



Some *Cocconeis* species (Bacillariophyceae) originally described by William Gregory and Robert Kaye Greville from the Firth of Clyde and Loch Fyne (Scotland)

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With 38 figures and 2 tables

Abstract: Several marine diatoms (Bacillariophyceae) were described from the Firth of Clyde and Loch Fyne (Scotland) among which 12 *Cocconeis* species by William Gregory in 1855–1857, with two additional species by Robert Kaye Greville in 1859. Five Gregory's original slides 'Arran57' (Greville's slide collection, housed in the Natural History Museum, BM) from Lamlash Bay (Arran Island, Firth of Clyde) were examined and several taxa marked by Greville (diamond circle on the cover slip and quotation on the label of these slides) are re-investigated: i.e., *Cocconeis arraniensis* Greville, *Cocconeis distans* W.Gregory, *Cocconeis nitida* W.Gregory, *Cocconeis ornata* W.Gregory and *Cocconeis pseudomarginata* W.Gregory. These species have been originally incompletely described by Gregory (1855–1857) and Greville (1859) and their illustrations by Greville are not always fully informative. Some ambiguity can be noted about species showing similarities in their morphology but likewise present in the material: i.e., *C. ornata* and *Cocconeis quarnerensis* (Grunow) A.W.F.Schmidt; i.e., *C. distans*, *C. nitida* and *Cocconeis gregoryi* sp. nov. Since the original raw material used by Gregory for the 'Arran57' slides was not found in BM, no scanning electron microscope observation of the material has been possible. Nevertheless, modern light microscopy permits to accurately focus on the striation and other features of the valves marked by Greville and to complete the original description and iconography of several taxa.

Key words: Achnanthales, *Cocconeidaceae*, William Gregory, Robert Kaye Greville, 'Arran57' type slides.

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Introduction

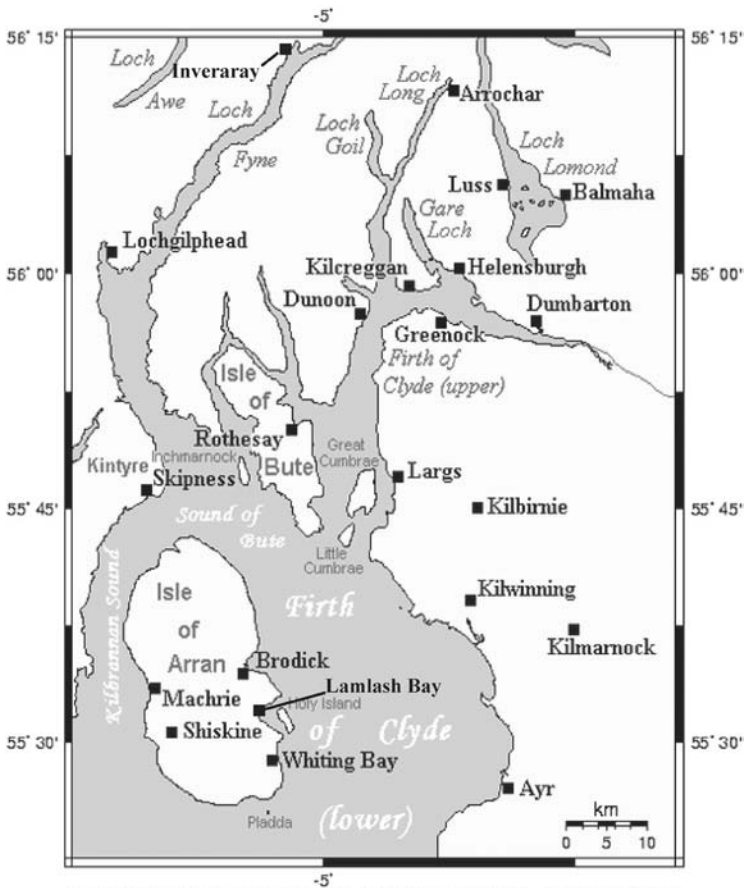
The British Association for the Advancement of Science (BAAS) dredging committee, composed of e.g., Charles Popham Miles, Robert Kaye Greville, John Hutton Balfour and Thomas Campbell Eyton, made regular dredgings for scientific purpose in Lamlash Bay (Arran Island, Firth of Clyde, Scotland), from 1834 to 1856 (Moore 2010). Gregory (1855), Gregory (1857a,b) and Greville (1859) examined several of these dredged samples and contributed to the knowledge of marine diatoms (Bacillariophyceae) off Lamlash Bay and Loch Fyne, particularly pertaining to the genus *Cocconeis* Ehrenberg (Table 1).

Gregory (loc. cit.) studied and described the diatoms from post-Tertiary diatomaceous sand dredged by the Duke of Argyll upstream of Loch Fyne (Glenshira near Inveraray, Fig. 1; Gregory 1855). Afterwards he described the diatoms from some marine current samples from Lamlash Bay (Arran Island, Fig. 1) dredged by Charles Popham Miles and George James Allman and from Loch Fyne by Dr Barclay and Duke of Argyll (Gregory 1857a,b). The iconography of all the latter papers was due to Greville. Finally, Gregory examined samples dredged in 1857 in Lamlash Bay by John Hutton Balfour (coll. Arran57), and noticed several new taxa but his death (24 April 1858) prevented him to publish these new taxa which were finally published by Greville (1859).

In total 12 new *Cocconeis* species were described from the Firth of Clyde and Loch Fyne by Gregory (1855, 1857a,b) and two by Greville (1859) (Table 1). In this paper we observed specimens of six of these species marked by Greville (ringed and labelled) on several 'Arran57' Gregory's original slides (Greville's slide collection, BM): i.e., *Cocconeis distans* W.Gregory, *Cocconeis nitida* W.Gregory, *Cocconeis ornata* W.Gregory, *Cocconeis pseudomarginata* W.Gregory (Gregory 1857a,b); *Cocconeis pinnata* W.Gregory ex Greville and *Cocconeis arraniensis* Greville (Greville 1859). The latter taxa were all originally illustrated by only one drawing referring most of time to the sternum valve (SV), with often the indication of a raphe seen through the SV (see text). Types were not indicated, nor by Gregory, neither by Greville since this was not the rule at that time, but the slide 'Arran57, BM.1560' has been afterwards assumed to be the holotype of *Cocconeis arraniensis* by Williams (1988), and 'Arran57, BM 4986' has been designated as lectotype of *Cocconeis pinnata* (Riaux-Gobin et al. 2014). From the examined 'Arran57' slides containing the above mentioned taxa marked by Greville, several taxa are re-investigated and their LM iconography completed. Several other taxa present on the slides and showing similarities with these *Cocconeis* species are briefly presented. Several ambiguities i.e., about the splitting or probable synonymy of *C. distans* and *C. granulifera* Greville are addressed. *Cocconeis gregoryi* sp. nov. is described.

Material and methods

Five slides annotated 'Arran57' and assigned to the original material (Gregory's material in Greville's slide collection, collector John Hutton Balfour, Natural History Museum, London, U.K.) have been examined (e.g., BM 4986, BM 1465, BM 1467, BM 1560 and BM 1217). Each slide has been labelled by Greville with an indication of particular taxa among which his new *Cocconeis* and some of the *Cocconeis* previously described by Gregory. No precise coordinates, such as Maltwood Finder, were



source [http://www.aquarius.geomar.de/omc/make_map.html here]

Fig. 1. Map of Firth of Clyde, Loch Fyne and Arran Island (Scotland, U.K.).

given for the location of specimens, only a rough position i.e., numbered diamond circles on the cover slips. The ringed specimens are not always easy to find. For an easier coordinate assignment-location of the specimens, and following Sterrenburg et al. (2012), we apposed a benchmark (not as precise and permanent as a mark with a diamond scribe, but a crux with a fine waterproof pencil, fixed by nail polish) which now indicates the 'x, y' origin on each slide. The coordinates of the marked specimens are now given in mm S and E.

The diatoms on the permanent slides were observed with a Zeiss Axiophot 200 microscope with differential interference contrast (DIC, obj. 100 × 2.5) and photographed with a Canon PowerShot G6 digital camera (CRIOBE-Perpignan University, France). The stria density is measured in the centre of the valve, between the margin and the axial area. Stria density on apices is given when it differs significantly from the latter.

Neither *Cocconeis distans*, *C. nitida*, *C. ornata*, nor *C. pseudomarginata* can be typified here, since the specimens observed do not pertain to the original material, but to material dredged from the same locality (Lamlash Bay, Arran Island, Scotland, Fig. 1) at a different date and by a different collector than the original material (Table 1).

Table 1: Gregory's and Greville's *Cocconeis* species from Firth of Clyde and Loch Fyne (Scotland), collector and original description reference. Glenshira locates on the upper Loch Fyne. * = illustrated in the present study. 'P' = indicates a preliminary AlgaeBase entry that has not been subjected to any kind of verification.

Species	Current name Synonymy	Collector(s)	Site(s)	Original description(s)
<i>Cocconeis arraniensis</i> Greville		Balfour	Lamlash Bay (Arran)	Greville 1859
<i>Cocconeis costata</i> W.Gregory		Duke of Argyll	Glenshira (upper Loch Fyne)	Gregory 1855, 1857a
<i>Cocconeis dirupta</i> W.Gregory		Miles	Corregills (Arran)	Gregory 1857b
* <i>Cocconeis distans</i> W.Gregory		Duke of Argyll & Allman	Glenshira & Lamlash Bay	Gregory 1855, 1857a,b
<i>Cocconeis</i> (?) <i>lamprostricta</i> W.Gregory	<i>Mastogloia lamprostricta</i> (W.Gregory) Desikachary & Sreelatha	Duke of Argyll	Glenshira (upper Loch Fyne)	Gregory 1857a
<i>Cocconeis major</i> W.Gregory	<i>Cocconeis pseudomarginata</i> W.Gregory	Allman & Miles	Lamlash Bay (Arran)	Gregory 1857b
* <i>Cocconeis nitida</i> W.Gregory	<i>Rhaphoneis nitida</i> (W.Gregory) Grunow	Allman & Miles	Lamlash Bay & Loch Fyne	Gregory 1857b
* <i>Cocconeis ornata</i> W.Gregory		Allman & Miles	Lamlash Bay & Loch Fyne	Gregory 1857b
<i>Cocconeis pinnata</i> W.Gregory ex Greville		Balfour	Lamlash Bay (Arran)	Greville 1859
* <i>Cocconeis pseudomarginata</i> W.Gregory		Allman & Miles	Lamlash Bay (Arran)	Gregory 1857b
<i>Cocconeis radiata</i> W.Gregory	'P'	Duke of Argyll	Glenshira (upper Loch Fyne)	Gregory 1857a
<i>Cocconeis speciosa</i> W.Gregory		Duke of Argyll	Glenshira (upper Loch Fyne)	Gregory 1855
<i>Cocconeis splendida</i> W.Gregory	<i>Orithoneis splendida</i> (W.Gregory) Grunow	Allman	Lamlash Bay (Arran)	Gregory 1857b
	<i>Mastogloia splendida</i> (W.Gregory) Peragallo			
<i>Cocconeis transversalis</i> W.Gregory	<i>Cocconeis scutellum</i> var. <i>parva</i> (Grunow) Cleve	Duke of Argyll	Glenshira (upper Loch Fyne)	Gregory 1855

For the description of the frustule, the morphological terminology follows Anonymous (1975), Ross et al. (1979) and Round et al. (1990). The valve with a raphe is designated as the raphe valve (RV) and the rapheless valve as the sternum valve (SV) (cf. Riaux-Gobin et al. 2013).

Results

Cocconeis arraniensis Greville

HOLOTYPE (?): (typified by Williams 1988; pl. 29, figs 1–3): Permanent 'Arran57' slide (BM 1560, Gregory's type material in Greville's slide collection, 'since no other slide is catalogued for this species' cf. Williams 1988: 24.

See original diagnose by Greville (1859, p. 80).

TYPE LOCALITY: Lamlash Bay (Scotland). Collector John Hutton Balfour, 1857.

ILLUSTRATION: Greville (1859; fig. 2, reproduced in Fig. 2A); Williams (1988; pl. 29, figs 1–3); our Figs 3–8, from Slide BM 1560, sector 1, coordinates 6.7 S, 13.9 E.

TAXONOMIC HISTORY: To our knowledge, no other quotation exists in the literature about *Cocconeis arraniensis* after the typification by Williams (1988).

VALVE MORPHOMETRY (our observations): 34.7 μm length, 19.4 μm width. SV: 12 striae in 10 μm (14 rounded areolae in 10 μm). Raphe valve (RV): 23–30 striae in 10 μm (22.5 areolae in 10 μm) (Table 2).

MORPHOLOGY: The original drawing (Fig. 2A) shows the SV striation with the RV raphe seen through the SV. The RV striation is illustrated in Williams (1988, pl. 29, fig. 3), nevertheless imperfectly since it is mostly the SV areolae through the RV that are visible on Williams's fig. 3, and not the real RV striation and areolae. The modern LM resolution permits to finely resolve the striation of the RV (Figs 3, 5–7), ca. 23 striae in 10 μm near the centre of the valve (Fig. 5) and slightly radiate and denser near apices (ca. 30 in 10 μm , Fig. 6, arrow). The central area is rounded and moderately enlarged (Fig. 5, arrow). The central raphe endings are well apart (Fig. 5). The terminal raphe fissures are close to the apex margin (Fig. 7, arrow). The SV striae are roughly grouped by two (Fig. 4). The SV sternum is straight and narrow (Fig. 8, arrows).

In the original morphometry of *C. arraniensis* the length, expressed in inch (0.0016"), was slightly overestimated (40.6 μm versus 34.7 μm , factor 0.85).

REMARKS: *Cocconeis arraniensis* shows some likeness with *Cocconeis clandestina* A.W.F.Schmidt in Schmidt et al. (1894, pl. 192, fig. 28; Riznyk 1973, figs 8–9) and *Cocconeis capensis* (Cholnoky) Witkowski (Witkowski et al. 2000; pl. 40, figs 9, 10; Riaux-Gobin et al. 2011; (?) *C. cf. capensis* pl. 83, figs 1–4). Note: the SEM illustration by Lisa Weimer in Cronin et al. (eds.) (2001) under *Cocconeis pediculus* Ehrenberg (pl. 2, fig. 2, SV) may be close to *Cocconeis arraniensis*.

Cocconeis ornata W.Gregory

See original diagnose by Gregory (1857b, p. 491)

ILLUSTRATION: Gregory (1857b; fig. 24, reproduced in Fig. 2B); Peragallo & Peragallo (1897; pl. 4, figs 14–16); Østrup (1910, *Cocconeis ornata* Greg.?, Tab. I, fig. 24, pl. XIII, fig. 14); Hustedt (1933, fig. 793).

Table 2: Morphological features of the discussed taxa.

	<i>C. gregoryi</i> sp. nov. (present study)	<i>C. disculus</i> (Schumann) Cleve (Hustedt 1933–1959)	<i>C. guttata</i> Hustedt & Aleem (Hustedt & Aleem 1951; Simonsen 1987)	<i>C. arraniensis</i> (present study)	<i>C. distans</i> (present study)	<i>Raphoneis</i> <i>nitida</i> (Cocco- <i>neis nitida</i> (present study)	<i>C. ornata</i> (present study)	<i>C. quarner- ensis</i> (present study)	<i>C. pseudo- marginata</i> (present study)
n	9	-	-	1	12	4	3	7	1
Valve shape	elliptical, subacute apices	elliptical to elliptical lanceolate, rounded apices	elliptical, rounded apices	elliptical, rounded apices	elliptical-lan- ceolate, sub- acute apices	broad oval, short subacute apices	oval	oblong- elliptical, subacute apices	broad elliptical
Length (μm)	24.7–30 (27.5 \pm 1.9)	20–25	15	34.7	29.1–55 (37.1 \pm 7.2)	37.5–58 (44.8 \pm 9.1)	35–43.5 (40.5 \pm 4.8)	32.4–36.7 (34.2 \pm 1.4)	34.4
Width (μm)	15.5–21.4 (18.8 \pm 1.8)	11–16	9	19.4	17.5–40 (24.7 \pm 5.6)	30–37 (32.3 \pm 3.3)	25.6–28 (27.1 \pm 1.3)	17–20.3 (19.2 \pm 1.2)	25.2
Striae on RV: density (in 10 μm)	18.3–23 (20.5 \pm 1.9)	22	22	23–30	13–14 (13.8 \pm 0.4)	no RV	14.5–15 (14.7 \pm 0.3)	9.5–10.5 (9.8 \pm 0.5)	22
orientation	strongly radiate towards apices	radiate	almost parallel, very slightly radiate towards apices	radiate towards apices	radiate		radiate	strongly radiate towards apices	radiate
Particular features	RV striae denser on apices		narrow, irregular apices	narrow, straight	one marginal row of denser areolae				
Sternum on SV	largely elliptical, constricted on the middle	narrow- lanceolate	narrow, irregular	narrow, straight	narrow	narrow elliptical	large elliptical area, with radiate design	large elliptical area	large

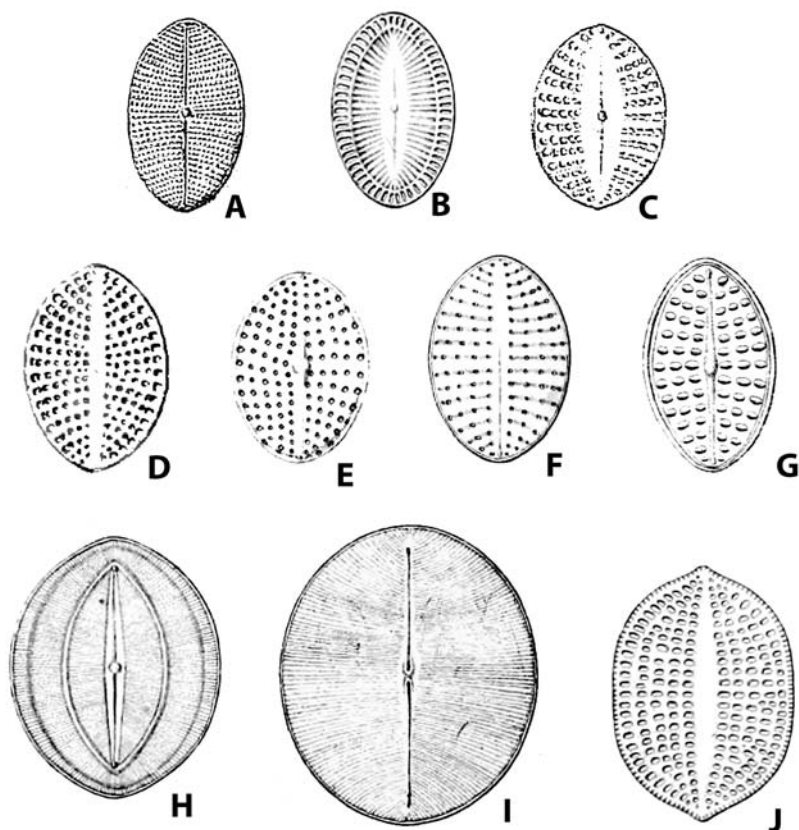
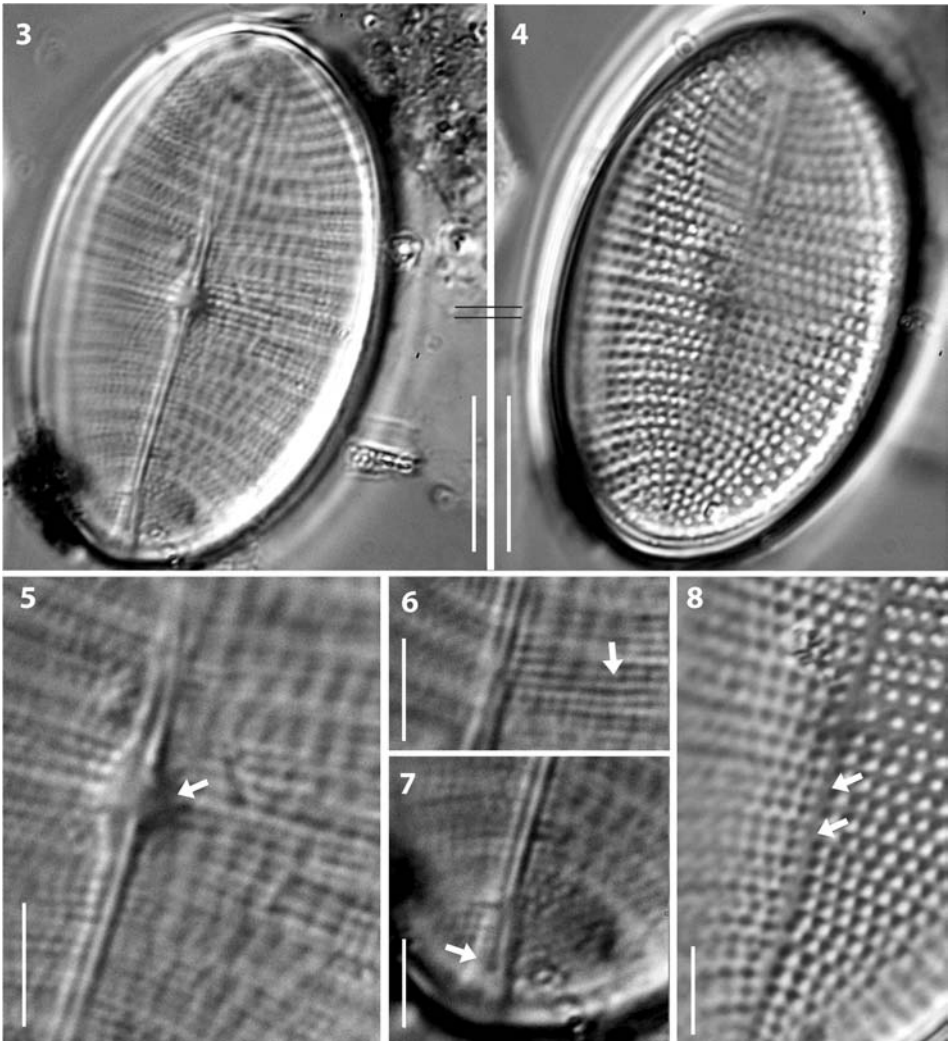


Fig. 2 A–J. Original drawings of A) *Cocconeis arraniensis* Greville (Greville 1859, fig. 2), B) *Cocconeis ornata* W.Gregory (Gregory 1857b, fig. 24), C) *Cocconeis pinnata* W.Gregory ex Greville (Greville 1859, pl. 6, fig. 1), D–F) *Cocconeis distans* W.Gregory (Gregory 1855, 1857a, 1857b), G) *Cocconeis granulifera* Greville (Greville 1861, fig. 19), H–I) *Cocconeis pseudomarginata* W.Gregory (Gregory 1857b, figs 27, as *Cocconeis pseudomarginata*, fig. 28 as *Cocconeis major*), J) *Raphoneis* (*Cocconeis*) *nitida* (W.Gregory) Grunow (Gregory 1857b, fig. 26).

ILLUSTRATION FROM 'ARRAN57' SLIDES: Figs 9–10, slide BM 1467, unmarked specimen, close to sector 6, coordinates 15.5 E, 14 S. Figs 11–12, slide BM 1465, specimen marked from Sector 1, coordinates 8.5 E, 2.5 S. Figs 13–14, slide BM 1217, specimen marked from sector 7, coordinates 13.3 E, 8.5 S.

TAXONOMIC HISTORY: Peragallo & Peragallo (1897) illustrated 3 SV (pl. 4, figs 14–16, ref. cit.) and mentioned the RV (without illustration) as being finely striated. Hustedt (1933) presents a SV and wrongly a RV (fig. 793) with a striation similar to that of the SV, while the latter illustrates a SV with the raphe seen through it. A variety, *Cocconeis ornata* var. *signata* (H.Peragallo & Peragallo) Hustedt, requires further examination since only the SV was observed (Hustedt 1933). Østrup (1910) presents illustrations of poor quality of (?) *Cocconeis ornata* (question mark by Østrup). More recently, Pestrea



Figs 3–8: *Cocconeis arraniensis* Greville from type slide 'Arran57' BM 1560 (Holotype), sector 1, coordinates 6.7 S, 13.9 E. Fig. 3, RV and Fig. 4, SV of a same frustule; Fig. 5, RV central area (arrow); Fig. 6, RV striae near apex (arrow); Fig. 7, RV, terminal raphe fissure, close to the margin (arrow); Fig. 8, SV narrow sternum (arrows). LM, scale bars: 10 μ m (Figs 3, 4); 5 μ m (Fig. 8); 3 μ m (Figs 5–7).

& Saint Martin (2002, fig. 5C) illustrate with LM a taxon assigned to *C. ornata*, but it shows similarities with *Cocconeis quarnerensis*.

Montgomery (1978; pl. 61, figs A–D, no RV) illustrates with SEM external SV views of *C. ornata* showing short marginal clearly biseriate striae. The embossed designs

on the SV middle field are composed of two (up to three) parts (Montgomery 1978), while among the three 'Arran57' specimens examined, only one presents such a feature. Several recent Internet illustrations of the SV of *C. ornata* are conforming to Peragallo & Peragallo (1897): Loir (2011), PlanktonNet (2013).

VALVE MORPHOMETRY ('ARRAN57' SPECIMENS, AMONG WHICH TWO ARE MARKED BY GREVILLE): our observations (Figs 5–10): 35–43.5 μm length, 25.6–28 μm width. SV: 4.7–5.8 striae in 10 μm (5.3 ± 0.3). RV: 13.5–16 striae in 10 μm (14.7 ± 0.3) (Table 2).

MORPHOLOGY: The middle field of the SV is largely elliptical and separated by a hyaline festooned rim from the short marginal striae (Fig. 9); this area shows 'striae' (or embossed designs apparently exempt of areolae, Montgomery 1978) in the prolongation of the marginal virgae and not in prolongation of the marginal striae as stated in the original description (see above). These embossed designs are moderately radiate (Figs 9, 11). The RV (illustrated for the first time, Figs 10, 12) has dense striae (14.7 ± 0.3 in 10 μm), equidistant and moderately radiate even on apices. Supplementary marginal RV striae are taking place on the mid-valve. There is no marginal rim on the RV. The central area of the RV is elliptical and transapically enlarged (Fig. 12, arrow). The raphe is straight with central raphe endings well a part and terminal raphe fissures close to the apex (Fig. 12).

REMARKS: If the original drawing due to Greville (Gregory 1857b; fig. 24, reproduced in Fig. 2B) refers to *Cocconeis ornata*, it illustrates the SV striation with the raphe seen through the SV. The stria density is not indicated in the original description, but can be extrapolated to 6 striae in 10 μm (slightly higher than in our measurements) since the valve length is originally mentioned as 0.0022". Note that the specimen drawn is narrower than the ringed 'Arran57' specimens. Furthermore, the middle field embossed designs are described and drawn as nearly vertical on apices (Fig. 2B) contrary to what our illustrations show (Figs 10, 12).

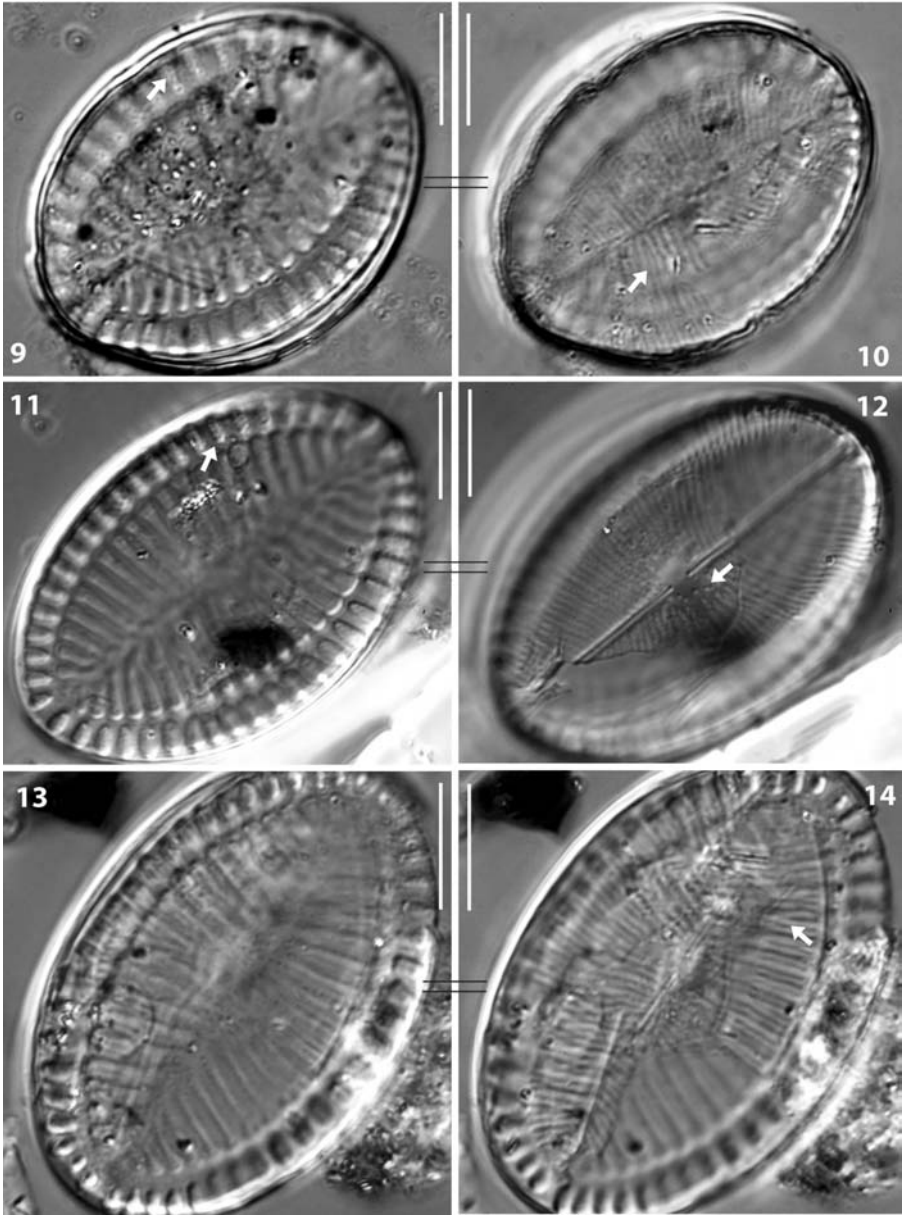
On the examined 'Arran57' slides, several specimens of *Cocconeis quarnerensis* are noticed (Figs 15–20). Even if *C. quarnerensis* valves have a smaller size and a higher stria density on the SV than *C. ornata* (Table 2), it cannot be excluded that the original drawing of *C. ornata* combined the two taxa (see particularly Figs 17 and 19, showing two specimens of *C. quarnerensis* with strongly radiate RV striae, along with the short SV marginal striae seen through the RV).

NOTE: The presence of *Cocconeis ornata* is not reported from any other Gregory's slide 'Arran 57' (in Greville's collection) (Jovita Yesilyurt, Natural History Museum, London, pers. com.). It would be necessary to obtain material from the samples originally studied by Gregory (1857b) to designate a lectotype: nevertheless, if no original sample can be found in the future, the original figure by Gregory (1857b; fig. 24) could serve as lectotype.

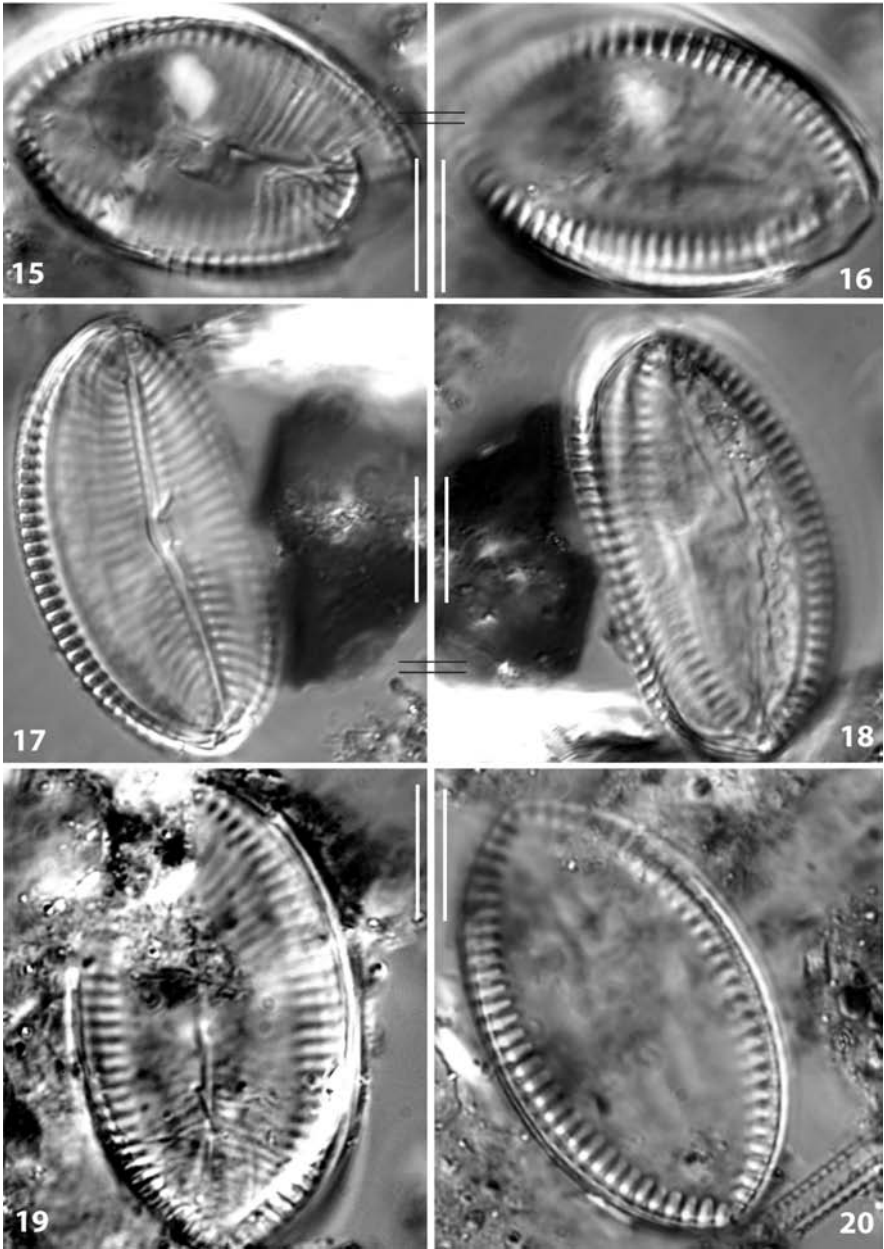
***Cocconeis quarnerensis* (Grunow) A.W.H.Schmidt**

BASIONYM: *Rhaphoneis quarnerensis* Grunow (1862; pl. 4.7: fig. 24).

HOMOTYPIC SYNONYM: *Planothidium quarnerense* (Grunow) Witkowski, Lange-Bertalot et Metzeltin in Witkowski et al. (2000; 123, pl. 55, figs 2–7). See comments in Sar et al. (2003) about this transfer.



Figs 9–14: *Cocconeis ornata* W.Gregory. Illustrations from 'Arran57' slides: Figs 9–10, slide BM 1467, unmarked specimen, close to sector 6, coordinates 15.5 E, 14 S. Fig. 9 (SV), Fig. 10 (RV, with dense striation, arrow) of the same specimen. Figs 11–12, slide BM 1465, specimen marked from sector 1, coordinates 8.5 E, 2.5 S. Fig. 11 (SV with biseriate short striae on the margin, arrow) and Fig. 12 (RV with round central area and intercalary striae, arrow) of the same specimen. Figs 13–14, slide BM 1217, specimen marked from sector 7, coordinates 13.3 E, 8.5 S. Fig. 13 (SV) and Fig. 14 (RV seen through the SV, with dense striation, arrow) of the same specimen. LM, scale bars: 10 μ m.



Figs 15–20: *Cocconeis quarnerensis* (Grunow) A.W.H.Schmidt. Illustrations from 'Arran57' slides: Figs 15–16, slide BM 1217, close to sector 1, coordinates 6 E, 10.5 S. Fig. 15 (RV), Fig. 16 (SV) of the same frustule. Figs 17–18, slide BM 1465, coordinates 17 E, 14 S. Fig. 17 (RV), Fig. 18 (SV) of the same frustule. Fig. 19, slide BM 1465, from sector 1, coordinates 8.5 E, 2.5 S (a complete frustule showing the 2 valves). Fig. 20, slide BM 4986, coordinates 8 E, 12.5 S (SV alone). LM, scale bars: 10 μ m.

ILLUSTRATION: Schmidt et al. (1894; pl. 192, figs 20–24). Peragallo & Peragallo (1897; pl. 2, figs 7, 8); Hustedt (1933, fig. 814).

ILLUSTRATION FROM 'ARRAN57' SLIDES: Figs 15–16, slide BM 1217, close to sector 1, coordinates 6 E, 10.5 S. Figs 17–18, slide BM 1465, coordinates 17 E, 14 S. Fig. 19, slide BM 1465, from sector 1, coordinates 8.5 E, 2.5 S. Fig. 20, slide BM 4986, coordinates 8 E, 12.5 S.

VALVE MORPHOMETRY (our observations, n=7, Figs 11–16): 32.4–36.7 μm length (34.3 ± 1.5), 17–20.2 μm width (19.2 ± 1.4). SV: 8.5–9 striae in 10 μm (8.6 ± 0.5). RV: 9.5–10.5 striae in 10 μm (9.8 ± 0.5) (Table 2).

REMARKS: The specimens from 'Arran57' slides match the descriptions of *Cocconeis quarnerensis* by Schmidt et al. (1874–1959), Peragallo & Peragallo (1897) and Hustedt (1933). The original drawing of *C. ornata* (Gregory 1857b; fig. 24, our Fig. 2B) could be a combination of the features of *C. ornata* with those of *C. quarnerensis*, since the latter taxon, not yet described in 1857 and thus unknown to Gregory, is not rare in the observed 'Arran57' slides.

Cocconeis pinnata W.Gregory ex Greville (1859: 79; pl. 6, fig. 1) emend Riaux-Gobin, Compère & Romero (see Riaux-Gobin et al. 2014)

LECTOTYPE (ref. cit.: BM 4986, specimen located at sector 5, position 4 S, 14.5 E, fig. 9)

ILLUSTRATION: Greville (1859; pl. 6, fig. 1, reproduced in Fig. 2C); Grunow in Van Heurck (1880; figs 6, 7); Cleve (1895, p. 181); Peragallo & Peragallo (1897; pl. 2, figs 11–14).

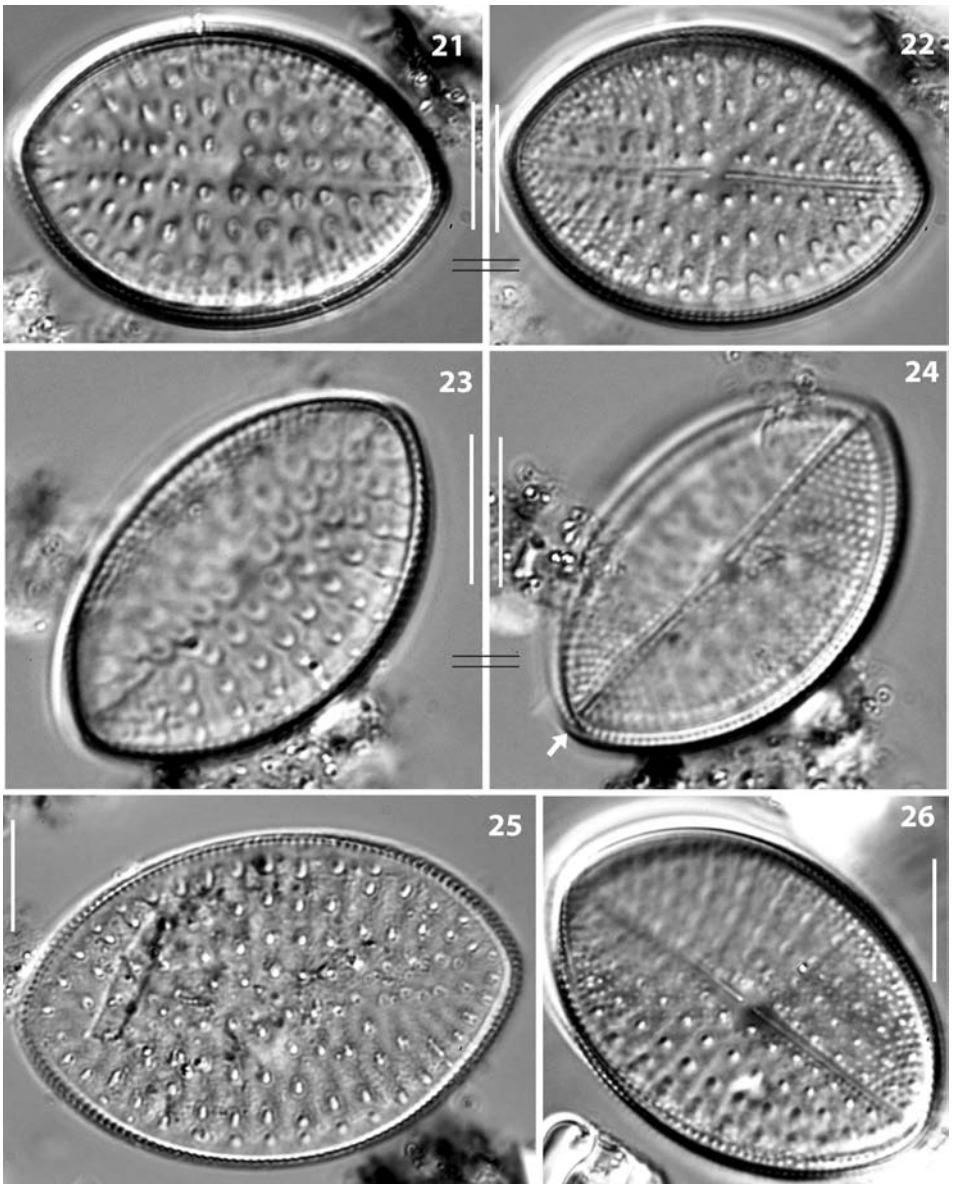
SEE VALVE MORPHOMETRY, ILLUSTRATION FROM 'ARRAN57' SLIDES AND EMENDED DESCRIPTION (Riaux-Gobin et al. 2014).

BRIEF DESCRIPTION: Sternum valve with a wide elliptical axial area, marginal area lacking areolae and depressed. Striae robust, raised, radiate and biseriate near the margin. Areolae externally ornamented by complex arborescent volae, internally occluded by a hymen with radial slits. Spherical corpuscles on the entire valve. SV valvocopula wide, flat and thick, open at one apex, bordered by large fimbriae. In internal view, presence of loculi. Raphe valve flat to slightly concave. Raphe straight, filiform, with simple distal raphe endings close to the margin. Central raphe endings close to each other and coaxial. Axial area narrow and straight. Central area small and oblong. Striae dense and radiate, composed of small, round areolae with one marginal row of 'flame'-like areolae. Shorter intercalary striae present. Areolae externally ornamented by short branched volae. Helictoglossae non-protruding, straight. RV valvocopula opened at one apex. In addition to valvocopulae, cingulum consisting of at least one flat copula.

Cocconeis distans W.Gregory

ILLUSTRATION: Gregory (1855; fig. 9, reproduced in Fig. 2D, considered afterwards by Gregory 1857a, as an illustration of *Cocconeis scutellum*); Gregory (1857a; fig. 25, reproduced in Fig. 2E); Gregory (1857b; fig. 23, reproduced in Fig. 2F); Hustedt (1933, fig. 797).

ILLUSTRATION FROM 'ARRAN57' SLIDES: Figs 21–22, slide BM 1467, unmarked specimen, coordinates 11.5 E, 3 S. Figs 23–24, slide BM 1465, specimen close to Sector 2, unmarked specimen. Fig. 25, slide BM 4986, specimen marked from Sector 2. Fig. 26, slide BM 4986, specimen marked from sector 3, coordinates 6 E, 5.5 S.



Figs 21–26: *Cocconeis distans* W.Gregory. Illustration from 'Arran57' slides: Figs 21–22, slide BM 1467, unmarked specimen, coordinates 11.5 E, 3 S. Fig. 21 illustrates the SV and Fig. 22 the RV of one frustule, with central raphe endings and RV striation well identifiable. Figs 23–24, slide BM 1465, specimen close to sector 2, unmarked specimen. Fig. 23 illustrates a SV and Fig. 24 the RV of one specimen (terminal raphe fissure, arrow). Fig. 25, slide BM 4986, specimen marked from sector 2 (SV alone). Fig. 26, slide BM 4986, specimen marked from sector 3, coordinates 6 E, 5.5 S (a complete frustule). LM, scale bars: 10 μ m.

VALVE MORPHOMETRY ('ARRAN57' SLIDES) (our observations): 29.1–55 μm length (37.1 ± 7.4), 17.5–40 μm width (24.7 ± 5.6). SV: 4.4 ± 0.3 striae in 10 μm . RV: 13.8 ± 0.4 striae in 10 μm ; marginal row of areolae with similar density in the two valves (av. 15.6 ± 1.6 in 10 μm , Table 2).

REMARKS: The original illustrations of *C. distans* are due to Greville (Gregory 1857a,b) but, afterwards this author described *C. granulifera* Greville (1861; p. 73, fig. 19, reproduced in Fig. 2G) that is currently considered a synonym of *C. distans* (VanLandingham 1968). In 'Arran57' slides two forms of *C. distans* can be noticed, 1) quite abundant specimens with small size, highly silicified (length averaging 30–35 μm and width 20–25 μm , cf. Figs 21–24, 26), while 2) the second form is scarcer and less silicified, with a bigger size (average 45 μm in length and 30 μm in width, Fig. 25). The stria density of the SV is similar in both forms. The RV has not been observed on the second form. These differences may have induced the creation of the second species, *C. granulifera* Greville (1861; fig. 19 and Williams (1988); pl. 29, fig. 10), that is currently considered a heterotypic synonym of *C. distans*.

Supporting the ambiguity between *C. distans* and *C. granulifera*, the illustration of *C. granulifera* Grunow by Peragallo & Peragallo (1897; pl. 3, figs 17, 18) has similarities with our specimens with low silicification and large size (Fig. 25). On the other hand, the illustration of *C. distans* by Peragallo & Peragallo (1897; pl. 3, figs 14–15) is very different from the original drawings by Greville (reproduced in Figs 2E,F). Peragallo & Peragallo (1897; pl. 3, fig. 19) illustrate a specimen under *C. granulifera* var.?, with a low and irregular striation on the SV and an elliptical large sternum (no RV illustrated). The latter taxon can be compared with the specimens found in the 'Aran57' slides and described here as *C. gregoryi* sp. nov. (see below).

***Cocconeis gregoryi* Riaux-Gobin, Compère et Ector sp. nov.**

HOLOTYPE: Permanent slide 'Arran57', from Gregory's type material in Greville's slide collection (BM 1467, Natural History Museum, London). Holotype specimen illustrated in Figs 27, 28.

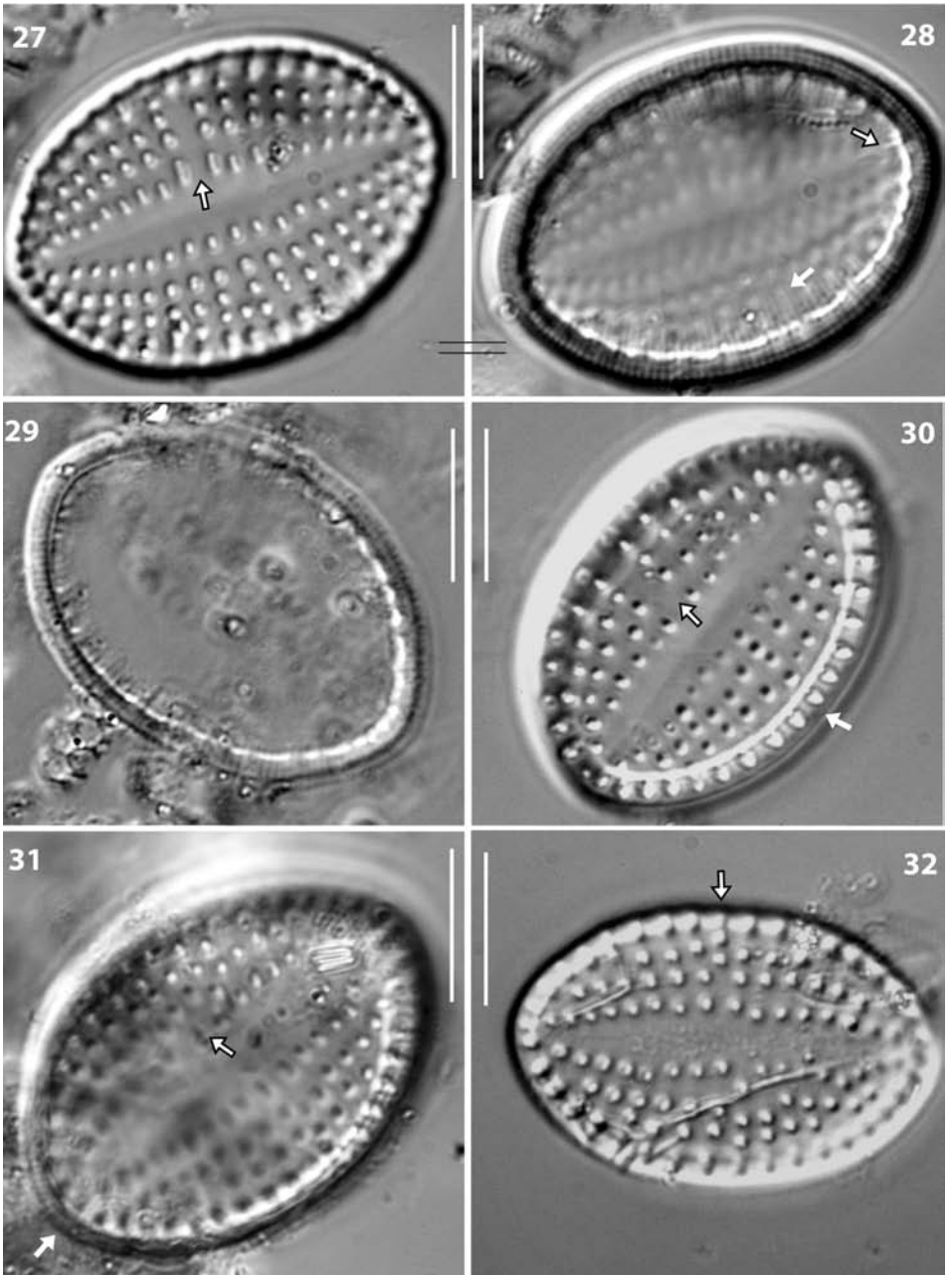
TYPE LOCALITY: Lamash Bay (Scotland). Collector John Hutton Balfour, 1857.

VALVE MORPHOMETRY ('ARRAN57' SLIDES): 24.7–30 μm length (27.5 ± 1.9), 15.5–21.4 μm width (18.8 ± 1.8). SV: 6.5–7 (6.5 ± 0.5) striae in 10 μm . RV: 18.3–23 (20.5 ± 1.9) striae in 10 μm (Table 2).

DESCRIPTION: Valves flat, elliptical-lanceolate, 24.7–30 long, 15.5–21.4 wide. SV with coarse structure, 6.5–7 radiate, transapical striae in 10 μm , composed of 4 to 5 large areolae with 'nitid' aspect, arranged along 3 to 4 apical striae. One stria lacking (or shorter) in the centre on one side of the SV (or on both sides) (Figs 27, 30, 31, framed arrows). Large lanceolate sternum, slightly narrowing in mid-valve. One marginal row of regular areolae (Fig. 30, white arrow) possibly separated from the rest of the valve by a hyaline rim (Fig. 30). RV finely and densely striated as illustrated in Fig. 28 (arrow) and Fig. 29 (18.3–23 striae in 10 μm). Presence of a hyaline and elevated rim on the margin of the RV (Figs 28, 29). Raphe difficult to resolve (framed arrow in Fig. 28).

ILLUSTRATION FROM 'ARRAN57' SLIDES: Figs 27–28, slide BM 1467, specimen marked as *Cocconeis nitida* from Sector 1, coordinates 3.7 E, 5 S. Fig. 29, from slide BM 1467. Fig. 30, from slide BM 4986, near sector 2. Fig. 31, slide 1467, coordinates 11.5 E, 7.5 S. Fig. 32, from slide BM 4986.

ETYMOLOGY: Named in honor of William Gregory.



Figs 27–32: *Cocconeis gregoryi* Riaux-Gobin, Compère et Ector. Illustration from 'Arran57' slides: Figs 27–28, slide BM 1467, specimen marked as *Cocconeis nitida* (= *Rhaphoneis nitida*, see text) from sector 1, coordinates 3.7 E, 5 S (illustration of *Cocconeis gregoryi* holotype). Fig. 27 illustrates the SV (with one stria lacking, framed arrow) and Fig. 28 the RV of one frustule, with dense striae (arrow) and a terminal raphe fissure (framed arrow). Fig. 29 (a corroded RV with the marginal rim), Fig. 30 (SV), Fig. 31 (SV), Fig. 32 (SV).

REMARKS: *Cocconeis gregoryi* shows likeness with *Cocconeis disculus* (Schumann) Cleve, but has several unique features (Table 2): 1) a slightly larger size (24.7–30 µm versus 20–25), 2) slightly less dense striae on the SV (6.5–7 striae in 10 µm versus 7–9), 3) SV areolae mainly rounded and 'nitid' and not transapically elongated, 4) one stria lacking or shorter, in the centre on one side – or on both sides – of the SV, 5) SV sternum lanceolate, wide and slightly constricted in mid-valve, 6) one marginal row of regular SV areolae, 7) an elevated festooned rim on the RV.

Likewise, *C. gregoryi* has some similarities with *C. guttata* Hustedt & Aleem (Table 2). Nevertheless, *C. guttata* has not this large elliptical SV sternum and has no marginal rim, neither in the RV nor in the SV. Furthermore the RV striae in *C. guttata* are only slightly radiate on apices while they are strongly radiate on the whole RV valve on *C. gregoryi* (Fig. 28).

C. gregoryi shows also some similarities with the specimen illustrated under the name *C. distans* in Schmidt et al. (1894; pl. 193, fig. 36), with a large lanceolate SV sternum slightly constricted in mid-valve. Nevertheless, the latter is not lacking a stria in mid-valve as in *C. gregoryi*.

It can be noted that one specimen (illustrated in Figs 27–28), has been labelled as *Cocconeis nitida* by Greville, probably due to the aspect of the areolae.

***Cocconeis pseudomarginata* W.Gregory**

SYNONYM: *Cocconeis major* W.Gregory (1857b; fig. 28, reproduced in Fig. 2I).

Both found in Allman's dredging from Lamash Bay, and dredging of Miles from the same locality.

ILLUSTRATION: Gregory (1857b; fig. 27, reproduced in Fig. 2H and fig. 28, reproduced in Fig. 2I); Peragallo & Peragallo (1897; pl. 2, figs 21–24); Hustedt (1933, fig. 813); SEM illustration in Romero & Navarro (1999).

ILLUSTRATION FROM 'ARRAN57' SLIDE: Figs 33–34, slide BM 4986, marked specimen, sector 4, coordinates 22.5 E, 3.5 S.

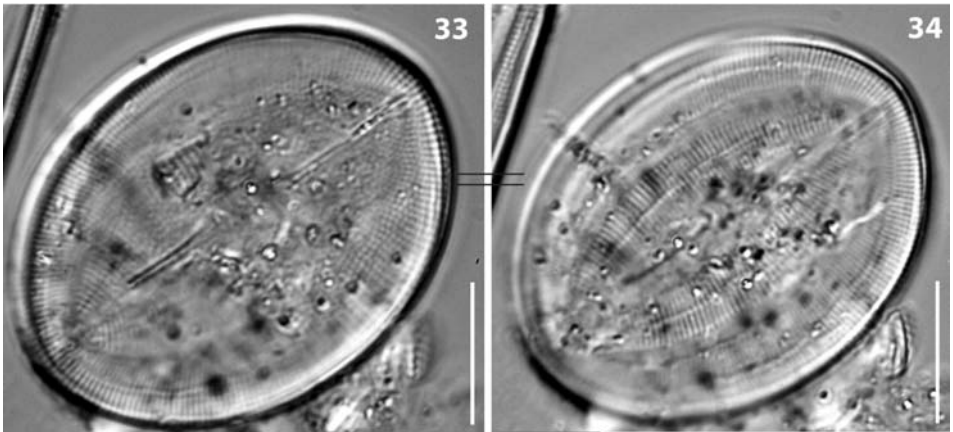
VALVE MORPHOMETRY ('ARRAN57' SLIDE) (our observations): 34.4 µm length, 25.2 µm width. SV: 24 striae in 10 µm on the margin of the valve. RV: 22 striae in 10 µm on the margin; 27.5 areolae in 10 µm on RV (Table 2).

REMARKS: The specimen marked by Greville in slide BM 4986 is very similar to that illustrated in Gregory (1857b, reproduced in Fig. 2H). The features of this taxon fit those of *C. pseudomarginata* as referred to in Hustedt (1933).

***Rhaphoneis nitida* (W.Gregory) Grunow**

BASEONYM: *Cocconeis nitida* W.Gregory (found in Lamash Bay and Loch Fyne, Gregory 1857b, p. 492);

from slide BM 1467. Fig. 30 (a SV with a marginal row of regular areolae, arrow, and one stria lacking, framed arrow), from slide BM 4986, near sector 2. Fig. 31 (SV with one stria lacking, framed arrow), slide 1467, coordinates 11.5 E, 7.5 S. Fig. 32 (SV with one stria lacking, framed arrow and the wide sternum constricted on the middle), from slide BM 4986. LM, scale bars: 10 µm.



Figs 33–34: *Cocconeis pseudomarginata* W.Gregory. Illustration from 'Arran57' slide: Figs 33–34, slide BM 4986, marked specimen, sector 4, coordinates 22.5 E, 3.5 S. Fig. 33 illustrates the RV and Fig. 34 the SV of the same frustule. LM, scale bars: 10 μ m.

HETEROTYPIC SYNONYM: *Raphoneis liburnica* Grunow 1867, p. 99.

ILLUSTRATION: Gregory (1857b; fig. 26, reproduced in Fig. 2J); Grunow 1867 (p. 99); illustrated as *Raphoneis liburnica* Grunow in Peragallo & Peragallo (1897; pl. 3, figs 20, 21); Hustedt (1933, fig. 683).

ILLUSTRATION FROM 'ARRAN57' SLIDES: Figs 35–36, slide BM 1465, unmarked specimen, coordinates 3.8 E, 4 S. Fig. 37, unmarked, slide BM 1465. Fig. 38, slide BM 1467, marked from sector 5, coordinates 13 E, 9.5 S.

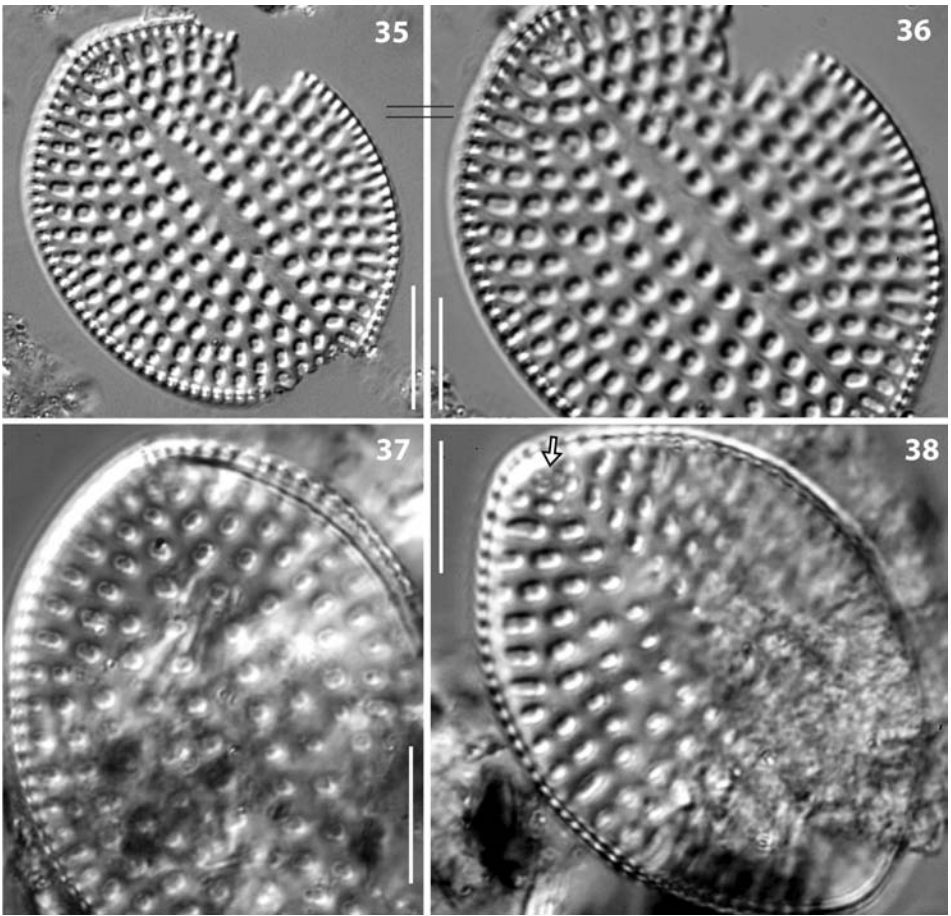
VALVE MORPHOMETRY ('ARRAN57' SLIDE) (our observations): 37.5–58 μ m length (44.8 ± 9.1), 30–37 μ m width (32.3 ± 3.3). 4–5 (4.6 ± 0.5) striae in 10 μ m. A marginal row of smaller areolae (8 ± 0.3 in 10 μ m).

REMARKS: The specimen observed in 'Arran57' slide BM 1465 fit the afterwards descriptions (e.g., Hustedt 1933).

Discussion and concluding remarks

The material 'Arran57' is particularly rich in *Cocconeis*: 8 taxa are mentioned or illustrated in the present paper. Furthermore, *Cocconeis britannica* Naegeli ex Kützing 1849, is also present in the 'Arran57' material (C.R.-G. pers. obs.). *Cocconeis costata* W.Gregory and *Cocconeis dirupta* W.Gregory were also described from the same region (Loch Fyne and Arran Island material, Gregory 1855, Gregory 1857b).

The actual LM pictures permit to illustrate the RV of several taxa originally only illustrated or described by their SV: i.e., *Cocconeis ornata*, *Cocconeis pinnata* and *Cocconeis distans*. Among these taxa, *C. pinnata* (detailed in SEM in Riaux-Gobin et al. 2013) has been often misidentified, until recently (Frenguelli & Orlando 1958; Romero



Figs 35–38: *Raphoneis nitida* (W.Gregory) Grunow. Illustration from 'Arran57' slides: Figs 35–36, slide BM 1465, unmarked specimen, coordinates 3.8 E, 4 S. Fig. 37, unmarked, slide BM 1465. Fig. 38, slide BM 1467, marked from sector 5, coordinates 13 E, 9.5 S. LM, scale bars: 10 μ m.

& Rivera 1996; Leterme et al. 2012). *C. ornata* has rarely been illustrated and only via its SV (e.g., Montgomery 1978). *C. distans* still remains much debated, with its synonym *Cocconeis granulifera* being considered a different taxon by Montgomery (1978) and Witkowski et al. (2000). Furthermore, Sar et al. (2003, figs 16–21 produced SEM illustration of *Cocconeis guttata* matching that of *C. distans*, proving that these taxa have been, until recently, confused or misidentified *Cocconeis quarnerensis*, present in 'Arran57' slides, can be easily discriminated from *C. ornata*, while the original drawing of the latter species can be a mixing between the two taxa, at that time both unpublished. *Cocconeis nitida* has been proved to be a Fragilariophyceae (Grunow 1867). Finally, a taxon with resemblance to

C. guttata, but with several unique features such as a large SV sternum slightly constricted in the middle, may also have similarity with *C. disculus* and is here described as *C. gregoryi*. The latter has 'nitid' areolae that have possibly induced its misidentification as *C. nitida* (see above).

It can be noted that the two authors, W.Gregory and R.K.Greville, did not mention the presence of the beautiful and complex *Cocconeis britannica* that had been formerly described by Kützing (1849). Furthermore *Cocconeis quarnerensis* quite abundant in the examined 'Arran57' slides will first be described as *Raphoneis quarnerensis* by Grunow (1862).

On a short period (1855–1859) the two involved researchers, W.Gregory (elected to the chair of chemistry at Edinburgh in 1844) and R.K.Greville (also interested in cryptogamic plants and macroalgae), permitted a fast advance in the taxonomy of temperate diatoms pertaining to *Cocconeis*, but also to several other genera.

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