The Psolidae of New Zealand and some additions to the Macquarie Ridge fauna
(Echinodermata: Holothuroidea: Psolidae)

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Abstract

One new species of Psolus and four new species of Psolidium are described from New Zealand and Macquarie Ridge: Psolus macquariensis sp. nov., Psolidium aequum sp. nov., Psolidium kermadeci sp. nov., Psolidium marriotti sp. nov. and Psolidium ramum sp. nov. Psolus neozelanicus is a subjective junior synonym of Psolus antarcticus. New material is assigned to Psolus squamatus (Müller) var. segregatus Perrier and the diagnostic characters noted. Psolidium whittakeri O’Loughlin and Ahearn, formerly known only from Antarctic waters, also occurs off New Zealand. Ten species of the family Psolidae are now known from New Zealand: five in the genus Psolus Oken, and five in the genus Psolidium Ludwig. A key to the New Zealand and included Macquarie material is provided.

Keywords
Psolus, Psolidium, New Zealand, Macquarie Ridge, sea cucumber, Psolidae, new species, keys

Introduction
The most recent inventory of New Zealand Holothuroidea (Mah et al., 2009) listed only three species in the family Psolidae Burmeister, 1837, and all were assigned to the genus Psolus Oken, 1815. One (Psolus neozelanicus Mortensen, 1925) was based on a single occurrence of a small specimen; another (Psolus squamatus (O.F. Müller, 1776)) was a known northern hemisphere species complex, and the third (Psolus ?n. sp.) remained unidentified. Examination of the considerable holdings of New Zealand’s National Institute of Water and Atmosphere Ltd (NIWA) Invertebrate Collection (NIC) provided the opportunity to review the New Zealand psolid fauna. An overview of the Australian psolid holothurians was recently published (Mackenzie and Whitfield, 2011); five new species were described and a comprehensive key to all 19 species now known in Australian and Macquarie waters was included in the new species descriptions.

In order to extract the ossicles, the body wall tissue was dissolved in liquid household bleach. The extracted ossicles were studied by light microscopy (Nikon YS2-H) and by scanning electron microscopy (Philips XL30S FEG SEM). Clean ossicles for SEM examination were spread on a glass disk, air-dried and coated with platinum for 10 min. Photographs and measurements of the ossicles were taken. Specimen pictures were taken with a Nikon DX camera with a 60 mm macro lens. All specimens, including holotypes and paratypes, are registered in the NIC in Wellington. The internal anatomy is not systematically diagnostic and is not included in the new species descriptions.

In the following species descriptions, the station details are in the following format: the catalogue number NIWA XXXXX (number of specimens), voyage abbreviation and station number, latitude and longitude, depth, date of collection.
Key to New Zealand and Macquarie Ridge species of Psolidae Burmeister, 1837

1 Tube feet project through dorsal and lateral scales: *Psolidium* Ludwig, 1886 .................................................. 6
   - Tube feet absent dorsally: *Psolus* Oken, 1815 .......... 2
2 Five symmetrical oral valves ........................................ 3
   - Not with 5 symmetrical oral valves .......................... 4
3 No encroachment of scales onto oral valves, no bowl ossicles ventrally — *Psolus antarcticus* (Philippi, 1857)
   - Some encroaching of scales onto oral valves, bowl ossicles present ventrally
      — *Psolus parantarcticus* Mackenzie and Whitfield, 2011
5 Profile low, smooth, domed. Anterior and anal openings not raised. Half-cylinders present in dorsal ossicles — *Psolus salottii* Mackenzie and Whitfield, 2011
   - Profile not low, smooth, domed. Anterior and anal openings raised. No half-cylinders present in dorsal ossicles — *Psolus squamatus* (Müller, 1776) var. *segregatus* Perrier, 1905
6 Dorsal and lateral tube feet conspicuous macroscopically. Ventral ossicles thin-walled plates with 3–4 perforations, up to 125 µm long, 40 µm wide — *Psolidium kermadeci* sp. nov.
   - Dorsal and lateral tube feet inconspicuous macroscopically. Ventral ossicles thick-walled plates ........................................ 7
7 Midventral row of tube feet. Dorsal and ventral ossicles contain branching rods (thorns) .................................................. 8
   - No midventral row of tube feet. Dorsal and ventral ossicles do not contain branching rods (thorns) .............................. 9
8 Less than 8 dorsal scales between oral and anal openings. Dorsal body wall appears rough. Largest specimen 16 mm total length. Tentacle trunk ossicles long, thick rods, sometimes perforated at ends or middle ........................................ 9
   - More than 8 dorsal scales between oral and anal openings. Smooth appearance dorsally. Specimens often greater than 16 mm total length. Largest tentacle trunk ossicles predominantly plates with large irregular perforations — *Psolidium whitakeri* O’Loughlin and Ahearn, 2008
9 Ventral ossicles flat to slightly curved, single-layered, knobbed perforated plates with predominantly 4 (sometimes more) uniform perforations ................................. 9
   - Ventral ossicles flat to slightly curved, single-layered, knobbed perforated plates with 2 large central perforations and numerous smaller marginal perforations — *Psolidium marriotti* sp. nov.

Order *Dendrochirotida* Grube, 1840 (restricted Pawson and Fell, 1965)

Family *Psolidae* Burmeister, 1837

*Diagnosis.* (See O’Loughlin and Maric, 2008). Body flattened, with well-defined ventral sole. Dorsal surface invested by imbricating scales. Ventral sole soft, surrounded by tube feet. Mouth and anus dorsally upturned.

Remarks. For synonymies, discussion, and a key to genera of Psolidae see O’Loughlin and Maric (2008) together with the amendments listed in O’Loughlin and Whitfield (2010) and Mackenzie and Whitfield (2011). There is a key to the Australian species of Psolidae in Mackenzie and Whitfield (2011), reflected in the key provided here.

*Type genus.* *Psolus* Oken, 1815 (original description; *Lepidopsolus* Bronn, 1860, and *Lophothuria* Verrill, 1867; synonymy by Théel, 1886).
Genus *Psolus* Oken, 1815

**Diagnosis.** (O’Loughlin and Whitfield 2010). Psolidae with large imbricating or contiguous dorsal and lateral scales; ventrolateral scales at margin clearly demarcated from thin sole that lacks conspicuous scales. Tube feet absent dorsally and laterally, sometimes present orally and anally.

*Psolus antarcticus* (Philippi, 1857)

Table 1, Figures 1, 3A–C

*Holothuria antarctica* Philippi, 1857: 133.


Material examined. Macquarie Ridge: NIWA 40954 (2) Stn TAN0803/93, 56.25°S 158.43°E, 400–820 m, 14/04/2008; NIWA 40887 (16) Stn TAN0803/94, 55.37°S 158.38°E, 501–577 m, 15/04/2008; NIWA 40758 (9) Stn TAN0803/91, 55.36°S 158.42°E, 605–709 m, 15/04/2008; NIWA 40853 (1) Stn TAN0803/94, 55.37°S 158.38°E, 501–577 m, 15/04/2008; NIWA 68127 (1) Stn E227, 54.68°S 158.91°E, 1190–1213 m, 25/04/2010; NIWA 71146 (1) Stn 2253/20, 44.7°S 176.6°E, 29/05/2006; NIWA 76335 (1) Stn S1065H, 44.14°S 178.5°E, 990 m, 05/05/1997.

**Description.** See Mackenzie and Whitfield (2011) for the most recent description of this species including photos of the ossicles. All material examined here concurs with this recent description and any variations or amendments are discussed below.

Colour. Preserved: white and pale brown; dorsal and lateral scales have pale brown centres with a white periphery. This differs from Mackenzie and Whitfield (2011), in which specimens examined were white only.

**Distribution.** Previously reported from South America (Magellanic region), South Georgia, Macquarie Island, 100–1666 m; extended here to New Zealand and further locations along Macquarie Ridge, 360–1480 m.

**Remarks.** Mackenzie and Whitfield (2011) recently confirmed the distribution of *Psolus antarcticus* (Philippi, 1857) as extending into Australian and Macquarie Island waters. Herein, we confirm that *P. antarcticus* is known from the continental...

Table 1. Distribution of New Zealand and Macquarie Ridge species of Psolidae Burmeister, 1837.

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution (new records are provided in bold)</th>
<th>Depth range (new records are provided in bold)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Psolus species</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Psolus antarcticus</em> (Philippi, 1857)</td>
<td>Magellanic region of South America; South Georgia; Macquarie Island; <strong>New Zealand; Macquarie Ridge</strong></td>
<td>100–1666 m</td>
</tr>
<tr>
<td><em>Psolus macquariensis</em> sp. nov.</td>
<td><strong>Macquarie Ridge</strong></td>
<td><strong>398–489 m</strong></td>
</tr>
<tr>
<td><em>Psolus parantarcticus</em> Mackenzie and Whitfield, 2011</td>
<td>Australia, Macquarie Island; <strong>New Zealand, Hikurangi Margin; Macquarie Ridge</strong></td>
<td>108–135 m; 104–1053 m</td>
</tr>
<tr>
<td><em>Psolus salottii</em> Mackenzie and Whitfield, 2011</td>
<td>South Australia; Macquarie Ridge</td>
<td>400–820 m</td>
</tr>
<tr>
<td><em>Psolus squamatus</em> (Müller, 1776) var. segregatus Perrier, 1905</td>
<td>South America, Straits of Magellan and Argentina; <strong>New Zealand, Hikurangi Margin, Chatham Rise</strong></td>
<td><strong>320–468 m, 817 m</strong></td>
</tr>
<tr>
<td><strong>Psolidium species</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Psolidium aequum</em> sp. nov.</td>
<td><strong>New Zealand, Hikurangi Margin</strong></td>
<td>1040–1059 m</td>
</tr>
<tr>
<td><em>Psolidium kermadeci</em> sp. nov.</td>
<td><strong>New Zealand, Kermadec Trench</strong></td>
<td>1380–1545 m</td>
</tr>
<tr>
<td><em>Psolidium marriotti</em> sp. nov.</td>
<td><strong>New Zealand, Hikurangi Margin, Chatham Rise, North Cape; Macquarie Ridge</strong></td>
<td>136–885 m</td>
</tr>
<tr>
<td><em>Psolidium ramum</em> sp. nov.</td>
<td><strong>New Zealand, North Island west coast canyons</strong></td>
<td>188–210 m</td>
</tr>
<tr>
<td><em>Psolidium whittakeri</em> O’Loughlin and Ahearn, 2008</td>
<td>Antarctica; South Sandwich Island; South Shetland Island; Bouvet Island; <strong>New Zealand</strong></td>
<td>146–759 m, 443–503 m</td>
</tr>
</tbody>
</table>
Figure 1. Map of area showing station locations of *Psolus* species in the New Zealand and Macquarie Ridge regions.

Figure 2. Map of area showing station locations of *Psolidium* species in the New Zealand and Macquarie Ridge regions.

Figure 3. *Psolus antarcticus* (Philippi, 1857) (A–C, NIWA 30627): A, dorsal view; B, ventral view; C, close up of 5 even oral valves with no scale encroachment. Scale bar 1 cm.
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Psolus neozeianicus Mortensen, 1925 was based on two small specimens from east of North Cape, New Zealand. It has not been collected since. This species was briefly discussed in Mackenzie and Whitfield (2011). We further judge from the type description of its knobbed perforated plates (four central perforations recognisable) and five symmetrical valves that this species is a subjective junior synonym of Psolus antarcticus. Mortensen (1925) discusses the ventral ossicles in both of our small specimens. All specimens previously identified as P. neozeianicus in both the NIC and Museum of Victoria (MV) have been re-examined and determined to be P. antarcticus or P. parantarcticus Mackenzie and Whitfield, 2011.

Psolus macquariensis sp. nov.

http://zoobank.org/urn:lsid:zoobank.org:act:B0AC4334-A7DF-4548-B5DB-D33715DB5A09

Table 1, Figures 1, 4A–C, 7A–F


Description. See Mackenzie and Whitfield (2011). All specimens examined concur with this description unless discussed below.

Colour. Preserved: white (Mackenzie and Whitfield, 2011), although in present material dorsal and lateral scales have some pale brown markings.


Remarks. Psolus macquariensis sp. nov. is closest to southern Australian species Psolus steuarti Mackenzie and Whitfield, 2011, with its similar granulated scales dorsally and laterally, and cups in the dorsal body wall. P. macquariensis sp. nov. differs from P. steuarti in the presence of midventral tube feet and in the dorsal and lateral ossicles consisting of only single-layered plates. Also, in P. macquariensis sp. nov., ventral ossicles are smooth perforated plates, while P. steuarti has knobbed plates.

Psolus parantarcticus Mackenzie and Whitfield, 2011

Table 1, Figure 1


Description. See Mackenzie and Whitfield (2011). All specimens examined concur with this description unless discussed below.

Colour. Preserved: white (Mackenzie and Whitfield, 2011), although in present material dorsal and lateral scales have some pale brown markings.


Remarks. Psolus parantarcticus Mackenzie and Whitfield 2011 was first described from Macquarie Island. We subsequently found two more specimens of this species in our New Zealand and Macquarie Ridge material. The encroaching valves, ventral bowl-shaped ossicles, and multilayered dorsolateral ossicles are distinctive morphological features that clearly differentiate this species from P. antarcticus. This study significantly extends the known depth range for P. parantarcticus from 135 to 1052 m.

Psolus salottii Mackenzie and Whitfield, 2011

Table 1, Figure 1

Figure 4. 

Psolus macquariensis sp. nov. paratype (A–C, NIWA 40314): A, dorsal view; B, ventral view showing some extended tube feet; C, lateral view. 

Psolus squamatus (Müller, 1776) var. segregatus Perrier, 1905 (D–E, NIWA 43709): D, dorsal view; E, lateral view. 

Psolus squamatus (Müller, 1776) var. segregatus Perrier, 1905 (F, NIWA 43714): lateral view of specimen with numerous sole ossicles. Scale bar 1 cm.
Figure 5. *Psolidium aequum* sp. nov. (A–B, NIWA 32259): A, dorsal view; B, lateral view. *Psolidium kermadeci* sp. nov. paratype (C–D, NIWA 64441): C, dorsal view showing conspicuous tube feet; D, ventral view. *Psolidium marriottii* sp. nov. paratype (E–F, NIWA 76126): E, dorsal view; F, ventral view. Scale bar 1 cm.
Figure 6. *Psolidium ramum* sp. nov. holotype (A–B, NIWA 73660): A, dorsal view; B, ventral view. Scale bar 1 cm.

Figure 7. *Psolus macquariensis* sp. nov. paratype (A–F, NIWA 40314): A–B, dorsal single-layered plate, dorsal cup; C–F, ventral ossicles, smooth perforated plates.
Description. See Whitfield and Mackenzie (2011). The material examined matches the description well, and we make the following additions: *Psolus salotti* Whitfield and Mackenzie, 2011, up to 71 mm length (NIWA 40355), 54 mm wide, 29 mm high. Oral valves large and inconsistent in shape, ranging from rectangular with blunt ends to approximately triangular with pointed tips. Valves usually 10; always greater than 5.

Colour. Preserved: white.

Distribution. South Australia, Macquarie Ridge (Whitfield and Mackenzie, 2011) and this paper, 400–600 m.

Remarks. The original description was based on one holotype specimen from southern Australia and four paratypes from Macquarie Island. We found an additional 46 specimens, confirming and extending the Whitfield and Mackenzie (2011) description. The dome-like lumps on the dorsolateral scales are not always visible, and they may only be on a few scales. The multilayered ossicles in the preparation are always distinctly dome-like and provide a useful diagnostic character for this species.

*Psolus squamatus* (Müller, 1776) var. *segregatus* Perrier, 1905

Table 1, Figure 1, 4D–F

*Psolus squamatus*, Düben and Koren, 1846 (var. ?)—Théel, 1886: 89–90, pl. 15-figs 1–2, pl. 6-fig. 2.

*Psolus antarcticus*—Ludwig, 1894: 98 (in note) (part).

*Psolus pauper* Ludwig, 1894. (Synonymy in Deichmann, 1941.)

*Psolus squamatus*—H.L. Clark, 1901: 165; 1901: 491. (Synonymy in Deichmann, 1941; non-*Psolus squamatus* (O.F. Müller, 1776).)


*Psolus squamatus* (Koren) var. *segregatus* Perrier.—Deichmann, 1941: 147–148, pl. 30-fig. 7.

*Psolus squamatus* (Koren, 1845).—Pawson, 1969: 129 (not *Psolus squamatus* (O.F. Müller, 1776)).


Material examined. New Zealand, Chatham Rise: NIWA 27619 (2) Stn TAN0701/14, 43.35°S 179.58°E, 409–423 m, 31/12/2006; NIWA 43709 (1) Stn TAN0801/4, 43.26°S 178.05°E, 320–339 m, 28/12/2007; NIWA 43714 (1) Stn TAN0801/37, 44.22°S 179.1°E, 484–492 m, 03/01/2008; NIWA 44805 (5) Stn TAN0501/90, 43.36°S 178.53°E, 371–384 m, 14/01/2005; NIWA 49919 (1) Stn TAN0801/64, 43.92°S 179.7°W, 405–420 m, 10/01/2003; NIWA 76127 (8) Stn TAN0201/20, 43.28°S 178.27°E, 348–358 m, 01/01/2002; NIWA 76128 (1) Stn ZI0972, 43.12°S 175.81°E, 467 m, 04/09/2001; NIWA 76129 (4) Stn ZI0931, 43.13°S 175.83°E, 441 m, 30/10/2001; NIWA 76130 (4) Stn ZI0929, 43.12°S 175.81°E, 467 m, 04/09/2001; NIWA 76131 (27) Stn ZI0918, 43.36°S 178.91°E, 393 m, 04/01/1999; NIWA 76132 (6) Stn ZI0829, 43.26°S 178.42°E, 374 m, 30/12/2000; NIWA 76133 (2) Stn ZI0585, 43.05°S 178.29°E, 341 m, 30/12/2000; NIWA 76134 (1) Stn ZI0583, 43.32°S 178.56°E, 398.0 m, 12/01/2001; NIWA 76424 (2) Stn TAN0601/10, 43.31°S 178.26°E, 324–340 m, 29/12/2005.

Description. Follows Perrier (1905) and Ekman (1923) with additional details based on the specimens examined. *Psolus* species up to 61 mm long, 30 mm high, 39 mm wide. Body form oval, mid- to high-domed profile with raised oral and anal valves, higher anteriorly. Oral opening surrounded by 7–12 long, irregular, triangular to oblong oral plates or plate fragments, inconsistent in shape and number, imbricating slightly, thickly calcareous, granular surface, demarcation between body scales and oral plates variable, usually some body scales encroaching at base of oral plates. Anal opening a series of small scales continuous with dorsal and lateral scales, no distinct plates, heavily imbricating in circular formation surrounding the anus.

Dorsal and lateral scales predominantly 3–5 mm wide, a few up to 12 mm wide, but decreasing in size towards anal and oral valves and at lateral edge, macroscopically evident, scales imbricate slightly; scale margin colouration consistently light (white or cream), usually with a brown centre, variable in intensity, can appear spotty; scales with coarsely granular surface, granules loose or attached, globular, up to 310 µm wide. Sole oval, without tapering analy or orally; inner series of tube feet arranged in 1–3 rows around the outer sole perimeter, crowded, can extend midventrally posteriorly and anteriorly; outer peripheral series of smaller tube feet in a spaced, single row, close to the ventral margin; midventral series of tube feet variably present, extending anteriorly or posteriorly only, or absent completely.

Dorsal and lateral ossicles mainly large multilayered plates covered in granules, as described above; some thickened plates up to 180 µm long; rare smooth perforated plates up to 130 µm long; rare single-layered plates with secondary layering in some specimens. Ventral ossicles perforated plates ranging from simple crosses without complete perforations to some with up to 15 perforations.

Colour. Preserved. Directly into ethanol: oral, anal valves and sole white; dorsal scales centrally graduating brown to cream, white on perimeter. Frozen then ethanol: cream scales, white plates, no brown centres (NIWA 43714, NIWA 44805).

Distribution. South America, Strait of Magellan and Argentina, 256–274 m. Extended to New Zealand, Chatham Rise, 320–492 m here.

Remarks. The majority of the New Zealand material fits the description above, but there is variability in the number and appearance of the ventral ossicles. The variability ranges from a complete absence of ossicles (majority of specimens) to specimens with rare broken pieces of single-layered, smooth perforated plates (0–3 perforations, NIWA 76130, NIWA 76127, NIWA 76128) and two specimens (NIWA 43714, NIWA 44805) yielding smooth perforated plates and rare broken pieces. These plates variably have marginal projections, low knobs, and can be flat to slightly concave.

Théel (1886), Ludwig (1894), Perrier (1905) and Vaney (1906) all tried but failed to find a diagnostic difference between the North Atlantic and southern American specimens of *Psolus squamatus* (O.F. Müller, 1776), but the opinion was shared that a bipolar species was unlikely, and accordingly Perrier (1905) erected the variety *segregatus* for the southern form. Ekman (1923) presented an exhaustive comparison of Norwegian and South American specimens and confirmed the status of the variety *Psolus squamatus* (Müller, 1776) var.
segregatus Perrier, 1905. In particular Ekman (1923) recognised the significant size difference in the dorsal and lateral surface granules. Deichmann (1941) and Massin and Hendrickx (2011) accepted the status of the variety. Pawson (1969) determined specimens from Chile to be *P. squamatus* and did not accept the distinct species or variety status.

O’Loughlin (pers. comm.) examined specimens in the Smithsonian Institution that were identified as *Psolus squamatus* (Müller, 1776), from Norway (USNM 8583), the West European Basin (USNM E38321), and Alaska (USNM 24536, USNM E27846). He concluded that there are two species represented and neither is conspecific with the Californian specimens (USNM E17011, USNM E16931), which are in turn not conspecific with southern American specimens from the Strait of Magellan (USNM E33632, USNM E33634, USNM E33635) and Argentina (USNM 22201). A useful character for distinguishing between the different putative species in this complex may be the presence or absence and size of surface granules. The species most similar to *P. squamatus* that range in their distribution from the North Atlantic and into the Pacific along the western coast of the Americas from Alaska to Cape Horn are united by the presence of larger surface granules. Overall, the dorsal surface loose granule size, and the sole ossicle perforations and sizes are the major differences between *P. squamatus* and *P. squamatus var. segregatus*. *Psolus squamatus var. segregatus* sole ossicles are perforated plates that are smaller (75–110 µm) compared with those of *P. squamatus* (150–300 µm).

The status of both the species and the variety is undergoing an extensive systematic review (Martinez, pers. comm.). Until this is complete, our New Zealand species is designated as *P. squamatus var. segregatus*, but with minor reservation. The largest ossicles we found (in only two specimens) ranged from 95–140 µm long, but never reached the size documented for *Psolus squamatus*. Also, the size of the dorsal granules for *P. squamatus var. segregatus* is documented at 330–470 µm compared with 150–250 µm in *P. squamatus*. Our New Zealand specimen’s dorsal granules were variable in size, but the loose ones were measured as predominantly 270–350 µm, with only a few larger ones variably present (up to 500 µm). Our minor reservation is the frequent absence of ossicles in the sole in our New Zealand specimens. Deichmann (1941), when discussing the variety, notes that the ossicles often disappear with age. Ossicles were predominantly absent in large specimens, hence our decision to place these New Zealand specimens in *P. squamatus var. segregatus*.

All these examined specimens come from similar locations and depths and are of comparable sizes.

**Genus Psolidium Ludwig, 1886**

**Diagnosis.** (After O’Loughlin and Marie, 2008). Dendrochirotid holothuroids; small, up to 40 mm long; midbody arched dorsally in transverse section, flat ventrally; dorsal and lateral body covered with imbricating scales, usually macroscopically conspicuous, sometimes obscured by integument, scales irregular in size and arrangement; scales decreasing in size ventrolaterally, orally and anally; lacking large oral valves; extensible oral cone with anterior, anterior–dorsal or dorsal orientation; extensible anal cone with posterior, posterior–dorsal or dorsal orientation; tube feet dorsally and laterally in midbody, passing through scales.

Sole distinct, oval to elongate; discrete margin created by junction of small imbricating ventrolateral scales, with thinly-walled, usually calcareous sole that lacks scales; peripheral band of tube feet, may be discontinuous across the interradii anteriorly and posteriorly; peripheral tube feet frequently of 2 sizes, those of outer series smaller; midventral radial series of tube feet present or absent.

Calleareous ring solid, plates subrectangular, radial and interradial plates with tapered anterior projections; radial plates with deep notch posteriorly, interradial plates with shallow concave indentation posteriorly; 10 dendritic tentacles, ventral 2 smaller.

Dorsal and lateral ossicles: multilayered or single-layered perforated plates (scales), always some with tube foot canals; integument covering scales may have cupped crosses, cups, ‘thorn’ ossicles (irregular branched rods pointed distally), buttons, perforated plates and rosettes; tube foot small endplates, and tube foot support ossicles that are irregular rods and plates, bent and curved, variably perforated.

Sole ossicles: interradii with small to large single-layered perforated plates (rarely with multilayering), smooth to variably knobbled and thickened, sometimes with cupped crosses, cups, thorn ossicles and rosettes; radii with additional tube foot ossicles, large endplates and tube foot support ossicles that are irregular rods and plates, bent and curved, variably perforated.

**Psolidium aequum** sp. nov.


Table 1, Figures 2, 5A–B, 8A–H.


Paratypes. NIWA 32023 (29), same as holotype locality and date.


**Description.** *Psolidium* species up to 10 mm long, 5.5 mm wide, 5 mm high. Profile moderately low, anal and oral ends commonly raised, no discrete oral or anal valves or plates. Dorsal and lateral scales continuous over body wall, up to 1.5 mm wide, decreasing in size towards the ventral sole. Scales orally and analyn smaller, less granular than other scales and paler in colour; dorsal and lateral scales brown, with a 0.25 mm pale grey to white margin; scales on ventral margin up to 0.5 mm wide and lighter in colour, imbricate. Dorsal and lateral tube feet small, inconspicuous, few visible. Tentacles 10, 8 + 2 (ventral smaller). Sole naked midventrally, peripheral series of closely set large tube feet in a single row, sometimes extending
Figure 8. *Psolidium aequum* sp. nov. paratype (A–H, NIWA 32023): A–B, dorsal scales with tube feet holes visible; C–H, ventral ossicles, knobbed plates with 4 uniform central perforations.
onto midventral radius anteriorly and posteriorly; no complete outer series of small peripheral tube feet but on some specimens few smaller tube feet scattered around ventral margin.

Dorsal and lateral ossicles large multilayered perforated plates (scales) with tube feet holes, sometimes with marginal thickening, secondary layering and anastomosing towards outer margins, up to 1580 µm wide with small inconspicuous tube foot canals up to 45 µm wide; large thick, single-layered plates up to 120 µm long with a smooth surface; tube foot support plates thin, rare (due to few dorsal or lateral tube feet) single-layered plates, curved, variably smooth or finely knobbed and relatively curved, up to 80 µm long and with up to 8 perforations. Ventral ossicles flat to slightly curved single-layered perforated plates up to 125 µm long, one side of plates knobbed, other side completely smooth, commonly with 4 perforations (up to 13). Perforations mostly uniform in size but sometimes a few smaller marginal perforations present; margin of plates sharp and angular. Tentacle ossicles long, thick rods, sometimes perforated at either end, less commonly perforated in the middle, rods up to 300 µm long, variable in shape, from straight to curved, rarely with a “bend” centrally but most commonly with a slight curve, blunt spines sometimes present on either side of centre, sometimes a cluster of perforations at the end of a rod. Smaller single-layered perforated plates, up to 80 µm long, perforations inconsistent in size, shape and arrangement, ranging from flat to curved.

Colour. Preserved: pale to dark brown with grey, light brown or white margins around dorsal and lateral scales. Tentacles brown.

**Distribution.** New Zealand, Hikurangi Margin, 1040–1059 m.

**Etymology.** The species name is Latin, meaning equal, to reflect the characteristic regular perforations in the ventral ossicles.

**Remarks.** *Psolidium aequum* sp. nov. differs from other *Psolidium* species by a combination of the ventral ossicles having predominantly four (sometimes more) uniform perforations, the presence of a few outer ventral peripheral tube feet, the presence of tentacle rod ossicles, commonly with perforations through the middle as well as blunt spines on either side of the middle.

*Psolidium kermadeci* sp. nov.


Table 1, Figures 2, 5C–D, 9A–D

**Material examined.** Holotype. New Zealand, Kermadec Trench: NIWA 72333 (1) Stn TAN0411/32, 35.36°S 178.52°E, 1425–1440 m, 07/03/2011.

Paratype. New Zealand, Kermadec Trench, NIWA 64441 (1) Stn TAN1007/51, 35.42°S 178.62°E, 1380–1545 m, 01/06/2010.


**Description.** *Psolidium* species up to 10 mm long, 4 mm wide, 3 mm high (preserved). Body form oval, profile dome-like with slightly raised oral and anal cones. Body wall scales macroscopically evident and continuous over domed dorsal and lateral surface, including oral and anal cones, largest scales up to 575 µm wide and 414 µm high, scale appearance glassy, beady, overall smooth, lacking any bumps or pillars. No discrete oral or anal valves or plates present, scales surrounding oral and anal cones reduced. Conspicuous dorsal tube feet evident, ranging from radial axis presence only through to several tube feet continuous onto interradials. Tentacles 10, 8 + 2 (ventral smaller). Sole distinct, calcareous, peripheral single row of tube feet, no smaller outer row, no midventral tube feet.

Dorsal ossicles are single-layered perforated scales, centrally some anastomosing, with tube feet holes evident, curved perforated support plates up to 55 µm wide. Ventral ossicles are thin-walled perforated plates with tiny blunt knobs, 3–4 perforations predominant, up to 125 µm long, perforations up to 40 µm wide.

**Colour.** Preserved: white.

**Distribution.** New Zealand, Kermadec Trench, 1380–1545 m.

**Etymology.** Named after Huon de Kermadec, an 18th century French navigator after whom the Kermadec islands were named, and eventually the Kermadec Trench, where the specimens were found.

**Remarks.** This description is based on two small specimens found in relatively close proximity to each other, at similar depths (>1000 m). This is the first record of a *Psolidium* from the Kermadec Trench. *Psolidium kermadeci* sp. nov. is closest to the southern Australian species *Psolidium granuliferum* (Clark, 1938), but differs in possessing conspicuous tube feet dorsal and laterally. Also, like all other Australian *Psolidium* species, *P. granuliferum* is found in shallow depths, whereas *P. kermadeci* is one of the deepest occurring *Psolidium* species in the South Pacific region. This species also differs from the other New Zealand *Psolidium* species described in this paper as the dorsal tube feet are conspicuous and projecting through the body wall scales, whereas the other new *Psolidium* species require microscopic investigations to determine if such tube feet are present. Additionally, the sole ossicles are much thinner, have fewer perforations, and carry spinous knobs marginally.

*Psolidium marriotti* sp. nov.


Table 1, Figures 2, 5E–F, 10A–E

**Material examined.** Holotype. New Zealand, Chatham Rise: NIWA 68137 (1) Stn N857, 43.54°S 179.54°E, 399 m, 17/12/1976.

Paratypes. NIWA 76126 (3) same as holotype.
**Description.** *Psolidium* species up to 16 mm long, 5 mm high, 8.5 mm wide. Profile moderately high, rarely flat, anal and oral ends commonly raised slightly. No distinct oral or anal valves or plates; these are a continuation of small body wall scales. Dorsal and lateral scales visible and continuous over body wall, up to 3 mm wide but most commonly 1.5–2 mm wide, covered in conspicuous fine granules. Ventral margin scales significantly smaller, reaching a maximum of 0.7 mm wide; two rows surround ventral margin. Dorsal and lateral tube feet can be seen under a microscope on some specimens.

Sole transparent, naked midventrally, peripheral series of large tube feet in 1–2 scattered rows that sit on ventral margin; smaller series of tube feet not present. Tube feet do not consistently extend onto midventral radius, but sometimes up to six tube feet can be clustered on the midventral radius posteriorly and anteriorly; feet a maximum of 0.25 mm apart.

Dorsal and lateral ossicles large multilayered plates (scales) up to 0.2 mm long with tube foot canals up to 40 μm wide, anastomosing, with secondary layering, thickening and/or heavy knobbing present marginally; single-layered plates with thickening, anastomosing and secondary layering also present, with few perforations, up to 190 μm long; tube foot support plates small thin, single-layered perforated plates with up to 18 perforations and up to 80 μm wide, plates curved up at opposing ends, perforations smaller on those upturned edges. Ventral ossicles single-layered perforated plates, surface generally heavily knobbed on one side, smooth on other surface, up to 24 perforations up to 125 μm wide, 2–4 larger central perforations (most commonly 2) with many smaller marginal perforations surrounding them, plate margins have blunt, rounded knobs; tentacle ossicles long rods up to 235 μm long, straight to curved to bent in shape, with

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Figure 9. *Psolidium kermadeci* sp. nov. holotype (A–D, NIWA 72333): A, dorsal scale with tube feet perforations; B, dorsal curved support plate; C–D, ventral ossicles, thin-walled perforated plates with spiny knobs on margins.
perforations at either end but not through the middle; small thin, single-layered plates, variably flat or curved to form a ‘U’ shape, up to 80 µm wide with up to 14 perforations; larger less curved single-layered plates up to 125 µm long with up to 12 thicker, larger perforations.

Colour. Preserved: dark to light brown with a grey to white margin around scales.

**Distribution.** New Zealand: Hikurangi Margin, Chatham Rise, North Cape; Macquarie Ridge; 136–885 m.

**Etymology.** Named for Peter Marriott, NIWA, who has provided the macro photos for this paper.

**Remarks.** *Psolidium marriotti* sp. nov. is similar to *Psolidium aequum* sp. nov., but is distinguished by the following characters: *P. marriotti* sp. nov. has an abundance of ventral ossicles, rounded and knobbed, with two larger central perforations and many small marginal perforations. In contrast, the ventral ossicles in *P. aequum* are sharper and more angular, with four larger central perforations. The tentacle rods of *P. marriotti* sp. nov. consistently have perforations through the middle and no blunt spines on the edges, whereas those of *P. aequum* sp. nov. only occasionally have perforations and always exhibit blunt edge spines. Additionally *P. marriotti* sp. nov. has no small, outer peripheral ventral tube feet. *P. marriotti* sp. nov. occurs at a shallower depth (135–885 m) than *P. aequum* sp. nov. (1040—1059 m), and it has a much greater geographic range, from New Zealand’s North Cape southward to the Macquarie Ridge.
Psolidium ramum sp. nov.

http://zoobank.org/urn:lsid:zoobank.org:act:A9BB906B-094B-4F5E-83C5-5FFD1C68CC9B

Table 1, Figures 2, 6A–B, 11A–H.


Description. Psolidium species up to 16 mm long, 8 mm wide, 2 mm high. Profile low, body form oval. Oral cone slightly higher than anal cone; no distinct oral or anal valves or plates, approximately 230 µm wide, macroscopically smooth, microscopically glassy and beady texture, lacking significant bumps or pillars. Body wall dorsal and lateral scales macroscopically evident and continuous over body wall, up to 2.3 mm at widest point. Tube feet numerous, up to 10 per scale, evident throughout dorsal and lateral scales. Tentacles 10; 8 + 2 (ventral smaller). Sole largely destroyed, with peripheral single row of larger tube feet and smaller outer non-continuous ring of tube feet; midventral row of tube feet present, only 2 feet found as a result of a damaged sole.

Dorsal and lateral ossicles include large multilayered thick scales with small perforations and conspicuous round tube feet holes up to 60 µm in diameter; numerous tube feet support plates up to 85 µm wide; rare single-layered plates with 4–9 perforations up to 70 µm wide; broken thorn (branching rod) ossicles present.

Ventral ossicles knobbled perforated plates up to 100 µm wide with blunt marginal projections, predominantly 4 projections, sometimes more projections peripherally, and thick elongate plates up to 160 µm long, without knobs, with
small perforations; small crosses up to 60 \( \mu \text{m} \) wide; thorn ossicles present, mainly broken, largest 135 \( \mu \text{m} \).

Colour. Preserved: white, with dorsal and lateral scales, grey centrally.

**Distribution.** New Zealand, North Island west coast, 188–210 m.

**Etymology.** The Latin word ‘ramum’ = branching, in reference to the branch-like thorn ossicles in the dorsal and ventral body wall of this species.

**Remarks.** This description is based on one specimen, of which the ventral sole was partially destroyed. The distinctive thorn ossicles, while rare, were present in both the dorsal and ventral body wall and have not been reported for any other New Zealand *Psolidium* species. In *Psolidium ramum* sp. nov. the ventral ossicles have predominantly 4 perforations; in *P. marriottii* sp. nov. they are numerous. *P. aequum* sp. nov. has larger perforations, thicker ossicles and many more angular knobs on ossicle margins. The thickened elongated plates are unique to *P. ramum* sp. nov. The northwest Australian species *P. parmatus* (Sluiter, 1901) and *P. nigrescens* Clark, 1938 also contain thorn ossicles similar to those of *P. ramum* sp. nov., but *P. parmatus* has bulbous pillars on the dorsal and lateral scales, and *P. nigrescens* is black, and has cups and crosses ventrally.

Further specimens would contribute to this description. The structure and distribution of ventral tube feet are difficult to determine, and there was little material available for ossicle extraction and SEM study. The tentacle ossicles could not be described due to the damaged state of the specimen, and these will need to be examined in the future.

**Psolidium whitakeri** O’Loughlin and Ahearn, 2008

*Psolidium incertum.*—Ludwig and Heding, 1935: 162–164, text-figs 28–29 (non-*Psolidium incertum* (Théel, 1886) = *P. poriferum* (Studer, 1876) (above).

*Psolidium whitakeri.*—O’Loughlin and Ahearn, 2008: 38, figs 3b–d, 8d–f.

**Material examined.** New Zealand, Hikurangi Margin: NIWA 63907 (1) Stn TAN1004/100, 42.13°S 174.54°E, 1375–1480 m, 24/04/2010; NIWA 63914 (1) Stn TAN1004/100, 42.13°S 174.54°E, 1375–1480 m, 24/04/2010. Kermadec Trench: NIWA 49868 (1) Stn TAN0413/40, 36.96°S 177.29°E, 1652–1669 m, 09/11/2004; NIWA 72086 (1) Stn TAN1105/27, 34.27°S 172.78°E, 66–67 m, 27/03/2011. Southern Plateau: NIWA 76139 (1) Stn E824, 46.97°S 166.54°E, 1217 m, 24/10/1967.

**Description.** O’Loughlin and Ahearn (2008) provide a recent and comprehensive description of this species. The material examined here concurs with this description.

**Distribution.** Antarctica, South Sandwich Island, South Shetland Island, Bouvet Island, 146–759 m; New Zealand, Hikurangi Margin, Kermadec Trench, Southern Plateau, 66–1669 m (this paper).

**Remarks.** *Psolidium whitakeri* O’Loughlin and Ahearn, 2008 is so far only known from the Southern Ocean around Antarctica. This current material has extended the range of this species around the Antarctic continent, as well as northwards into Subantarctic and temperate latitudes. Additionally, the reported depth range has been extended from 759 m to 1669 m at the more northern record (NIWA 49868).

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