.5 times as long as palm; length ratio of chela to ischium 1:1.7:1.6:1.5. Third pereopod (fig. 5f) slender; length ratio of dactylus to ischium 1:1.9:3.4:2.5:2.6. Fourth pereopod (fig. 5g) moderately stout; dactylus (fig. 5h) narrowly spatulate, about 0.6 times as long as propodus, margins naked; dactylus–propodus articulation about 30°; propodus about 5.0 times longer than wide; carpus shorter than propodus, with numerous long setae on dorsal margin; row of long setae on dorsal and ventral margins of merus and ischium (dorsal setae longer than ventral setae). Fifth pereopod (fig. 5i) slightly shorter than fourth pereopod; dactylus slender, subspatulate, longer than dactylus of fourth pereopod, about 0.8 times as long as propodus.

Uropodal exopod with minute posterolateral tooth and minute spinule just located mesial to posterolateral tooth (Fig. 5j).

Colouration. Not known.

Distribution. Known only from the type locality off southeastern Victoria, at a depth of 1608 m.

Remarks. *Metacrangon poorei* sp. nov. is morphologically very similar to *M. variabilis* (Rathbun, 1902) from the northeastern Pacific and *M. proxima* Kim, 2005 from Japan in the disposition of teeth on the carapace and the development of the middorsal carina of the abdomen. Nevertheless, the new species is easily distinguished from the latter two species by the following characters: the rostrum is acutely pointed and reaches to the distal corneal margins in *M. poorei*, whereas it is blunt or subacute at the tip and falls far short of the distal corneal margins in the latter two species; the anterolateral angle of the postorbital carina is rounded in *M. poorei*, rather than bearing a small triangular tooth or denticle in the latter two species; the lateral carina on the fifth abdominal somite is obsolete in *M. poorei* sp. nov, but it is distinct in the latter two species; and the stylocerite of the antennule reaches the distolateral process on the first peduncular segment in the new species, rather than falling far short of it in the latter two species.

Etymology. It is our pleasure to dedicate this new species to our esteemed colleague, Dr. Gary C. B. Poore.

Metacrangon spinidorsalis sp. nov.

Metacrangon sp.(Poore, 2004, 139, fig. 36f)
Metacrangon sp. MoV 5423. (Poore *et al*., 2008, 81)

Figures 6–10

Material examined. Holotype: Australia, Western Australia, off Point Hillier (35°22.54'S, 117°12.25'E – 35°22.54'S, 117°12.25'E), 539 m, 22 Nov 2005, FRV *Southern Surveyor*, beam trawl (stn SS10/2005/019), WAM C45115 (1 female, cl 10.4 mm).

Paratypes: Tasmania, Tasman Sea off Maria Island (42°42.8'S, 148°22.2'E), 450 m, 25 Jun 1984, RV *Soela*, demersal beam trawl (stn S03/84/77), NMV J40886 (1 female, cl 7.6 mm); Southern Ocean, 48 km west of Richardson Point (41°15.0'S, 144°08.0'E), 520 m, 20 Oct 1984, Frank and Bryce demersal trawl (stn S05/84/51), NMV J40954 (1 female, cl 9.0 mm). Western Australia, off Point Hillier (35°22.54'S, 117°12.25'E – 35°22.54'S, 117°12.25'E), 539 m, 22 Nov 2005, FRV *Southern Surveyor*, beam trawl (stn SS10/2005/019), NMV J54497 (3 females, cl 5.4–10.4 mm, 6 males, cl 6.1–7.0 mm); off Bald Island (35°04.01'S, 118°39.50'E – 35°13.40'S, 118°40.30'E), 728–710 m, 23 Nov 2005 (stn SS10/2005/032), NMV J19215 (1 female, cl 7.7 mm); (35°12.49'S, 118°39.04'E – 35°12.14'S, 118°40.08'E), 431–408 m, 24 Nov 2005 (stn SS10/2005/034), WAM C45116 (1 female, cl 6.9 mm); off Perth Canyon (31°59.33'N, 115°10.59'E – 32°00.07'S, 115°10.41'E), 508–478 m, 29 Nov 2005 (stn SS10/2005/068), NMV J54512 (4 females cl 6.7–9.5 mm, 1 male cl 6.5 mm).

Description. Female. Body (fig. 6) moderately robust. Rostrum (figs 7a–b) narrowly triangular with acute apex in dorsal view, directed forward, 0.20–0.25 times as long as carapace; dorsal surface nearly flat; lateral margin slightly arched in lateral view, merging into postorbital region of carapace; midventral carina low, ventral margin slightly sinuous in lateral view. Carapace (figs 6, 7a) slightly widened posteriorly, slightly longer than wide postorbitally; surface covered with very short setae; dorsal midline with two moderately small teeth; anterior tooth arising at rostral base, not overlapping rostrum, slightly larger than posterior (cardiac) tooth; posterior (cardiac) tooth arising at 0.55–0.60 of carapace length; submedian teeth moderately small; hepatic tooth relatively small; antennal tooth moderately strong, directed forward in dorsal view, somewhat ascending in lateral view (angle about 30° against horizontal plane of carapace), acuminate, far falling short of rostral apex; orbital cleft present, but only weakly delimited; anterolateral margin between antennal and branchiostegal tooth concave, with tiny spinule inferior to base of antennal tooth; branchiostegal tooth moderately strong, directed forward in dorsal view and somewhat dorsally in lateral view, reaching dorsodistal margin of antennal basicerite; pterygostomial tooth small, not visible in lateral view; postorbital carina clearly delimited, accompanied by longitudinal suture; epibranchial carina weakly delimited.

In spawning molts, thoracic sternum concave, armature absent; only fifth sternite with small tubercles medially. In nonspawning molts, fifth sternite with sharp, procurved tooth; sixth to seventh somites each with rounded, strongly compressed prominence, becoming higher posteriorly.

Abdomen (figs 6, 7c) slightly sculptured; anterior two somites without trace of middorsal carina anteriorly, but second tergum with distinct spiniform middorsal tooth located at anterior end of posterior section; third somite with trace of middorsal carina, and fourth somite with broad, clearly delimited middorsal carina. First and second pleura each with blunt tooth on ventral margin; third pleuron with blunt tooth at anteroventral angle; fourth pleuron unarmed. Fifth somite with low, but distinct middorsal carina; posterodorsal margin faintly produced medially; posterolateral margin unarmed; pleuron with posteroventral angle subacutely pointed, ventral margin gently convex. Sixth somite with distinct, straight submedian carinae, not reaching posterodorsal margin; dorsolateral carina distinct, reaching to posterodorsal margin; posterodorsal margin produced, faintly bilobed; pleuron flared laterally, posteroventral tooth small, acute or subacute; posterolateral process strong, directed slightly laterally, terminating in sharp tooth. Telson (fig. 7c) longer than sixth somite, tapering to acute tip; dorsal surface deeply grooved mesially, with three pairs of lateral spines, anterior-most pair located at about midlength; two plumose setae posterior to third pair of lateral spines (fig. 7d).

In spawning molt, first to fourth abdominal sternites unarmed; fifth sternite with low median tubercle. Sixth abdominal sternite shallow depressed medially.

Eye (figs 7a–b) slightly longer than wide; cornea slightly wider than eyestalk, light brown or opaque in preservative, corneal width 0.14–0.15 of carapace length; eyestalk with small, papilla-like dorsal tubercle.

Antennular peduncle (figs 7a–b) moderately stout, overreaching midlength of antennal scale. First segment with prominent, blunt distolateral process directed dorsally; distomesial margin unarmed; stylocerite falling slightly short of distolateral process, acutely or subacutely pointed, lateral margin gently convex. Second segment slightly widened distally, distinctly longer than wide, with prominent, blunt distolateral process. Third segment wider than long. Outer flagellum overreaching distal margin of lamella of antennal scale by about 0.4 length, consisting of 10–11 articles.

Antennal basicerite (fig. 7e) stout, with sharply pointed dorsodistal lateral angle and short ventrolateral tooth slightly overreaching dorsodistal lateral angle; carpocerite subcylindrical, reaching distal 0.20 of antennal scale. Antennal scale (figs 7a, 7e) about 0.50 times as long as carapace and 2.3 times longer than wide; lateral margin faintly sinuous; distolateral tooth relatively wide, slightly falling short of rounded distal margin of lamella.

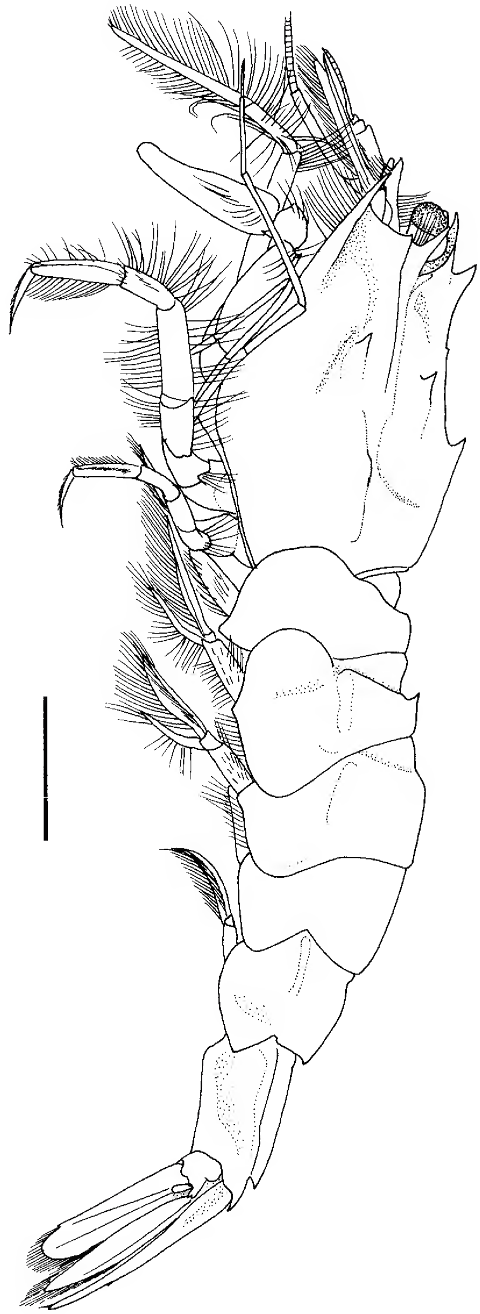

Figure 6. *Metacrangon spinidorsalis* sp. nov., holotype, female (cl 10.4 mm), WAM C45115, entire animal in lateral view. Scale bar = 5 mm.

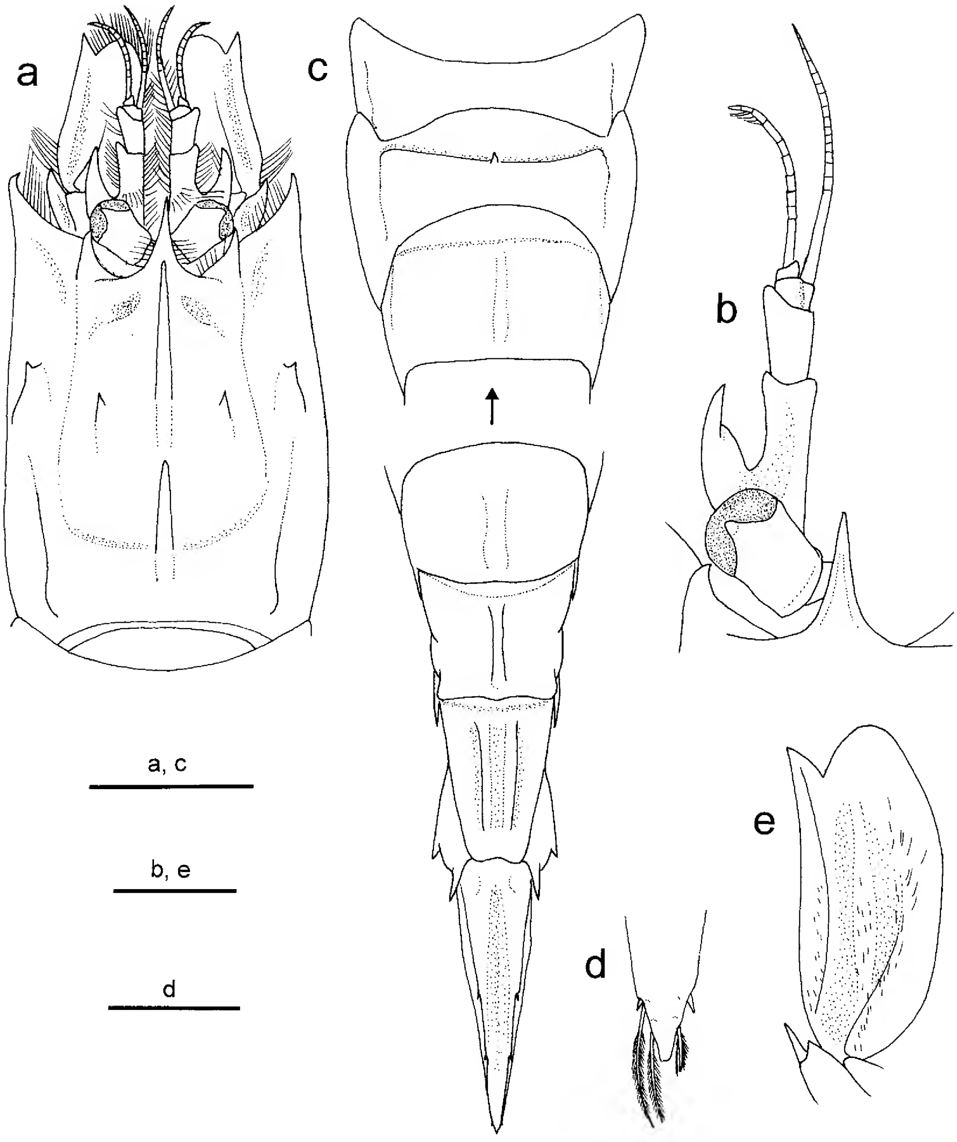

Figure 7. *Metacrangon spinidorsalis* sp. nov., holotype, female (cl 10.4 mm), WAM C45115: a, carapace and cephalic appendages, dorsal view; b, anterior part of carapace (left side), left eye and left antennule, dorsal view (setae omitted); c, abdomen, dorsal view; d, distal part of telson, dorsal view; e, left antennal scale, dorsal view. Scale bars = 5 mm for a and c; 2 mm for b and e; 1 mm for d.

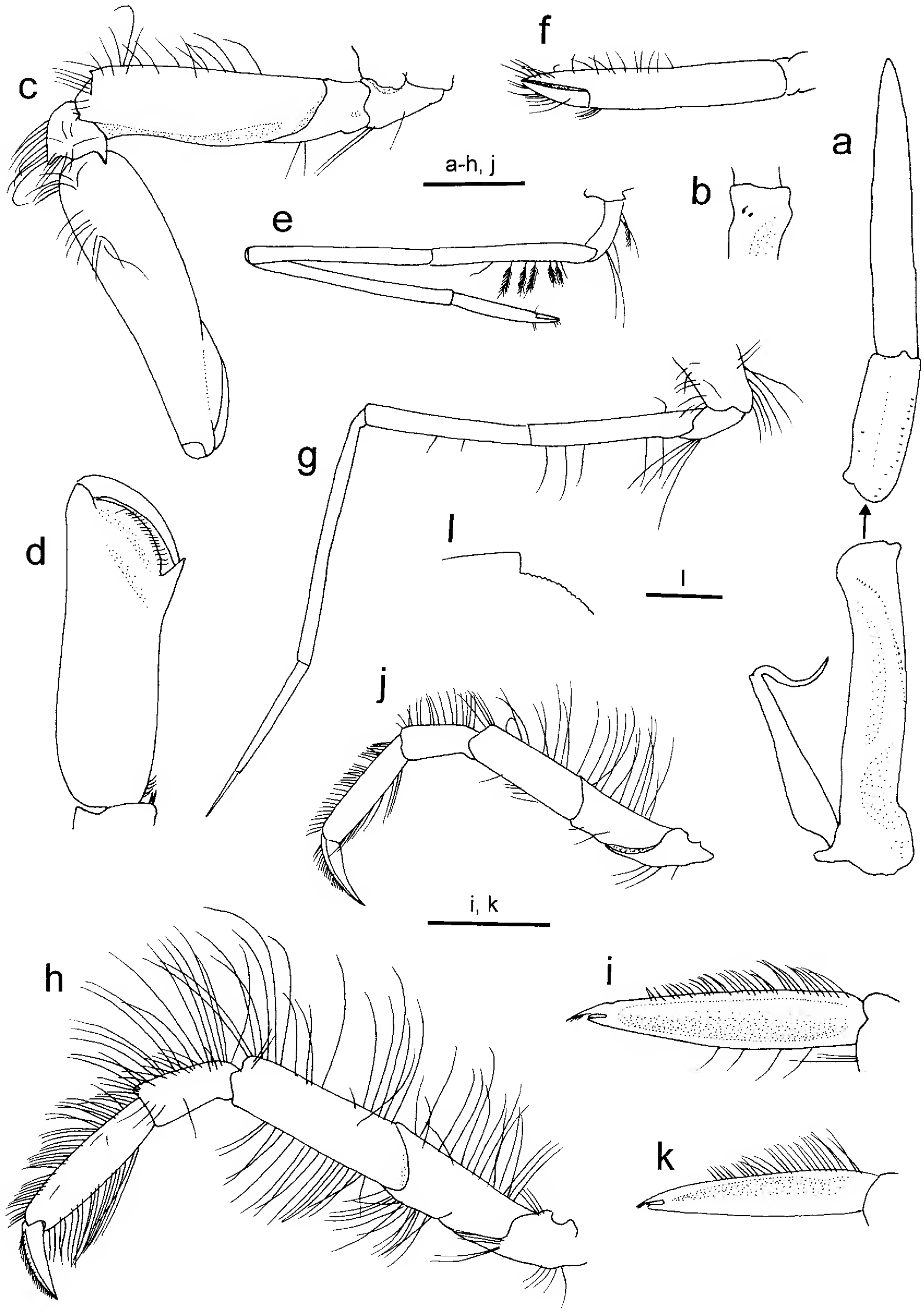

Figure 8. *Metacrangon spinidorsalis* sp. nov., holotype, female (cl 10.4 mm), WAM C45115; left thoracic appendages: a, third maxilliped, dorsal view (setae omitted); b, distal part of antepenultimate segment of third maxilliped, ventral view; c, first pereopod, lateral view; d, same, subchela, dorsal (extensor) view; e, second pereopod, lateral view (coxa damaged); f, same, chela, extensor view; g, third pereopod, lateral view; h, fourth pereopod, lateral view; i, same, dactylus, flexor view; j, fifth pereopod, lateral view; k, same, dactylus, flexor view; l, posterolateral tooth of right uropodal exopod, dorsal view (setae omitted). Scale bars = 2 mm for a–h and j; 1 mm for i and k; 0.5 mm for l.

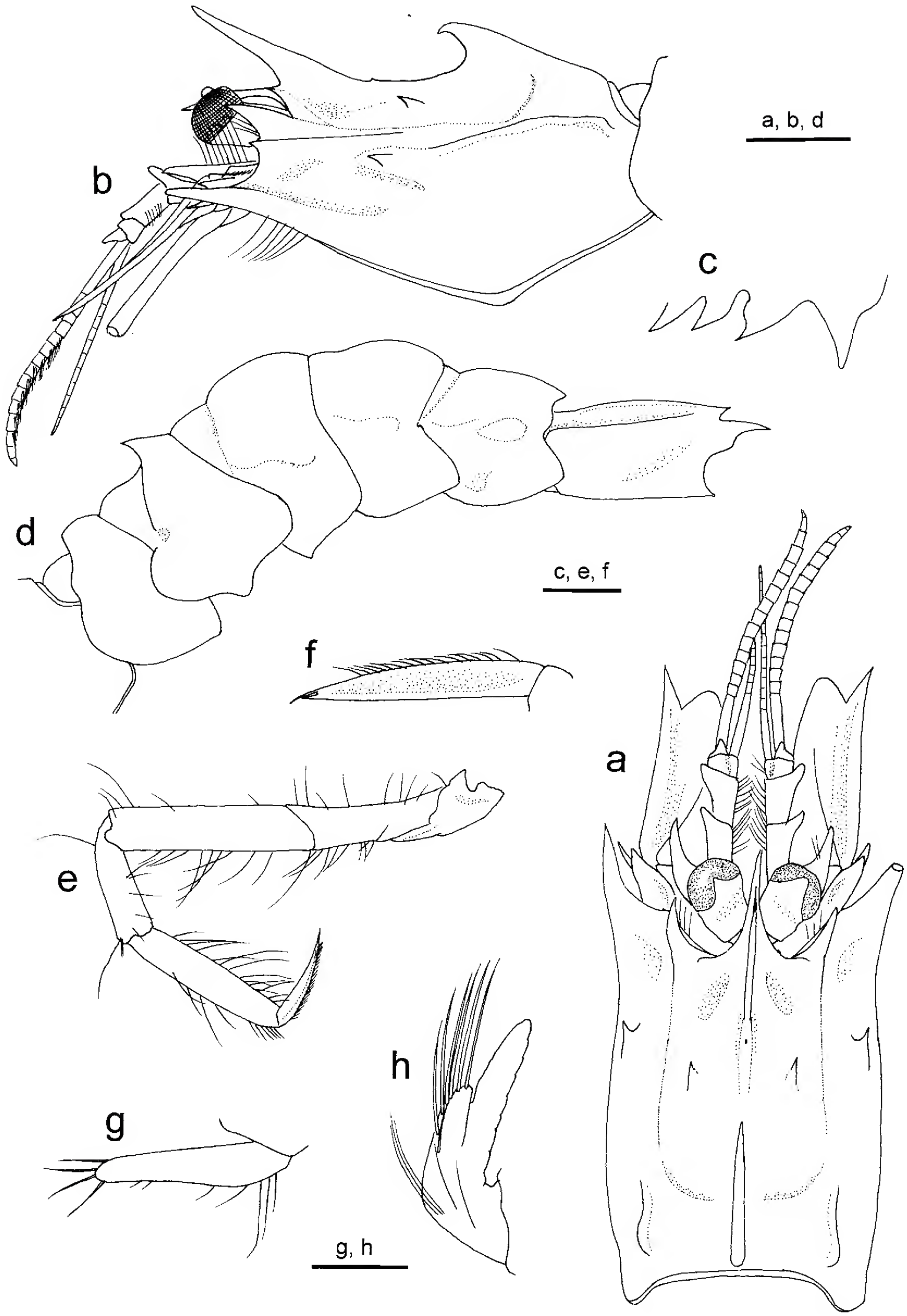

Figure 9. *Metacrangon spinidorsalis* sp. nov., paratype, male (cl 6.5 mm), NMV J54512: a, carapace and cephalic appendages, dorsal view; b, same, lateral view; c, thoracic teeth, ventrolateral view; d, abdomen, lateral view; e, left fourth pereopod, lateral view; f, same, dactylus, flexor view; g, endopod of left first pleopod, ventral view; h, endopod and appendix masculina of left second pleopod, mesial view. Scale bars = 2 mm for a, b and d; 1 mm for c and e; 0.5 mm for f–h.

Figure 10. *Metacrangon spinidorsalis* sp. nov., paratype, male (cl 6.2 mm), NMV J54497, lateral view taken of live specimen on board FRV *Southern Surveyor*. Scale bar = 10 mm.

Third maxilliped (fig. 8a) relatively slender, overreaching antennal scale by 0.6 length of ultimate segment; margins and dorsal surface of distal two segments with numerous short to long setae. Ultimate segment gradually tapering distally, 6.5–7.0 times longer than wide. Penultimate segment about 2.6 times longer than wide. Antepenultimate segment sinuously curved in dorsal view, with thick tuft of long setae dorsodistally; ventral surface with two minute spiniform setae subdistally (fig. 8b). Coxa with rounded lateral process (not figured). Exopod falling far short of distal margin of antepenultimate segment, with well-developed flagellum.

First pereopod (figs 8c–d) moderately stout, reaching distal margin of antennal scale; palm 3.0–3.5 times longer than wide, not widened proximally or distally, cutting edge oblique; lateral and mesial margins nearly straight; thumb moderately broad; carpus with small ventrolateral tooth, otherwise unarmed on lateral margin; merus with small dorsodistal tooth, ventral margin sinuous, crested. Second pereopod (fig. 8e) reaching nearly to midlength of antennal scale; dactylus about 0.5 times as long as palm; cutting edges of fingers with row of minute spiniform setae (fig. 8f); length ratio of chela to ischium 1:1.9:1.6:1.5; coxa with prominent flap-like process (not figured). Third pereopod (fig. 8g) slender, nearly reaching distal margin of antennal scale by tip of dactylus; length ratio of dactylus to ischium 1:2.2:4.6:2.9:3.2. Fourth pereopod (fig. 8h) moderately stout, slightly overreaching midlength of antennal scale by dactylus; dactylus (fig. 8i) spatulate, about 0.8 times as long as propodus, upper margin with row of dense stiff setae, lower margin with few sparse setae; tip of dactylus terminating in two unequal projections flanking unguis, upper projection longer, with minute setae; dactylus–propodus articulation about 45°; propodus about 3.6 times longer than wide, bearing row of dense stiff setae on dorsal and ventral margins; carpus shorter than propodus, with numerous long setae on dorsal margin; row of long setae on dorsal and ventral margins of merus and ischium (dorsal setae longer than ventral setae). Fifth pereopod (fig. 8j) distinctly shorter than fourth pereopod, falling far short of base of branchiostegal tooth; dactylus (fig. 8k) subspatulate, shorter than dactylus of fourth pereopod, about 0.6 times as long as propodus; setation much less than in fourth pereopod.

Uropod (fig. 6) not reaching tip of telson; exopod with nearly straight lateral margin, posterolateral angle terminating in truncate tooth (fig. 8l); no movable spinule mesial to posterolateral tooth; endopod longer and narrower than exopod.

Male. Rostrum nearly spiniform (fig. 9A), 0.25–0.35 times as long as carapace, slightly overreaching distal corneal margins. Carapace (figs 9a–b) with two prominent middorsal teeth, anterior tooth elongate, arising slightly anterior to or just at level of posterior margin of orbit, overlapping rostrum; posterior tooth strong, hooked; branchiostegal tooth strong, curved slightly laterally, distinctly overreaching distolateral angle of antennal basicerite. Fifth to eighth thoracic sternites (fig. 9c) with prominent, acute teeth becoming larger posteriorly.

Middorsal tooth on second abdominal somite larger than in female; pleural ventral teeth on anterior three somites more pronounced in females (fig. 9d).

Corneal width 0.18–0.20 of carapace length (fig. 9a). Outer antennular flagellum (fig. 9a–b) overreaching antennal scale by 0.8 length, consisting of 15–18 articles. Antennal scale (fig. 9a) 0.55–0.60 times as long as carapace; distolateral tooth distinctly overreaching distal lamella.

Fourth pereopod (fig. 9e) more slender than in females (propodi about 4.5 times longer than wide); dactylus (fig. 9f) narrowly spatulate.

Endopod of first pleopod (fig. 9g) tapering distally to rounded tip, bearing four stiff setae terminally. Second pleopod with appendix masculina reaching about distal 0.6 of endopod, bearing about 10 long spiniform setae (fig. 9h).

Colouration. Carapace, abdominal somites, pereopods, telson and uropods relatively uniform browny red colour. Body, legs and first pereopods covered with whitish pigment spots; similar spots also present, but less pronounced on generally paler second to fifth pereopods.

Distribution. The present material contains specimens from two rather distant localities, namely southwestern Australia and Tasmania, suggesting that this species is widely distributed in southern Australia, at depths of 408–728 m.

Remarks. As is apparent from the above description, *Metacrangon spinidorsalis* sp. nov. shows considerable degree of sexual dimorphism in the development of the middorsal teeth on the carapace and the shape of the antennal scale.

This new species is referable to the *Metacrangon jacqueti* species group because of the disposition of teeth on the carapace, the presence of ventral tooth on each first to third abdominal pleuron, and the setose margins of the dactyli of the fourth and fifth pereopods (Komai, 1997). The following nine species are referred to this informal species group (Komai, 1997; Retamal and Gorny, 2003): *M. agassizi* (Smith, 1882) from the northwestern Atlantic; *M. bahamondei* Retamal and Gorny, 2003 from southern part of Chile; *M. bellmarleyi* (Stebbing, 1914) from western to southern Africa; *M. crosnieri* Komai, 1997 from Madagascar; *M. jacqueti* from the northeastern Atlantic; *M. knoxi* from the Chatham Rise, New Zealand; *M. ochotensis* (Kobjakova, 1955) from the South Kuril Islands in the northwestern Pacific; *M. procax* (Faxon, 1893) from California to Peru in the eastern Pacific; and *M. similis* Komai, 1997 from Japan. However, *M. spinidorsalis* is unique even within the genus, as it possesses a distinct middorsal tooth on the second abdominal tergite. Furthermore, in this new species, the orbital cleft is only weakly delimited. In this regard, this new species is intermediate between *M. knoxi* (where the orbital cleft is absent) and other species in the *M. jacqueti* species group (where the orbital cleft is distinct). The small anterior middorsal tooth on the carapace in females, which does not overlap the rostrum, also distinguishes *M. spinidorsalis* from other species in the *M. jacqueti* species group.

Etymology. Named in reference to the characteristic spiniform tooth on the second abdominal tergite.

Concluding remarks

This study reports the significant findings of three new species of *Metacrangon* from rather high latitudinal areas in the southern oceans of Australia, increasing the number of species known from the southern hemisphere from five to eight. The previously described species known from the southern hemisphere are *M. bahamondei*, *M. bellmarleyi*, *M. crosnieri*, *M. knoxi* and *M. richardsoni* (Yaldwyn, 1960) (cf. Yaldwyn, 1960; Komai, 1997; Retamal & Gorny, 2003). With the exception of *M. richardsoni*, all of them are referred to the *M. jacqueti* species group. Although *Metacrangon* has been well represented by the north Pacific species, it is suggested that the diversity of the genus in the southern hemisphere is much higher than we expected. Other genera of the family have also been shown to be species rich in southern Australian waters with new species and range extensions recently reported for *Lissosabinea* Christoffersen, 1988 and *Philocheras* Stebbing, 1900 (Komai, 2008; Taylor and Collins, 2009; Taylor, 2010).

Key to Australian species of *Metacrangon*

1. Carapace with anterior middorsal tooth arising at level of rostral base; second abdominal tergite with middorsal tooth; dactylus of fourth pereopod with marginal setae .... *M. spinidorsalis* sp. nov.

– Carapace with anterior middorsal tooth arising distinctly posterior to rostral base; second abdominal tergite unarmed; dactylus of fourth pereopod naked marginally 2

2. Rostrum overreaching distal corneal margins; orbital cleft absent; middorsal carina on first to fifth abdominal somites crested; antennular stylocerite falling short of distolateral process of first peduncular segment .... *M. australis* sp. nov.

– Rostrum just reaching distal corneal margins; orbital cleft present; middorsal carina on first to fifth abdominal somites not crested; antennular stylocerite reaching distolateral process of first peduncular segment .... *M. poorei* sp. nov.

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A revision of Antarctic and some Indo-Pacific apodid sea cucumbers (Echinodermata: Holothuroidea: Apodida)

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Abstract

O'Loughlin, P.M. and VandenSpiegel, D. 2010. A revision of Antarctic and some Indo-Pacific apodid sea cucumbers (Echinodermata: Holothuroidea: Apodida). *Memoirs of Museum Victoria* 67: 61–95.

Eight new apodid species from Antarctica are described: myriotrochids *Achiridota smirnovi* sp. nov., *Myriotrochus nikiae* sp. nov., *Prototrochus linseae* sp. nov., *Prototrochus barnesi* sp. nov., and chiridotids *Kolostoneura griffithsi* sp. nov., *Scoliorhapis bipearli* sp. nov., *Scoliorhapis massini* sp. nov., *Taeniogyrus prydzi* sp. nov. Genera *Scoliorhapis* H. L. Clark, *Taeniogyrus* Semper and *Trochodota* Ludwig are reviewed. *Scoliodotella* Oguro is a junior synonym of *Scoliorhapis* H. L. Clark. *Trochodota* Ludwig type species is fixed as *Holothuria (Fistularia) purpurea* Lesson. *Trochodota* Ludwig is a junior synonym of *Taeniogyrus* Semper. *Sigmodota* Studer type species is fixed as *Chiridota contorta* Ludwig, and *Sigmodota* Studer is raised out of synonymy with *Taeniogyrus* Semper. Species assigned to *Sigmodota* are *Chiridota contorta* Ludwig, *Taeniogyrus dubius* H. L. Clark (as *Sigmodota dubia*) and *Taeniogyrus magnibaculus* Massin and Hétérier (as *Sigmodota magnibacula*). Non-Antarctic new genus *Rowedota* gen. nov. is erected with type species *Taeniogyrus allani* Joshua, and other assigned species *Trochodota epiphyka* O'Loughlin, *Trochodota mira* Cherbonnier, *Trochodota shepherdi* Rowe and *Trochodota vivipara* Cherbonnier. *Trochodota* species not assigned to *Rowedota* gen. nov. and *Sigmodota* Studer are assigned to *Taeniogyrus* Semper. Other Antarctic apodid species discussed are *Myriotrochus antarcticus* Smirnov and Bardsley, *Myriotrochus hesperides* O'Loughlin and Manjón-Cabeza and *Taeniogyrus antarcticus* Heding. Non-Antarctic apodid species discussed are *Chiridota pisanii* Ludwig, *Chiridota australiana* Stimpson and *Trochodota maculata* H. L. Clark. The spelling of the species name *Myriotrochus macquariensis* Belyaev and Mironov is corrected. A table with Antarctic Apodida species and their distributions is provided. A table with specimen and ossicle sizes for some Taeniogyrinae species is provided. A key to genera of Taeniogyrinae is provided. Species names are standardized to: *macquariensis*; *studeri*; *theeli*.

Keywords

Achiridota, *Chiridota*, *Kolostoneura*, *Myriotrochus*, *Paradota*, *Prototroch*us, *Scoliorhapis*, *Scoliodotella*, *Sigmodota*, *Taeniogyrus*, *Trochodota*, emended diagnoses, new genus, new species, Antarctic, Bellingshausen Sea, Indo–Pacific, Prydz Bay, Ross Sea, Scotia Sea, Weddell Sea.

Introduction

This review of Antarctic apodid genera and species has become possible with the opportunities to study numbers of Antarctic holothuroid collections (Table 1).

ANARE 1993 collected with a Van Veen grab and epibenthic sled, and recent BIOPEARL expeditions used an epibenthic sled, and both yielded many very small specimens including the apodids that are reported in this study. Tissue samples from recent NIWA and US AMLR and BAS collections are currently being processed for molecular sequences, but this systematic study is based exclusively on morphological characters and the species recognized as morpho-species.

Numerous systematic problems have arisen during the study of species of Taeniogyrinae Smirnov, 1998. There has been a significant history of misidentifications of Antarctic and Magellanic species. A succession of authors has been dissatisfied with the systematic status of one or both of the genera *Taeniogyrus* Semper, 1867 and *Trochodota* Ludwig, 1891, including Dendy (1909), Joshua (1914), H. L. Clark (1921), Rowe (1976), Rowe (in Rowe and Gates 1995), Smirnov (1997), Massin and Hétérier (2004) and O'Loughlin and VandenSpiegel (2007). The presence or absence of clusters of wheels in the body wall is the generic diagnostic distinction between *Taeniogyrus* and *Trochodota* species, and has proved to be subjective and unsatisfactory. And a useful generic diagnostic character for taeniogyrinid species, namely the arrangement of teeth on the inner rim of the wheel ossicles, became potentially lost because of a misunderstanding in a revision of a type species. We attempt to improve systematic clarity around these issues.

Table 1. Antarctic collections studied.

Names of expeditions	Localities	Specimens lodged
Terra Nova 1910–1913	Ross Sea	Natural History Museum (London)
Discovery Expedition	South Atlantic, Scotia Sea	Natural History Museum (London)
BANZARE	Eastern Antarctica, Kerguelen Islands	South Australian Museum
US Antarctic Research Program	Antarctic Ocean	US National Museum of Natural History (Smithsonian Institution)
ANARE	Prydz Bay, Heard Island	Museum Victoria, Tasmanian Museum, South Australian Museum
Tangaroa Ross Sea	Ross Sea	New Zealand Institute of Water and Atmospheric Research
Hesperides BENTART–2003, BENTART–2006	Amundsen Sea, Bellingshausen Sea	University of Malaga
British Antarctic Survey BIOPEARL 2006, BIOPEARL 2008	Bellingshausen Sea, Scotia Sea	Natural History Museum (London), Museum Victoria
US Antarctic Marine Living Resources 2004, 2005, 2009	South Atlantic, Scotia Sea	Museum Victoria
US Antarctic Marine Living Resources 2006	Antarctic Peninsula	US National Museum of Natural History (Smithsonian Institution)

Methods

Photographs of preserved specimens (Figure 1) were taken using a Pentax K–7 camera with Olympus 38 mm macro lens on bellows. Photographs were taken at f11–f16 using twin flashes. The photograph of a preserved specimen of *Myriotrochus antarcticus* was taken using a Leica MZ12.5 compound microscope, Q imaging camera, and Auto-Montage software. The photograph of a preserved specimen of *Taeniogyrus australianus* was taken using a SLR Canon EOS5D digital camera with 65 mm lens. For scanning electron microscope (SEM) observations ossicles were cleared of associated soft tissues in commercial bleach, air-dried, mounted on aluminium stubs, and coated with gold. Observations were made using a JEOL JSM–6480LV SEM. Measurements were made with Smile view software. Montage photographs of ossicles were taken using a Leica CTR5000 compound microscope, Leica DC500 digital camera, and Auto-Montage software. Drawings were done by Mark O'Loughlin.

Corrected taxa spellings

Myriotrochus macquariensis Belyaev and Mironov, 1981 was named for material collected near Macquarie Island, and the original spelling of the species name as *macquoriensis* was a *lapsus calami*. We correct the "incorrect original spelling" to *macquariensis* in accord with Article 32.5 of the ICZN (1999).

Ludwig (1875) and some subsequent authors used the generic name *Chirodota* instead of *Chiridota* Eschscholtz, 1829. The correct spelling *Chiridota* is used throughout this paper.

Théel (1886a) erected the species *Chiridota studerii*. The species name has various spellings in the literature and we use the appropriate spelling *studeri* throughout this work.

Heding (1928) erected the species *Scoliodota theelii*. We use the appropriate spelling *theeli* throughout this work.

Abbreviations

AM	Australian Museum (echinoderm registration numbers with prefix J).
AMLR	Antarctic Marine Living Resources.
ANARE	Australian National Antarctic Research Expedition.
BANZARE	British, Australian, New Zealand Antarctic Research Expedition.
BAS	British Antarctic Survey.
BIOROSS–NIWA	*Tangaroa* 2004 expedition to the Ross Sea.
ICZN	International Code of Zoological Nomenclature (1999).
MNA	University of Genoa registration number prefix for BIOROSS *Tangaroa* 2004 and other Ross Sea holothuroid specimens.
NHM	British Museum of Natural History.
NIWA	New Zealand Institute of Water and Atmospheric Research.
NMNH	National Museum of Natural History, Smithsonian Institution.

NMV	Museum Victoria (echinoderm registration numbers with prefix F).
NZ IPY–CAML	New Zealand International Polar Year–Census of Antarctic Marine Life Project cruise TAN0802.
RBINS	Royal Belgian Institute of Natural Sciences. All SEM material observed during this study is deposited in RBINS.
SAM	South Australia Museum.
TMAG	Tasmania Museum and Art Gallery.
USARP	United States Antarctic Research Progam.
USNM	United States National Museum. Historically three types of registration have been used for USNM specimens: Echinoderm catalogue numbers prior to 1920 did not have a prefix, subsequently had the prefix E, and since 2001 the EMU on-line system has been used and registrations reported as USNM without an E prefix.

Numbers in brackets after registrations refer to numbers of specimens in lots.

In this work Antarctic refers to the region south of the Polar Front/Antarctic Convergence.

Relevant history of species misidentification

Three chiridotid species occur in the Magellanic/Falklands region (north of the Polar Front/Antarctic Convergence): *Chiridota pisanii* Ludwig, 1886 (12 tentacles, wheels in papillae in body wall, lacking hooks); *Chiridota contorta* Ludwig, 1875 (12 tentacles, wheels in discrete clusters / papillae in the body wall, and hooks); *Holothuria (Fistularia) purpurea* Lesson, 1830 (10 tentacles, wheels not in clusters in body wall, and hooks). *Taeniogyrus antarcticus* Heding, 1931 (10 tentacles, wheels in some groups, and hooks in body wall) has been found only south of the Polar Front at South Georgia, Shag Rocks and the S Orkney Is (see below), but not in the Falklands/Magellanic region.

Lampert (1885, 1886) discussed *Chiridota purpurea* (Lesson), and provided complete synonymies. Subsequently Lampert (1889) recognized that the material that he had described was *Chiridota contorta* Ludwig, and retained only Bell (1881) in his synonymy for *Chiridota purpurea* (Lesson).

Studer (1876) erected a new genus *Sigmodota* because of the presence of sigmoid hooks in an apodid species from both the Kerguelen Is and Magellanic region. He reported 12 tentacles, ignored the original description of 10 tentacles by Lesson (1830), and referred *Holothuria* (*Fistularia*) *purpurea* Lesson, 1830 to his *Sigmodota*. Théel (1886a, page 16) thought that it was "very peculiar" that no *Challenger* specimen from the Kerguelen Is and Strait of Magellan had 12 tentacles and hooks but no wheels. All *Challenger* specimens had aggregations of wheels, and Théel wondered if "the very scattered aggregations of wheels had escaped the attention of Studer". After more than another century of collecting in these two regions still no specimen with 12 tentacles and hooks but lacking wheels has been found. We agree with Théel's concern (1886a, page 16) and judge that Studer did not notice the presence of wheels in his material since the only Chiridotidae species that has been found in the Kerguelen Is (see O'Loughlin 2009) and also in the Magellanic region (this work) is *Chiridota contorta* Ludwig (with 12 tentacles, hooks and wheels). We agree with Ludwig's (1898) judgment that Studer's *Sigmodota purpurea* (Lesson, 1830) is a junior synonym of *Chiridota contorta* Ludwig.

Théel (1886a) judged that the material referred by Studer (1876) to *Sigmodota purpurea* (Lesson) was not *Holothuria* (*Fistularia*) *purpurea* Lesson, presumably because of an absence of wheels. He erected a new species *Chiridota studeri* Théel, 1886, understanding the species to have 12 tentacles, hooks, and no wheels. Lampert (1889) retained *Chiridota studeri* Théel, but described material with 10 tentacles, hooks and wheels not in papillae. That material was *Holothuria* (*Fistularia*) *purpurea* Lesson. For the reasons given in the paragraph above we again agree with Ludwig's (1898) judgment that *Chiridota studeri* Théel, 1886 is a junior synonym of *Chiridota contorta* Ludwig.

In the same report Théel (1886a) described specimens from the Falkland Is as having 12 tentacles, scattered aggregations of wheels in the body wall, an absence of hooks, and minute rods in the muscle bands. He judged that this material from the Falkland Is was the true *Holothuria* (*Fistularia*) *purpurea* Lesson since it came from the type locality. We again agree with Ludwig's (1898) judgment that Théel's *Holothuria* (*Fistularia*) *purpurea* Lesson is *Chiridota pisanii* Ludwig (described in the same year 1886).

Ludwig (1891) included the two species *Chiridota studeri* Théel, 1886 and *Chiridota venusta* Semon, 1887 in his new genus *Trochodota* Ludwig, 1891. Ludwig (1898) subsequently changed the identification of his included species *Chiridota studeri* Théel, 1886 to *Trochodota purpurea* (Lesson, 1830).

Ossicle clusters in generic diagnosis

Dendy and Hindle (1907) remarked that in regard to wheels being grouped into papillae or scattered it was "undesirable to recognize any generic distinction between these two forms". In establishing the new species *Chiridota benhami* Dendy, 1909 (a junior synonym of *Chiridota dunedinensis* Parker, 1881) Dendy remarked that it was "clearly impossible to base generic distinctions merely upon the arrangement or even upon the presence or absence of the wheels". Joshua (1914) found the degree to which wheels were aggregated in *Trochodota allani* Joshua, 1912 varied greatly, and that "grouped" and "scattered" applied to wheels in this one species. H. L. Clark (1921) used the generic distinction in his key of "wheels gathered into sharply defined papillae" or "wheels scattered, often numerous enough to be crowded into ill-defined heaps". Rowe (1976) noted that for his species *Trochodota shepherdi* wheels are grouped into more than "ill-defined heaps" but not into papillae. He judged that the degree to which wheels were grouped was not a useful generic diagnostic character. Rowe also noted the anomaly that H. L. Clark (1921) used grouping of hooks for species distinction and grouping of wheels for generic distinction.

We have observed a range of wheel and hook arrangements in the body wall (see O'Loughlin and VandenSpiegel 2007). Wheels may be: clustered into discrete papillae, macroscopically noticeable as white spots, as in *Chiridota australiana* Stimpson, 1855, *Chiridota contorta* Ludwig, *Taeniogyrus heterosigmus* Heding, 1931 and *Taeniogyrus magnibaculus* Massin and Hétérier, 2004; or clustered into longitudinal interradial bands as in *Trochodota shepherdi* Rowe, 1976; or aligned in irregular bands adjacent to the longitudinal muscles as in *Trochodota roebucki* Joshua, 1914 and *Taeniogyrus tantulus* O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); or loosely grouped into small clusters in larger specimens as in *Taeniogyrus antarcticus* Heding.

Hooks may be: grouped closely into small papillae as in *Chiridota australiana* Stimpson; aligned over and adjacent to the longitudinal muscles as in *Taeniogyrus papillis* O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); aligned transversely in paired series over the edges of the longitudinal muscles as in *Trochodota roebucki* Joshua; scattered in all interradii as in *Taeniogyrus heterosigmus* Heding.

We judge that the arrangement of wheels and hooks in the body wall of chiridotid species may be useful as a species diagnostic character but not useful at generic level. A consequence is our synonymy below of *Trochodota* Ludwig, 1891 with *Taeniogyrus* Semper, 1867.

Wheel form in generic diagnosis

H. L. Clark (1921) thought that the teeth on the inner rim of the wheels of *Trochodota purpurea* were in groups. This was erroneous according to Smirnov (1997), and our observations. A figure of a wheel of *Chiridota purpurea* (as *Chiridota studeri* Théel) in Lampert 1889 (fig. 12a) does show a discontinuous series of teeth that are only over the spokes. This does not occur in any chiridotid wheels, and must be an error in illustration.

Rowe (1976) based his emended diagnoses of *Taeniogyrus* and *Trochodota* on the diagnostic character of wheels with continuous and those with discontinuous grouped teeth on the inner rim. Rowe (1976) considered *Trochodota purpurea* to be the type species for *Trochodota*, and followed H. L. Clark (1921) in thinking that the teeth on the inner rim of the wheels were discontinuous. *Trochodota* species were those with discontinuous series of teeth. As noted by Smirnov (1997) the Rowe review was unacceptable because the teeth are continuous around the rim in the type species.

O'Loughlin and VandenSpiegel (2007) followed the emended diagnosis of *Trochodota* by Rowe (1976). We now reject that position. But we agree with Rowe (1976) that the form of the wheels is useful at a generic diagnostic level, and erect a new genus to accommodate taeniogyrinid species with discontinuous series of teeth on the wheels.

Tentacle number in generic diagnosis

Tentacle number is not an inconsequential variable in apodid genera and species since it is interdependent with the structure of the calcareous ring. This is recognized in the diagnoses of genera of Myriotrochidae where species with 12 tentacles and two ring plates each with pairs of anterior projections are assigned to genus *Myriotrochus* Steenstrup, 1851, and those with 10 tentacles and single anterior projections on all 10 ring plates are assigned to genus *Prototrochus* Belyaev and Mironov, 1982. The Taeniogyrinae genera type species of *Taeniogyrus* Semper and *Trochodota* Ludwig have 10 plates in the calcareous ring and 10 tentacles, and the historical diagnostic character distinguishing the species of these two genera is the unsatisfactory degree to which wheels are grouped in the body wall. We judge that these two genera are synonyms, and raise the genus *Sigmodota* Studer, 1876, for which the type has 12 calcareous ring plates and 12 tentacles, out of synonymy to accommodate taeniogyrinid species with wheels, hooks and 12 tentacles.

Key to genera of subfamily Taeniogyrinae

1. Irregular thick spinous plates with wheel-spoked perforations present in body wall .... ***Archedota*** O'Loughlin (in O'Loughlin and VandenSpiegel)
— Lacking thick spinous plates in body wall 2
2. Lacking sigmoid hooks and chiridotid wheels in body wall .... ***Kolostoneura*** Becher
— Sigmoid hooks with or without chiridotid wheels in body wall 3
3. Sigmoid hooks only in body wall .... ***Scoliorhapis*** H. L. Clark
— Sigmoid hooks and chiridotid wheels in body wall 4
4. Chiridotid wheels with discontinuous series of teeth around inner rim of wheels .... ***Rowedota*** gen. nov.
— Chiridotid wheels with continuous series of teeth around inner rim of wheels 5
5. Tentacles 12, and 12 plates in calcareous ring .... ***Sigmodota*** Studer
— Tentacles 10, and 10 plates in calcareous ring .... ***Taeniogyrus*** Semper

Order **Apodida** Brandt, 1835 (sensu Östergren 1907)

Suborder **Myriotrochina** Smirnov, 1998

Diagnosis (Smirnov 1998). Ten or 12 digitate or peltato-digitate tentacles. Plates of calcareous ring with large anterior projections; excavations for tentacular ampullae are on anterior side of calcareous ring. Madreporite placed close to water ring. No ciliated funnels. One polian vesicle. Body wall ossicles represented by wheels with large numbers of spokes (8–25) and without a complex hub (single family Myriotrochidae).

Myriotrochidae Théel, 1877

Diagnosis. As for suborder.

Acanthotrochus antarcticus Belyaev and Mironov, 1981

Table 2

Acanthotrochus antarcticus Belyaev and Mironov, 1981a: 526–528, pl. 1(4–7), figs 3a–d, tables 3, 4.—Belyaev and Mironov, 1982: 108, fig. 18.

Table 2. Antarctic species of Apodida, and their distributions. *Chiridota pisanii* Ludwig* and *Taeniogyrus purpureus* (Lesson)* are listed but to date have not been recorded south of the Polar Front and are not Antarctic. Except for undescribed species, sources of data are given in the text.

Taxon	Distribution
Myriotrochidae Théel, 1877	
Acanthotrochus antarcticus Belyaev and Mironov, 1981	Eastern Antarctica, 65°S 155°E, 2800 m.
Acanthotrochus species (by Bohn in Gebruk et al. 2003, p. 119)	South Orkney Is, 2914 m.
Achiridota smirnovi sp. nov.	Prydz Bay, Amery Depression, Fram Bank, 518–788 m.
Myriotrochus antarcticus Smirnov and Bardsley, 1997	Eastern Antarctica, MacRobertson Shelf, 113 m; Western Antarctica, S Orkney Is, 216 m; Weddell Sea, 193 m.
Myriotrochus hesperides O'Loughlin and Manjón-Cabeza, 2009	Antarctic Peninsula, 65.47°S 69.03°W, 350 m.
Myriotrochus macquariensis Belyaev and Mironov, 1981	SW Pacific Ocean, Hjort Trench, 59°S 158°E, 3010–4640 m.
Myriotrochus nikiae sp. nov.	Eastern Antarctica, Ross Sea, 71°S 175°E, 2283 m.
Myriotrochus species (in Belyaev and Mironov 1982, p. 104)	Drake Passage, South Sandwich Trench.
Myriotrochus species (by Bohn in Gebruk et al. 2003, p. 119)	South Orkney Is, NW Weddell Sea, 2084–5190 m.
Neolepidotrochus variodentatus (Belyaev and Mironov, 1978)	South Sandwich Trench, 6766–7934 m.
Prototrochus barnesi sp. nov.	Scotia Sea, Shag Rocks, 206 m.
Prototrochus bipartitodentatus (Belyaev and Mironov, 1978)	South Sandwich Trench, 7700–8100 m.
Prototrochus linseae sp. nov.	Scotia Sea, South Shetland Is, 192–1544 m.
Prototrochus species (in Belyaev and Mironov 1982, pp. 92, 93)	South Sandwich Trench, 6050–6150 m.
Prototrochus species (by Bohn in Gebruk et al. 2003, p. 119)	South Orkney Is, 2375–5190 m.
Chiridotidae Östergren, 1898	
**Chiridota pisanii* Ludwig, 1886	South America S of 42°S, Falkland Is, Burdwood Bank, 0–102 m.
Kolostoneura griffithsi sp. nov.	Scotia Sea, South Orkney Is, 506 m.
Scoliorhapis biopearli sp. nov.	South Shetland Is, 1544 m.
Scoliorhapis massini sp. nov.	Scotia Sea, Shag Rocks, 206 m (? Falkland Is, 118 m).
Sigmodota contorta (Ludwig, 1875)	Antarctic Ocean, Bouvet I., South Georgia, S Shetland Is, S Orkney Is, 46–503 m. South America, south of 42° in the west, S of 47°S in the east. Indian Ocean, Heard, Kerguelen, Marion Is, 2–228 m. Indonesia, Java Sea, 82 m.
Sigmodota magnibacula (Massin and Hétérier, 2004)	Western Antarctica, Weddell Sea, S Orkney Is, 172–240 m. Eastern Antarctica, Ross Sea, Terre Adélie, Wilkes Land, Prydz Bay, MacRobertson Shelf, 8–525 m.
Taeniogyrus antarcticus Heding, 1931	Scotia Sea, S Orkney Is, South Georgia, Shag Rocks, 206–216 m.
Taeniogyrus prydzi sp. nov.	Eastern Antarctica, MacRobertson Shelf, 109–121 m; Prydz Bay Channel, Outfall slope, 795–830 m.
**Taeniogyrus purpureus* (Lesson, 1830)	Falkland Is; Magellanic region, 0–64 m.
Paradota weddellensis Gutt, 1990	Antarctic Ocean, Antarctic Peninsula, 126–265 m; Bellingshausen Sea, 97–1191 m; Ross Sea, 85–658 m; Prydz Bay, 505–578 m; Scotia Sea, 59–759 m; Weddell Sea, 225–655 m; Heard I., 120–215 m.
Synaptidae Burmeister, 1837	
Labidoplax species (by Bohn in Gebruk et al. 2003, p. 119)	South Orkney Is, 2893–3683 m.

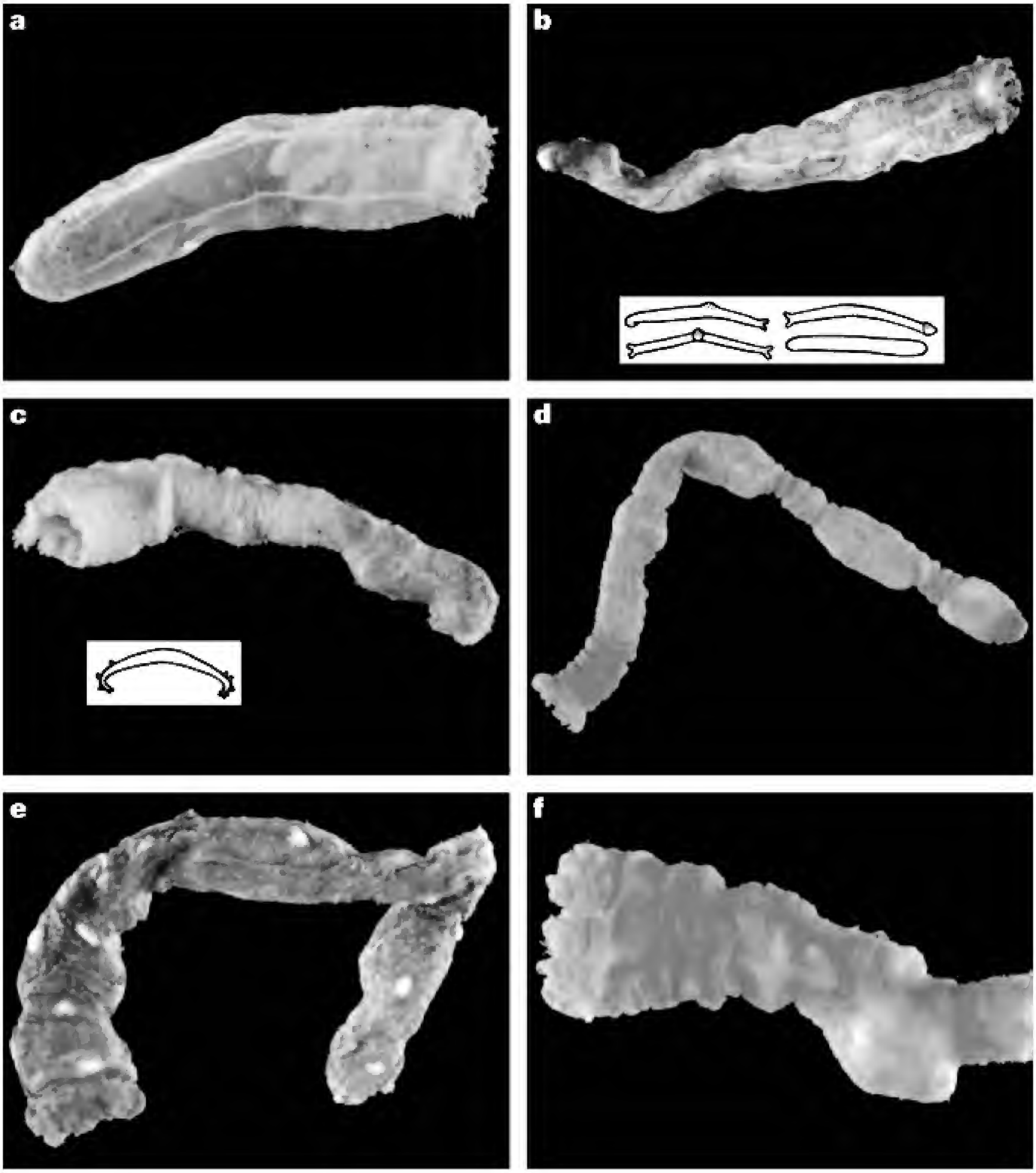

Figure 1. Colour photos of preserved specimens of apodid species. a, *Prototrochus linseae* sp. nov. (7 mm long; S Shetland Is; holotype, NMV F168631); b, *Kolostoneura griffithsi* sp. nov. (12 mm long; insert drawings of tentacle rods, 96–112 μm long; S Orkney Is; holotype, NMV F168634); c, *Scoliorhapis biopearli* sp. nov. (6 mm long; insert drawing of tentacle rod, 115 μm long; S Shetland Is; holotype, NMV F168633); d, *Scoliorhapis massini* sp. nov. (20 mm long; Shag Rocks; holotype, NMV F168635); e, *Sigmodota magnibacula* (Massin and Hétérier, 2004) (15 mm long; S Orkney Is; NMV F168629); f, *Taeniogyrus antarcticus* Heding, 1931 (15 mm long; S Orkney Is; NMV F168630).

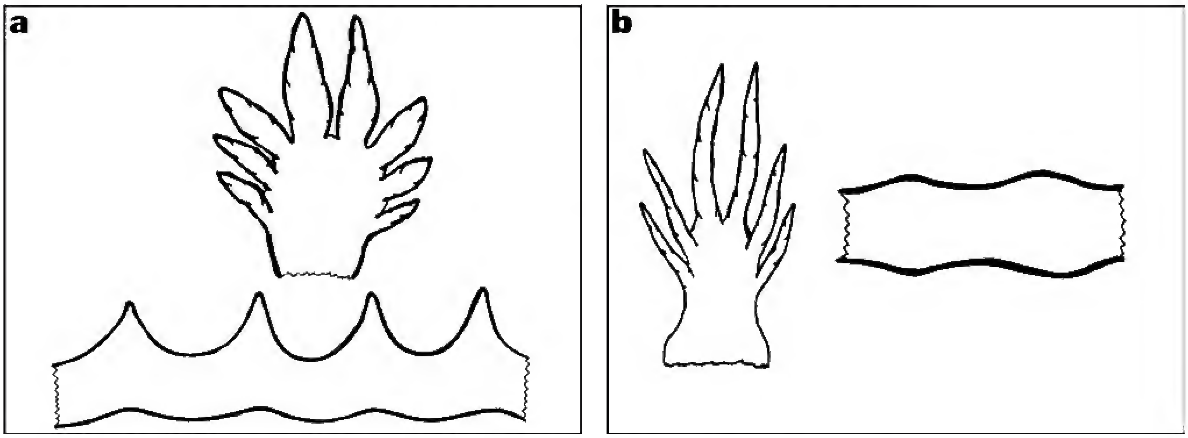

Figure 2. a, drawing of tentacle and part of non-calcareous ring of *Achiridota smirnovi* sp. nov. (Prydz Bay; holotype, NMV F68687); b, drawing of tentacle and part of calcareous ring of *Kolostoneura griffithsi* sp. nov. (S Orkney Is; holotype, NMV F168634).

Distribution. Eastern Antarctica, off Oates Land, Mawson Peninsula, 65°S 155° E, 2800 m.

Remarks. The distinguishing characters of species of *Acanthotrochus* Danielssen and Koren, 1879 are: wheel ossicles of more than one type, some with outward-pointing teeth on rim; wheels with outward pointing teeth lack inward-pointing teeth; anterior projections of the calcareous ring plates longer than the basal height of the plate; radial canal pore situated lower than the base of the anterior plate projection (see Gage and Billet 1986).

Achiridota Clark, 1908

Achiridota H. L. Clark, 1908: 126.—Heding, 1935: 16.—Smirnov, 1998: 521.

Diagnosis (of type species, following Fisher 1907, and Smirnov 1998). Tentacles 12, trunk stout, digits small; 6–8 pairs of digits per tentacle, increasing in size distally, distal digits paired not single; calcareous ring well developed, radial and interradial plates with anterior projection/tooth, straight posterior margin; lacking ossicles; single polian vesicle; madreporite at anterior edge of dorsal mesentery, close to ring canal; gonad tufts with central trunk and simple or dichotomous branches.

Type species. *Anapta inermis* Fisher, 1907 (Hawaiian Is, 466–772 m).

Other species. *Achiridota profunda* Heding, 1935 (N Atlantic, 2700 m); *Achiridota smirnovi* sp. nov. (E Antarctica, 518–788 m).

Remarks. *Achiridota* Clark, 1908 was initially assigned to Chiridotidae, but was subsequently assigned to Myriotrochidae by Smirnov (1998) on the basis of having: large anterior teeth on the plates of the calcareous ring; single polian vesicle; madreporite close to ring canal. Although Heding (1935) referred two new species to *Achiridota* he argued convincingly that one of his species (*Achiridota ingolfi* Heding, 1935) was more *Chiridota*-like because of the form of the calcareous ring and presence of 11 polian vesicles. We judge that *Achiridota ingolfi* belongs more appropriately in *Chiridota* Eschscholtz, 1829.

Achiridota smirnovi sp. nov.

Figure 2a; table 2

chiridotid sp. MoV 2019 O'Loughlin et al., 1994: 553, 554.

Material examined. Holotype. Eastern Antarctica, Prydz Bay, Amery Depression, 68°06'S 72°15'E, 788 m, stn ANARE AA93–60, M. O'Loughlin, 28 Jan 1993, NMV F68687.

Paratype. Prydz Bay, edge of Fram Bank, 66°55'S 69°12'E, 518 m, stn ANARE AA93–75, 31 Jan 1993, NMV F68686.

Diagnosis. Achiridotid species up to 15 mm long (posterior end of body missing on 11 mm long holotype); 12 peltato-digitate tentacles, 4 pairs of digits per tentacle, pair distally, increasing in size distally; tentacle ampullae cup-like, on anterior edge of non-calcareous ring; lacking ossicles in body wall, tentacles; lacking calcareous ring; single polian vesicle; madreporite on long straight canal; gonad tubules with multiple branching; lacking ciliated funnels.

Colour (preserved). Holotype with reddish-brown flecking on semi-translucent off-white body, red-brown tentacles; other specimen semi-translucent off-white, tentacles pale reddish-yellow.

Distribution. Eastern Antarctica, Prydz Bay, 518–788 m.

Etymology. Named for Alexei Smirnov (Zoological Institute of the Russian Academy of Sciences, St. Petersburg) in recognition of his description of the first myriotrochid species from the Antarctic shelf, and with appreciation of his significant contribution to the systematics of Apodida.

Remarks. Apodid specimens collected from Prydz Bay during the same cruise as these specimens, and preserved in the same way (directly in 70% ethanol), have retained their ossicles in good or slightly eroded condition. It is most unlikely that the complete absence of calcareous parts in the two specimens on which *Achiridota smirnovi* sp. nov. is based is a result of preservation.

Generic assignment of this new species is problematic because of the absence of a calcareous ring and body wall ossicles. But the tentacles do arise from anterior cup-like depressions around the non-calcareous ring, as in *Achiridota* H. L. Clark. The species has the *Achiridota* diagnostic characters of: 12 peltato-digitate tentacles; single polian vesicle; lacking ossicles in tentacles, body wall; lacking ciliated funnels. But the madreporite is situated at the end of a long straight canal, and is not close to the water canal. We assign the new species to *Achiridota* Clark with reservations because of the absence of a calcareous ring and position of the madreporite distant from the ring canal. These two characters distinguish *Achiridota smirnovi* sp. nov. from *Achiridota inermis* (Fisher) and *Achiridota profunda* Heding. Additional diagnostic distinctions are the presence of 6–8 pairs of tentacle digits in *Achiridota inermis* (4 pairs in *A. smirnovi*), and 7–8 pairs of tentacle digits and unbranched gonad tubules in *Achiridota profunda* (branched in *A. smirnovi*).

Myriotrochus Steenstrup, 1851

Diagnosis (following Gage and Billet 1986). Myriotrochid with 12 tentacles; calcareous ring bilaterally symmetrical; dorsolateral radial plates with two anterior projections; wheel ossicles of one type with rim teeth pointing only towards centre of hub; wheel hub lacking holes, and if holes are present they are distributed regularly in a circle around the centre of the hub; rod ossicles absent.

Myriotrochus antarcticus Smirnov and Bardsley, 1997

Figures 3, 4; table 2

Myriotrochus sp. MoV 2039 O'Loughlin et al., 1994: 553, table 2.
Myriotrochus antarcticus Smirnov and Bardsley, 1997: 109–111, fig. 1, table 1.—O'Loughlin et al. 2009: 9.

Material examined. Holotype. Eastern Antarctica, 66°55'S 62°32'E, 113 m, M. O'Loughlin, 11 Feb 1993, NMV F69125.

Other material. Western Antarctica, South Orkney Is, 60.82°S 46.49°W, 216 m, BAS stn PB–EBS–4, 18 Mar 2006, NMV F168638 (1); F168643 (1 whole, for molecular sequence, tissue code MOL AF 805); RBINS IG 31 459 (2 whole, for SEM figures); NHM 2010. 48–49 (2); Weddell Sea, 71.25° S 13.00° W, 193 m, RBINS 628686 (1).

Diagnosis (following Smirnov and Bardsley 1997 for Prydz Bay holotype). Myriotrochid species up to 8 mm long; 12 peltato-digitate tentacles, up to 8–12 digits per tentacle, distalmost pair longest; lacking tentacle ossicles; calcareous ring comprising 10 plates, ventral plates not significantly longer than dorsal plates; two dorsolateral radial plates each with 2 prominent tapering anterior projections, remaining plates with single prominent tapering anterior projection; posterior margin of calcareous ring slightly undulating, not concave; ossicles myriotrochid wheels only, scattered sparsely and uniformly throughout body wall; wheels of one type, all teeth pointing to centre of hub; wheel ossicle diameters 140–150 µm (for S Orkneys specimens 80–144 µm; for Weddell Sea specimen 108–133 µm), spokes 15–16 (for S Orkneys 13–16; for Weddell Sea 13–15), teeth 22–24 (for S Orkneys 19–25; for Weddell Sea 22–24), spokes/teeth % 66.7–68.2 (for South Orkneys 64–68; for Weddell Sea 60.8–65.2), hub diameter/wheel diameter % 18.0–18.6 (for S Orkneys 16.0–18.1), teeth length/wheel diameter % 18.0–18.6 (for S Orkneys 14.4–16.0).

Colour (preserved). Body grey, translucent; tentacles white.

Distribution. Antarctic shelf species; Eastern Antarctica, western MacRobertson Shelf, 113 m; Western Antarctica, South Orkney Is, 216 m; Weddell Sea, 193 m (range 113–216 m).

Remarks. For *Myriotrochus antarcticus* Smirnov and Bardsley, 1997 there are only minor morphological differences for the limited number of measurements for specimens from the Scotia Sea, Weddell Sea and Prydz Bay, suggesting a morpho-species with an eastern and western Antarctic distribution.

Myriotrochus hesperides O'Loughlin and Manjón-Cabeza, 2009

Figure 5a; table 2

Myriotrochus hesperides O'Loughlin and Manjón-Cabeza (in O'Loughlin et al., 2009): 9, fig. 2e, f, table 1.

Diagnosis (following O'Loughlin et al. 2009). Myriotrochid species up to 13 mm long; 12 peltato-digitate tentacles, about 7 small rounded digits per tentacle; lacking tentacle ossicles; plates of calcareous ring asymmetrical with pointed anterior projections / teeth, 2 radial plates each with 2 anterior projections, remaining plates with single anterior projection, wide rounded tongue-like posterior projections of variable length; ossicles myriotrochid wheels only, few only in posterior dorsal body wall; wheels of one type, all teeth pointing towards centre of hub; spokes irregular, about half branching proximally, some branches not reaching rim, some spokes with cross-connections; teeth variably sub-equal or different in size; hubs small, irregular, not disc-like, lacking perforations, formed by junction of spokes; largest wheel with diameter 248 µm, hub diameter 40 µm, 13 spokes at hub, 23 spokes at rim, 30 equal teeth; smallest wheel with diameter 200 µm, hub diameter 24 µm, 12 spokes at hub, 16 spokes at rim, 28 unequal teeth.

Distribution. Antarctic Peninsula, 65.47°S 69.03°W, 350 m.

Remarks. *Myriotrochus hesperides* O'Loughlin and Manjón-Cabeza, 2009 was the second Antarctic shelf *Myriotrochus* species to be described. Amongst *Myriotrochus* species it is closest to *Myriotrochus clarki* Gage and Billett, 1986 from the Rockall Trough in the N Atlantic at 1605–2515 m. The species are distinguished in O'Loughlin et al. 2009.

Myriotrochus macquariensis Belyaev and Mironov, 1981

Table 2

Myriotrochus macquoriensis Belyaev and Mironov, 1981b: 169–170, fig. 4, tables 3, 4, pl. figs 4, 5.—Belyaev and Mironov, 1982: 105, fig. 15.

Distribution. SW Pacific/Antarctic Ocean, Hjort Trench, 59°S 158°E, 3010–4640 m.

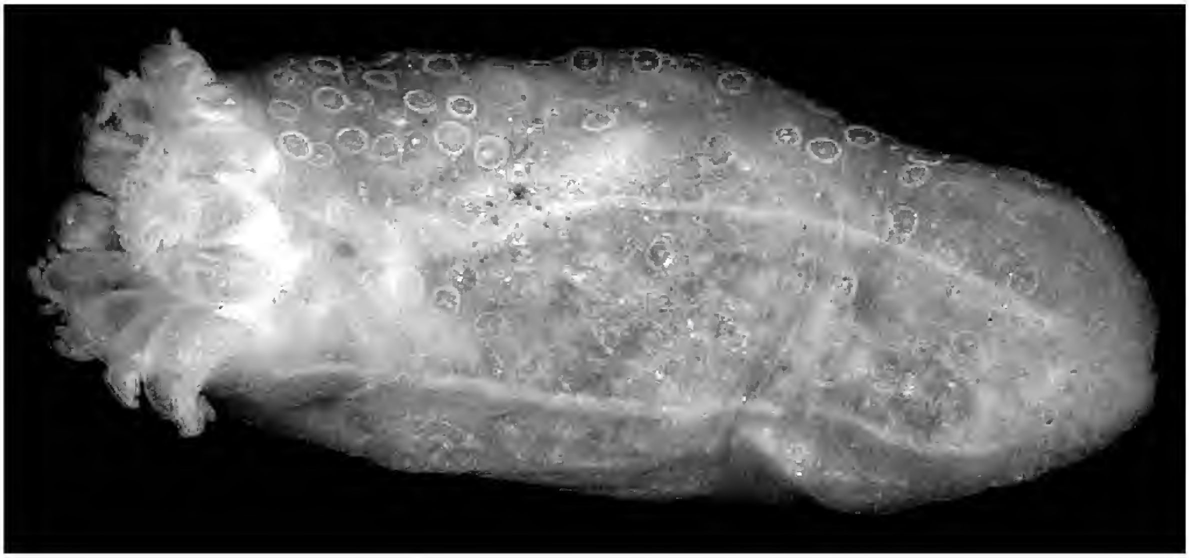

Figure 3. Photo of *Myriotrochus antarcticus* Smirnov and Bardsley, 1997, showing 12 peltato-digitate tentacles, calcareous ring with high anterior pointed projections, and wheels distributed throughout body wall (7 mm long; S Orkney Is, 216 m; RBINS IG 31 459).

Remarks. The spelling of the species name is corrected as reported at the beginning of this paper.

Myriotrochus nikiae sp. nov.

Figure 5b; table 2

Material examined. Holotype. Antarctica, Ross Sea, 71.23° S 174.44° E, 2281–2283 m, NZ IPY–CAML stn TAN0802/171, N. Davey, 26 Feb 2008, NIWA 37812 (in two parts).

Diagnosis. Myriotrochid species up to 33 mm long (2 parts combined); body wall thick, soft; 12 tentacles, withdrawn; lacking tentacle ossicles; calcareous ring comprising 10 plates; two dorsolateral radial plates each with 2 prominent tapering anterior projections, remaining plates with single prominent tapering anterior projection; posterior margin of calcareous ring slightly undulating, not concave; sac-like calcareous madreporite, dorsal, close to ring; single ventral polian vesicle; gonad comprises thick digitiform unbranched tubules arising in a series along gonoduct, 9 on one side of mesentery; ossicles in body wall myriotrochid wheels only, found throughout body wall; wheels of one type, all teeth pointing to centre of hub; hub large and disc-like, perforated, with regular circle of perforations separated by sometimes irregular hub spokes aligned with longer outer wheel spokes, some hub spokes branched distally; teeth blunt and rounded, of irregular length, generally longer over spokes than between spokes.

Measurements for 9 wheels: wheel ossicle diameters 320–400 μm, hub disc diameters 168–216 μm, inner hub diameter 24–32 μm, teeth length 48 μm, spokes 11–15, teeth 22–36, spokes/teeth % 36–50, hub disc diameter/wheel diameter % 51–52, teeth length/wheel diameter % 12–15.

Colour (preserved). Body grey, not translucent; few small dark brown spots on tentacles.

Distribution. Eastern Antarctica, Ross Sea, 2283 m.

Etymology. Named for Niki Davey (NIWA), with appreciation of her generous and skilled collaborative assistance in determining Antarctic and New Zealand holothuroids.

Remarks. The specimen size, grey colour, form and size of the wheels, and form of the calcareous ring of *Myriotrochus nikiae* sp. nov. are similar to those of *Myriotrochus bathybius* H. L. Clark, 1920 from the eastern tropical Pacific Ocean (4°33'S 87°43'W, 3669 m), and according to Gage and Billett (1986) from the northeast Atlantic Ocean (Rockall Trough, 1800–2925 m, and Porcupine Seabight, 3680–4310 m). Gage and Billett (1986) further judged *Myriotrochus bathybius* to be cosmopolitan at abyssal depths. Differences are such that we judge that the Antarctic specimen represents a related but different species.

For *Myriotrochus bathybius*, Clark (1920) gave three wheel diameters of 240, 300 and 340 μm (size range smaller than for *M. nikiae*), and two teeth counts of 37 and 38 (more numerous than for *M. nikiae*). More significant for us is a wheel of *M. bathybius* that was illustrated in Clark 1920, and the teeth are uniform in length and distinctly pointed. Smirnov (1999, fig. 4) illustrated similar teeth for *Myriotrochus (Oligotrochus) bathybius*. The form of these teeth is in contrast with the irregular lengths of the quite rounded teeth of *M. nikiae*. Clark (1920) noted seven dark spots between tentacle bases. These are not present in the Antarctic specimen, but some dark spots are present on the tentacles.

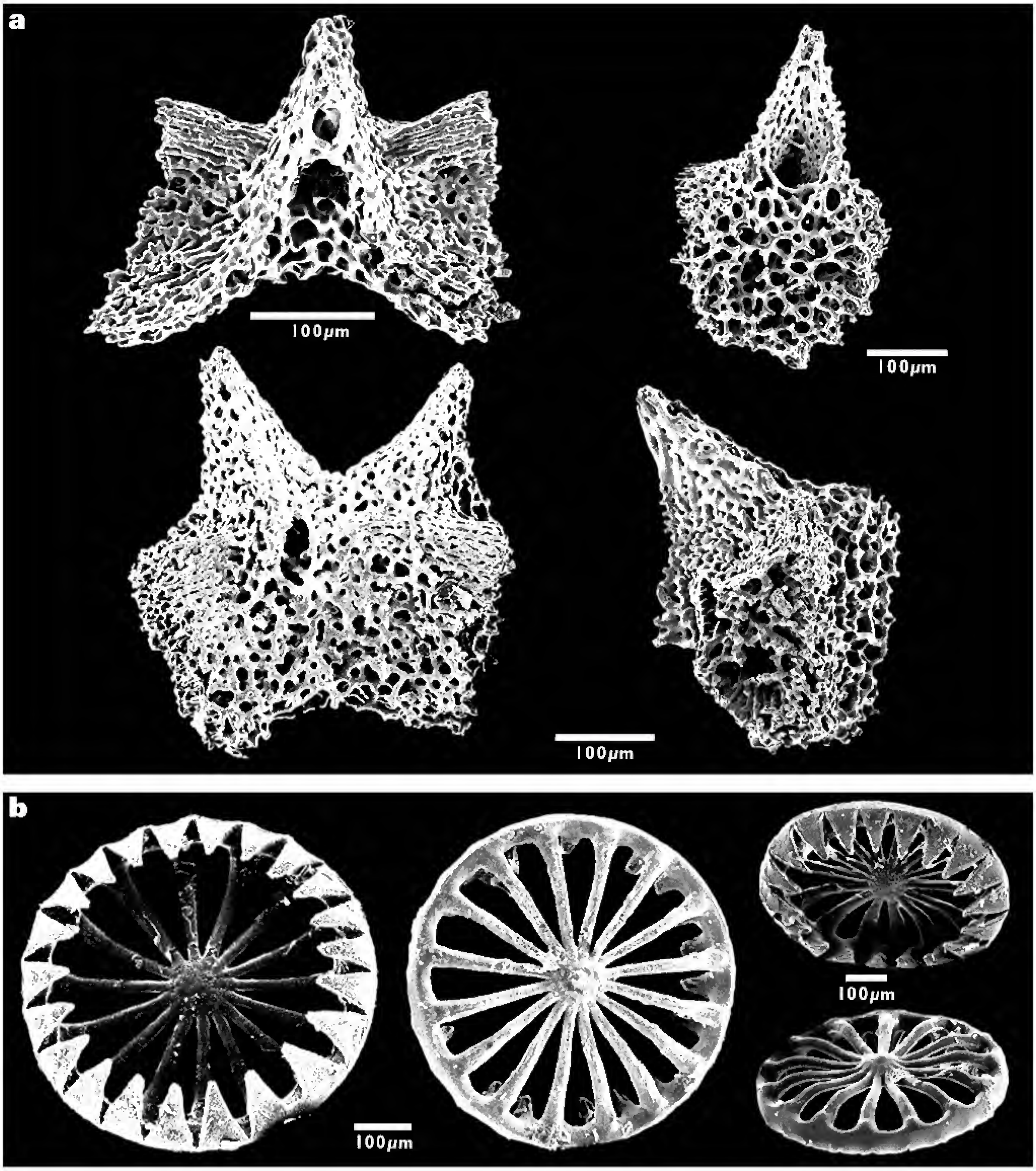

Figure 4. *Myriotrochus antarcticus* Smirnov and Bardsley, 1997 (S Orkney Is, 216 m; RBINS IG 31 459). a, SEM of plates of the calcareous ring with prominent anterior projections and undulating posterior margin and canals, dorso-lateral radial plate (lower left) with two anterior projections; b, SEM of wheels from the body wall.

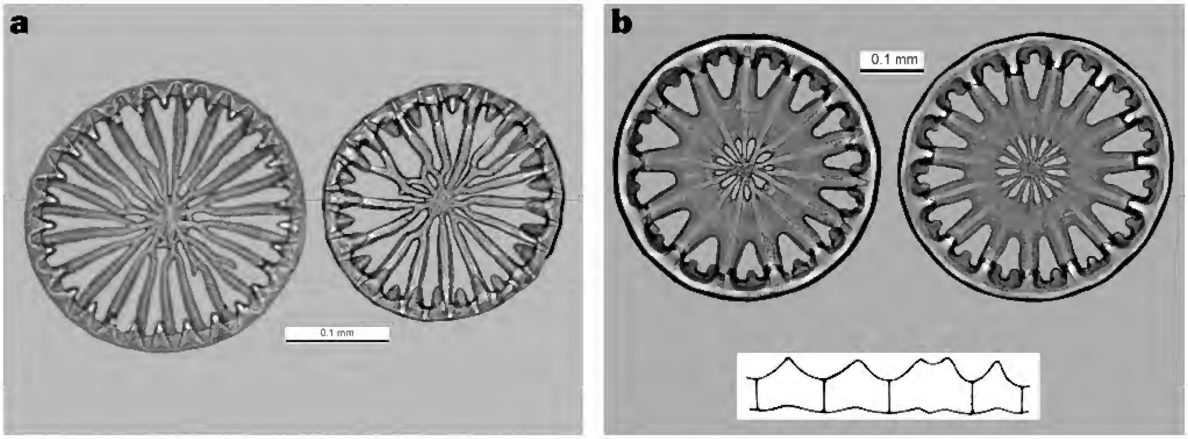

Figure 5. a, montage photo of wheels from body wall of holotype of *Myriotrochus hesperides* O'Loughlin and Manjón-Cabeza, 2009 (Antarctic Peninsula; slide NMV F161516); b, montage photos of wheels from body wall of holotype of *Myriotrochus nikiae* sp. nov., with insert drawing of dorso-lateral radial (2 anterior projections) and adjacent inter-radial (single anterior projection) plates from calcareous ring (Ross Sea; NIWA 37812).

For *Myriotrochus bathybius*, Gage and Billett (1986) reported a possible rough texture of the body wall in larger specimens (soft, thick body wall for *M. nikiae*), and the calcareous ring clearly visible through the body wall (not visible through the thick body wall of *M. nikiae*). Gage and Billett (1986) illustrated tapered teeth of uniform length with narrowly rounded points (in contrast with the bluntly rounded teeth of variable length for *M. nikiae*).

As noted in the diagnosis the tentacles of the single specimen of *Myriotrochus nikiae* are withdrawn, and it was not possible to confidently describe them as "conical with lateral digits" or "peltato-digitate" as required for assignment to subgenus *Oligotrochus* M. Sars or subgenus *Myriotrochus* Steenstrup respectively (see Smirnov 1999).

Neolepidotrochus variodentatus (Belyaev and Mironov, 1978)

Table 2

Myriotrochus variodentatus Belyaev and Mironov, 1978: 202–204, fig. 4, tables 1, 4, pl. 1 figs 4–6, 9.

Lepidotrochus variodentatus.—Belyaev and Mironov, 1980: 1812, 1818, tables 1, 5.—Belyaev and Mironov, 1982 : 109, fig. 18.

Neolepidotrochus variodentatus.—Bohn, 2005: 234.

Distribution. South Sandwich Trench, 6766–7934 m.

Remarks. Bohn (2005) recognized that *Lepidotrochus* Belyaev and Mironov, 1980 is a junior homonym of *Lepidotrochus* Koken, 1894, and erected the replacement name *Neolepidotrochus*. The distinguishing characters of species of *Neolepidotrochus* Bohn, 2005 are: wheel ossicles with outward-pointing teeth also have inward-pointing teeth; anterior projections of the calcareous ring plates are lower than the basal height of the plates; radial canal pore is situated higher than the base of the anterior plate projection (see Gage and Billet 1986).

Prototrochus Belyaev and Mironov, 1982

Diagnosis (after Gage and Billett 1986). Myriotrochid with 10 tentacles; calcareous ring symmetrical, with dorsal and ventral plates subequal in size; dorsolateral radial plates with single anterior projection; wheels with teeth distributed regularly, pointing towards centre of hub; rods absent from body wall, sometime occurring in and around tentacles.

Remarks. Belyaev and Mironov (1982) noted in erecting their new genus *Prototrochus* that the wheels of their included species *Prototrochus bipartitodentatus* (Belyaev and Mironov, 1978) were exceptional within their diagnosis as there are small external teeth at the base of the internal teeth.

Prototrochus barnesi sp. nov.

Figure 6; table 2

Material examined. Holotype. Antarctica, Scotia Sea, Shag Rocks, 53.63°S 40.91°W, 206 m, BAS stn SR–EBS–4, 11 Apr 2006, NMV F168637.

Paratypes. Type locality and date, NHM 2010.54 (1); RBINS IG 31 459 (1, SEM).

Diagnosis. Myriotrochid species up to 3 mm long; 10 peltato-digitate tentacles, 7 digits per tentacle, including a distal terminal one; tentacle rods present, straight and curved, some with central swelling, some with swollen end, 40–170 μm long; sparse myriotrochid wheels in body wall, slightly scalloped margin at each tooth; wheel ossicle diameters 72–104 μm, spokes 13–15, teeth 22–27, spokes/teeth % 50–59, hub diameters 19–26 μm, hub diameter/wheel diameter % 25–38, teeth length/wheel diameter % 12–20.

Colour (preserved). Off-white.

Distribution. Western Antarctica, Scotia Sea, Shag Rocks, 206 m.

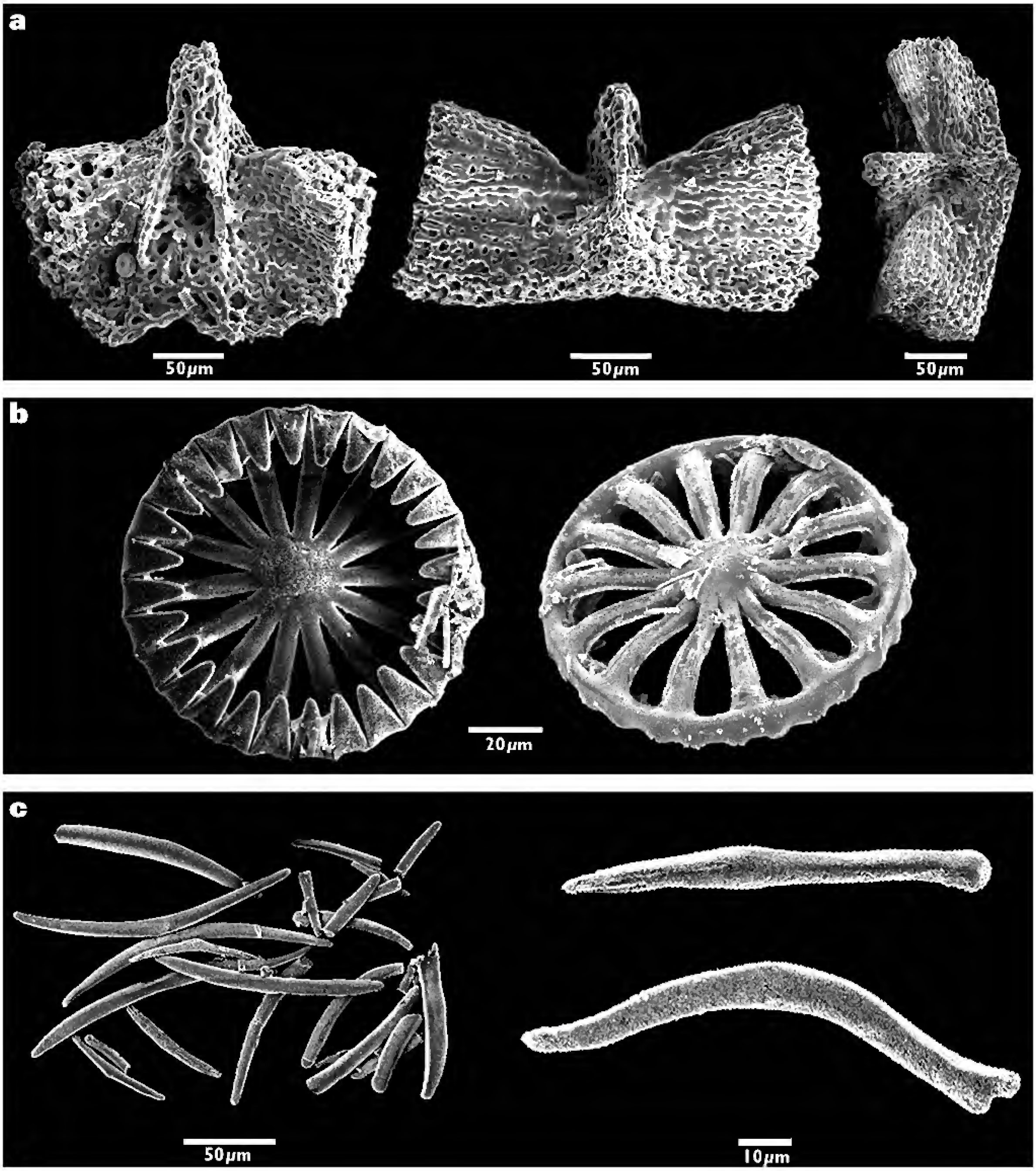

Figure 6. *Prototrochus barnesi* sp. nov. (Shag Rocks; RBINS IG 31 459). a, SEM of plates of the calcareous ring with prominent single anterior projections; b, SEM of wheels from the body wall; c, SEM of rods from tentacles.

Etymology. Named for David Barnes (British Antarctic Survey), in appreciation of his role in the BAS BIOPEARL expeditions and the collection of specimens studied here.

Remarks. Belyaev and Mironov (1982) referred 12 species to their new genus *Prototrochus*. O'Loughlin and VandenSpiegel (2007) added three new *Prototrochus* species from the continental slope of Australia, all lacking tentacle ossicles. The only *Prototrochus* species recorded from Antarctica is *Prototrochus bipartitodentatus* (Belyaev and Mironov, 1978) from the South Sandwich Trench at 7700–8100 m. This species lacks tentacle rods and has external teeth around the rim of the wheels. *Prototrochus barnesi* sp. nov. has wheels with internal teeth only, and has tentacle rods, a rare character for *Prototrochus* species. The only other *Prototrochus* species with tentacle rods is the similarly small *Prototrochus minutus* (Östergren, 1905), described from the coast of Korea at 60–65 m depth. Three diagnostic characters distinguish *Prototrochus minutus* from *Prototrochus barnesi*: sometimes distally and centrally branched tentacle rods; longer tentacle rods (mostly 140–200 μm long); significantly larger wheels (mostly 100–150 μm diameter).

Prototrochus bipartitodentatus (Belyaev and Mironov, 1978)

Table 2

Myriotrochus bipartitodentatus Belyaev and Mironov, 1978: 201–202, fig. 3, tables 1, 3, pl. 1 fig. 1.

Prototrochus bipartitodentatus.—Belyaev and Mironov, 1982: 86, 92, fig. 6.

Distribution. South Sandwich Trench, 7700–8100 m.

Remarks. *Prototrochus bipartitodentatus* (Belyaev and Mironov) is distinguished from all other *Prototrochus* species by the presence of small external teeth at the base of the internal teeth of the wheels.

Prototrochus linseae sp. nov.

Figures 1a, 7; table 2

Material examined. Holotype. Antarctica, Scotia Sea, South Shetland Is, 62.53°S 61.83°W, 192 m, BAS stn LI–EBS–4, 4 Mar 2006, NMV F168631.

Paratypes. Type locality and date, NHM 2010.50 (1); RBINS IG 31 459 (2, SEM).

Other material. South Shetland Is, 61.61°S 55.22°W, 1544 m, BAS stn EI–EBS–1, 12 Mar 2006, NHM 2010.53 (1).

Diagnosis. Myriotrochid species up to 7 mm long; 10 tentacles; lacking tentacle rods; scattered myriotrochid wheels only in body wall; wheel ossicle diameters 125–137 μm, spokes 10–11, teeth 22–24, spokes/teeth % 45, hub diameters 30–34 μm, hub diameter/wheel diameter % 24.0–24.7, teeth length/wheel diameter % 12.9–13.0.

Colour (preserved). Body pale yellow-brown to off-white, translucent; tentacles yellow.

Distribution. Antarctica, Scotia Sea, South Shetland Is, 192–1544 m.

Etymology. Named for Katrin Linse (British Antarctic Survey), in appreciation of her role in the BAS BIOPEARL expeditions and the collection of specimens studied here, and with gratitude for her gracious collaboration in making BAS specimens available for this study and providing relevant data.

Remarks. Most of the 12 species referred to their new genus *Prototrochus* by Belyaev and Mironov (1982) lack tentacle ossicles, as does *Prototrochus linseae* sp. nov. Most of the species lacking tentacle ossicles are from the deep trenches (6450–10700 m in Belyaev and Mironov 1882). Only *Prototrochus bipartitodentatus* (Belyaev and Mironov, 1978) has been recorded from the Antarctic (South Sandwich Trench, 7700–8100 m). It has external teeth around the rim of the wheels that *Prototrochus linseae* does not. Belyaev and Mironov (1982) list three shallower species (540–3000 m), two from the Mediterranean Sea and *Prototrochus australis* (Belyaev and Mironov, 1981) from the Tasman Sea. O'Loughlin and VandenSpiegel (2007) list three additional species from the Tasman Sea: *Prototrochus burni* O'Loughlin, 2007*, *Prototrochus staplesi* O'Loughlin, 2007* and *Prototrochus taniae* O'Loughlin, 2007* (*all in O'Loughlin and VandenSpiegel 2007). As demonstrated by reference to Table 1 and Figure 10 in O'Loughlin and VandenSpiegel (2007), *Prototrochus linseae* is distinguished from the four Tasman Sea *Prototrochus* species by the form of the wheels: smallest wheels; largest teeth; widest uniformly broad spokes, with sharp constriction at the hub; largest hub.

Suborder **Synaptina** Smirnov, 1998

Diagnosis (Smirnov, 1998). Plates of calcareous ring without prominent anterior projections; excavations for tentacular ampullae lie on outer side of calcareous ring. Madreporite situated far from water ring at end of long stone canal. Ciliated funnels present. One to many polian vesicles. Body wall ossicles may be wheels of chiridotid type with 6 spokes and a complex hub and/or sigmoid hooks, or anchors and anchor plates. Wheels of larvae and juveniles with more spokes and small denticles on inner side of rim.

Families. Chiridotidae Östergren, 1898; Synaptidae Burmeister, 1837.

Chiridotidae Östergren, 1898

Diagnosis (Smirnov 1998). Synaptina with 10, 12 or 18 peltato-digitate, pinnate or bifurcate tentacles. Juveniles with bifurcate tentacles. Body wall ossicles wheels of chiridotid type and/or sigmoid hooks. Chiridotid type wheels with 6 spokes, numerous small denticles on inner side of rim and a complex hub; on lower side of each spoke a branch leans against the lower end of the hub forming a star structure. Ossicles in tentacles usually rods with branched ends.

Subfamilies. Taeniogyrinae Smirnov, 1998; Chiridotinae Östergren, 1898 (sensu Smirnov 1998).

Subfamily **Taeniogyrinae** Smirnov, 1998

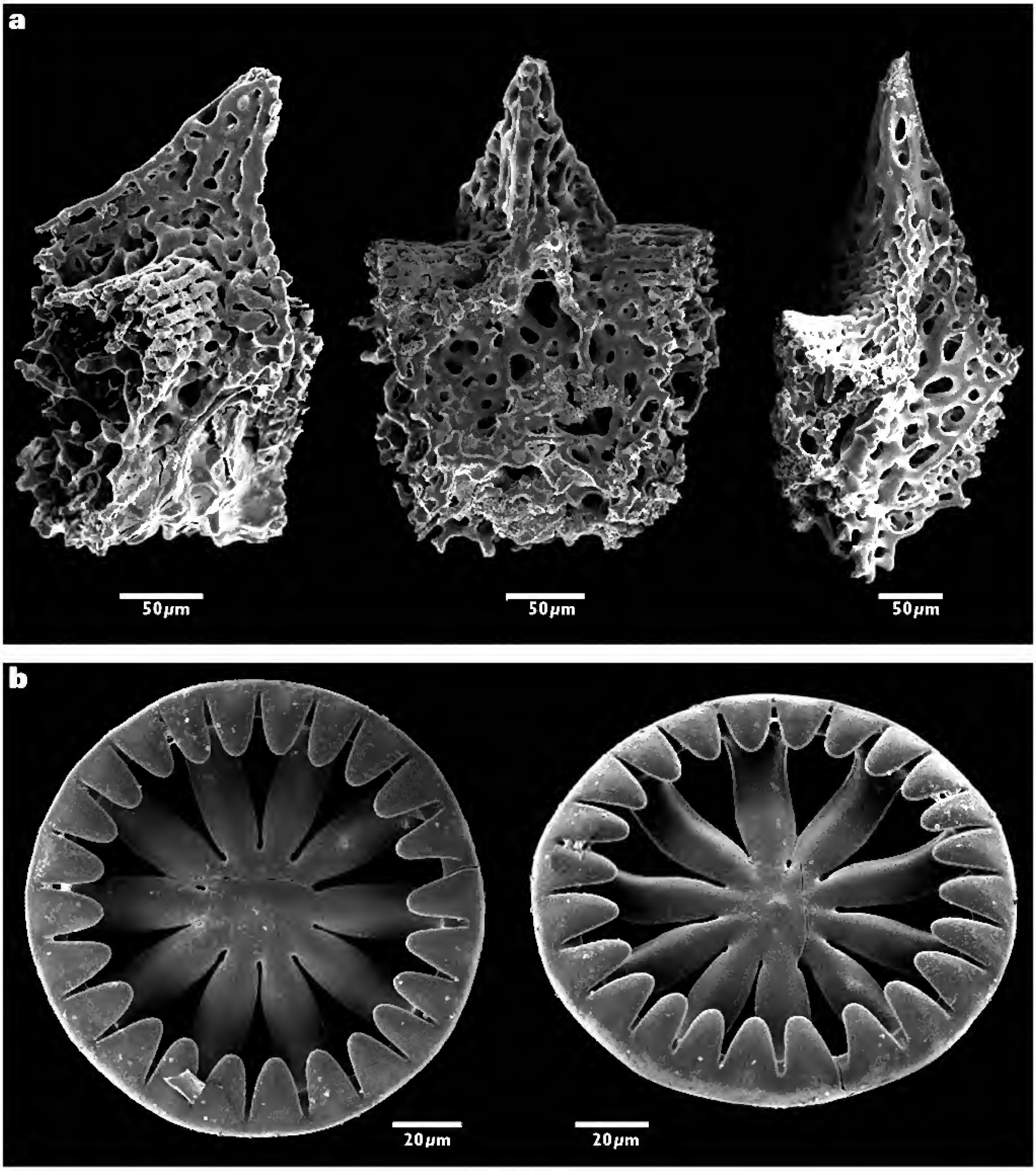

Figure 7. *Prototrochus linseae* sp. nov. (S Shetland Is; RBINS IG 31 459). a, SEM of plates of the calcareous ring with prominent single anterior projections; b, SEM of wheels from the body wall.

Diagnosis (Smirnov 1998). Chiridotidae with 10 or 12 tentacles. Body wall ossicles wheels of chiridotid type and sigmoid hooks or sigmoid hooks only. Radial plates of calcareous ring not perforated but sometimes slightly notched in anterior (upper) face for passage of nerves.

Included genera. Archedota O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel 2007); *Kolostoneura* Becher, 1909; *Rowedota* gen. nov.; *Scoliorhapis* H. L. Clark, 1946; *Sigmodota* Studer, 1876; *Taeniogyrus* Semper, 1867.

Remarks. Achiridota Clark, 1908 was initially placed in Chiridotidae, but was assigned to Myriotrochidae by Smirnov (1998) on the basis of having: large anterior teeth on the plates of the calcareous ring; single polian vesicle; madreporite close to calcareous canal. *Sigmodota* Studer is raised out of synonymy with *Taeniogyrus* Semper (below). *Trochodota* Ludwig, 1891 is made a junior synonym of *Taeniogyrus* Semper (below). *Scoliodotella* Oguro, 1961 is made a junior synonym of *Scoliorhapis* H. L. Clark (below).

Kolostoneura Becher, 1909

Kolostoneura Becher, 1909: 42.—H. L. Clark, 1921: 164.—Mortensen, 1925: 384–386.—Heding, 1928: 277, 278.—Pawson, 1970: 44.—Smirnov, 1998: 519.

Diagnosis (of type species, following Dendy and Hindle 1907 and Mortensen 1925). Taeniogyrinid genus with 10 peltato-digitate tentacles, each with 12 digits increasing in size distally; tentacle rods present; lacking ossicles in body wall; calcareous ring present, 5 subrectangular, transversely elongate radial and 5 subequal, interradial plates, lacking anterior projections / teeth; single polian vesicle; madreporite canal long, straight, madreporite distant from water ring; branched gonad tubules; ciliated funnels present.

Type species. Rhabdomolgus novae-zealandiae Dendy and Hindle, 1907 (New Zealand, Chatham Is, coastal shallows).

Other species. Kolostoneura griffithsi sp. nov. (Antarctica, Scotia Sea, 506 m).

Remarks. Smirnov (1998) noted that although *Kolostoneura* lacks ossicles in the body wall its morphological characters place it near *Taeniogyrus* and *Trochodota* and thus in family Taeniogyrinae. Mortensen (1925) found a very small, damaged specimen that he judged to be *Kolostoneura novae-zealandiae* (Dendy and Hindle) that was infested with parasitic snails and had hooks and wheels in the body wall. He postulated that the ossicles of the ancestral species were present through the influence of the parasite. Perhaps ossicles are typically present in small specimens of this species, and then lost as size increases as happens with many holothuroid species (such as with the apodid *Taeniogyrus magnibaculus* Massin and Hétérier, 2004 below). If this is the case then genus *Kolostoneura* would be a junior synonym of *Taeniogyrus* Semper, 1867 (see below).

Kolostoneura griffithsi sp. nov.

Figures 1b, 2b; table 2

Material examined. Holotype. South Orkney Is, 60.99°S 46.83°W, 506 m, BAS stn PB–EBS–3, 18 Mar 2006, NMV F168634.

Diagnosis. Taeniogyrinid species 12 mm long; 10 peltato-digitate tentacles, 3–4 pairs of digits per tentacle; no ossicles in body wall; tentacle rods present, some with central hub, some with bifurcate ends, 96–112 μm long; solid calcareous ring, plates lack anterior projections/teeth, posterior margin slightly concave; single polian vesicle; madreporite with short curved canal, close to water ring; gonad tubules not present; lacking ciliated funnels.

Colour (preserved). Dark purple-red flecking on grey to off-white semi-translucent body wall.

Distribution. Antarctica, Scotia Sea, South Orkney Is, 506 m.

Etymology. Named for Huw Griffiths (British Antarctic Survey), in appreciation of his role in the BAS BIOPEARL expeditions and the collection of specimens studied here.

Remarks. Kolostoneura griffithsi sp. nov. exhibits the diagnostic characters of the type species of *Kolostoneura* Becher, 1909, except that it has fewer tentacle digits, has calcareous ring plates that are not transversely elongate, and lacks ciliated funnels. However, Mortensen (1925) noted that ciliated funnels were sometimes scarce or absent along the mesentery in the material that he examined.

Rowedota gen. nov.

Figure 8

Diagnosis. Taeniogyrinid genus with 10 tentacles, each with 1–4 pairs of digits; chiridotid-type wheels and sigmoid hooks in body wall, rods in tentacles; wheels with teeth on inner rim in 6 discrete groups, discontinuous between spokes, not continuous series around rim; wheels scattered or aligned in the body wall, not in distinct papillae; sigmoid hooks scattered; single polian vesicle; ciliated funnels present.

Type species. Taeniogyrus allani Joshua, 1912 (see O'Loughlin and VandenSpiegel 2007).

Other species. Trochodota epiphyka O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); *Trochodota shepherdi* Rowe, 1976; *Trochodota vivipara* Cherbonnier, 1988; *Trochodota mira* Cherbonnier, 1988.

Etymology. Named for Dr Frank W. E. Rowe, Senior Fellow of the Australian Museum, with appreciation of his contribution to echinoderm systematics and of his role as a valued mentor and colleague.

Remarks. Rowe (1976) based his emended diagnoses of *Taeniogyrus* and *Trochodota* on an important diagnostic character that distinguished two types of wheels amongst species of Taeniogyrinae, namely those with a continuous series and those with discontinuous grouped teeth on the inner rim. We judge that this is a significant generic character and on this diagnostic character erect the new genus. The genus has further morphological coherence with all included species having 10 tentacles, up to only 4 pairs of tentacle digits, a single

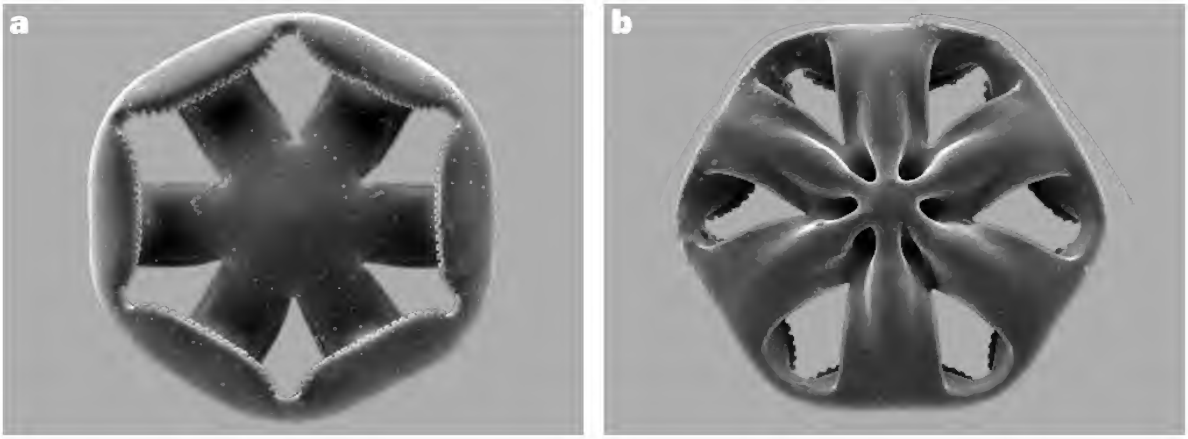

Figure 8. a, b, SEM of wheels from body wall of *Rowedota allani* (Joshua, 1912) illustrating the *Rowedota* gen. nov. generic character of discontinuous series of teeth around the inner rim (SE Australia; from lot NMV F82715).

polian vesicle, and the wheels never grouped into discrete papillae or bands. The new genus has geographical coherence with all included species occurring on both sides of the Indian Ocean off Australia and Madagascar.

We have included the presence of a single polian vesicle and ciliated funnels in the generic diagnosis of *Rowedota* gen. nov., but the presence of ciliated funnels in the Cherbonnier (1988) species and presence of a single polian vesicle in *Trochodota mira* have yet to be confirmed.

Frank Rowe (pers. comm.) considers the rods in the body wall illustrated by Cherbonnier (1988) for his *Trochodota mira* to be contaminants. Species to date referred to *Trochodota*, other than those referred here to the new genus *Rowedota*, are referred to *Taeniogyrus* (below). The wheels of *Trochodota maculata* H. L. Clark, 1921 have continuous series of teeth in the inner rim (see below). Rowe (1976) followed Clark (1921) who thought that the wheels in his new species *Trochodota maculata* had discontinuous series of teeth. The 1921 illustration of a wheel suggests that Clark was viewing the wheel from the side on which the continuous series is not evident as the series is partly obscured by the spokes.

No species of *Rowedota* gen. nov. occurs in Antarctica. The new genus is erected within this revision of genera of Taeniogyrinae.

Scoliorhapis Clark, 1946

Table 3

Scoliodota Heding, 1928: 277, 278, 319 (junior homonym of *Scoliodota* H. L. Clark, 1908).

Scoliorhapis H. L. Clark, 1946: 461.—Rowe (in Rowe and Gates), 1995: 267.—Smirnov, 1998: 519.—Kerr, 2001: 57.—O'Loughlin and VandenSpiegel, 2007: 53.

Scoliodotella Oguro, 1961: 2–3.

Diagnosis (emended from H. L. Clark 1946). Taeniogyrinae with 10 or 12 peltato-digitate tentacles, each with up to 8 pairs of digits; single polian vesicle; ciliated funnels present; body wall ossicles sigmoid hooks only, hooks scattered or some clustering or alignment; lacking wheels in body wall; tentacle ossicles bracket-shaped or rods.

Type species. Scoliodota theeli Heding, 1928.

Type locality. Australia, New South Wales, Port Jackson.

Other species. Scoliorhapis biopearli sp. nov. (Scotia Sea, S Shetland Is, 1544 m); *Scoliodota lindbergi* Djakonov (in Djakonov et al.), 1958 (Sea of Okhotsk, South Sakhalin and South Kurile Is, 8–22 m); *Scoliorhapis massini* sp. nov. (Scotia Sea, Shag Rocks, 206 m); *Scoliodotella uchidai* Oguro, 1961 (Cape Aikappu, Japan, shallows).

Remarks. The significant emendation to the diagnosis by H. L. Clark (1946) is the inclusion of species that have 12 tentacles. This is in response to *Scoliorhapis massini* sp nov. (below) having 12 tentacles.

Oguro (1961) erected his new genus *Scoliodotella* for chiridotid specimens with sigmoid hooks but no wheels in the body wall. He considered referring his new species to *Scoliodota* H. L. Clark, 1908, unaware that H. L. Clark had rejected *Scoliodota* and erected the genus *Scoliorhapis*. Oguro did not refer his new species to *Scoliodota* because the hooks were not grouped into papillae. We reject clustering of ossicles as a sound generic diagnostic character, and consider *Scoliodotella* to be a junior synonym of *Scoliorhapis*.

Chiridota japonica Marenzeller, 1881 was erected for material from Japan. The species was poorly described. Théel (1886a) referred damaged specimens from Australia (New South Wales) to *Chiridota japonica* Marenzeller. *Scoliodota* H. L. Clark, 1908 was erected as a new monotypic genus for *Chiridota japonica* Marenzeller from Japan and the Théel material from New South Wales on the basis of hook ossicles only in the body wall. But Clark (1908) commented that the

Table 3. Specimen and ossicle sizes for some species of Taeniogyrinae.

Selected species of *Scoliorhapis*, *Sigmodota* and *Taeniogyrus*	Locality (this work) or authors	Maximum preserved length	Wheel diameter µm	Hook length µm	Tentacle rod length µm	Tentacle number
Scoliorhapis species						
Soliorhapis theeli (type species)	Heding 1928	no data	absent	100–140	106	10
Scoliorhapis biopearli sp. nov.	S Shetland Is (this work)	6 mm	absent	168–184	112–120	10
Scoliorhapis massini sp. nov.	Shag Rocks (this work)	20 mm	absent	88–104	up to 80	12
Scoliorhapis ? massini sp. nov.	Falkland Is (this work)	50 mm	absent	120–176	120–160	12
Sigmodota species						
Sigmodota contorta (type species for *Sigmodota*)	Ludwig 1875	45 mm	94	140–160	no data	12
	Ludwig 1898	45 mm	44–130	170–200	156–182	12
	H. L. Clark 1921	no data	42–130	170–210	170	12
	Ekman 1925	44 mm	45–120	140–170	no data	no data
	Pawson 1964	50 mm	42–130	140–200	170	12
	Massin & Hétérier 2004	45 mm	35–100	160–250	140–170	12
	Bouvet I. (this work)	10 mm	40–88	224–240	120–128	12
	Falkland Is (this work)	40 mm	40–128	136–200	80–184	12
	S Georgia (this work)	45 mm	48–96	192–248	80–144	12
	S Georgia (this work)	8 mm	56–72	no data	up to 128	12
	S Orkney Is (this work)	9 mm	40–88	152–184	96–112	12
	S Shetland Is (this work)	15 mm	56–104	168–176	96–112	12
	Magellanic (this work)	40 mm	up to 136	up to 208	up to 184	12
	Heard I. (this work)	no data	88–104	192–208	104–168	12
	Summary	**50 mm**	**35–136**	**136–250**	**80–184**	**12**
Sigmodota dubia	Fisher 1907	60 mm	90–175	185–230	no data	12
Sigmodota magnibacula	Massin & Hétérier 2004	72 mm	100–200	160–180	170–280	12
	S Orkney Is (this work)	70 mm	112–160	192–216	256–296	12
	S Orkney Is (this work)	15 mm	56–120	128–176	176–216	12
	Ross Sea (this work)	25 mm	96–136	152–200	192–240	12
	Ross Sea (this work)	73 mm	110–140	170–190	200–270	12
	Wilkes Land (this work)	60 mm	up to 104	up to 192	up to 272	12
	Prydz Bay (this work)	105 mm	80–186	176–192	184–320	12
	Summary	**105 mm**	**56–200**	**128–216**	**170–320**	**12**
Taeniogyrus species						
Taeniogyrus antarcticus	Heding 1931	no data	no data	172–200	83–103	10
	S Orkney Is (this work)	15 mm	64–80	200–208	128	10
	S Orkney Is (this work)	7 mm	40–64	120–152	80–104	10
	S Orkney Is (this work)	3 mm	48–72	112–120	128	10
	S Orkney Is (this work)	2 mm	40–56	80–88	80	10
	Shag Rocks (this work)	8 mm	48–64	144–168	no data	10
	Shag Rocks (this work)	1 mm	48–64	64–80	64–72	10
	Summary	**15 mm**	**40–80**	**64–208**	**64–128**	**10**
Taeniogyrus australianus (type species for *Taeniogyrus*)	Australia (this work)	95 mm	48–88	112–136	72–104	10
	Heding 1928	60 mm	70–100	up to 110	110	10
	Summary	**95 mm**	**48–100**	**110–136**	**72–110**	**10**
Taeniogyrus maculatus	H. L. Clark 1921	26 mm	50–100	66–77	about 45	10
	Newcastle (this work)	21 mm	48–104	80–96	56–72	10
	Summary	**26 mm**	**48–104**	**66–96**	**45–72**	**10**
Taeniogyrus prydzi sp. nov.	Prydz Bay (this work)	7 mm	up to 90	232–240	136–144	10
	Prydz Bay (this work)	50 mm	up to 90	256–272	136–152	10
	Summary	**50 mm**	**up to 90**	**232–272**	**136–152**	**10**
Taeniogyrus purpureus	Ludwig 1898	33 mm	165–182	135–156	78–87	10
	Ekman 1925	33 mm	70–180	80–150	no data	no data
	H. L. Clark 1921	no data	154–182	125–150	76–87	no data
	Pawson 1964	100 mm	130–180	120–130	average 78	10
	Magellanic (this work)	15 mm	80–144	120–160	56–120	10
	Summary	**100 mm**	**70–182**	**80–160**	**56–120**	**10**

Marenzeller and Théel materials might represent different species. Ohshima (1913) reported that *Chiridota japonica* von Marenzeller had both hook and wheel ossicles, and belonged to *Trochodota* Ludwig, 1891.

Clark (1921) rejected his own genus *Scoliodota* Clark, 1908 on the grounds that his type species *Chiridota japonica* von Marenzeller belonged to *Trochodota* Ludwig. Heding (1928) stated that Clark (1921) abandoned *Scoliodota* Clark without considering the Théel specimens from New South Wales. Heding (1928) erected a new species for the New South Wales specimens that lacked wheels, and referred them to *Scoliodota* Clark. Heding (1928) nominated his *Scoliodota theeli* Heding, 1928 as the new type for *Scoliodota* Clark, 1908.

Clark (1946) insisted that he selected Japanese material as type for his *Scoliodota*, although that is not explicit in the text (Clark 1908). Clark (1946) rejected Heding's resurrection of *Scoliodota* Clark, and erected a new monotypic genus *Scoliorhapis* Clark, 1946 with type species *Scoliodota theeli* Heding, 1928.

Clark (1921) noted that *Chiridota geminifera* Dendy and Hindle, 1907 had hook ossicles but lacked wheels, but because of the single small and damaged type specimen considered the material to be unreliable for referral to *Scoliodota* Clark. He considered *Chiridota geminifera* Dendy and Hindle to be a junior synonym of *Trochodota dunedinensis* (Parker, 1881).

Scoliorhapis biopearli sp. nov.

Figure 1c; tables 2, 3

Material examined. Holotype. South Shetland Is, 61.61°S 51.22°W, 1544 m, BAS stn EI–EBS–1, NMV F168633.

Diagnosis. Conical form, widest orally, tapered anally, dorsal projecting over ventral orally, 6 mm long; 10 tentacles, number of digits not evident; tentacle ossicles curved bracket-shaped rods with bluntly spinous distal outer edges, 112–120 μm long; body wall ossicles sigmoid hooks only, in close transverse alignment, not clustered, hooks 168–184 μm long.

Colour (preserved). White to translucent.

Distribution. South Shetland Is, 1544 m.

Etymology. Named for the British Antarctic Survey BIOPEARL expedition that collected and documented this specimen.

Remarks. This species is erected for a single, small BAS BIOPEARL specimen with tentacle and body wall ossicles that are eroded but retain distinguishable form and size. The presence of hooks only, and not wheels, in the body wall distinguishes this apodid specimen as a species of *Scoliorhapis* Clark. The distinctive presence of 10 tentacles distinguishes this species from the second new species of *Soliorhapis* Clark from Antarctica described below. *Scoliorhapis biopearli* sp. nov. is distinguished from the type species *Scoliorhapis theeli* (Heding) from eastern Australia by the larger size of the hooks (see Table 3) and transverse arrangement of the hooks in the body wall, and the spinous ends of the bracket-shaped tentacle ossicles.

Scoliorhapis massini sp. nov.

Figures 1d, 9a, b; tables 2, 3

Material examined. Holotype. Scotia Sea, Shag Rocks, 53.63°S 40.91°W, 206 m, BAS stn SR–EBS–4, NMV F168635.

Other material. Falkland Is, 50°55'S 59°58'W, 118 m, *Discovery Expedition*, *William Scoresby* stn 756, 10 Oct 1931, NHM 2010.105–109 (5).

Diagnosis. Elongate, thin, 20 mm long; 12 tentacles, 3 pairs of digits; tentacle ossicles slightly curved rods with central swelling and bifurcate ends, up to 80 μm long; body wall ossicles sigmoid hooks only, not clustered, hooks 88–104 μm long.

Colour (preserved). Reddish brown.

Distribution. Scotia Sea, Shag Rocks, 206 m.

Etymology. Named for Dr Claude Massin (Royal Belgian Institute of Natural Sciences), with appreciation of a lifetime of magnificent contribution to holothuroid systematics and in particular here to Antarctic apodid studies.

Remarks. *Scoliorhapis massini* sp. nov. is erected for a single BAS BIOPEARL specimen that is in good condition. It is distinguished from the other two species of *Scoliorhapis* by the presence of 12 tentacles. In addition it has tentacle ossicles that are rods, not bracket-shaped, and the sigmoid hooks and tentacle rods are smaller than in the other two species (see Table 3).

Hérouard (1906) provided the very limited description of 12 tentacles and hook ossicles for specimens from the Bellingshausen Sea that he determined to be *Sigmodota studeri* (Théel). The few diagnostic details would fit *Scoliorhapis massini* sp. nov.

The *Discovery* (1931) Falkland Is specimens occur at a similar depth to the Shag Rocks specimen and are provisionally referred to *Scoliorhapis massini* sp. nov. They are: brown; lack wheels; longer (up to 50 mm long); have 12 tentacles, each with more pairs of digits (up to 6); the ossicles are eroded; the tentacle rods are of similar form but longer (120–160 um long); the hooks longer (120–176 um long). The significantly larger ossicles may reflect the larger specimen sizes or another new species of *Scoliorhapis*.

Sigmodota Studer, 1876

Table 3

Sigmodota Studer, 1876: 454.—Théel, 1886a: 16, 33.—Ludwig, 1898: 73, 81–82.—Östergren, 1898: 117–118.—H. L. Clark, 1908: 121.—Dendy and Hindle, 1907: 113.—Heding, 1928: 277.—Pawson, 1964: 466.—Smirnov, 1998: 519.

Diagnosis. Taeniogyrinid genus with 12 plates in calcareous ring, 12 tentacles, peltato-digitate, 4–7 pairs of digits per tentacle, terminal pair longest; rods in tentacles; chiridotid wheels and sigmoid hooks in body wall; teeth on the inner rim of wheels in continuous series; wheels grouped into papillae, hooks scattered in body wall; no miliary granules in longitudinal muscles; 3–10 polian vesicles; ciliated funnels present.

Type species. Type species fixed here (under Article 70.3.2 of the 1999 edition of the ICZN Code) as *Chiridota contorta* Ludwig, 1875, misidentified as *Holothuria* (*Fistularia*) *purpurea* Lesson, 1830 in the original monotypy designation by Studer (1876).

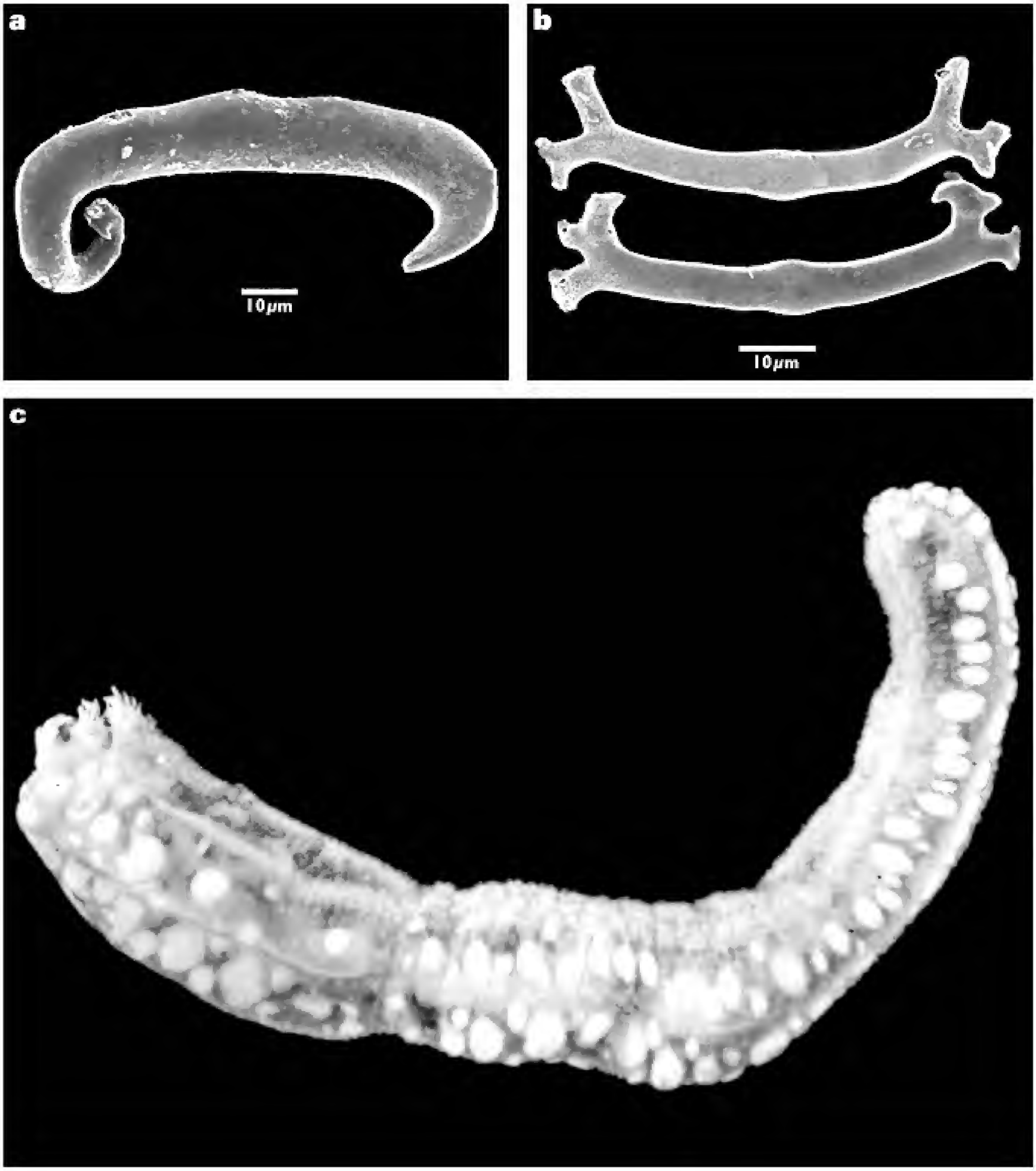

Figure 9. a, b, ossicles from the holotype of *Scoliorhapis massini* sp. nov. (Shag Rocks; NMV F168635). a, SEM of hook from the body wall; b, SEM of rods from a tentacle. c, enhanced colour photo of preserved specimen of *Taeniogyrus australianus* (Stimpson, 1855), showing wheel cluster papillae (large) and hook clusters (small) (27 mm long; Australia, Sydney Harbour, 1968; AM J16377).

Other species. *Taeniogyrus dubius* H. L. Clark, 1921 (as *S. dubia*); *Taeniogyrus magnibaculus* Massin and Hétérier, 2004 (as *S. magnibacula*).

Remarks. We follow Ludwig (1898) and H. L. Clark (1908) and agree that Studer's *Sigmodota purpurea* (Lesson, 1830) is a junior synonym of *Taeniogyrus contortus* (Ludwig, 1875). Studer (1876) erected his new genus *Sigmodota* for the species *Holothuria* (*Fistularia*) *purpurea* Lesson, 1830 because of the presence of sigmoid hooks in apodid specimens from the Kerguelen Is and Magellanic region. He reported 12 tentacles, and ignored the 10 tentacles in the species *Holothuria* (*Fistularia*) *purpurea* Lesson. As understood by Ludwig 1898 and H. L. Clark 1908 and as argued above by us in "Relevant history of species misidentification" the material that Studer examined had 12 tentacles, hooks and wheels.

H. L. Clark (1908) judged *Sigmodota* Studer to be a junior synonym of *Taeniogyrus* Semper, 1867, which he diagnosed as having: 10 or 12 peltato-digitate tentacles; 1 or several polian vesicles; ciliated funnels not in stalked clusters; wheels in papillae; large sigmoid hooks scattered in body wall; lacking miliary granules. He included two species: *Taeniogyrus australianus* (Stimpson, 1855), with 10 tentacles, hooks in papillae, single polian vesicle; and *Taeniogyrus contortus* (Ludwig, 1875), with 12 tentacles, hooks scattered, 6 or 7 polian vesicles.

As discussed above in "Ossicle clusters in generic diagnosis" we reject ossicle aggregation in the body wall as a generic diagnostic character, and judge that tentacle number is a good generic character. Thus we raise *Sigmodota* Studer out of synonymy with *Taeniogyrus* Semper, 1867 on the basis of the type species *Chiridota contorta* Ludwig having 12 tentacles and the type species of *Taeniogyrus*, *Chiridota australiana* Stimpson, having 10.

We examined specimens of *Sigmodota contorta* (Ludwig) and *Sigmodota magnibacula* (Massin and Hétérier) and found that there were consistently 12 subequal plates in the calcareous ring. Plates were fused, and joined beneath the tentacle bases attached to the outside face of the ring. Each plate had a low anterior projection and a shallow concave posterior indentation.

Sigmodota contorta (Ludwig, 1875)

Figure 10; tables 2, 3

Chiridota contorta Ludwig, 1875: 80–81, pl. 6, figs 6a–c.—Lampert, 1885: 234.—Théel, 1886a: 16, 33, pl. 2 fig. 2.—Théel, 1886b: 20.—Lampert, 1889: 853–854.—Ludwig, 1891: 359.—Östergren, 1897: 154.—Ludwig, 1897: 217–219.—Ludwig, 1898: 73–83, pl. 3 figs 37–42.—Perrier, 1905: 77–78.

Sigmodota purpurea.—Studer, 1876: 454.—Studer, 1879: 123.

Chiridota purpurea.—Bell, 1881: 101.—Lampert, 1885: 236.—Lampert, 1886: 18–21, figs 17–20.—Ludwig, 1886: 29, 30.

Chiridota studeri Théel, 1886a: 33.—Lampert in Studer, 1889: 163, 283, 285, 308.

Sigmodota contorta.—Östergren, 1898: 118.—Sluiter, 1901: 134.

Sigmodota studeri.—Hérouard, 1906: 15.

Taeniogyrus contortus.—H. L. Clark, 1908: 121–123, pl. 7 figs 8–13.—H. L. Clark, 1921: 165.—Ekman, 1925: 147–148.—Ekman, 1927: 416–417 (part *Sigmodota magnibacula* (Massin and Hétérier, 2004)).—Heding, 1928: 311, fig. 66(1–9).—Deichman, 1947: 348–349.—Pawson, 1964: 466, 467.—Pawson, 1969a: 126, 141.—Pawson, 1969b: 38, map 6.—Pawson, 1971: 289, figs 1, 2.—Arnaud, 1974: 585.—Hernandez, 1981: 164, figs 1k, l, 4d, e.—Gutt, 1988: 24 (part if not all *Sigmodota magnibacula* (Massin and Hétérier, 2004)).—Gutt, 1991: 324 (part if not all *Sigmodota magnibacula* (Massin and Hétérier, 2004)).—Massin, 1992: 311.—Branch et al., 1993: 40, 56, 61, 65.—O'Loughlin, 2002: 298, 300, 301, tables 1, 2 (part *Sigmodota magnibacula* (Massin and Hétérier, 2004); see material examined).—Massin and Hétérier, 2004: 442, 443, table 1.—O'Loughlin, 2009: 2, table 1.

Taeniogyrus contortus antarcticus.—Panning, 1936: 17, 18, fig. 8.—Pawson, 1969a: 141. (non *Taeniogyrus antarcticus* Heding, 1931)

Chiridota pisanii.—O'Loughlin, 2002: 298, tables 1, 4 (= *Sigmodota contorta*; non *Chiridota pisanii* Ludwig, 1886).

Material examined. South America, Argentina, Santa Cruz, east of Grande Bay, *Albatross* Stn 2771, 51°34'S 68°00'W, 91 m, 1888, USNM 19826 (3); Chile, Inutil Bay, 53°35'S 69°45'W, 37–46 m, 1969, USNM E33679 (13); 53°34'S 69°59'W, 82–91 m, 1970, USNM E33715 (9).

Falkland Is, 52°10'S 64°56'W, 150 m, *Discovery Expedition*, *William Scoresby* stn 816, 14 Jan 1932, NHM 2010.55–62 (8); 54°00'S 64°58'W, 118 m, *Discovery Expedition*, *William Scoresby* stn 88, 6 Apr 1927, NHM 2010.63–68 (6); E Falkland Is, 75 m, *Discovery Expedition*, *William Scoresby* stn 84, 24 Mar 1927, NHM 2010.69–70 (2); 296 m, *Discovery Expedition*, *William Scoresby* stn 773, 31 Oct 1931, NHM 2010.71–74 (4); Saldanka Bay, *Discovery Expedition*, *William Scoresby* Marine Station 82, 6 Sep 1926, NHM 2010.75–84 (many).

Antarctic Ocean, Bouvet I., ICEFISH 2004 stn 80–BT42, 54.40°S 03.48°W, 159 m, NMV F104990 (1).

South Georgia, ICEFISH 2004 stn 38–BT18, 54.00°S 37.66°W, 46 m, NMV F104799 (1); 18–25 m, *Discovery Expedition*, *William Scoresby* stn 25, 17 Dec 1926, NHM 2010.85–94 (11); RBINS IG 31 459 (1, SEM); 2 m, *Discovery Expedition*, *William Scoresby* stn 56, 14 Jan 1927, NHM 2010.95–96 (2); 179–235 m, *Discovery Expedition*, stn 39, 25 Mar 1926, NHM 2010.97–98 (2); 0–100 m, *Discovery Expedition*, stn 126, 19 Dec 1926, NHM 2010.99 (1); 26–83 m, *Discovery Expedition*, *William Scoresby* stn 62, 19 Jan 1927, NHM 2010.100–103 (4); Leith Harbour, 22–55 m, *Discovery Expedition*, stn 1941, 29 Dec 1936, NHM 2010.104 (1).

S Shetland Is, 61.34°S 55.20°W, 204 m, 3 Dec 2006, BAS stn EI–EBS–4, NMV F168628 (1).

S Orkney Is, 53.60°S 37.90°W, 503 m, BAS stn SG–EBS–3, NMV F168632 (1); NMV F168642 (2 specimens as tissues); NHM 2010.35–47 (13); RBINS IG 31 459 (2, SEM figures).

Indian Ocean, Heard I., ANARE, 52°41'–53°13'S 72°56'–73°41'E, 120–228 m, NMV F84977 (1), F84978 (1), F84979 (1); Kerguelen Is, 49°33'S 69°49'E, 20 m, SAM K2384 (1); BANZARE stn 12, 49°28'S 70°04'E, 4–5 m, 1929, SAM K1839 (1); BANZARE stn 49, 49°30'S 69°48'E, 2–20 m, 1930, SAM K1840 (1).

Diagnosis. Sigmodotid species up to 50 mm long (preserved); tentacles 12, 4–7 pairs of digits, longest distally; wheels in distinct papillae, scattered over interradii, more numerous dorsally and anteriorly, wheels 35–136 μm diameter; hooks scattered, frequently about twice the size of the wheels, 136–250 μm long; tentacle rods 80–184 μm long, significantly shorter than hooks; up to 7 unequal polian vesicles; gonad tubules dichotomously branched.

Type locality. Unknown (3 specimens).

Colour (preserved). Predominantly dark reddish-brown, rarely grey and translucent.

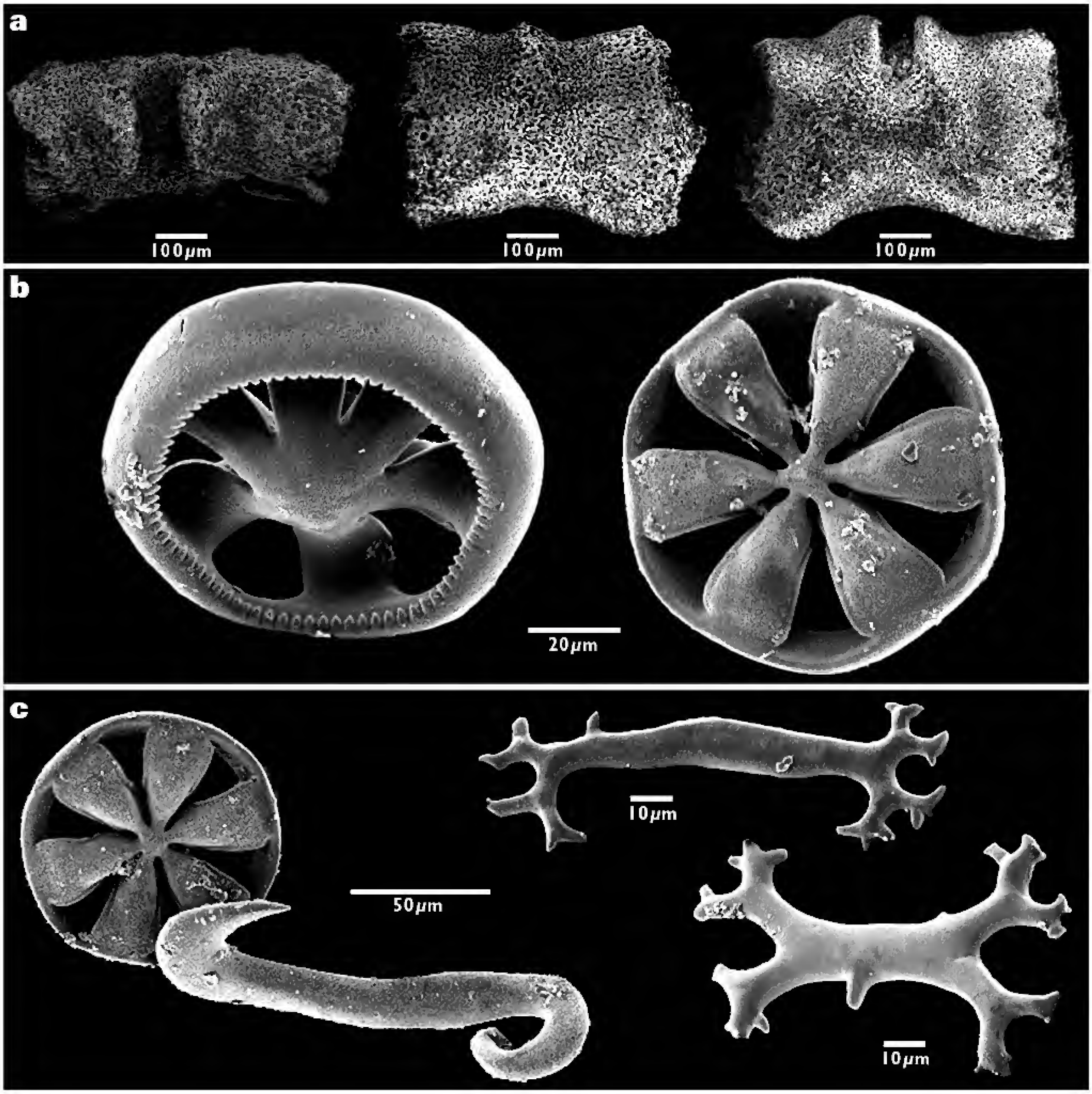

Figure 10. SEM images for specimens of *Sigmodota contorta* (Ludwig, 1875). a, plates from calcareous ring (specimen from *Discovery Expedition*, *William Scoresby* stn 25, South Georgia, 18–27 m, RBINS IG 31 459). b, c, ossicles from S Shetland Is specimen (NMV F168628); b, wheels from body wall; c, hook and wheel from body wall (left), rods from tentacle (right).

Distribution. Western Antarctica, Bouvet I., 159 m; South Georgia, 46 m; S Shetland Is, 204 m; S Orkney Is, 503 m.

South America, south of 42° in the west, S of 47°S in the east (Pawson 1969a).

Indian Ocean, Heard I., 120–228 m; Kerguelen Is, 2–20 m, 116 m (Lampert 1889); Marion I., 125–132 m (Branch et al. 1993).

Java Sea, 82 m (Sluiter 1901).

Remarks. Specimens of the species *Sigmodota contorta* (Ludwig) have been subjected to many misidentifications, as discussed at the beginning of this work and as is evident in the synonymy above.

Sluiter (1901) determined 3 *Siboga* specimens (stn 319) up to 10 mm long from the Java Sea at 82 m as *Sigmodota contorta* (Ludwig).

Hérouard (1906) provided the very limited description of 12 tentacles and hook ossicles for specimens from the Bellingshausen Sea that he determined to be *Sigmodota studeri* (Théel). The few diagnostic details would fit *Scoliorhapis massini* sp. nov. (above).

Panning (1936) examined specimens from South Georgia that he judged to be *Taeniogyrus antarcticus* Heding, 1931. He found the specimens close to *Taeniogyrus contortus* (Ludwig), and made the Heding species a subspecies (*Taeniogyrus contortus antarcticus* Heding). Based on tentacle number (12) and ossicle sizes, we judge that Panning (1936) was in fact examining specimens of *Sigmodota contorta* (Ludwig).

Massin and Hétérier (2004) erected their species *Taeniogyrus magnibaculus* for specimens from the Weddell Sea subsequent to the work of Cherbonnier (1974), Gutt (1988, 1991), and O'Loughlin (2002) who reported *Taeniogyrus contortus* (Ludwig) from the regions of Terre Adélie, the Weddell Sea and Prydz Bay respectively. The Prydz Bay material has been redetermined as *Taeniogyrus magnibaculus*, which has also been found by us in the Ross Sea and off Wilkes Land. *Taeniogyrus contortus* (Ludwig) has not been found on coastal eastern Antarctica, and it is anticipated that the Cherbonnier reference was to *Taeniogyrus magnibaculus* and this synonymy is given below. Likewise Gutt (1988, 1991) reported *Taeniogyrus contortus* from the Weddell Sea. We anticipate that some or possibly all of his material was *Taeniogyrus magnibaculus*. *Taeniogyrus contortus* and *Taeniogyrus magnibaculus* are generally allopatric, except in the South Orkney Is.

The mistaken identification by O'Loughlin (2002) of Heard I. specimens as *Chiridota pisanii* Ludwig, 1886 was corrected by Bohn in Altnöder et al. (2007), and discussed by O'Loughlin (2009). The specimens are listed here as *Taeniogyrus contortus* (Ludwig).

Sigmodota dubia (H. L. Clark, 1921)

Table 3

Taeniogyrus species Fisher, 1907: 735, pl. 82 fig. 2.

Taeniogyrus dubius H. L. Clark, 1921: 166 (key and note).—Heding, 1928: 311.—Massin and Hétérier, 2004: 442, 443, table 1.

Distribution. Hawaiian Is, Oahu I., 403–470 m.

Remarks. Fisher (1907) reported 12 tentacles, 10 polian vesicles of unequal size, and aggregations of wheels. His specimen and ossicle meaurements are given in Table 3. H. L. Clark (1921) named the species. Fisher (1907) noted that this species was close to *Taeniogyrus contortus* (Ludwig), and distinguished it by the larger number of polian vesicles (10, unequal) and size and form of the sigmoid ossicles. We found the wheels of *Sigmodota dubia* as reported by Fisher (1907) to be significantly larger than our measurements for *Sigmodota contorta*, but the hooks not significantly smaller, as was judged by Fisher (1907) (see Table 3).

Sigmodota magnibacula (Massin and Hétérier, 2004)

Figure 1e, 11; tables 2, 3

Taeniogyrus contortus.—Ekman, 1927: 416–417.—Cherbonnier, 1974: 610.—Gutt, 1988: 24.—Gutt, 1991: 324. (all or part probably non *Taeniogyrus contortus* (Ludwig, 1875))

Taeniogyrus cf. *contortus*.—O'Loughlin et al., 1994: 553, 554.

Taeniogyrus magnibaculus Massin and Heterier, 2004: 441–444, figs 1, 2, table 1.

Material examined. Scotia Sea, South Orkney Is, 60.82°S 46.49°W, 216 m, BAS stn PB-EBS-4, 2006, NMV F168629 (1); NMV F168639 (1 specimen as tissue sample MOL AF 798); NHM 2010.1–4 (4); RBINS IG 31 459 (1, SEM figures); 60°50'S 44°30'W, 172 m, US AMLR 2009 stn 16–31, NMV F168840 (13); 61°13'S 45°56'W, 240 m, US AMLR stn 41–46, NMV F168841 (8).

Eastern Antarctica, Ross Sea, McMurdo Sound, 366 m, *Terra Nova* stn 348, 13 Feb 1912, NHM 1932.8.11.216–217 (2); NHM 1932.8.11.218 (1); Cape Adare, 71°53'S 170°11'E, 220 m, BIOROSS stn TAN0402/94, NIWA 61060 (2); Ross Sea, 74°43'S 164°08'E, 140 m, MNA 2440 (1); 74°43'S 164°07'E, 120 m, MNA 2446 (10); 74°45'S 164°15'E, 219 m, MNA 2462 (1); IPY–CAML stn TAN0802/26, 74°58'S 170°27'E, 285 m, NIWA 35724 (4); stn TAN0802/31, 74°59'S 170°27'E, 283 m, NIWA 35776 (1).

Wilkes Land, 66°18'S 110°32'E, 101 m, USARP 1961, USNM E33725 (25).

Prydz Bay, ANARE 1987, stn 51, 525 m, NMV F76847 (1); stn 22, 165 m, NMV F168862 (1); stn 38, 312 m, NMV F168863 (3); N end of Fram Bank, 67°05'S 68°59'E, 216 m, ANARE AA93–131, NMV F69100 (2).

MacRobertson Shelf, 67°16'S 65°25'E, 121 m, ANARE AA93–127, NMV F68691 (20); 66°55'S 62°32'E, 113 m, AA93–124, NMV F69099 (2); Mawson Base, 8 m, ANARE 1972, NMV F168839 (1).

Diagnosis. Sigmodotid species up to 105 mm long (preserved); 12 peltato-digitate tentacles, 6 pairs of digits per tentacle, apical pair largest, decreasing in size towards base of tentacle trunk; rows of interradial off-white papillae comprising clusters of chiridotid wheels; wheels 56–200 μm diameter; hooks scattered in body wall, 128–216 μm long, blunt spines on outer surface of hook variably present and of variable size; tentacle rods irregularly straight, slightly swollen mid-rod, tapered, short branches distally, 170–320 μm long; calcareous ring and ossicles sometimes absent in largest specimens; 3 polian vesicles.

Colour (preserved). Body wall and tentacles dark red-brown to violet-brown epidermally, dark grey underneath.

Distribution. Antarctic, Weddell Sea, 72°29'S 26°57'W, 226 m (Massin and Hétérier 2004); South Orkney Is, 172–240 m;

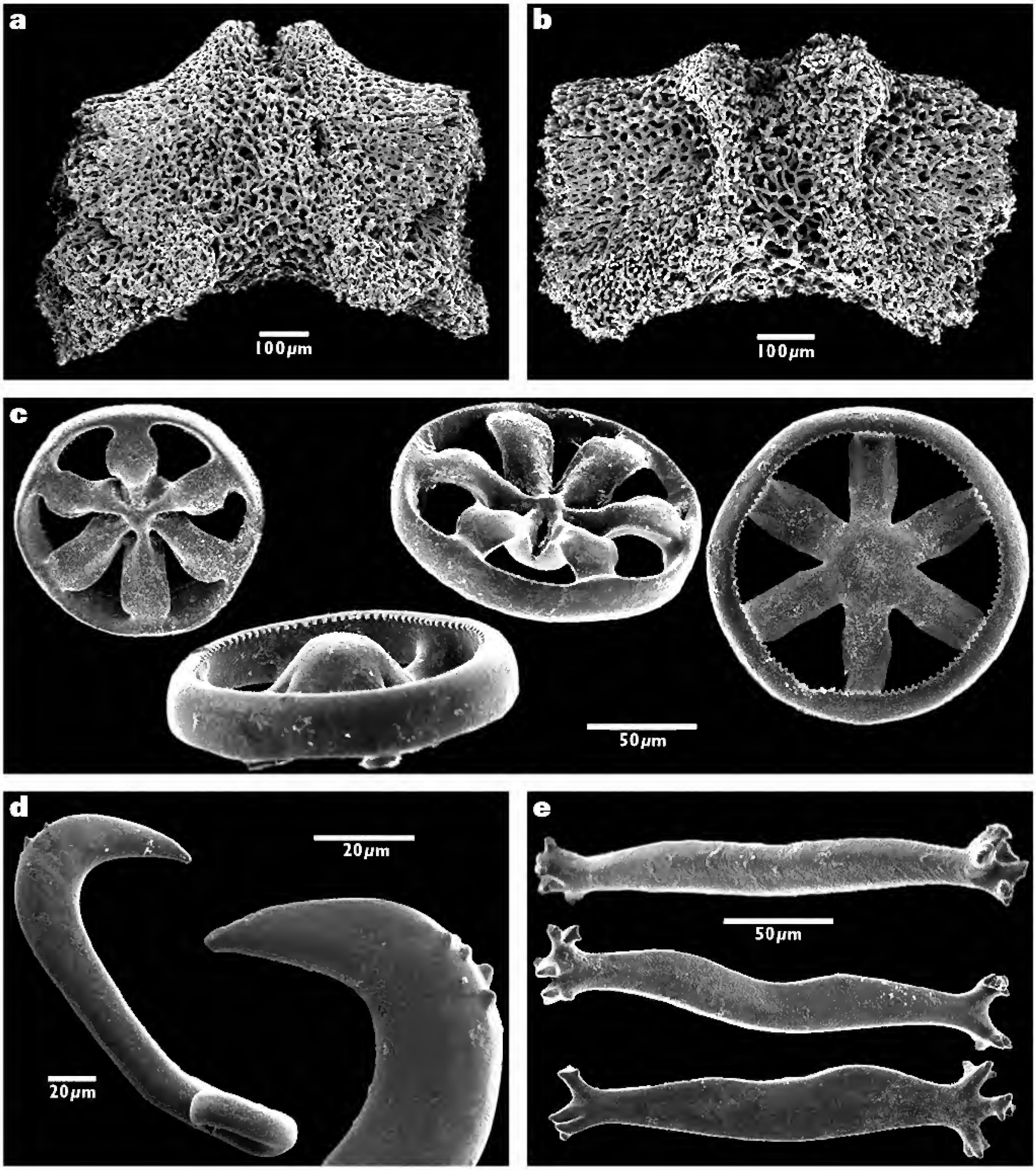

Figure 11. SEM images for specimens of *Sigmodota magnibacula* (Massin and Hétérier, 2004). a, b, plates from calcareous ring (Prydz Bay; RBINS IG 31 459 ex NMV F68691); c, wheels from body wall (S Orkney Is; RBINS IG 31 459 ex NMV F168842); d, hooks from body wall (S Orkney Is; RBINS IG 31 459); e, rods from tentacles (S Orkney Is; RBINS IG 31 459 ex NMV F168842).

Ross Sea, 120–366 m; Terre Adélie, 170–250 m (Cherbonnier 1974); Wilkes Land, 101 m; Prydz Bay, 165–525 m; MacRobertson Shelf, 8–121 m.

Remarks. As can be seen in Table 3 the maximum size of specimens, and length and form of the tentacle rods, are good diagnostic characters for *Sigmodota magnibacula* (Massin and Hétérier). Diameter of wheels and length of hooks are comparable, but tentacle rods much larger. As discussed above in the Remarks under *Sigmodota contorta* (Ludwig), the eastern Antarctic material of Cherbonnier (1974) is judged to be *Sigmodota magnibacula*, as is some or all of the Weddell Sea material of Gutt (1988, 1991). In discussing *Taeniogyrus contortus* (Ludwig) from the "Winterstation", Ekman (1927) made mention of what is probably this species. Massin and Hétérier (2004) noted that this species was "living on the spines of cidarid echinoids". We have not seen evidence of such an association. The US AMLR specimens were found inside Demospongiae.

Taeniogyrus Semper, 1867

Table 3

Taeniogyrus Semper, 1867: 23.—Smirnov, 1998: 519.
(For synonymies see Ludwig 1898 and Pawson 1964).
Trochodota Ludwig, 1891: 358.—Pawson, 1968: 24.—Pawson, 1970: 46.—Smirnov, 1998: 519.
(For synonymies see Ludwig 1898 and Pawson 1964).

Type species of *Taeniogyrus* Semper, 1867. *Chiridota australiana* Stimpson, 1855 (monotypy).

Type species of *Trochodota* Ludwig, 1891. Rowe (in Rowe and Gates 1995) proposed that "a case needs to be put to the ICZN to establish *Holothuria (Fistularia) purpurea* Lesson, 1830 as type species of *Trochodota* Ludwig, 1891. Type species: *Chiridota studeri* Théel, 1886, sensu Ludwig, 1891=*Holothuria (Fistularia) purpurea* Lesson, 1830 (not Théel, 1886=*Taeniogyrus contortus* (Ludwig, 1875)) by subsequent designation, Rowe, F. W. E., this work." The type species proposed by Rowe is fixed here (under Article 69.2.4 of the 1999 edition of the ICZN Code) as *Holothuria (Fistularia) purpurea* Lesson, 1830, misidentified as *Chiridota studeri* Théel, 1886a in the original inclusion of two species in his new genus by Ludwig (1891).

Other included species. *Taeniogyrus antarcticus* Heding, 1931; *Chiridota benhami* Dendy, 1909; *Taeniogyrus cidaridis* Ohshima, 1915; *Taeniogyrus clavus* Heding, 1928; *Taeniogyrus dayi* Cherbonnier, 1952; *Taeniogyrus dendyi* Mortensen, 1925; *Trochodota diasema* H. L. Clark, 1921 (as *T. diasemus*); *Chiridota dunedinensis* Parker, 1881; *Taeniogyrus heterosigmus* Heding, 1931; *Trochodota inexpectata* Smirnov, 1989 (as *T. inexpectatus*); *Chiridota japonica* von Mareneller, 1881 (as *T. japonicus*); *Taeniogyrus keiensis* Heding, 1928; *Trochodota maculata* H. L. Clark, 1921 (as *T. maculatus*); *Trochodota neocaladonica* Smirnov, 1997 (as *T. neocaladonicus*); *Taeniogyrus papillis* O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); *Taeniogyrus prydzi* sp. nov.; *Holothuria (Fistularia) purpurea* Lesson, 1830 (as *T. purpureus*); *Trochodota roebucki* Joshua, 1914; *Trochodota rosea* Ohshima, 1914 (as *T. roseus*); *Taeniogyrus tantulus* O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); *Chiridota venusta* Semon, 1887 (as *T. venustus*).

Diagnosis. Taeniogyrinid genus with 10 peltato-digitate tentacles; 4–8 pairs of digits, terminal pair longest; rods in tentacles; chiridotid wheels and sigmoid hooks in body wall; teeth on the inner rim of wheels in continuous series; wheels and hooks variably grouped or scattered in body wall; no miliary granules in longitudinal muscles; 1–12 polian vesicles; ciliated funnels present.

Remarks. The succession of authors who have expressed dissatisfaction with the genera *Taeniogyrus* Semper and *Trochodota* Ludwig is mentioned in the Introduction. As discussed at the beginning of this paper and stated in the Remarks under *Sigmodota* we reject ossicle aggregation in the body wall as a generic diagnostic character, and judge that tentacle number is a good generic character. We thus raise *Sigmodota* Studer (taeniogyrinid species with 12 tentacles) out of synonymy with *Taeniogyrus* Semper (10 tentacles), and synonymise *Trochodota* Ludwig with *Taeniogyrus* Semper (taeniogyrinids with 10 tentacles).

Taeniogyrus antarcticus Heding, 1931

Figures 1f, 12; tables 2, 3

Taeniogyrus antarcticus Heding, 1931: 685–691, fig. 15(1–12).—Pawson, 1969a: 141.—Massin and Hétérier, 2004: 442–443, table 1.

Material examined. Western Antarctica, Scotia Sea, S Orkney Is, 60.82°S 46.49°W, 216 m, BAS stn PB–EBS–4, 18 Mar 2006, NMV F168630 (1); NMV F168640 (2 as tissue samples, codes MOL AF799, 800); NMV F168641 (2 as tissue samples, codes MOL AF801, 802); NHM 2010.5–14 (10); NHM 2010.15–34 (20); RBINS IG 31 459 (2 whole, SEM figures).

Shag Rocks, 53.63°S 40.91°W, 206 m, BAS stn SR–EBS–4, 11 Apr 2006, NMV F168636 (1); RBINS IG 31 459 (1 whole, SEM figures); NHM 2010.51–52 (2).

Diagnosis. Up to 15 mm long; 10 tentacles; 5 pairs of digits, terminal/distal pair longest; 3–9 polian vesicles; few long, thin ciliated funnels with long membranaceous collar, short funnel, and distinct peduncle; chiridotid wheels 40–80 μm diameter (no data in Heding 1931; 40–80 μm, S Orkney Is; 48–64 μm, Shag Rocks), wheels in a few small clusters dorsally; hooks scattered in body wall, 64–208 μm long (172–200 μm, Heding 1931 fig. 15; 80–208 μm, S Orkney Is; 64–168 μm, Shag Rocks); tentacle rods straight to slightly bent to bracket-shaped, dichotomously branching ends, rare blunt spines along rods, rare rounded hub in mid-rod, 64–128 μm long (83–103 μm, Heding 1931 fig. 15; 80–128 μm, S Orkney Is; 64–72 μm, Shag Rocks).

Colour (preserved). Pale yellow-brown.

Distribution. Western Antarctica, Scotia Sea, South Orkney Is, South Georgia, Shag Rocks, 206–216 m (0–15 m for South Georgia in Massin and Hétérier 2004).

Remarks. Heding (1931) erected his new species for many specimens from South Georgia, by distinguishing them within a discussion of *Taeniogyrus contortus* (Ludwig). Massin and

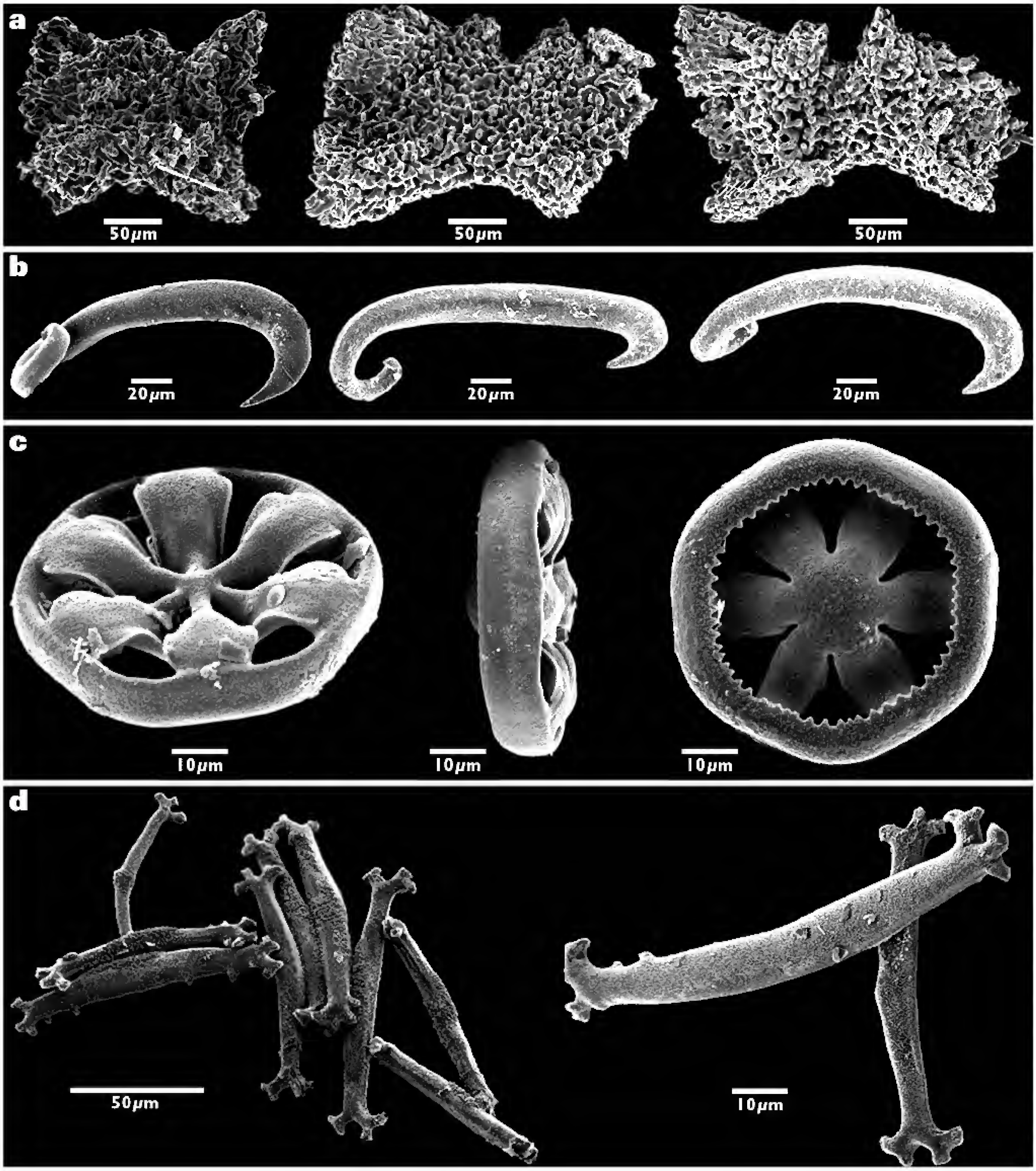

Figure 12. SEM images for specimen of *Taeniogyrus antarcticus* Heding, 1931 (S Orkney Is; RBINS IG 31 459). a, plates from the calcareous ring; b, hooks from the body wall; c, wheels from the body wall; d, rods from the tentacles.

Hétérier (2004 table) listed 12 tentacles for *Taeniogyrus antarcticus* Heding, but in the last sentence of his discussion Heding (1931) noted that *Taeniogyrus contortus* specimens all had 12 tentacles "apart from this example" (referring to his new species *Taeniogyrus antarcticus*).

Panning (1936) considered *Taeniogyrus antarcticus* Heding to be at best a subspecies of *Taeniogyrus contortus* Ludwig. Pawson (1969a) followed Panning (1936). On the basis of tentacle number we disagree. Based on tentacle number and ossicle sizes we judge that the specimens from South Georgia that were examined by Panning (1936) were *Sigmodota contorta* (Ludwig).

There are significant differences in the measurement sizes available for ossicles from different localities in the Scotia Sea, as can be seen in Table 3. The variations may be the result of size of specimen sampled or location of the sample taken from the body wall. Or the variations may indicate cryptic speciation. In this study we found that for this species the limited data available indicate that maximum ossicle size increases with specimen size. The type locality for *Taeniogyrus antarcticus* Heding is South Georgia.

Taeniogyrus antarcticus Heding, 1931 is the sole western Antarctic species of *Taeniogyrus*. A new species of *Taeniogyrus* from eastern Antarctica is described below, with significantly longer sigmoid hooks and a single polian vesicle.

Taeniogyrus australianus (Stimpson, 1855)

Figures 9c, 13; table 3

Chiridota australiana Stimpson, 1855: 386.—Lampert, 1885: 230.—Ludwig, 1898: 82–83.

Taeniogyrus australianus.—Semper, 1867: 23.—H. L. Clark, 1908: 122.—H. L. Clark, 1921: 166.—Heding, 1928: 310, 311, 315–316, fig. 67(9–16).—H. L. Clark, 1946: 459.—Rowe (in Rowe and Gates), 1995: 267.

Sigmodota australiana.—Östergren, 1898: 118.

Material examined. Australia, Sydney, Collaroy, Long Reef, in sand, AM J20086 (2); same lot, RBINS IG 31 459 (1 whole for SEM images); AM J12542 (1); Middle Harbour, AM J16377 (1); Lord Howe I., AM J16373 (1); Heron I., AM J19570 (11).

Diagnosis. Taeniogyrid species up to 95 mm long (preserved); 10 peltato-digitate tentacles, 6–7 pairs of digits per tentacle, longest distally; single madreporite at oral end of dorsal mesentery, mushroom-like head; single ventral elongate sac-like polian vesicle; 2 series of crowded ciliated funnels, on left edge of left ventral radial muscle, and right edge of mid-ventral radial muscle; chiridotid wheels in large to small discrete papillae, wheels 48–88 μm diameter; sigmoid hooks in small papillae, not scattered, hooks 120–136 μm long; tentacle rods thickened centrally, slightly curved, bifurcate ends, 72–104 μm long.

Distribution. Eastern Australia (Mooloolaba in Queensland to Ulladulla in New South Wales; Great Barrier Reef; Heron I.; Lord Howe I.; 0–15 m (Rowe and Gates 1995).

Remarks. *Taeniogyrus australianus* (Stimpson) is not an Antarctic apodid species but has not been fully illustrated in previous works and is included here as it is the type species of the revised genus *Taeniogyrus*, and its identity was confused by Théel (1886a). He described two specimens of *Chiridota australiana* Stimpson from Port William (with uncertainty whether New Zealand or Falkland Is) that were 35 mm long, with 10 tentacles, each with 4 pairs of digits, a single polian vesicle, wheels 140 μm diameter with no evidence of clustering, hooks 140 μm long. We agree with Ludwig (1898) that this evidence points to *Taeniogyrus purpureus* (Lesson) and the Falkland Is.

Taeniogyrus maculatus (H. L. Clark, 1921)

Figure 14; table 3

Trochodota maculata H. L. Clark, 1921: 163, pl. 36 figs 14–21.—H. L. Clark, 1946: 460.—Rowe, 1976: 203–205, table 1.—Rowe (in Rowe and Gates) 1995: 268.—Smirnov, 1997: 16.

Material examined. E Australia, New South Wales, Newcastle, Swansea Channel, 3 m, 30 Aug 1988, AM J21895 (9); same lot, RBINS IG 31 459 (1 whole for SEM images).

Diagnosis. Up to 21 mm long (preserved; 26 mm long in Clark 1921); body wall papillate, semi-translucent; tentacles 10, 3 pairs of digits (4–5 in Clark 1921); curved to slightly bracket-shaped tentacle rods; wheels with 6 spokes, spokes broad at rim, narrow at hub, teeth on inner rim of wheels in continuous series; sigmoid hooks with fine spinelets on outer surface of projecting pointed hook, hooks scattered in body wall (hooks in small groups and scattered in Clark 1921); ciliated funnels along base of mid-dorsal mesentery; single sac-like polian vesicle; gonad comprises 2 elongate sacs (ossicle measurements in Table 3).

Colour (preserved). Pale to dark reddish-brown. Colour live is pink with numerous minute dark spots (Clark 1921).

Type locality. N Australia, Torres Strait, Murray Is, Mer, reef flat.

Distribution. Tropical Australia, 0–20 m (Rowe in Rowe and Gates 1995).

Remarks. *Taeniogyrus maculatus* (H. L. Clark) is not an Antarctic apodid species but is included here to clarify its generic assignment. The figure of a wheel in H. L. Clark (1921) indicates that the wheel was viewed from the outside and the continuity of teeth around the inner rim obscured by the spokes. This led H. L. Clark to wrongly conclude that the distribution of the teeth was discontinuous. Rowe (1976) followed H. L. Clark (1921). In this study all wheels have continuous series of teeth.

Taeniogyrus prydzi sp. nov.

Figure 15; tables 2, 3

Taeniogyrus sp. MoV 2007 O'Loughlin et al., 1994: 553, 554.

Taeniogyrus sp. MoV 2010 O'Loughlin et al., 1994: 553, 554.

Material examined. Holotype. Eastern Antarctica, MacRobertson Shelf, stn ANARE AA 93–124, 66°55'S 62°32'E, 113 m, M. O'Loughlin, NMV F68690.

Paratypes. MacRobertson Shelf, Edge of Nielsen Basin, stn ANARE AA 93–127, 67°16'S 65°25'E, 109–121 m, NMV F69120 (1); NMV F68689 (1, 2 pieces); Prydz Bay, N of Fram Bank, stn ANARE AA 93–142, 66°49'S 70°25'E, 795–830 m, NMV F68688 (3); NMV F76096 (1).

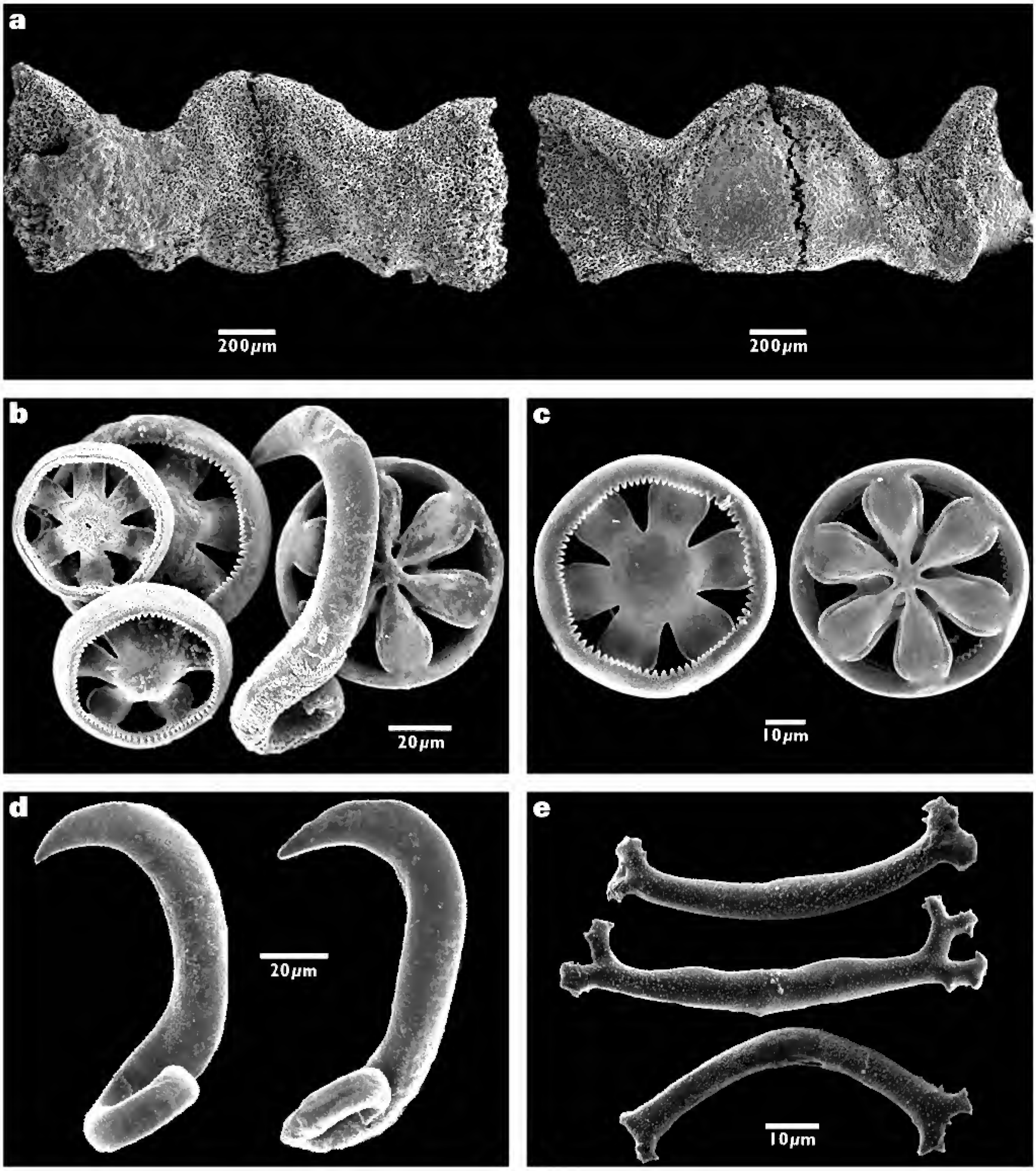

Figure 13. SEM images for specimen of *Taeniogyrus australianus* (Stimpson, 1855) (Long Reef, Collaroy, Sydney; RBINS IG 31 459 ex AM J20086). a, plates from calcareous ring; b, wheels and hook from body wall; c, wheels from body wall; d, hooks from body wall; e, rods from tentacles.

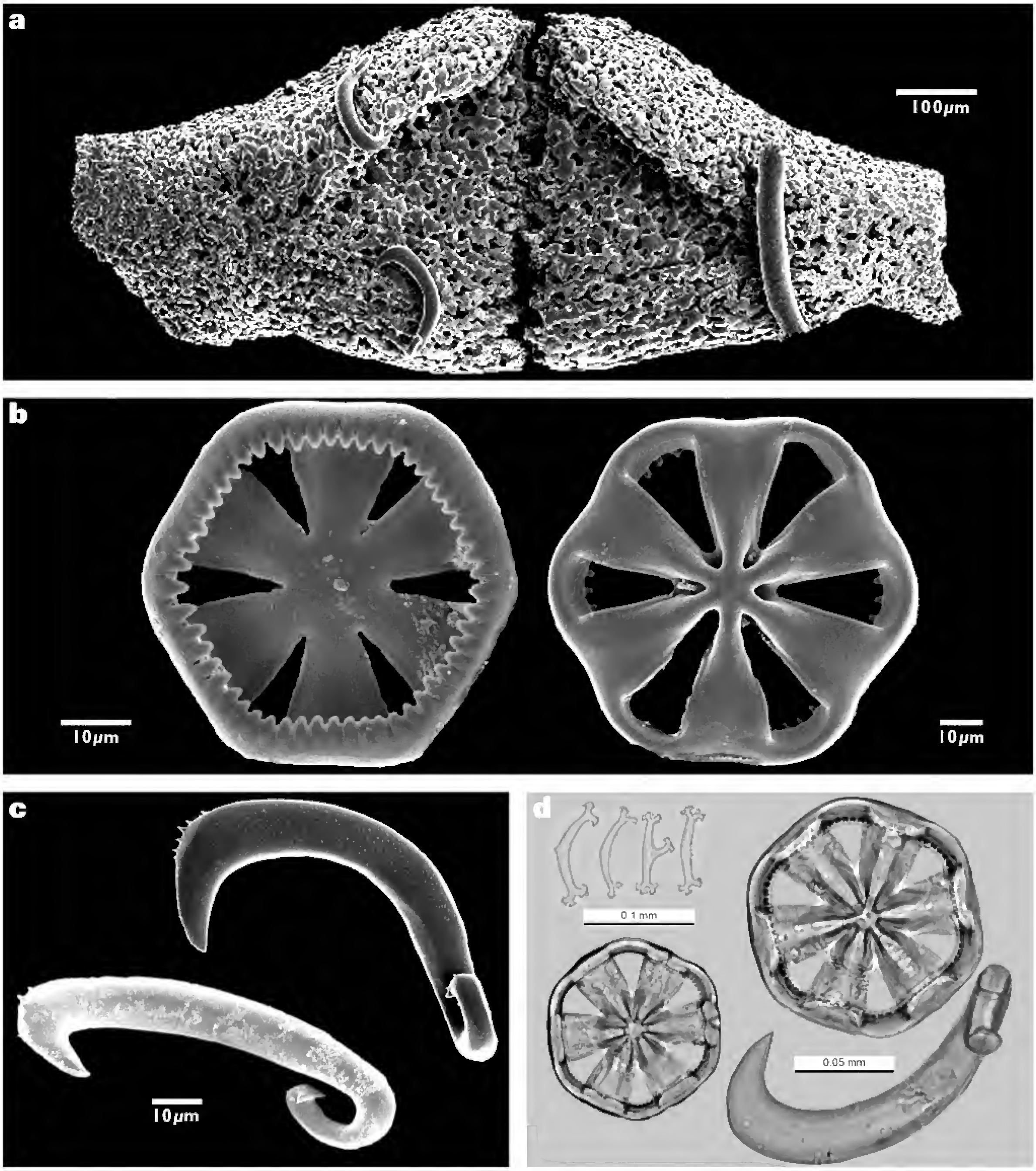

Figure 14. SEM images for specimen of *Taeniogyrus maculatus* (H. L. Clark, 1921) (Swansea Channel, E Australia; RBINS IG 31 459 ex AM J21895). a, calcareous ring plates (with hook contaminants); b, wheels from body wall; c, hooks from body wall. d, montage photographs of ossicles of *Taeniogyrus purpureus* (Lesson, 1830) (Strait of Magellan; USNM 1004241); rods from tentacle, and wheels and hook from body wall.

Diagnosis. Up to 50 mm long; 10 tentacles, 6 pairs of digits per tentacle, digits increasing in length distally; tentacle ossicles rods, thick, predominantly straight, short blunt branches distally, rare centrally, rods 136–152 µm long; chiridotid wheels with continuous series of teeth on inner rim; single dorsal series of wheel aggregations, a few irregularly scattered wheel clusters dorso-laterally; no wheel aggregations ventrally; chiridotid wheels up to 90 µm diameter; sigmoid hooks scattered in body wall, 232–272 µm long; single polian vesicle; numerous gonad tubules arising from a common hub; single ventral interradial series of ciliated funnels.

Distribution. Eastern Antarctica, MacRobertson Shelf, 109–121 m; Prydz Bay Channel, outfall slope, 795–830 m.

Etymology. Named for Prydz Bay in eastern Antarctica near the type locality.

Remarks. The ossicles in the type specimens show evidence of erosion but are adequate for systematic assessment. The eastern Antarctic *Taeniogyrus prydzi* sp. nov. is distinguished from the western Antarctic *Taeniogyrus antarcticus* Heding by the single polian vesicle and significantly longer sigmoid hooks (see Table 3).

Taeniogyrus purpureus (Lesson, 1830)

Figure 14d; tables 2, 3

Holothuria (Fistularia) purpurea Lesson, 1830: 155–156, pl. 52, fig. 2.—Rowe (in Rowe and Gates), 1995: 268.

Chiridota purpurea.—Jäger, 1833: 16.—Brandt, 1835: 259.—Dujardin and Hupé, 1862: 616.—Semper, 1867: 23.—Théel, 1886a: 35–36.—Lampert 1889: 851.

Chiridota australiana.—Théel, 1886a: 16 (non *Chiridota australiana* Stimpson, 1855).

Chiridota studeri.—Lampert 1889: 849–850, pl. 24 fig. 12.—Ludwig 1891: 359–360 (non *Chiridota studeri* Théel, 1886).

Trochodota purpurea.—Ludwig, 1898: 83–87, pl. 3 figs 43–45.—Perrier, 1905: 76–77.—H. L. Clark, 1908: 123–124.—H. L. Clark, 1921: 166.—Pawson, 1964: 466.—Ekman, 1925: 149–150.—Deichmann, 1947: 349.—Pawson, 1969a: 141.—Pawson, 1969b: 38, map 6.—Rowe, 1976: 203–205, table 1.—Hernandez, 1981: 164, 166, figs 1i, j, 4b, c.—Rowe (in Rowe and Gates), 1995: 268.—Smirnov, 1997: 16.

Material examined. Strait of Magellan, mouth of strait, 64 m, USNM 1004241 (2); Isla Bertrand, Puerto Grande, intertidal, Royal Society 1958 Expedition, USNM E16375 (1, no ossicles remaining).

Diagnosis (Pawson 1964). Tentacles 10, each with 2–6 pairs of digits; wheels 130–180 µm diameter (80–144 µm this work, USNM 1004241), scattered in body wall; sigmoid hooks 120–130 µm long (120–160 µm this work, USNM 1004241), scattered in body wall; tentacle rods average 78 µm long (56–120 µm this work, USNM 1004241), bracket-shaped (rare in this work), with dichotomously branching ends; colour commonly purple.

Type locality. Puerto Soledad (Port Solitude), Falkland Is.

Distribution. South America, Strait of Magellan, 64 m (this work); Falkland Is (type locality).

Remarks. In his key to the species of *Trochodota*, H. L. Clark (1921) implied that *Trochodota purpurea* has discontinuous series of teeth on the inner rim of the wheels. Smirnov (1997) observed continuous series of teeth, and pointed out that Hernandez (1981) illustrated a wheel of *Trochodota purpurea* with continuous teeth. We confirm that observation here (Fig. 14d). Ossicle dimensions are given in Table 3. *Holothuria (Fistularia) purpurea* Lesson, 1830 is fixed in this work (above) as type species of *Trochodota* Ludwig, 1891, but we then judge *Trochodota* to be a junior synonym of *Taeniogyrus* Semper, 1867.

It is established above that *Chiridota studeri* Théel is a junior synonym of *Sigmodota contorta* (Ludwig), and this is listed in that synonymy. Lampert (1889, pp. 849, 850) discussed material from the Strait of Magellan that he referred to *Chiridota studeri* Théel, but his description of 10 tentacles, hooks and wheels not in papillae clearly refers to *Taeniogyrus purpureus* (Lesson), and this reference is listed in the synonym here.

We agree above with Ludwig (1898) that the Théel (1886a) specimens of *Chiridota australiana* Stimpson were *Taeniogyrus purpureus* (Lesson).

Subfamily **Chiridotinae** Östergren, 1898 (sensu Smirnov 1998)

Diagnosis (Smirnov, 1998). Chiridotidae with 12 or 18 tentacles. Body wall ossicles wheels of chiridotid type gathered into papillae, and/or rods. Radial plates of calcareous ring perforated or with deep notch in anterior face for passage of nerves. There are 4–30 polian vesicles.

Genera (Smirnov 1998). *Chiridota* Eschscholtz, 1829; *Paradota* Heding (in Ludwig and Heding), 1935; *Polycheira* H. L. Clark, 1908.

Chiridota Eschscholtz, 1829

Synonymy. See Pawson 1964.

Diagnosis (Pawson 1964). Tentacles 12, digits 3–10 pairs, terminal pair longest; polian vesicles 3–20; ossicles six-spoked wheels collected into papillae with varying numbers of wheels of diverse sizes; small curved rods with enlarged ends may be present; minute miliary granules often present in longitudinal muscles; lacking sigmoid hooks.

Type species. *Chiridota discolor* Eschscholtz, 1829

Type locality. Sitka; Sea of Okhotsk.

Chiridota pisanii Ludwig, 1886

Table 2

Chiridota purpurea.—Théel, 1886: 15, pl. 2 fig. 1 (= *Chiridota pisanii* Ludwig, 1886; non *Holothuria* (*Fistularia*) *purpurea* Lesson, 1830; see Ludwig 1898).

(For complete synonymy see Bohn in Altnöder et al. 2007).

Material examined. S Atlantic Ocean, Burdwood Bank, ICEFISH 2004 stn 1–OT1, 54.22°S 59.84°W, 93 m NMV F106959 (1); ICEFISH 2004 stn 1–OT2, 54.22°S 59.83°W, 93 m NMV F106963 (4); Patagonia, 52°12'S 67°19'W, 95 m, *Discovery Expedition*, *William Scoresby* stn 750, 19 Sept 1931, NHM 2010.110 (1, wheel cluster only); Argentina,

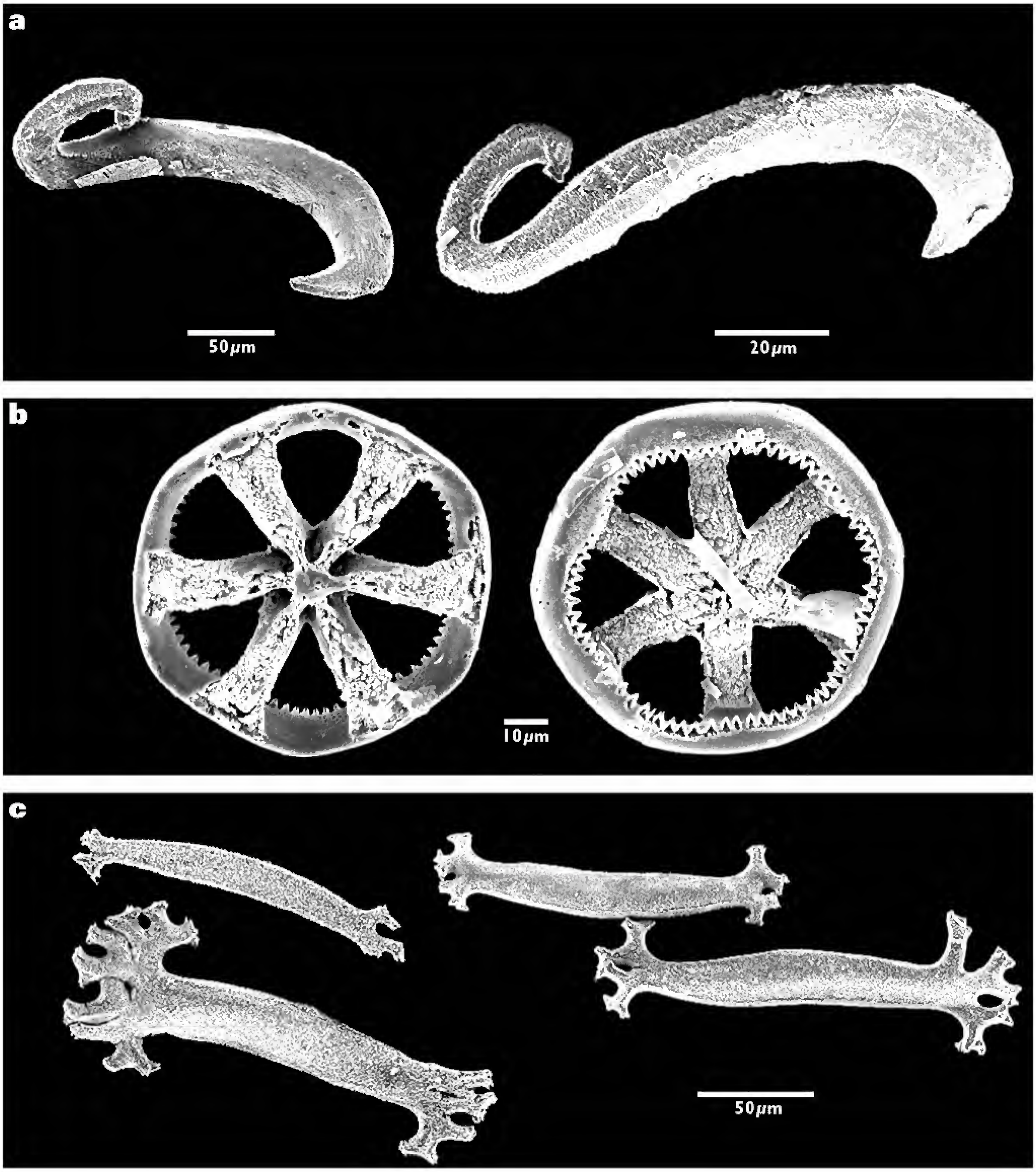

Figure 15. SEM images for holotype of *Taeniogyrus prydzi* sp. nov. (Prydz Bay; NMV F68690). a, hooks from body wall; b, wheels from body wall; c, rods from tentacles.

Tierra del Fuego, 54°00'S 67°24'W, 0 m, 1999, NMV F86016 (2); Cape Horn, 56°20'S 67°10'W, 121 m, *Discovery Expedition*, *William Scoresby* stn 388, 16 Apr 1930, NHM 2010.111 (1).

Diagnosis (from Bohn in Altnöder et al. 2007). Up to 68 mm long (130 mm in Ludwig 1898); tentacles 12, 4–7 pair of digits per tentacle, longest distally, tentacle rods with variably branched ends, sometimes central hub, 16–69 μm long; calcareous ring with 5 radial 7 interradial plates, all radial plates perforated for passage of nerve; polian vesicles 4–11 (–16 in Théel 1886); single ciliated urns at base of mesenteries, numerous in mid-dorsal and left dorsal interradius, sparse in right ventral interradius; chiridotid wheels with serrations on inner side continuous, gathered into papillae in single series in dorsal interradii, inconspicuous or lacking in ventral interradii, 43–147 μm diameter; miliary granules in longitudinal muscles 14–49 μm long.

Colour (preserved). Off-white to pink to reddish-brown.

Distribution. Pacific and Atlantic coasts of southern South America (south of 42°S), Falkland Is, 0–102 m (Bohn in Altnöder et al. 2007); Burdwood Bank, 93 m (this work); Cape Horn, 121 m (this work).

Remarks. Chiridota pisanii Ludwig has not been reported south of the Polar Front, and is not an Antarctic species. Bohn (in Altnöder et al. 2007) has provided a comprehensive systematic treatment with illustrations. He queried the identity of the *Challenger* Falkland Is specimens determined by Théel (1886) as *Chiridota purpurea*, and subsequently judged by Ludwig (1898) to be *Chiridota pisanii*, since the wheel sizes were larger (140–160 μm diameter) than his measurements for *Chiridota pisanii* (43–147 μm diameter). Our ossicle measurements for Burdwood Bank specimens are: wheels 80–144 μm diameter; tentacle rods 48–80 μm long.

O'Loughlin (2002) initially failed to find hook ossicles in specimens from Heard I. and identified them as *Chiridota pisanii*. Hook ossicles were subsequently found, and the material re-determined as *Taeniogyrus contortus* (see O'Loughlin 2009).

Paradota Heding, 1935

Paradota Heding (in Ludwig and Heding), 1935: 150–151, fig. 14.—Gutt, 1990: 125–126.—Massin, 1992: 321–323.—Smirnov, 1998: 520.

Diagnosis. Tentacles 12, peltato-digitate, with 5 to 7 pairs of digits, longest distally; rod ossicles in tentacles; lacking ossicles in the body wall; 1 to 11 polian vesicles.

Type species. Achiridota ingolfi Heding, 1935.

Other species. Paradota weddellensis Gutt, 1990; *Paradota marionensis* Massin, 1992.

Remarks. Heding (in Ludwig and Heding 1935) erected *Paradota* for family Chiridotidae. Gutt (1990) referred *Paradota* to the Synpatidae Burmeister, 1837. Smirnov (1998) judged that the morphology of genus *Paradota* was close to that of genus *Chiridota* and referred *Paradota* to subfamily Chiridotinae.

Paradota weddellensis Gutt, 1990

Figure 16; table 2

Paradota weddellensis Gutt, 1990: 125–126, figs 11–14, table 3.—Massin, 1992: 322–323.—O'Loughlin et al. 2009: table 1.

Material examined. Scotia Sea, South Orkney Is, US AMLR stn 104, 63°13.92'S 59°27.47'W, 759 m, NMV F168842 (5); South Sandwich Is, 351–393 m, USNM E49614 (20+); South Shetland Is, 59 m, USNM E49620 (1).

Antarctic Peninsula, Joinville I., 265 m, USNM E49619 (1); Palmer Archipelago, 126 m, USNM E49616 (1).

Ross Sea, NIWA expedition 2001, 66°49'S 162°37'E, 292 m, NIWA 61095 (1); stn TAN0602/448, 66°56'S 162°57'E, 85 m, NIWA 49800 (1); NZ IPY–CAML stn TAN0802/272, 66°96'S 170°93'E, 658 m, NIWA 38869 (1).

Prydz Bay, ANARE 1987 stn 7, 68°40'S 77°12'E, 505–578 m, NMV F76845 (1); NMV F76846 (1).

Heard I., ANARE AA92–01, 52°57'S 73°21'E, 159–176 m, NMV F84977 (1); AA92–06, 53°13'S 73°40'E, 120 m, NMV F84979 (1); AA92–08, 52°41'S 72°56'E, 215 m, NMV F84978 (1).

Diagnosis (after Gutt 1990). Chiridotinid species up to 180 mm long; body wall thick; tentacles 12, peltato-digitate, 5–7 pairs of digits; calcareous ring lacking anterior and posterior projections; 4 polian vesicles; tentacles with irregular rod ossicles, many slightly bracket-shaped, some with branched ends, some with projections mid-rod; body wall lacking ossicles; longitudinal muscles with rare miliary granules.

Distribution. Circum-antarctic, south of Polar Front, 59–1191 m; Weddell Sea, 225–655 m (Gutt 1990); Scotia Sea, 59–759 m; Antarctic Peninsula, 126–265 m; Bellingshausen Sea, Antarctic Peninsula, Peter I Island, 97–1191 m (O'Loughlin et al. 2009); Ross Sea, 85–658 m; Prydz Bay, 505–578 m; Heard I., 120–215 m.

Remarks. Paradota weddellensis Gutt is a large apodid with a widespread polar distribution south of the Antarctic Convergence. *Paradota marionensis* Massin, 1992 occurs north of the Convergence at Marion and Prince Edward Is (Massin 1992). We found rare miliary granules up to 40 μm long in Ross Sea material.

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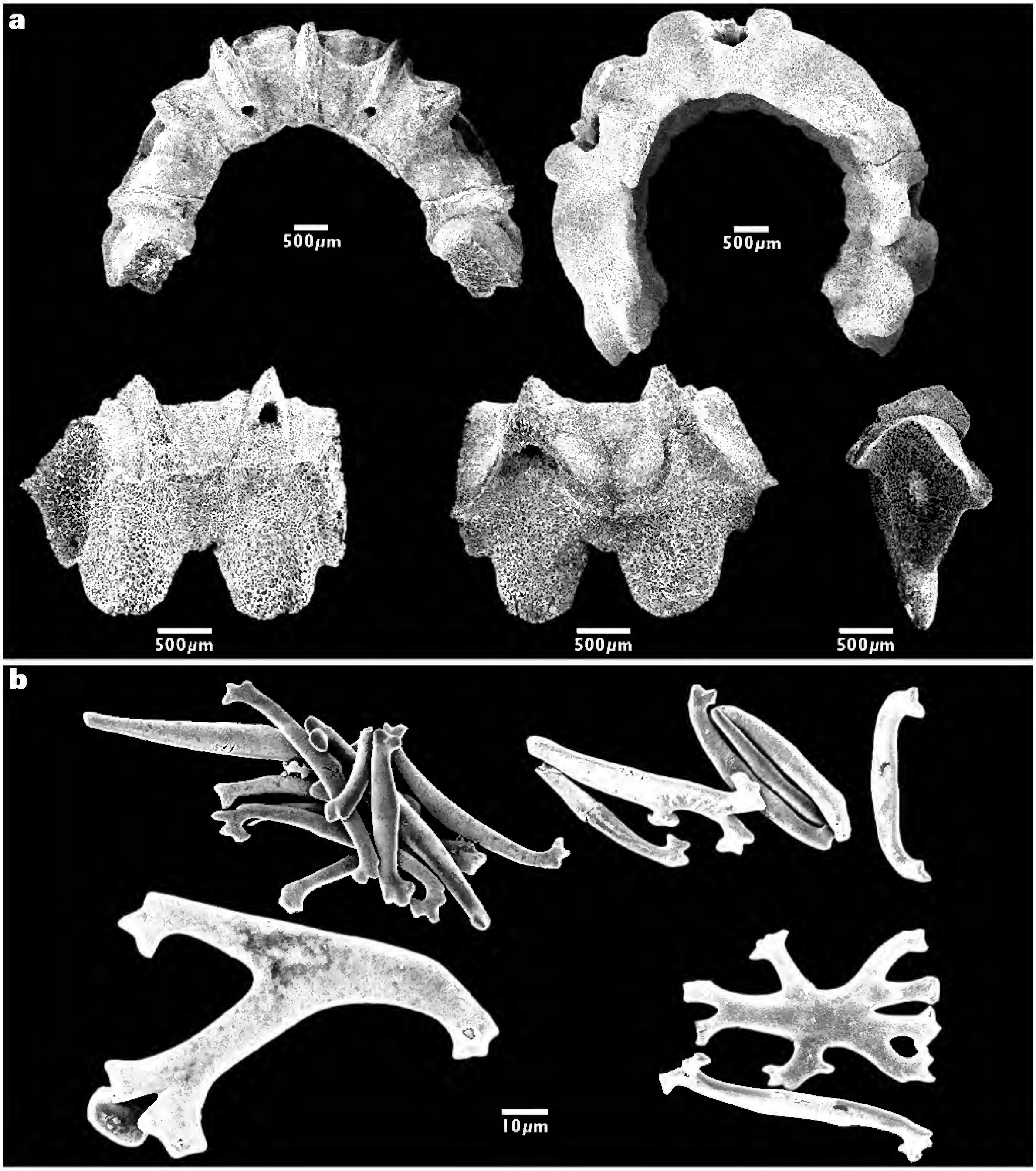

Figure 16. SEM images for specimens of *Paradota weddellensis* Gutt, 1990. a, calcareous ring plates: (from top left) anterior view, posterior view, internal view, external view, section view (South Orkney Is; NMV F168842); b, rods from tentacles (Prydz Bay; NMV F76846).

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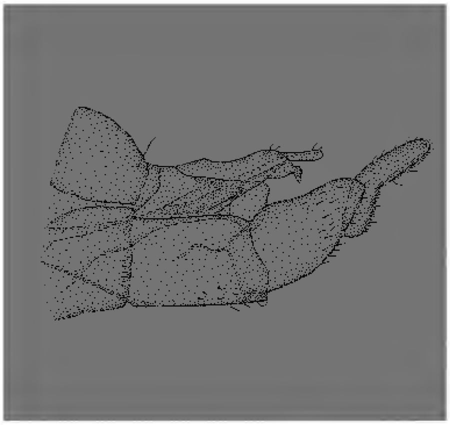

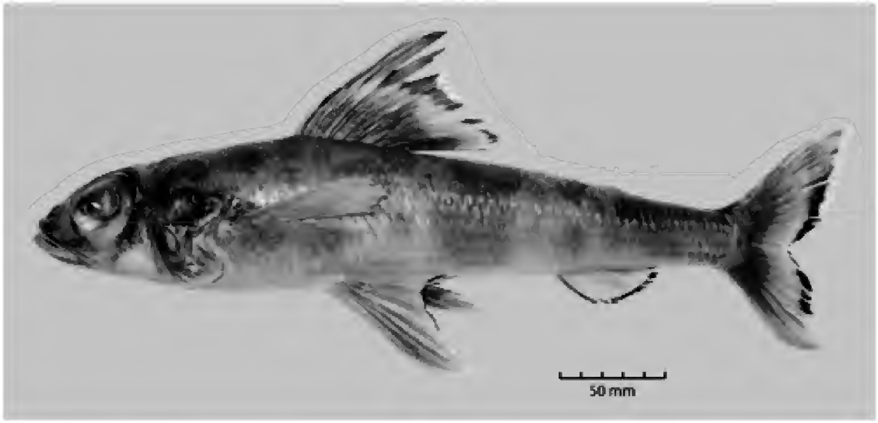

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