Isodiscus Rattray: a problematic fossil marine genus

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Abstract

The fossil marine genus Isodiscus Rattray presently comprises three species, I. debyi (E.Grove & G.Sturt) Rattray, I. mirificus Rattray and I. coronalis Brun; all are rare. One new species I. watanabei is described here. The genus is confined to the middle to late Eocene and its morphological features present difficulties in assigning it to a family or order. A new family Isodiscaceae is proposed and relationships discussed.

Key index words: diatom, Isodiscaceae fam. nov., Isodiscus, Isodiscus watanabei sp. nov., porelli, sipho marginalis

Introduction

Grove & Sturt (1887) in their studies on the Late Eocene deposit at Oamaru, Otago, New Zealand included a specimen of a species shown to them by Julien Deby which they doubtfully assigned to the genus Lampriscus as Lampriscus ? debii (debyi) E.Grove & G.Sturt. They provided both a description and an illustration (p. 138, pl. XI fig. 27). In 1888 Grunow published a list of species from Oamaru stating that both he and Grove & Sturt agreed with the names published. In the list Lampriscus debyi was transferred to Eupodiscus ? debyi E.Grove & G.Sturt. They added comment, probably by Grunow, that the taxon was not a Lampriscus, doubtfully a Eupodiscus, but probably belonged to a new genus, (Bot. Centralbl. 34, p. 38).

Rattray (1888), on finding a new species that had characters in common with Eupodiscus debyi erected a new genus, Isodiscus, to accommodate the two species, I. debyi (E.Grove & G.Sturt) Rattray and I. mirificus Rattray, both recorded from the Oamaru diatomite as rare. Since then an additional species, Isodiscus coronalis, has been added by Brun (1895) recorded from Totara, Oamaru, New Zealand and Mount Hillaby, Barbados. He gave a very brief description and provided an illustration. It also is rare and there are no specimens of this species present in the B.M. collections.

On examination of the Eocene material cored by R.V. Conrad on the Continental Shelf, Southern Ocean, a new species of Isodiscus was found and it, together with I. debyi, have been examined by SEM and LM so that the characters of the genus can be clarified and, together with the information on I. mirificus and I. coronalis, the genus assigned to a family. To date only Schütt (1896), Van Heurck (1896) and Nikolaev & Harwood (2000, 2001) have placed Isodiscus in a family, Schütt & Van Heurck in the Eupodisceae and Nikolaev & Harwood in the order Auliscales Gleser, family Aulisccaeae Hendey.

Material and methods

Slides examined:

Isodiscus debyi (E.Grove & G.Sturt) Rattray
No holotype could be found either in the Deby coll'. or in the Grove or Sturt collections.

Isodiscus mirificus Rattray
BM Adams G.C. 1661, Oamaru (Tempère mount); BM Adams H.170, Oamaru (Tempère mount). Herb Hendey 4327, Oamaru.
No holotype could be located.

Isodiscus watanabei sp. nov.
BM 101107. Holotype. Continental slope, R.V. Conrad, Cruise 12, N.W. Falkland Islands, Core 237, Depth 2000 fathoms, Lat. 47°45.7'S, Long 57°38.5'W.
Details of samples used for SEM investigations:

Otago 212, New Zealand material ex Brigger.
Late Eocene.
Falkland Plateau, Conrad Cruise 12, Core 237. Middle or late Eocene.

All specimens examined by SEM were prepared by the methods outlined in Hendey & Sims (1984). The terminology follows that of Ross et al. (1979).

Taxonomic account

**Isodiscus debyi (debii) (E.Grove & G.Sturt)**

* Rattray (1888, p. 920) — Edwards (1991, pl. 14, fig. 182)

* Lampriscus ? debyi (debii) E.Grove & G.Sturt (1887, p. 138, pl. XI, fig. 27)

* Eupodiscus ? debyi (E.Grove & G.Sturt) E. Grove & G.Sturt in Grunow (1888, p. 38)

Figs 1–14

Valves circular 80–220 μm in diameter. Valve face flat with narrow gently rounded mantle (Figs 2, 5, 11). Valve face with circular hyaline central area and slightly irregular radial rows of areolae with locular walls (Fig. 11). Six to ten circular to subcircular well-defined and raised areas of porelli are positioned around the valve margin, extending on to the mantle, with two lying opposite each other, larger than the others (Fig. 11). Areas of porelli ranging in size from 18–25 μm for the two larger ones and 15–18 μm for the smaller ones. The valve margin is a narrow hyaline band on the valve exterior (Figs 2, 5) extending into the interior as a broad hollow flange, c. 7–7.5 μm wide with radial rows of poroid areolae covering both surfaces of the hollow flange (Figs 7–9, 12). On the valve exterior a single row of larger areolae is positioned above the marginal rim (Figs 2, 4, 5) and these open into the flange forming a large sipho marginalis.

A circular hyaline area lies at the valve centre (10–14 μm in diameter) within which are a few scattered poroid areolae and the openings from the rimoportulae (Figs 3, 13, arrowhead). This area appears to be solid silica but from it somewhat irregular rows of areolae with locular walls extend to the valve margin curving round the areas of porelli (Figs 1, 2, 5). The basal layer is punctured by interrupted radial rows of poroid areolae which extend to the valve margin, the rows becoming denser and more regular between the marginal groups of porelli (Figs 7–9, 14). In fractured specimens and LM the locular walls are evident in the outer 2/3rds of the valve face. However the basal layer of poroid areolae is continuous and not confined between the bases of the locular walls, i.e. not separate and distinct so they cannot be termed cribra (Fig. 9). On the valve exterior it would appear the locular walls expand laterally forming circular openings varying in size and, on some specimens, the openings are extended to form longitudinal openings lying in a radial position near the valve entre (Figs 1–3). The openings from the rimoportulae are scattered within the hyaline central area (Figs 12, 13). On the exterior they are small, oval and lie flush with the valve face (Fig. 3). On the interior they are elongate slits with slightly raised “lips” (Fig. 10).

No girdle bands have been observed. Specimens are rare.

**Locality**: Oamaru, New Zealand—Allen’s Farm; Cormack’s siding; Forrester’s Hill and non. loc.

**Age**: Late Eocene to early Oligocene.

**Isodiscus debyi (E.Grove & G.Sturt) Rattray** is the generitype proposed by Ross & Sims in Round, Crawford & Mann (1990).

**Isodiscus watanabei P.A.Sims sp. nov.**

* Figs 15–29

Valves circular, diameter 49–65 μm; valve face flat with narrow gently rounded mantle. Two large circular-subcircular discrete groups of porelli without a hyaline rim, 16–20 μm diameter, lie opposite each other, each slightly raised above the valve face and extending over the valve mantle almost reaching the valve margin. Valve face and mantle with irregular radial rows of areolae with locular walls (3–4 in 10 μm). Central area small, circular, diameter c. 2–2.5 μm, bordered by a ring of 6–7 elongate slits, openings of rimoportulae. The valve margin is a narrow hyaline band that extends internally as a large hollow flange, c. 7 μm broad, forming a sipho marginalis.

**Holotype**: selected specimen on BM 101107

**Locality**: Falkland Plateau, Conrad Cruise 12,
The genus *Isodiscus*

Figs 1–6. *Isodiscus debyi* (E.Grove & G.Sturt) Rattray. Otago 212, New Zealand. Scanning electron micrographs, valve exterior. Figs 1, 2 bar = 50 µm; Fig. 5 bar = 20 µm; Figs 3, 4 bar = 10 µm; Fig. 6 bar = 2 µm. **Fig. 1.** Fractured valve. **Fig. 2.** Specimen tilted showing 4 raised areas of porelli. **Fig. 3.** Openings from rimoportulae (arrowhead), external openings of areolae. Note elongated openings in radial arrangement. **Fig. 4.** Raised area with porelli in radial rows, also single row of larger areolae above marginal rim. **Fig. 5.** Fractured specimen showing loculate valve structure. **Fig. 6.** Detail of valve structure. Note small spines on valve surface.
Figs 7–10. *Isodiscus debyi*. Otago 212, N.Z. SEM valve interior. Figs 7, 8 bar = 20 µm; Fig. 10 bar = 10 µm. Figs 7, 8. Valve interior showing central rimoportulae and broad marginal flange (siphon marginalis). Fig. 9. Basal layer with interrupted radial rows of poroid areolae. Fig. 10. Openings from central rimoportulae.

Core 237. Lat. 47°45.7' S, Long. 57°38.5' W. Age: Middle or late Eocene.

**SEM observations**

Two very large circular–subcircular discrete groups of porelli (diameter 16–20 µm) slightly raised above the circular valve face, lie opposite each other covering more than half the valve diameter (Fig. 15) extending over the mantle almost reaching the valve margin (Fig. 16). The areas of porelli (c. 22 porelli in 10 µm) are radially aligned and without a hyaline rim (Fig. 17).

The valve structure is locular, the locular walls overlying a basal layer of poroid areolae arranged in interrupted radial rows. These form a continuous pattern and are not separated into cribra by the locular walls (Figs 21, 22, 25). On the outer valve surface the areolar openings are circular, varying in size (Figs 15–20) and each appears to be formed by the hyaline locular
The genus *Isodiscus*

Figs 11-14. *Isodiscus debyi*. Light micrographs. Figs 11, 12 bar = 20 µm; Figs 13, 14 bar = 10 µm.

Figs 11, 12. BM 63388 Cormack's Siding, Oamaru. Valve at different focal levels showing exterior and interior. Figs 13, 14. Herb. Hendey 4326. Forrester's Hill, Oamaru. Fig. 13. Hyaline central area with rimoportulae (arrowhead), margin with detail of porelli in raised area. Fig. 14. Another focal level showing loculate walls and basal layer of poroid areolae.
Figs 15–20. *Isodiscus watanabei* sp. nov. Falkland Plateau, Conrad Cruise 12, Core 237. SEM valve exterior. Figs 15, 16 bar = 10 µm; Fig. 17 bar = 5 µm; Figs 18–20 bar = 2 µm. **Fig. 15.** Valve lying flat. **Fig. 16.** Valve tilted showing 2 large raised areas of porelli, central aperture and scattered solid spines. **Fig. 17.** Detail of porelli in radial rows. Note smaller areolae in area around porelli. **Fig. 18.** Central aperture with exterior openings from 6 rimoportulae. **Fig. 19.** Single row of larger areolae lying above marginal rim. **Fig. 20.** Detail valve surface at junction between areolae with locular walls and porelli (top).
The genus *Isodiscus*

**Figs 21–26.** *Isodiscus watanabei* sp. nov. Conrad Cruise 12, Core 237. SEM valve interior. Figs 21, 22 bar = 10 µm; Figs 23, 26 bar = 5 µm; Figs 24, 25 bar = 2 µm. Figs 21, 22. Fractured valve with central aperture encircled by openings from rimoportulae, interrupted radial rows of poroid areolae, 2 areas of porelli and hollow marginal flange. Fig. 23. Marginal flange with radial rows of poroid areolae. Fig. 24. Interior openings of rimoportulae. Fig. 25. Fractured valve showing loculate valve structure with continuous area of poroid areolae not confined into cribra. Fig. 26. External basal row of areolae opening into internal hollow flange (sipho marginalis).
Figs 27–29. *Isodiscus watanabei* sp. nov. HOLOTYPE BM 101107. L.M. Bars = 10 µm. Fig. 27. Two large discrete areas of porelli in radial rows, locular walls of areolae and small hyaline central aperture with openings from 6 rimoportulae. Figs 28, 29. Two focal levels of holotype with interior view (Fig. 29) showing area of marginal flange (arrowhead).

walls expanding at the valve surface—a pseudoloculus? (Fig. 25). Scattered over the valve face are solid spines, each with a buttressed base (Fig. 20). The small circular central area is an aperture bordered by a ring of six or seven barely raised rimoportulae (Figs 18, 24).

The valve margin is narrow, c. 1 µm, hyaline (Fig. 19) and extends into the valve interior as a hollow flange c. 7 µm broad. It is punctured by radial rows of poroid areolae (Figs 21–23, 26). The single row of marginal pores that lie above the exterior valve margin is connected to the interior of the hollow flange forming a siphon marginalis (Figs 19, 26).

No girdle bands have been seen. Specimens are rare in the only locality in which this taxon has been found.

*Isodiscus mirificus* Rattray (1888, p. 920, pl. XVI, fig. 4) – Bergon *et al.* (1890, p. 23, pl. III, fig. 2); Van Heurck (1896, p. 490, fig. 227); Laporte & Lefèbure (1929, pl. 3, fig. 16). *Eupodiscus mirificus* (Rattray) F.Schütt (1896, p. 80, fig. 123) – Edwards (1991, pl. 12, fig. 160).

Figs 30–34

Valves circular, diameter 85–138 µm, with flat valve face and narrow mantle. Mostly two, rarely three, large circular–subcircular discrete groups of porelli (c. 9 µm in diameter) lie at the valve margin together with numerous (13–18) smaller groups, varying in size and regularly arranged between the larger ones (Fig. 30). All groups of porelli are raised slightly above the valve face and extend on to the valve mantle giving the valve outline a slightly crenulate appearance.
The genus *Isodiscus*

Figs 30-34. *Isodiscus mirificus* Rattray. Figs 30-32. B.M. Adams colln. H.170 Oamaru; Figs 33, 34. Herb. Hendey 4327, Oamaru, New Zealand. Light Micrographs. Figs 30, 33, 34 bar = 10 µm; Figs 31, 32 bar = 5 µm. **Fig. 30.** Valve with two large marginal areas of porelli and 17 smaller ones each differing in size. Valve face with interrupted radial rows of poroid areolae and openings from rimoportulae in subcentral position. **Fig. 31.** Detail showing porelli in radial rows. **Fig. 32.** Openings from rimoportulae. **Figs 33, 34.** The same valve seen exterior view through coverslip and reversed to show marginal flange (sipho marginalis).
Poroid areolae cover the valve face, those at the valve centre in irregular patches (Fig. 32), towards the margin in interrupted radial rows which, between the areas of porelli, are more densely packed and in distinct radial rows, 14–20 areolae in 10 µm (Figs 30, 31). The rimoportulae are elongate slits arranged in an irregular circle outside the valve centre (Fig. 32).

The valve margin is a narrow hyaline band on the exterior which extends into the interior as a broad hollow flange c. 10–12 µm wide (Fig. 34 taken reverse side of slide).

No girdle bands have been seen. Specimens are rare.

**Locality**: Oamaru, New Zealand—William’s Bluff and non. loc.

**Age**: Late Eocene.

**Isodiscus coronalis** Brun (1895, pl. XVII, fig. 98).


Brun provided an illustration (Fig. 35) and the comment that the “Espèce très distineste de l’*Isod. mirificus* de Rattray.” The localities given are Totorara (New Zealand), Mount Hillaby (Barbados)—Fossile. There are no records of slides of *Isodiscus* (or *Eupodiscus*) *coronalis* in the Brun collection held at the Conservatoire et Jardin botaniques, Geneva.

From the illustration (Fig. 35) it would appear that the valve structure is poroid and there are alternating lozenge-shaped and circular raised marginal structures but any detail of these structures is missing. There is no indication of any central area or rimoportulae present nor of a sipho marginalis so until specimens are found its inclusion in the genus _Isodiscus_ cannot be confirmed and it is not possible to include it in the Discussion.

**Discussion**

There are genera that are difficult to place, with confidence, into a family whether using the classification of Simonsen (1979), Round et al. (1990) or Nikolaev & Harwood (2000, 2001). _Isodiscus_ is such a genus.

The characters defining _Isodiscus_ are the circular valve outline, narrow gently convex mantle and flat valve face with well-defined circular—subcircular raised groups of porelli positioned at the valve/mantle junction, often differing in size, all without a hyaline rim. The rimoportulae are central and present as elongate slits between narrow raised lips on the interior and lie almost flush with the valve face on the valve exterior. All three species have a broad hollow marginal flange punctured by rows of poroid areolae—a well-developed sipho marginalis (see Prasad et al. 1997, Sims 2001).

_Isodiscus debyi_ and _I. watanabei_ have a Jocular valve structure with hexagonal walls, the areolae lying in irregular radial rows. The basal layer is punctured by interrupted radial rows of poroid areolae forming a continuous layer, i.e. not separated into cribra by the bases of the locular walls. On the exterior the areolar openings are circular, vary in size and are without any signs of a velum but appear to be extensions of the locular walls. This type of valve structure is uncommon (pseudoloculate?) and unknown to me in valves with central rimoportulae. Both species have solid spines on the valve surface and those of _I. watanabei_ are distinct and have a buttressed base.

_Isodiscus mirificus_ has no locular walls but interrupted radial rows of poroid areolae similar in distribution and numbers to those on the basal wall.
layer of the other two species. This difference in valve structure would place *I. mirificus* in a separate genus and possibly family following the classification system of Nikolaev & Harwood (2000, 2001). However, the characters these three species have in common, e.g. circular valve outline, discrete groups of marginal porelli with two larger ones lying opposite each other, others when present often differing in size, central rimoportulae of the same structure plus a broad hollow internal marginal flange, makes it far more likely that they are closely related rather than being a case of parallel evolution. Some large and distinct genera, e.g. *Aulacodiscus* Ehrenb., *Actinoptychus* Ehrenb. have species placed within them that have loculate areolae whilst others have poroid areolae and should Nikolaev & Harwood’s classification be applied these species would be placed in separate genera.

The marginal circular–subcircular discrete groups of porelli appear to be identical in all species, apart from size. They are positioned over the valve mantle junction, are slightly elevated, convex in outline with the porelli radially aligned. Their surface is uneven giving the appearance that the depth of each pore differs slightly. There is no hyaline rim but there is an indication that the surrounding areolae decrease in size (Figs 17, 20, 23). This observation together with the convex shape of the structure, rather than flat, suggest each may be a pseudocellus rather than an ocellus but even this feature is doubtfully assigned as most pseudocelli have vela and these do not. Schütt (1896), Van Heurck (1896) and Nikolaev & Harwood (2000, 2001) have placed the genus in families with ocelli. However, the central position of the rimoportulae also indicates *Isodiscus* is not a eupodiscoid sensu Simonsen (1979) although the possession of well-developed sipho marginalis is a feature common to eupodiscoids but so far unknown in the biddulphioids. A circular valve outline is also a common feature of the eupodiscoids.

An unusual feature of *Isodiscus debyi* is the appearance, on some specimens, of radially aligned elongate chambers (Figs 1–3) replacing the circular areolar openings on the valve exterior. In *Isodiscus watanabei* the large circular central aperture is also uncommon. The only such central aperture known to me is that in *Porodiscus nitiatus* var. *armatus* Rattray but in this species the remains of a silica network are attached to the interior wall of the aperture (Sims 1989, fig. 51). The distinguishing features of *Isodiscus* as discussed above are not present in any family as presently circumscribed so a new family is proposed to encompass them – the Isodiscaceae.

**Family Isodiscaceae fam. nov.**

Valves circular with narrow mantle. Valve surface flat with 2 (or 3) large circular–subcircular areas of raised porelli lying opposite (or at regular intervals) at valve/mantle junction, often with smaller circular areas of porelli positioned regularly between larger ones. Rimoportulae central, multiple, with internal openings elongate. Valve interior with interrupted radial rows of poroid areolae and well-developed sipho marginalis. **Typus**: *Isodiscus* Rattray 1888

Taking into consideration the combination of features present in *Isodiscus* it appears more likely that the Isodiscaceae belongs with the biddulphioids rather than the eupodiscoids due to the presence of multiple central rimoportulae and the two (rarely three) larger raised circular areas of porelli (pseudocelli) lying opposite each other (or at regular intervals) that suggests a polarity present in the biddulphioids.

**Acknowledgements**

Thanks are due to Peter York, Nick Hayes and Pat Hart for help with photography and Gillian Lockett and Geraldine Reid for assistance.

**References**


