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FINE MORPHOLOGY OF *COSCINODISCUS JONESIANUS* AND *COSCINODISCUS COMMUTATUS* AND THEIR TRANSFER TO *COSCINODISCOPSIS* GEN. NOV.

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Keywords: *Coscinodiscus jonesianus*, *Coscinodiscus commutatus*, *Coscinodiscopsis* gen. nov., diatoms.

The present study was devoted to the morphology, taxonomy, and distribution of *Coscinodiscus jonesianus* (Greville) Ostenfeld and *C. commutatus* Grunow. As far as was determined there were no previous studies of the fine morphology of the latter taxon. Therefore, this analysis presents differences between the taxa and reliable information for biogeographical studies. Planktonic samples were collected between October 1994 and September 2000 at seven stations along the northern coast of Buenos Aires Province. Samples and slides from the Hustedt Collection containing *C. commutatus* from the North Sea were analyzed and compared with material collected from Buenos Aires coastal waters. Raw and cleaned samples were analyzed using light and scanning electron microscopy. The presence/absence of an irregular ring of mesorimoportulae over the valve surface, and the striation pattern of the valvocopulae were determined as the only striking features that differentiated the taxa. Based on the modern generic limits of *Coscinodiscus*, *C. jonesianus* and *C commutatus* differ from other species in the external morphology of micro-rimoportulae and macrorimoportulae. We therefore propose the creation of the new genus *Coscinodiscopsis* Sar & Sunesen.

INTRODUCTION

The genus *Coscinodiscus* was erected by Ehrenberg (1839) who gave the size and areolae pattern as diagnostic features. VanLandingham (1968) considered 400 taxa in the genus, fossil and recent, to be validly published. More recently, Fryxell & Hasle (1972, 1973) transferred several species of *Coscinodiscus* to the genera *Thalassiosira* Cleve emend. Hasle and *Actinocyclus* Ehrenberg. *Coscinodiscus trioculatus* Taylor was established as type species of the genus *Minidiscus* Hasle (1973), *Coscinodiscus nitidus* Gregory as type species of the genus *Psammodiscus* Round & Mann (1980), *Coscinodiscus wittianus* Pantoseck as type species of the genus *Thalassiosiropsis* Hasle & Syvertsen (1985), *Coscinodiscus stellaris* Roper was transferred to the genus *Stellarima* by Hasle & Sims (1986a) and a group of species

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with a central rimoportula and one marginal ring of rimoportulae were transferred to the genus *Azpeitia* Peragallo by Fryxell *et al.* (1986).

According to Fourtanier & Kociolek (1999) *Coscinodiscus* is a conserved name with *C. argus* Ehrenberg as conserved type by resolution of the International Botanical Congress of Yokohama (ICBN, Greuter *et al.* 1994) based on arguments given by Fryxell (1978), who accepted the criterion of selection of the type previously presented by Ross & Sims (1974).

Hasle & Sims (1986b) analyzed the original Ehrenberg's slides and material from the type localities of *Coscinodiscus argus* Ehrenberg and *C. radiatus* Ehrenberg, and amended the description of the genus *Coscinodiscus* clarifying its generic limits. They pointed out that this genus is characterized by: loculate areolae with external vela and internal foramina on the valve; marginal ring of rimoportulae including two larger processes projecting inwards by not outwards; sometimes two marginal rings of rimoportulae and/or some irregular rings on the valve face; a central area without rimoportulae; and usually three bands per theca.

The diagnostic features used to distinguish species in the genus were proposed and discussed by Fryxell & Ashworth (1988) and additionally by Sancetta (1987) and Hasle & Lange (1992).

The present study concerns the fine morphology of *Coscinodiscus jonesianus* (Greville) Ostenfeld and *Coscinodiscus commutatus* Grunow from coastal waters of Buenos Aires. Prasad & Livingston (1996) indicated, in their comprehensive paper about *C. jonesianus*, that this taxon shares all but two of the characters helpful in delimiting *Coscinodiscus* as proposed by Hasle & Sims (1986b), the absence of any external projections of the rimoportulae and only two types of rimoportulae. As far as was determined there were no previous studies of the fine morphology of *C. commutatus* and the type material was lost. However, material from the North Sea is available in Hustedt's Collection and was used here for comparisons. The purpose of this paper is to document morphological features of both analyzed taxa, to compare them, to analyze their distribution and to propose the necessary taxonomic changes.

MATERIAL AND METHODS

Material was collected at seven sampling stations along the coast of Buenos Aires Province between latitudes 36°20' S and 37°20' S. Sampling frequency was seasonal during the period October 1994–October 1996, bi-monthly from October 1996–January 1999 and monthly from October 1999–September 2000. Qualitative samples were taken from the surface layer of the water column, between 0 and 5 meters depth, with 30 µm net hauls and fixed with 4% formalin. Thirty-four samplings were carried out and 211 qualitative samples were collected.

Samples were treated to eliminate organic matter following Hasle & Fryxell (1970) and Prygiel & Coste (2000). The cleaned material was mounted for its analysis with light (LM) and scanning electron microscopy (SEM) according to Ferrario *et al.* (1995). Raw and treated samples, and permanent slides were incorporated to the Colección de Diatomeas Argentinas, deposited at the Departamento Científico Ficología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata under the numbers LPC 4250 to 4449 and 4485 to 4495.

Two slides labelled by Hustedt: *Coscinodiscus jonesianus* var. *commutata* (Grunow) Hustedt; i.e., slide B2/74 Bremerhaven, Kaiserhafen, 26–6–1917 and B2/78, Cuxhaven, were analyzed, neither had unmounted material. However, other materials from the Hustedt Collection at Bremerhaven, sample E335 from Cuxhaven, Elbmündung, leg. Reichelt with unmounted material from which a slide was made by Hustedt but without reference to any taxa, and sample E10427, from the river Elbe, Krautsand, Cordylophora, collected by Caspers, were examined.

For light microscopy Wild M20 and Nikon Microphot FX using phase contrast and Axioplan D 7082 with camera SIS color view III were used either with bright field or Nomarski differential interference contrast optics. For scanning electron microscopy Jeol JSMT 100, Jeol JSM 6360 LV, ISI-DS 130 SEM and Fei Quanta FEG 200 were used.

The bibliography of the fine structure of diatom frustules employed is essentially that compiled by Gaul *et al.* (1993) and Henderson & Reimer (2003). The terminology used is that recommended by Ross *et al.* (1979), Brooks (1975a, b, c), Fryxell & Ashworth (1988), and Prasad & Livingston (1996).

RESULTS

Analysis of material from Buenos Aires coastal waters

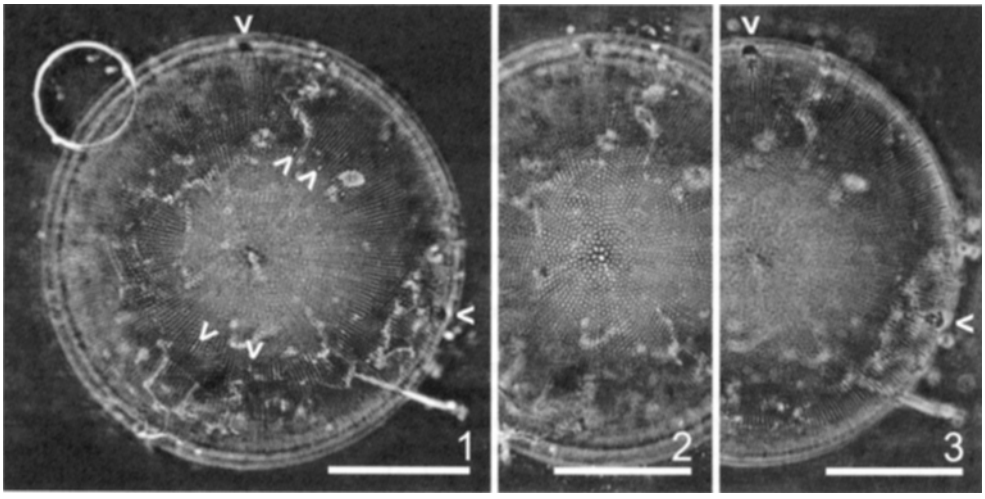
***Coscinodiscus jonesianus* (Greville) Ostenfeld** (Figs 1–14, Table 1)

Ostenfeld 1915, p. 13, fig. 7 a, b; Hustedt 1928, p. 438, fig. 239 a-f; Lee 1989, p. 69, figs 1–19; Prasad & Livingston 1996, p. 247, figs 1–23.

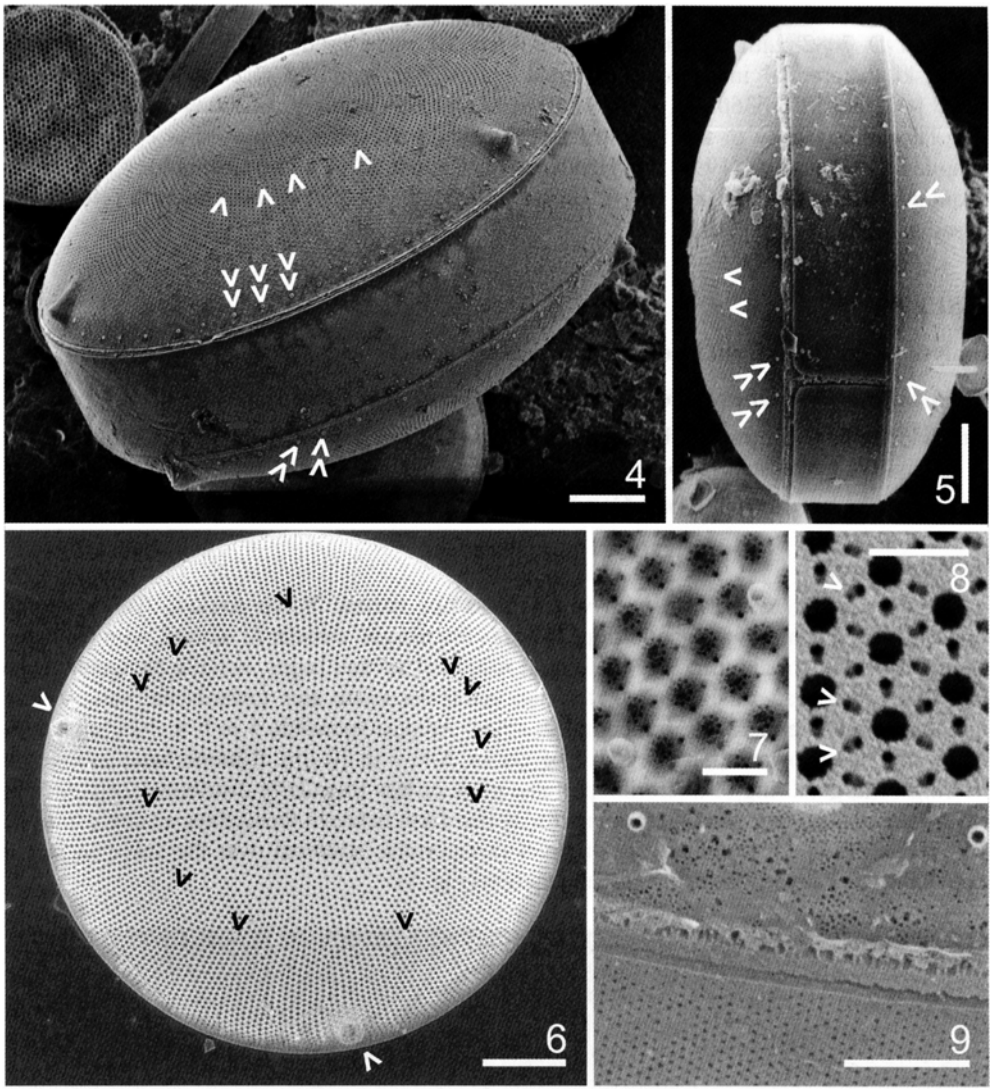
Basionym: *Eupodiscus jonesianus* Greville 1862, p. 22, pl. 2, fig. 3.

Light microscopy

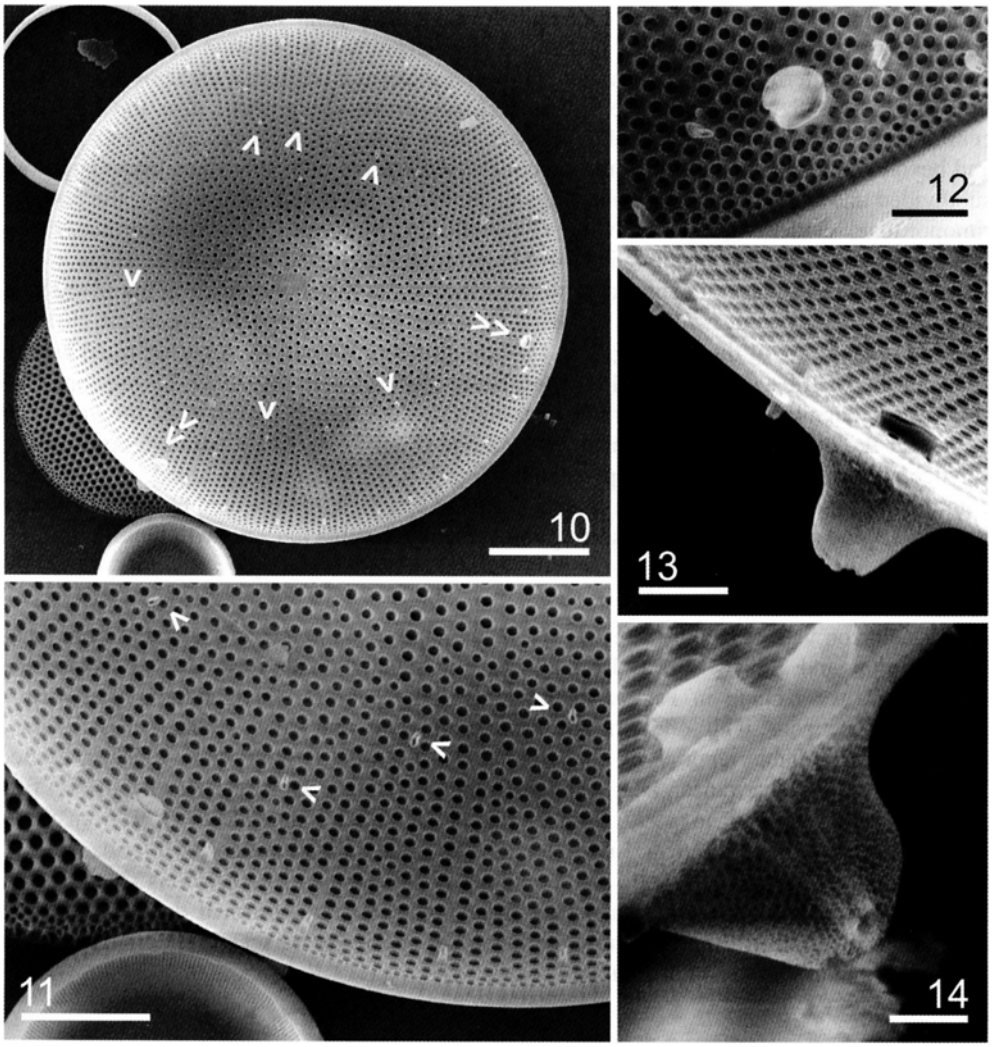
Cells solitary, cylindrical, with watch glass-like valves. Valve convex, flat or slightly depressed in the centre, with gentle slope towards the margin, circular in outline, with diameters ranging from 106 to 226 μm (Fig. 1). Central rosette of several larger, radially elongate areolae (Fig. 2). Areolar pattern fasciculate, forming spiral decussate arcs towards the valve centre. Complete striae alternating with incomplete striae. Areolae roundish, 5 to 6 in 10 μm near the centre, no denser towards the margin or barely so, 6 to 7 in 10 μm. Rimoportulae arranged in two rings. Marginal ring of microrimoportulae more or less irregularly distributed, separated by 3 to 14 striae, including two macrorimoportulae that form between themselves an angle of about 105° to 120° (Fig. 3). Irregular ring of small rimoportulae scattered over the valve surface at about half-way between the centre and the margin (Fig. 1).



Figs 1–3. *Coscinodiscus jonesianus* from Buenos Aires coastal waters. LM. Different focuses of the same valve. **Fig. 1**. Valve showing macrorimoportulae (marginal arrows) and irregular ring of small rimoportulae scattered over the valve surface (arrows). **Fig. 2**. Detail of the valve showing the central rosette. **Fig. 3**. Note marginal ring of rimoportulae including two macrorimoportulae (arrows). Scale bars = 50 μm.



Figs 4–9. *Coscinodiscus jonesianus* from Buenos Aires coastal waters. SEM. External views. **Fig. 4**. Frustule tilted to show valve with marginal ring of microrimoportulae (double arrows), macrorimoportulae covered by conical structures, and irregular ring of mesorimoportulae (arrows). Note the narrow, open copula and broad valvocopula. **Fig. 5**. Frustule in girdle view showing the broad, open, collar-shaped valvocopula and the narrow copula with long ligula. Single arrows show external tubes of the mesorimoportulae and double arrows external tubes of the microrimoportulae. **Fig. 6**. Valve showing the areola pattern and the irregular ring of mesorimoportulae (black arrows). Note eroded conical structures (white arrows) showing the tube of the macrorimoportulae at the centre. **Fig. 7**. Detail of the valve showing complex criba. Note two external tubes of the mesorimoportulae. **Fig. 8**. Detail of an eroded valve showing the central and subsidiary areas of perforation of the criba, arrowheads show the passage pores. **Fig. 9**. Detail of a frustule showing the narrow copula, and valvocopula ornamented by vertical rows of poroids secondary ordered in decussate rows. Scale bars = 20 μm (Figs 4–6); 5 μm (Fig. 9); 2 μm (Figs 7, 8).



Figs 10–14. *Coscinodiscus jonesianus* from Buenos Aires coastal waters. SEM. Internal views. **Fig. 10.** General appearance of the valve. Note marginal ring of microrimoportulae, ring of mesorimoportulae (arrows) over the valve surface and macrorimoportulae (double arrows). **Fig. 11**. Note wider interestriae radiating from the marginal rimoportulae. Arrows show sessile mesorimoportulae. **Fig. 12**. Detail of the valve margin showing a macrorimoportula stub-shaped and four microrimoportulae shortly pedicellate and flabellate. **Fig. 13**. Detail of the valve margin showing macrorimoportula internally stub-shaped and externally covered by a conical structure, and two internally pedicellate microrimoportulae, with external tubes. **Fig. 14**. Note the external tube of the macrorimoportulae covered by a conical structure with confluent criba. Scale bars = 20 μm (Fig. 10); 10 μm (Fig. 11); 5 μm (Figs 12, 13); 2 μm (Fig. 14).

Scanning electron microscopy

Areolae with external criba and internal foramina (Figs 7, 11). Central rosette of areolae with eccentric location of the foramina, visible as a hyaline area internally (Figs 6, 10). Cribum with complex pattern of perforations (Figs 7, 8). Central area of cribum with 4 to 20 circular pores, more or less concentrically disposed. Subsidiary areas of perforation, usually six, shared

with the contiguous areolae (Fig. 8), extending across the locular walls of the areola (passage pores) (Fig. 8 arrowheads). Pores of central and subsidiary perforation areas occluded by cribella. This pattern of criba perforation showed variations in different areas of the valve. At the valve centre the areolae of the rosette lack some subsidiary areas, near the rosette the central areas of perforation are smaller and subsidiary areas are narrower up to ½ to ¼ radius, and beyond and near the margin some specimens show criba with subsidiary areas larger and subdivided and others confluent criba (Figs 6, 9). Wider interstriae radiate from the marginal rimoportulae, evident in internal view (Figs 10–13). Marginal microrimoportulae shortly pedicellate and flabellate inside (Figs 10–13), with short, conical tube outside (Figs 4, 5, 9, 13). Macrorimoportulae stub-shaped, with horseshoe slit at distal end inside (Figs 11–13), and with long external tube, wider at the base than the apex, covered by a conical structure, opening with a pore at the top (Fig. 14). Conical structure formed by some enlarged areolae, with confluent criba (Figs 4, 13–14). Mesorimoportulae (after Prasad & Livingston 1996) slightly smaller than microrimoportulae, sessile, fan-shaped, and placed over the valve face usually at the beginning of some incomplete striae (Figs 7, 10, 11). Cingulum consisting of valvocopula and one copula, both open bands (Figs 4, 5, 9). Valvocopula broad, collar-shaped, with the ends usually abutting quite closely, 21 to 35 μm high, ornamented by vertical rows of poroids, secondary ordered in decussating rows (Fig. 9). Copula narrow, with long ligula.

Distribution

This taxon was erected by Greville (1862) as *Eupodiscus jonesianus* sampled from guano from Ceylon and Indian coasts. Because the investigated taxon resembles *Coscinodiscus commutatus*, we include in its distribution only those reports where authors described or illustrated specimens with one ring of rimoportulae on the valve surface. *Coscinodiscus jonesianus* was reliably reported by Ostenfeld (1915) from the Boeton Strait, Celebes; Hustedt (1928) from the Mediterranean Sea; Allen & Cupp (1935) from Java Sea; Hendey (1964) from the English Channel; Takano (1990) from the Inland Sea of Sato, Japan; Lee (1989) from coastal waters of Korea; and Prasad & Livingston (1996) from coastal waters of Florida, Gulf of México. Ferrario & Galván (1989) and Vouilloud (2003) summarized previous reports of this taxon from Argentinean marine waters but these could not be confirmed due to insufficient morphological detail. During this study we found the species to be scarce throughout the year although sometimes common in autumn.

***Coscinodiscus commutatus* Grunow** (Figs 15, 16, 23–34, Table 2)

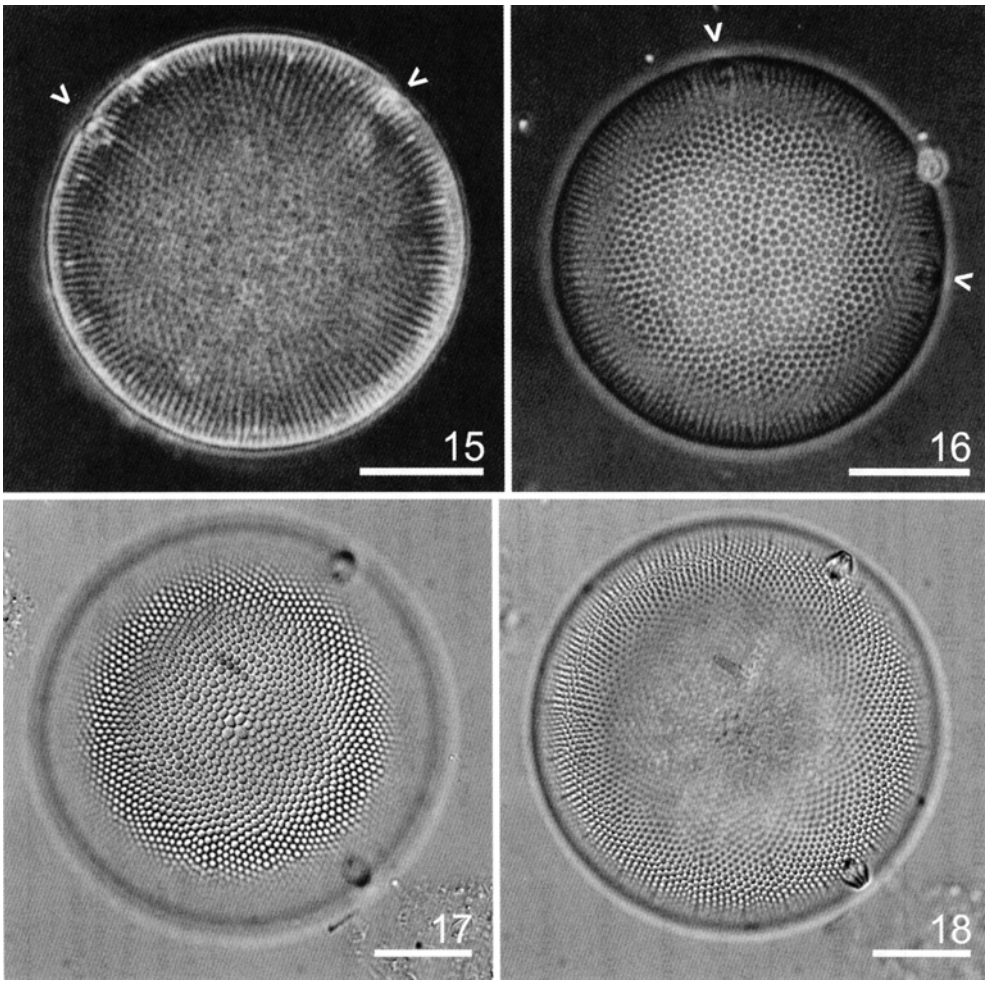
Grunow 1884, p. 79; Ostenfeld 1915, p. 14; Hustedt 1928, p. 440, fig. 240 [as *C. jonesianus* var. *commutata* (Grunow) Hustedt]; Allen & Cupp 1935, p. 117, fig. 11 a-d [as *C. jonesianus* var. *commutata*].

Light microscopy

Cells solitary, cylindrical, with watch glass-like valves. Valve convex, flat or slightly depressed in the centre and slope gently towards the margin; circular in outline, with diameters ranging from 46 to 144 μm (Figs 15, 16). Inconspicuous central rosette of slightly larger areolae, sometimes absent (Fig. 16). Areolar pattern radial, secondary pattern forming very evident spiral decussate arcs (Fig. 16). Complete striae alternating with incomplete striae (Fig. 15). Areolae roundish, 5 to 6 in 10 μm near the centre, as dense or barely denser towards the margin, 6 to 7 in 10 μm. Rimoportulae disposed in one marginal ring. Microrimoportulae irregularly distributed, separated by 4 to 13 striae (Figs 15, 16). Two macrorimoportulae forming between themselves an angle of about 90° to 117° (Figs 15, 16).

Table 1. Comparison among *Coscinodiscus jonesianus* from Buenos Aires coastal waters and from other areas with data obtained from the literature. Asterisk = data not described by author/authors but observed by us in the illustrations; nd = no data.

Authors	Diameter in μm	Areolae in 10 μm		Marginal ring of rimoportulae		Mesorimoportulae over the valve surface	Observations
		Near centre	Near margin	Microrimoportulae	Macrorimoportulae, number and angle between them		
Greville (1862) by Prasad & Livingston (1996)	153–156	6	7	1.2 in 10 μm, 6–13 μm apart	Two, 100°	One ring, midway between margin and centre	*Areola pattern fasciculate
Ostenfeld (1915)	200–280	n/d	n/d	numerous	Two, * 120°	One irregular ring, between margin and centre	Areola pattern fasciculate, with central rosette
Hustedt (1928)	140–280	5–6	9	10–20 μm apart	Two, 100–120° apart	One irregular ring, between margin and centre	With distinct central rosette
Allen & Cupp (1935)	260–430	5–6	13–15	8–10 μm apart	Two, 110–125° apart	One irregular ring, halfway between centre and margin	* Areola pattern fasciculate, with more or less distinct central rosette present or absent
Hendey (1964)	140–250	5–6	13–15	8–10 μm apart	Two, 110–120° apart	One irregular ring, at about half radius	With more or less distinct central rosette
Takano in Fukuyo *et al.* (1990)	140–250	5–6	13–15	ca. 4 areolae apart from the valve margin	Two, 110° apart	One irregular ring, around the middle of radius	With central rosette
Lee (1989)	102–146	4–6	6–8	3–12 striae apart	Two, 110–120° apart	One irregular ring, halfway between the margin and the centre	* Areola pattern fasciculate, with more or less distinct central rosette. * Valvocopula with vertical rows of poroids, secondary ordered in decussating rows.
Prasad & Livingston (1996)	140–165	6–7	7–8	1.3–1.4 in 10 μm, 4.5–8.6 μm apart, 6–8 striae apart	Two, 102–110° apart	One irregular ring, midway between the centre and valve margin	* Areola pattern fasciculate, with distinct central rosette.
This study	106–226	5–6	6–7	1–2 in 10 μm, 3–16.6 μm apart, 3–14 striae apart	Two, 105–120° apart	One irregular ring, about halfway between the centre and the valve margin	Areola pattern fasciculate, with more or less distinct central rosette. Valvocopula with vertical rows of poroids, secondary ordered in decussating rows.



Figs 15–18. *Coscinodiscus commutatus*. LM. Figs 15, 16. Specimens from Buenos Aires coastal waters. **Fig. 15**. Valve showing macrorimoportulae (arrows) included in the marginal ring of microrimoportulae. **Fig. 16**. Valve without central rosette, showing areola pattern radial, secondary forming very evident spiral decussate arcs. Note the absence of mesorimoportulae. **Figs 17, 18**. Specimen from slide B2/74 (Bremerhaven), designated here as neotype. Same valve in different focuses. Note areola pattern radial, secondary forming very evident spiral decussate arcs. Scale bars = 20 μm.

Scanning electron microscopy

Areolae with criba external and foramina internal (Figs 25–27, 32, 33). Central areolae with eccentric location of the foramina, visible internally as a small hyaline area (Figs 30, 31), sometimes inconspicuous (Fig. 24). Cribum with complex pattern of perforation, similar to those described above for *Coscinodiscus jonesianus* (Figs 25–27). Wider interstriae radiating from the marginal rimportulae, evident internally (Figs 32, 33). Marginal microrimoportulae shortly pedicellate, slightly widened towards the distal end inside (Fig. 33), and with short, conical tubes outside (Figs 23, 25, 27). Macrorimoportulae stub-shaped, with horseshoe slit at distal end inside (Figs 32–34), with long external tube, wider in the base than in the apex, covered by a conical porous structure, and pore opening at the apex (Figs 27, 28, 32, 34).

Conical structure similar to that of *C. jonesianus*, but larger in relation to the size of valves. Cingulum consisting of valvocopula and one copula, both open bands. Valvocopula broad, collar-shaped, with the ends usually abutting closely, ornamented by vertical rows of poroids, 30–32 in 10 μm, with orthostichous secondary arrangement (Figs 28, 29). Copula narrow.

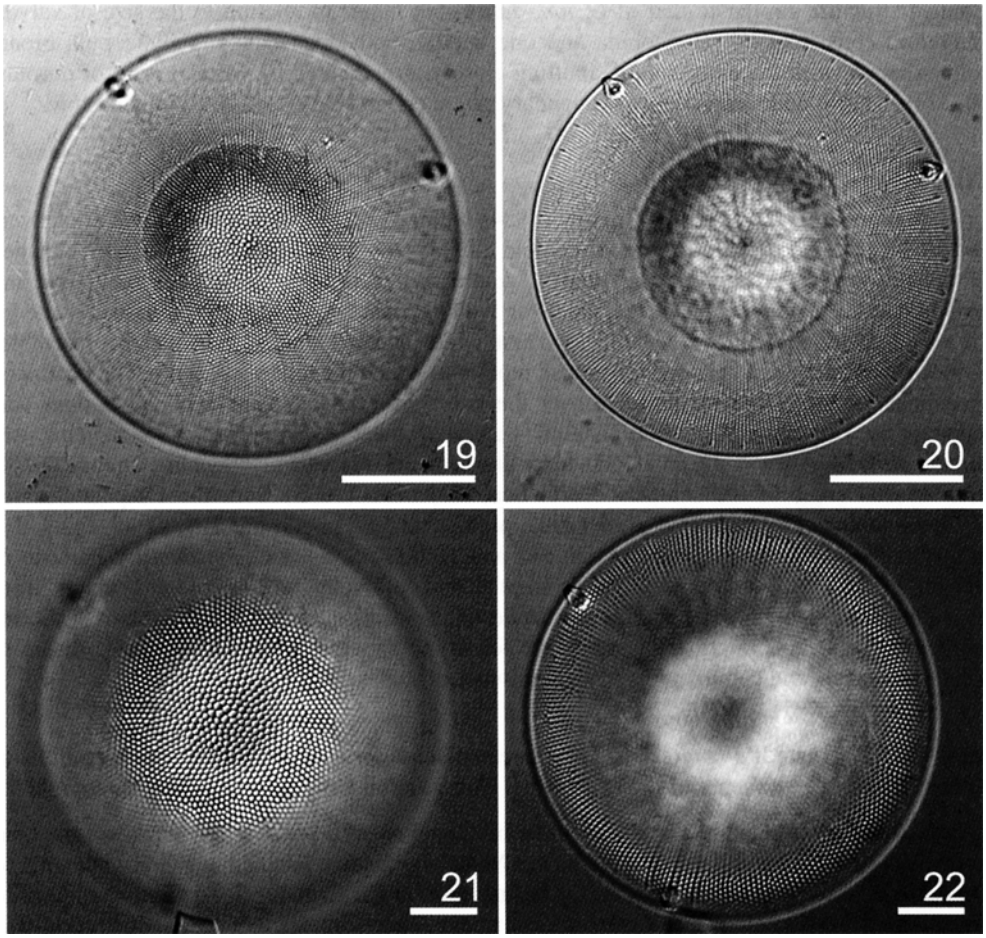
Distribution

This taxon was erected by Grunow (1884) who pointed out that it appears in Cuxhaven, Brazil, China and in Peru guano. Ostenfeld (1915) considered that Grunow had included *C. commutatus* (ex maxima parte) and *C. jonesianus* under the name *C. commutatus* and proposed to keep Greville's name for the taxon with tropical distribution and Grunow's name for the taxon distributed in the North Sea. Taking into account that *C. commutatus* resembles *C. jonesianus*, included here are only those reports in which the authors described or illustrated specimens without mesorimoportulae over the valve surface. *Coscinodiscus commutatus* was reported by Hustedt (1928) from coastal waters of the North-Sea (as *C. jonesianus* var. *commutata*), by Allen & Cupp (1935) from the Java Sea (as var. *commutata*), Drebes (1974) from coastal areas of the southern North Sea, Makarova (1993) from the Caspian Sea (as *C. jonesianus*) and by Makarova *et al.* (2002, pl. 47, figs 5, 7, pl. 48, figs 1–9, pl. 49, figs 1–10) from the Black Sea, Azov Sea, Caspian Sea and Okhotsk Sea (as *C. jonesianus*). Ferrario & Galván (1989) and Vouilloud (2003) summarized previous reports of this taxon from Argentinean marine waters; however this could not be confirmed because of lack of sufficient morphological details. During this study we found the species throughout the year, scarce in winter and spring and common to abundant in summer and autumn.

Analysis of Hustedt's materials of *Coscinodiscus jonesianus* var. *commutata* from Bremerhaven, Cuxhaven and the river Elbe. Comparison with material from Buenos Aires

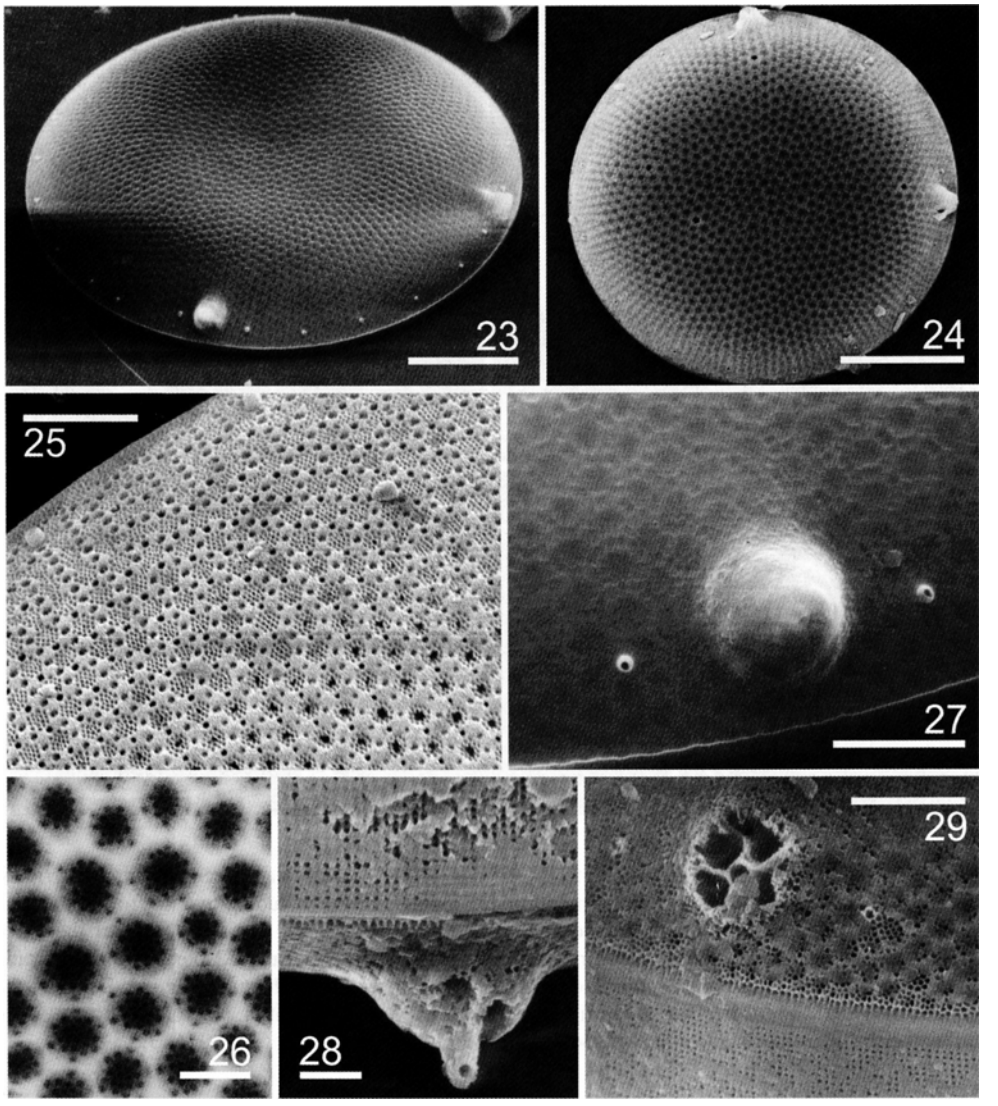
In order to establish the specific limits of *Coscinodiscus commutatus* Grunow, material from Grunow's Collection, Naturhistorisches Museum, Vienna, labelled as "*C. commutatus* or *Eupodiscus*? *commutatus*" was asked for but no slide in the Grunow Collection was found or has otherwise been determined under these names. Therefore, the Hustedt's Collection was searched, for duplicate slides of the type material. Only two slides were found, one from Bremerhaven (slide B2/74) and one from Cuxhaven (slide B2/78), both labelled by Hustedt as containing this taxon. Unfortunately, no unmounted material from which the slides were made was available therefore the sample E10427 from the river Elbe, near Cuxhaven, collected by Casper and labelled by Hustedt along with another sample, E335 from Cuxhaven which contained the taxon, though not labelled by Hustedt, were examined. In addition, a slide of the sample E335 was also examined with LM (Figs 21, 22). Table 3 summarizes Hustedt's and Argentinean material characteristics.

Specimens found on slide B2/74 from Bremerhaven show coarse structure (Figs 17, 18), with 71 to 84 μm in diameter, 4.5–6 areolae in 10 μm near the valve centre and 6.5–7 in the marginal area. Central rosette of areolae sometimes inconspicuous or absent, and areolar pattern radial with secondary spiral decussate arcs very evident. The microrimoportulae are disposed in one marginal ring, 1–2 in 10 μm (4.5–11 μm apart, 4–10 striae apart) and the valve surface does not show mesorimoportulae. These specimens coincide in general appearance and morphometric data with specimens of *Coscinodiscus commutatus* from Buenos Aires coastal waters analyzed with LM (Figs 15, 16).

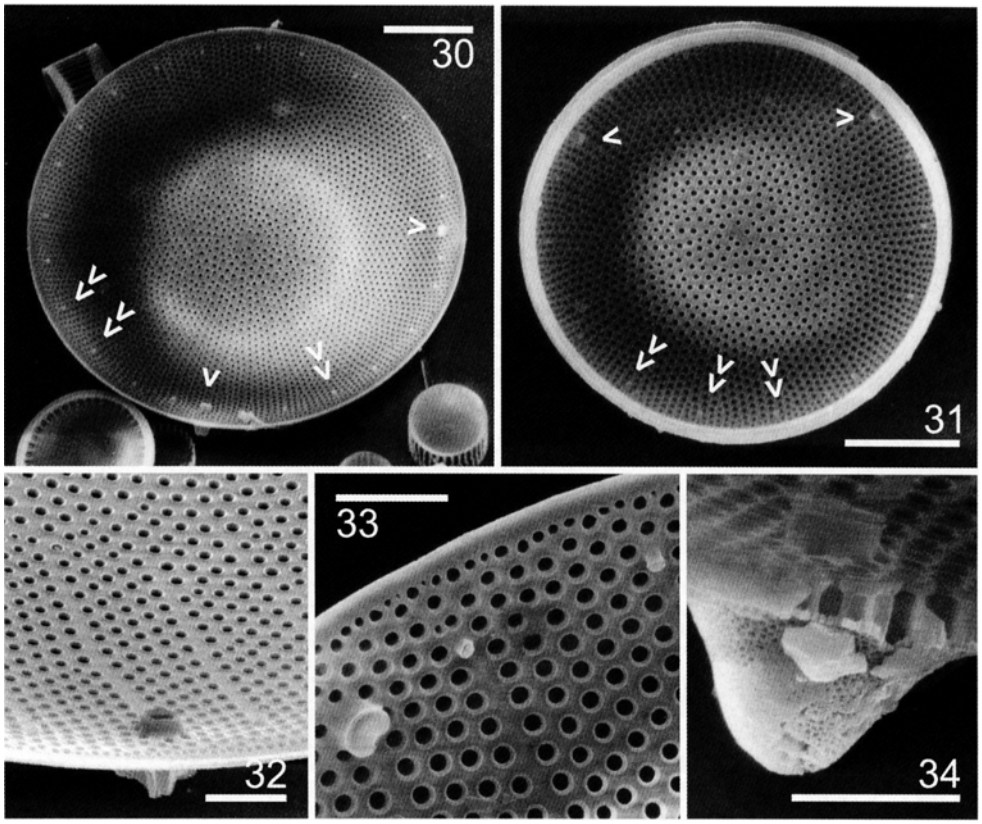


Figs 19–22. *Coscinodiscus commutatus*. LM. **Figs 19, 20**. Specimen from slide B2/78 (Cuxhaven). Same valve in different focuses. Areola pattern fasciculate, secondary forming spiral decussate arcs towards the valve centre. **Figs 21, 22**. Specimen from sample E335 from Cuxhaven. Same valve in different focuses. Areola pattern radial, secondary forming very evident spiral decussate arcs. Note the absence of mesorimoportulae. Scale bars = 50 μm (Figs 19, 20); 20 μm (Figs 21, 22).

Specimens found on slide B2/78 from Cuxhaven are larger and have finer structure (Figs 19, 20) than those from Bremerhaven (Figs 17, 18), with 121 to 166 μm in diameter, 4–6 areolae in 10 μm at the valve centre and 7–8 in marginal area, central rosette of areolae more conspicuous, and areolar pattern fasciculate with less evident secondary spiral decussate arcs. The microrimoportulae are disposed in one marginal ring, 1–2 in 10 μm (6.1–16 μm apart, 6–13 striae apart) and the mesorimoportulae are absent on the valve surface. On the slide there are five selected valves that show some areolae larger than the others, generally at the origin of the incomplete striae (Fig. 19). The specimens from Cuxhaven (slide B2/78) are similar in general appearance and morphometric data to those from Buenos Aires coastal waters determined as *Coscinodiscus jonesianus* (Figs 1–3), but differs from them by lacking mesorimoportulae over the valve face like *C. commutatus*. These specimens might be considered as the transitional forms mentioned by Hustedt (1928) from the North Sea.



Figs 23–29. *Coscinodiscus commutatus* from Buenos Aires coastal waters. SEM. External views. **Figs 23, 24**. Valves showing conical structures and ring of microrimoportulae with external tubes. Note the absence of mesorimoportulae over the valve surface. **Fig. 25**. Detail of the valve showing criba with subsidiary areas of perforation larger towards the margin. **Fig. 26**. Detail of the complex pattern of perforation of the criba. Note perforations occluded by cribella. **Fig. 27**. Detail of the valve margin with a conical structure opening throughout a pore in the top and two external tubes of microrimoportulae. **Fig. 28**. Detail of a frustule in girdle view. Note the eroded conical structure showing the tube of a macrorimoportula and the valvocopula ornamented by vertical rows of poroids, with secondary orthostichous arrangement. **Fig. 29**. Eroded conical structure. Note macrorimoportula tube surrounded by several large areolae. Scale bars = 20 μm (Figs 23, 24); 5 μm (Figs 25, 27, 29); 2 μm (Figs 26, 28).



Figs 30–34. *Coscinodiscus commutatus* from Buenos Aires coastal waters. SEM. Internal views. **Figs 30, 31**. Valves show a ring of microrimoportulae (double arrows) including two macrorimoportulae (arrows). Note the absence of mesorimoportulae over the valve surface. **Fig. 32**. Detail of the valve margin showing wider interestriae radiating from the marginal rimoportulae. Note macrorimoportula internally stub-shaped, and conical structure broken showing a section of the tube. **Fig. 33**. Detail of the macrorimoportula and pedicellate microrimoportulae. **Fig. 34**. Detail of a macrorimoportula. Note confluent criba over the conical structure. Scale bars = 20 μm (Figs 30, 31); 5 μm (Figs 32–34).

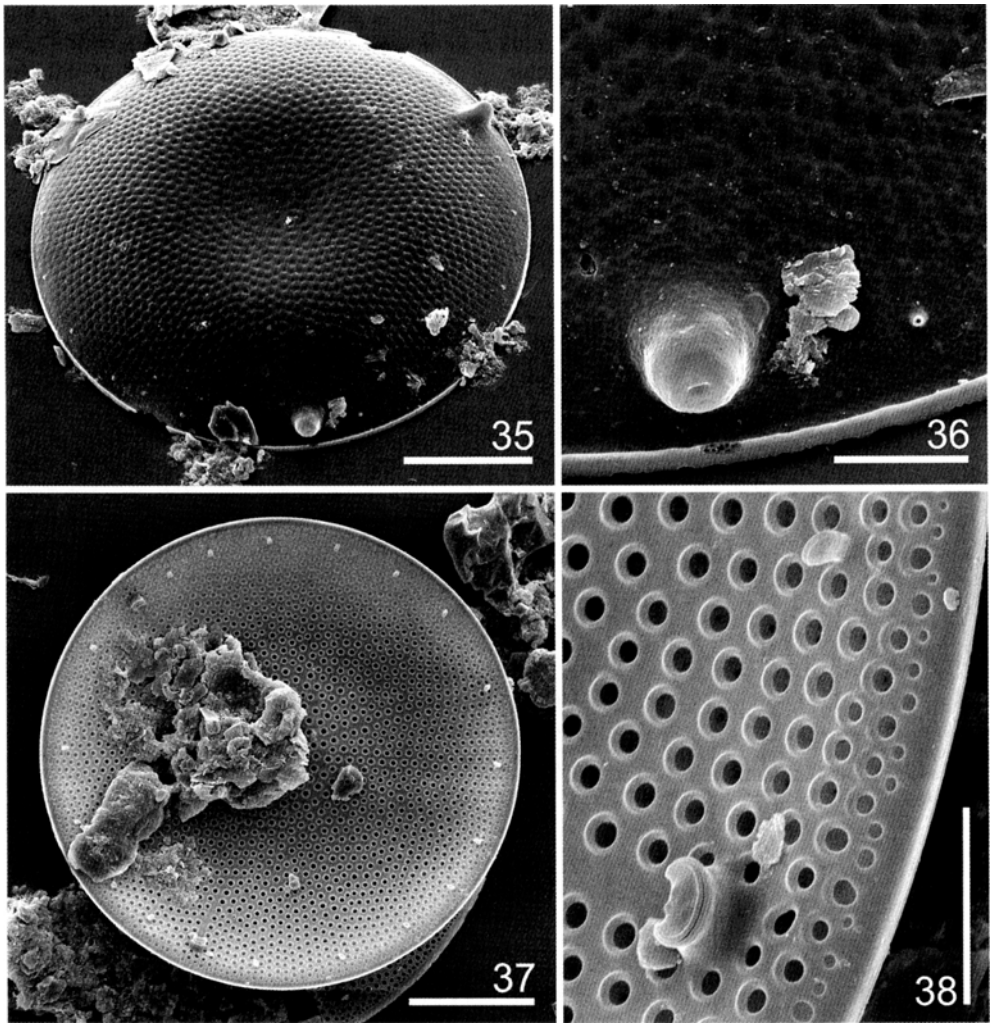
SEM analysis of sample E10427 from the Elbe and sample E335 from Cuxhaven, allow us to determine that all specimens found there lack mesorimoportulae over the valve surface. Nevertheless, we found in Hustedt's material a morphological variation not registered in Buenos Aires material. We observed that while smaller specimens from the Elbe and Cuxhaven (Figs 21, 22, 35–38, 39, 41) and those on the slide B2/74 (Figs 17, 18), closely resemble *Coscinodiscus commutatus* from Buenos Aires coastal waters, the larger ones show fasciculate areolar pattern and finer structure (Figs 40, 42) as those on slide B2/78 (Figs 19, 20), and resemble in general appearance *C. jonesianus* from Buenos Aires except by lacking mesorimoportulae and showing a more depressed central valve surface. Besides, Hustedt's specimens show a few or several areolae with foramen completely occluded by vaulted siliceous layer internally (Figs 41–43) and sometimes with slightly smaller areolae in the origin of the incomplete striae (Figs 41, 42), probably interpreted by Hustedt as "interstitialmaschen".

Table 2. Comparison among *Coscinodiscus commutatus* from Buenos Aires coastal waters, from Northern Sea, and other areas with data obtained in the literature. Asterisk = data not described by author/authors but observed by us in the illustrations; nd = no data; ? = data no confirmed in the illustrations.

Authors	Diameter in μm	Areolae in 10 μm		Marginal ring of rimoportulae		Mesorimoportulae over the valve surface	Observations
		Near centre	Near margin	Microrimoportulae	Macrorimoportulae, number and angle between them		
Grunow (1884)	n/d	n/d	n/d	numerous	Two, smaller than 180°	n/d	* Areola pattern radial
Ostenfeld (1915)	Cell medium sized	n/d	n/d	numerous	Two, about 100°	Absent	Coarser structure. * Areola pattern radial, with central rosette.
Hustedt (1928), as *C. jonesianus* var. *commutata*	70–160	4–5	8	10–20 μm apart	Two, * about 115°	Absent or if present no forming a ring	With inconspicuous central rosette. * Areola pattern radial.
Allen & Cupp (1935), as *C. jonesianus* var. *commutata*	81–134	4–5	8	8–10 μm apart	Two, 110–120°	Absent	* Areola pattern radial, with inconspicuous central rosette
Makarova (1993), as *C. jonesianus*	* 90	5–6	7–9	1–2 in 10 μm, 7–8 striae apart	Two, 100–120°	Absent	Areola pattern radial, with central rosette
Makarova *et al.* (2002), as *C. jonesianus*	31.4–240?	5–7	7–10	1 in 10 μm, 5–9 striae apart	Two, 100–120°	Absent	* Areola pattern radial to fasciculate, with central rosette. Valvocopula ornamented by vertical rows of poroids, with secondary orthostichous arrangement.
This study. Hustedt's material, as *C. jonesianus* var. *commutata*	69–166	4–6	6.5–8	1–2 in 10 μm, 4.5–19 μm apart, 4–17 striae apart	Two, 100–120°	Absent	Areola pattern radial to fasciculate, with central rosette more or less distinct or absent.
This study. Material from Buenos Aires	46–144	5–6	6–7	1–2 in 10 μm, 6.5–16.7 μm apart, 4–13 striae apart	Two, 90–117°	Absent	Areola pattern radial, with central rosette more or less distinct or absent. Valvocopula ornamented by vertical rows of poroids, with secondary orthostichous arrangement.

Table 3. Comparison among *Coscinodiscus commutatus* from Northern Sea and *C. commutatus* and *C. jonesianus* from Buenos Aires coastal waters.

Material	Diameter in μm	Areolae in 10 μm		Marginal ring of rimoportulae		Mesorimoportulae over the valve surface	Observations
		Near centre	Near margin	Microrimoportulae	Macrorimoportulae, number and angle between them		
Hustedt's Collection							
B2/74 from Bremerhaven	71–84	4.5–6	6.5–7	1–2 in 10 μm, 4.5–11 μm apart, 4–10 striae apart	Two, 110–112° apart	Absent	Areolar pattern radial with secondary spiral decussate arcs very evident.
B2/78 from Cuxhaven	121–166	4–6	7–8	1–2 in 10 μm, 6.1–16 μm apart, 6–13 striae apart	Two, 105–116° apart	Absent	Areolar pattern fasciculate with less evident secondary spiral decussate arcs
E335 from Cuxhaven	100–130	4.5–6	6.5–8	0–2 in 10 μm, 6.1–16 μm apart, 6.6–19 striae apart	Two, 107–120° apart	Absent	Areolar pattern radial with secondary spiral decussate arcs very evident.
E10427 from Elbe	76–86	5.5–6	7–7.5	1–2 in 10 μm, 6–15.5 μm apart, 5–12 striae apart	Two, 112–120° apart	Absent	Areolar pattern radial with secondary spiral decussate arcs very evident.
From Argentina							
C. commutatus	46–144	5–6	6–7	1–2 in 10 μm, 6.5–16.7 μm apart, 4–13 striae apart	Two, 90–117° apart	Absent	Areola pattern radial, with secondary spiral decussate arcs very evident. Valvocopula ornamented by vertical rows of poroids, with secondary orthostichous arrangement.
C. jonesianus	106–226	5–6	6–7	1–2 in 10 μm, 3–16.6 μm apart, 3–14 striae apart	Two, 105–120° apart	One irregular ring, about ½ between the centre and the valve margin	Areola pattern fasciculate, with less evident secondary spiral decussate arcs. Valvocopula with vertical rows of poroids, secondary ordered in decussating rows.

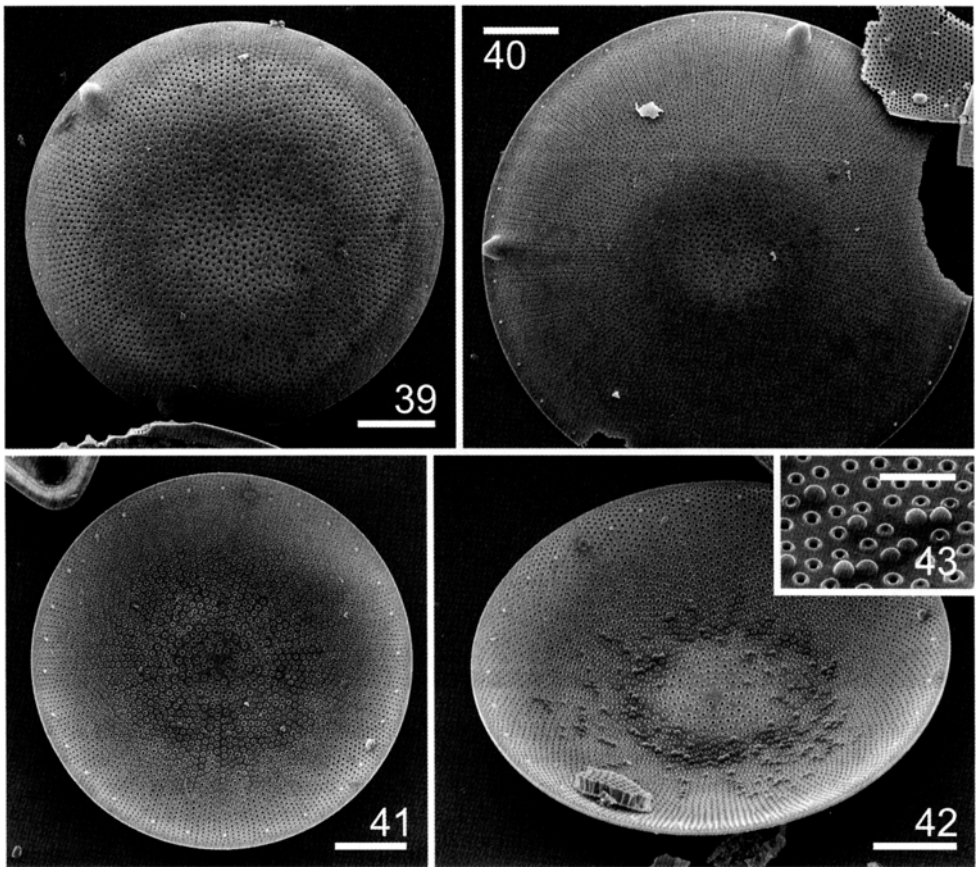


Figs 35–38. *Coscinodiscus commutatus* from sample E10427 (Elbe). SEM. **Fig. 35.** Valve tilted in external view. Note the absence of mesorimoportulae over the valve face. **Fig. 36.** Detail of fig. 35 showing the conical structure and a microrimoportula tube. **Fig. 37.** Valve in internal view. Note the absence of mesorimoportulae over the valve face. **Fig. 38.** Detail of fig. 37. showing the stub-shaped macrorimoportula and a shortly pedicellate microrimoportulae. Scale bars = 20 μm (Figs 35, 37), 5 μm (Figs 36, 38).

DISCUSSION

Coscinodiscus jonesianus was illustrated (as *Eupodiscus jonesianus*) by Greville (1862, pl. 2, fig. 3) without showing an irregular ring of mesorimoportulae on the valve face. Subsequently, Ostenfeld (1915) extended the description of this taxon and point to the presence of a ring of "very small apiculi halfway between the margin and the centre". Specimen photographed by Williams (1988, pl. 38, figs 4–6) and by Prasad & Livingston (1996, figs 3–7) from type material (the same illustrated by Greville considering the location of the macrorimoportulae and some detritus) shows an irregular ring of processes halfway between the

centre and the valve margin that corresponds to the irregular ring of mesorimoportulae. These were also depicted by Ostenfeld (1915). Using light and scanning electron microscopy, Prasad & Livingston (1996) examined specimens of *C. jonesianus* from the Gulf of México, compared them with type material, confirmed the specific limits given by Ostenfeld (1915) and provided a more comprehensive description of the taxon. Specimens of *Coscinodiscus jonesianus* in the material from Buenos Aires coastal waters agree in general appearance, morphometric data and fine morphology with those described by Prasad & Livingston (1996) and by Lee (1989) (Table 1) although they present subtle differences in the density of mesorimoportulae over the valve surface from specimens illustrated by Prasad & Livingston (1996).



Figs 39–43. *Coscinodiscus commutatus* from sample E335 (Cuxhaven). SEM. **Figs 39, 40**. Valves of different sizes in external view. **Figs 41, 42**. Valves of different sizes in internal view. Note the areolae with foramen completely occluded by vaulted siliceous layer internally and absence of mesorimoportulae. **Fig. 43**. Detail of areolae with foramen occluded. Scale bars = 20 µm (Figs 39–42), 5 µm (Fig. 43).

Coscinodiscus commutatus was erected by Grunow (1884) with a short description and citing a specimen from Peru Guano illustrated by A. Schmidt (1874–1959, pl. 60, fig. 16) which is a fragment and only shows the areolar pattern. Subsequently, Ostenfeld (1915) clarified the specific limits of *C. commutatus* and pointed out that it "...is closely related to that from our sample [*C. jonesianus*], but it differs in the much coarser structure and in the

absence of the very small apiculi halfway between the margin and the centre". Hustedt (1928) transferred *Coscinodiscus commutatus* to the rank of variety as *Coscinodiscus jonesianus* var. *commutata* pointing out that the "interstitialmaschen" form an irregular ring over the valve surface in *C. jonesianus* but do not form a ring or are totally lacking in *C. jonesianus* var. *commutata*.

During this study we found two different taxa from Buenos Aires coastal waters that fit the specific limits given by Ostenfeld (1915), but we have never found transitional forms. *Coscinodiscus jonesianus*, as delimited by Prasad & Livingston (1996) based on type material analysis, is characterized by finer structure, larger size, and an irregular ring of mesorimoportulae over the valve surface and *Coscinodiscus commutatus*, by coarser structure, smaller size, and totally lacking mesorimoportulae on the valve surface. Both species have a valvocopula ornamented by vertical rows of poroids, however the secondary pattern of striation shows a consistent difference, being decussate in *C. jonesianus* as illustrated by Lee (1989, fig. 8) and in this study (Fig. 9), and orthostichous in *C. commutatus* shown in this study (Figs 28, 29).

Analysis of Hustedt's material of *Coscinodiscus jonesianus* var. *commutata* allows us to establish that all the examined specimens lack mesorimoportulae over the valve surface, corresponding to *C. commutatus* despite some of them being larger, finer in structure, sometimes with few or several areolae with foramen completely occluded by vaulted siliceous layer internally and with a fasciculate areolar pattern resembling *C. jonesianus* described by Ostenfeld (1915), Lee (1989), Prasad & Livingston (1996) and in the present study. According to the information obtained from Hustedt's material we agree with the opinion of Hustedt (1928) in believing the areolar pattern to be a feature of second order importance and we conclude that the only striking features to differentiate both analyzed taxa are the presence/absence of a irregular ring of rimoportulae over the valve surface, proposed by Ostenfeld (1915), and the striation pattern of the valvocopulae proposed in this study.

Makarova *et al.* (2002) included *C. commutatus* Grunow and *C. jonesianus* var. *commutata* (Grunow) Hustedt as synonyms of *C. jonesianus*. They illustrated with LM, two specimens with finer structure and areola pattern fasciculate (pl. 47, figs 1, 2) and two others with coarser structure and smaller size (pl. 47, figs 3, 4), all them lacking rimoportulae over the valve surface as shown in their SEM photographs (pl. 47, fig. 5; pl. 48, figs 1–9). Additionally, they present a micrograph of a valvocopula (pl. 47, fig. 7) with an orthostichous secondary pattern of striation. Based on these two latter striking features we consider that the material studied by Makarova *et al.* (2002) corresponds to *C. commutatus*.

Neither *Coscinodiscus jonesianus* nor *Coscinodiscus commutatus* fit the generic limits established by Hasle & Sims (1986b) because of the external tubes of the microrimoportulae and the conical covering on the outer tube of the macrorimoportulae.

Sims (1989) analyzing with SE Cretaceous and Paleogene *Coscinodiscus* species separated them in three distinct groups. All these groups have valves with circular outline, loculate areolae with internal formina and external criba and a ring of marginal rimoportulae, features that characterize the Coscinodiscaceae Kützing emend. Round & Crawford in Round *et al.* (1990). Only Group 1, illustrated by *C. japonicus* Pantocsek, presents two macrorimoportulae within a marginal ring of microrimoportulae, coincident with the pattern of processes described by Hasle & Sims (1986b) in the emended diagnosis of the genus *Coscinodiscus* sensu stricto. The other two groups lack macrorimoportulae and have another pattern of processes, two areas of packed rimoportulae within a marginal ring of microrimoportulae in Group 2, illustrated by *C. morsianus* (Grunow) Sims, and a single ring of closely spaced small microrimoportulae in Group 3, illustrated by *C. solidus* Strelnikova. Based on this analysis, Sims (1989) suggested that the definition of *Coscinodiscus* would have

to be expanded to include Groups 2 and 3. In our opinion, this suggested expansion would result in a genus containing:

species with two macrorimoportulae within a ring of microrimoportulae, all processes with no external tubes, or

species with two areas of packed microrimoportulae (which correspond in position to macrorimoportulae) within a marginal ring of microrimoportulae, processes with or without external tubes, or

species with a single ring of closely spaced microrimoportulae without external tubes.

If *C. jonesianus* and *C. commutatus*, analyzed in this study, were to remain within *Coscinodiscus* it would also contain:

species with two macrorimoportulae with external tubes covered by a conical structure within a ring of microrimoportulae with external tubes.

Taking into account that the concept of the genus *Coscinodiscus* as emended by Hasle & Sims (1986b) is well defined with clear generic limits, we consider that expanding the generic circumscription would signify transforming *Coscinodiscus* into a badly defined, heterogeneous genus. We therefore believe that the creation of a new genus *Coscinodiscopsis* Sar & Sunesen is justified to include *C. jonesianus* and *C. commutatus*. In addition, it is also possible that Sim's Groups 2 and 3 should be excluded from *Coscinodiscus* sensu stricto and located in new genera.

***Coscinodiscopsis* Sar & Sunesen gen. nov.**

Description:

Cellulae solitariae, rectangulatae a cingulo visae plus minusve lentiformesi. Cingula duabus taeniis constata. Taeniae omnes apertae. Valvocopula lata, seriebus verticalibus pororum. Copula angusta, ligula longa et angusta. Valvae circulares convexae non limbatae. Superficies valve complanata vel leviter concava circum centrum. Rosula centralis areolis majoribus praesens vel absens. Areolae loculatae cum velis in parte exteriore valvae et foraminibus internis in radiatis ad fasciculatis seriebus dispositis, interdum a fornicato siliceo strato occlusis. Cribum centralibus et subsidiariis perforatis areis, pori extra cribellibus occlusi. Criba ad marginibus valvae confluentia. Annulus unicus marginalis microrimoportularum irregulariter dispositarum. Duae macrorimoportulae sitae in annulo marginale microrimoportularum, leviter crassior quam microrimoportulae, inter eas angulum circiter 90–120° formantes. Annulus irregularis mesorimoportularum interdum praesens in facie valvae, plus minusve ½ distantia ex margine versus centrum locatus. Microrimoportulae et mesorimoportulae tubis externis brevis et cylindricis. Macrorimoportulae tubo externo longo structurae conica induto, et breviter pedicellato, rima hippocreipformi secus marginem. Plantae marinae planctonicae.

Cells solitary, cylindrical with watch glass-like valves. Cingula formed by two open bands. Valvocopula broad, with vertical rows of pores. Copula narrow, with a long and narrow ligula. Valve circular, convex, flat or slightly depressed in the central area, without a distinct valve mantle. Central rosette of slightly larger areolae present or absent. Loculate areolae with external vela and internal foramina sometimes occluded by vaulted siliceous layer. Areolae arranged in radial to fasciculate rows. Velum is a cribum, with a central area and subsidiary areas of perforation, pores occluded by cribella. Criba confluent towards the valve margin. One marginal ring of microrimoportulae irregularly disposed including two macrorimoportulae. Irregular

ring of mesorimoportulae sometimes present on the valve face, at about ½ of the radius. Microrimoportula and mesorimoportulae, with external, short and cylindrical tubes. Macrorimoportulae forming an angle of between 90° and 120°, stub-shaped internally, with horseshoe-like slit at the distal end, and with a long external tube surrounded by a cone-shaped structure.

Derivation: The suffix "opsis" (Gr.) makes reference to similarity to an object, in this case *Coscinodiscus*.

Specie typica: *Coscinodiscopsis jonesiana* (Greville) Sar & Sunesen comb. nov.

***Coscinodiscopsis jonesiana* (Greville) Sar & Sunesen comb. nov.**

Basionym: *Eupodiscus jonesianus* Greville 1862, p. 22, pl. 2, fig. 3.

Synonym: *Coscinodiscus jonesianus* (Greville) Ostenfeld.

Holotype: Dr. Macrae, BM2389. According to Williams (1988, p. 32, pl. 38, figs 4–6) this slide is the only one in Greville's collection.

Type locality: Guano locality unknown, collected in Ceylon and others parts of the Indian coast.

***Coscinodiscopsis commutata* (Grunow) Sar & Sunesen comb. nov.**

Basionym: *Coscinodiscus commutatus* Grunow 1884, p. 79.

Synonym: *Coscinodiscus jonesianus* var. *commutata* (Grunow) Hustedt 1928, p. 440, fig. 240.

Holotype: not designated.

Neotype: designated here, slide B2/74 Bremerhaven, Kaiserhafen, 26–6–1917, deposited in the Hustedt Collection at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven.

Type locality: Bremerhaven.

Genera more closely related to *Coscinodiscopsis* are *Coscinodiscus* s. s. and *Craspedodiscus*. The three genera are similar in the valve outline, morphology of the areolae, and pattern of distribution of micro- and macrorimoportulae. *Coscinodiscopsis* differs from both latter genera by the external morphology of the microrimoportulae with tubes and macrorimoportulae, external tubes of which are covered by a conspicuous conical structure. In addition, *Craspedodiscus* differs from *Coscinodiscopsis* by presenting a concentrically waved valve surface.

The new genus *Coscinodiscopsis* belongs to the Family *Coscinodiscaceae* Kützing emended Round & Crawford in Round *et al.* (1990). Any deeper analysis of the generic and family limits within the Coscinodiscales Round & Crawford is beyond the aims of this paper.

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