



Article

***Cocconeis churalis*: a new marine diatom (Bacillariophyta, Cocconeidaceae) from Japan**

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Abstract

A new species of *Cocconeis*, *C. churalis*, was found on a red seaweed collected from the Southwest Islands of Japan. Its morphology was examined with both light and scanning electron microscopy and the details are described here. This small diatom is characterized by the concave raphid valve with a slightly sigmoid raphe and uniseriate striae consists of circular areolae occluded by hymenes with perforations arranged in centric array type, the convex araphid valve with uniseriate striae consists of several alveoli occluded hymenes with perforations arranged in a parallel array type, and the cingulum consists of four non-fimbriated girdle bands including a valvocopula.

Key words: *Cocconeis churalis*, Japan, marine diatom, new species

Introduction

Cocconeis Ehrenberg (Bacillariophyta: Cocconeidaceae) is a worldwide genus comprising of at least 280 species (VanLandingham 1968), which inhabit freshwater, brackish water and marine environments. It is defined by being heterovalvate and by the diversity of structures of raphe, areola, and cingulum. *Cocconeis* has not been comprehensively studied for its morphological structure. The last treatment of the morphology and distribution of marine species of *Cocconeis* from Japan, which recorded 21 species (unpublished data), was undertaken in a series of papers by Suzuki *et al.* (Suzuki & Nagumo 2003a, 2004, Suzuki *et al.* 2001a–d, 2008, and Suzuki & Tanaka 2006). Many of these species are epiphytic on seaweed (Tiffany 2011, and references therein) and characterized by their raphid valves having uniseriate striae, the araphid valves having chambered alveoli and their non-fimbriate valvocopula (Suzuki *et al.* 2001a, c, d, De Stefano & Romero 2005).

In the present study, an unrecognized species of *Cocconeis* was found growing on the red seaweed *Murrayella pericladus* (C. Agardh) Schmitz (Rhodomelaceae, Rhodophyceae) from the coast of Ishigaki Island, the Southwest Islands, Okinawa Pref., Japan. Critical examination, using light (LM) and scanning electron microscopy (SEM), as well as a review of the literature, support the view that this diatom is a new species; we propose the name *C. churalis* Hide. Suzuki. Details of its morphological features are described below.

Material and methods

Samples containing *Cocconeis churalis* were obtained from the following seaweeds collected from the intertidal zone of the coast of Ibaruma (24°31'16.20"N, 124°16'48.72"E), Ishigaki Island, the Southwest Islands, Ishigaki-shi, Okinawa Pref., Japan by H. Suzuki who was one of the authors,

- I. *Murrayella pericladus* (C. Agardh) Schmitz (Rhodomelaceae, Rhodophyceae) on 4 March 2005, material and slide BM 101651, and
- II. *Bostrychia tenella* (Lamouroux) J. Agardh (Rhodomelaceae, Rhodophyceae) on 17 March 1999, MTUF-AL-HS0080.

Both samples were fixed with 25 % glutaraldehyde solution.

The material was treated using the bleaching method (Nagumo & Kobayasi 1990, Nagumo 1995, Osada & Nagumo 2001). Light and electron microscopy techniques were essentially those used previously (Suzuki *et al.* 2001a–d, 2008, Suzuki & Tanaka 2006). The stria density and the valve size were counted by 20 and 30 valves, respectively. Prepared specimens were examined using HITACHI S-5000 SEM (The Nippon Dental University School of Life Dentistry at Tokyo) operating at 2kV. The terminology used is that outlined in Anonymous (1975) and Ross *et al.* (1979), with additional terms from Kobayasi *et al.* (2006).

New species description

Division Bacillariophyta

Class Bacillariophyceae Haeckel 1878 *emend.* D.G. Mann in Round *et al.* 1990

Order Achnanthes Silva 1962

Family Cocconeidaceae Kützing 1844

Genus *Cocconeis* Ehrenberg 1837

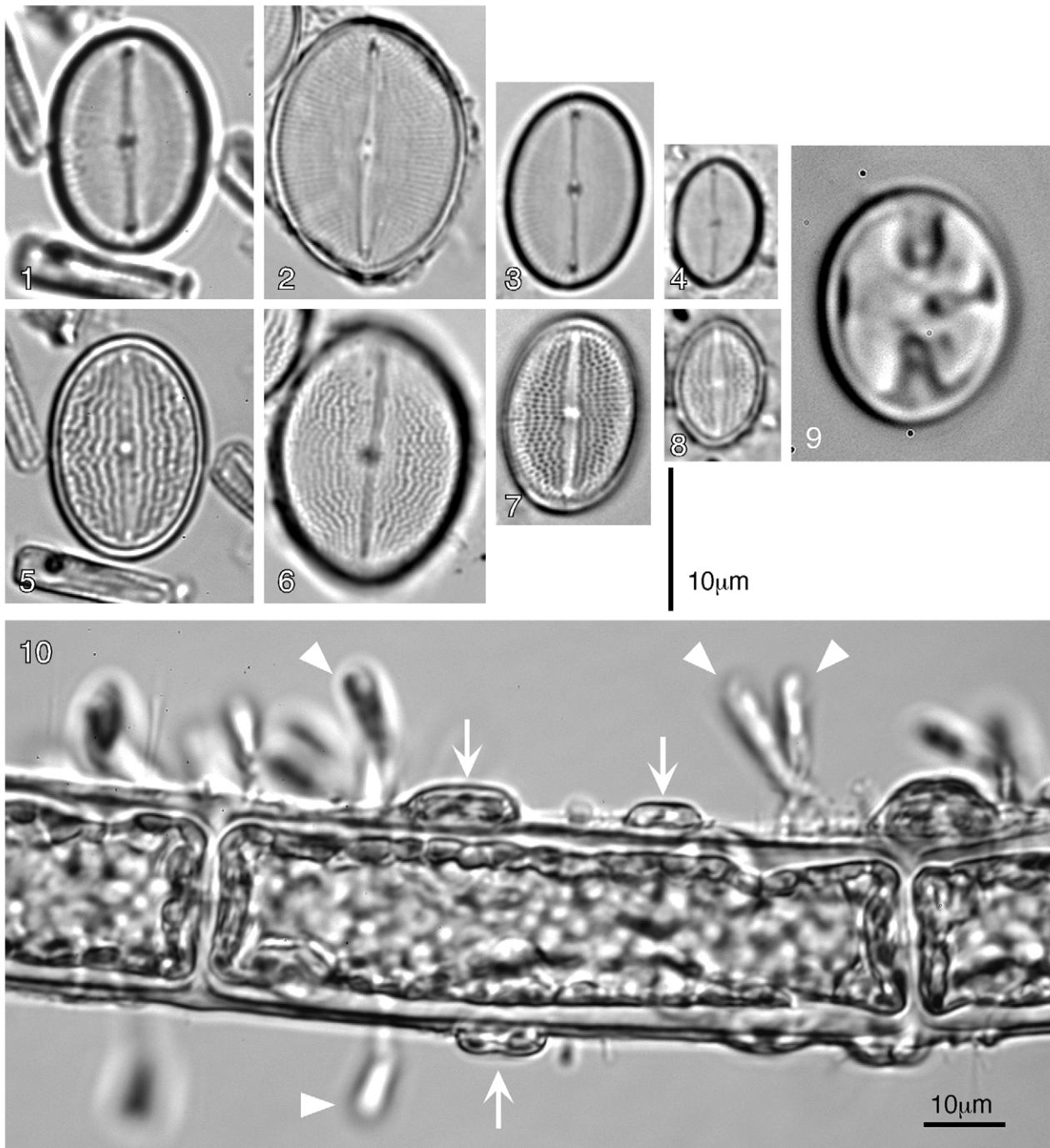
Cocconeis churalis Hide. Suzuki, *sp. nov.* (Figs 1–32)

Frustules heterovalvate. Valve small, elliptical to oval, 8.5–20.0 µm long, 6.0–15.0 µm wide. Raphid valve (RV) concave, raphe slightly sigmoid, central area small, elliptic to orbicular. Striae uniseriate, radiate, 29–36 in 10 µm. Submarginal hyaline area absent. Araphid valve (ARV) convex. Striae alveolus, radiate, 32–38 in 10 µm. Alveolus opens by means of circular to elliptical foramen, viewed internally. Alveolus occluded by hymen. Cingulum consisting of four girdle bands, valvocopula non fimbriate.

Type:—JAPAN. Okinawa Pref., Ishigaki-shi, the Southwest Islands, Ishigaki Island, Ibaruma (24°31'16.20"N, 124°16'48.72"E). Sample collected from surface *Murrayella pericladus* (J. Agardh) Schmitz (Rhodomelaceae, Rhodophyceae) on 4 March 2005. Holotype material and slide; BM 101651 (holotype represented by valves on Figs 1, 5).

Distribution and ecology:—*Cocconeis churalis* has been found only from the type locality and was not recorded in the previous study of the Nansei Islands (including Ishigaki Island and other tropical and subtropical regions) (Takano 1962, Nagumo & Hara 1990, Nagumo & Tanaka 1990, Witkowski *et al.* 2000, Hein *et al.* 2008).

Cocconeis churalis grows abundantly on *Murrayella pericladus* in Ishigaki Island, Japan (Fig. 10, arrows). *Tabularia parva* (Kütz.) D.M. Williams & Round and *Gomphonemopsis pseudexigua* (Simonsen) Medlin were found growing epiphytically (Fig. 10, arrowheads).

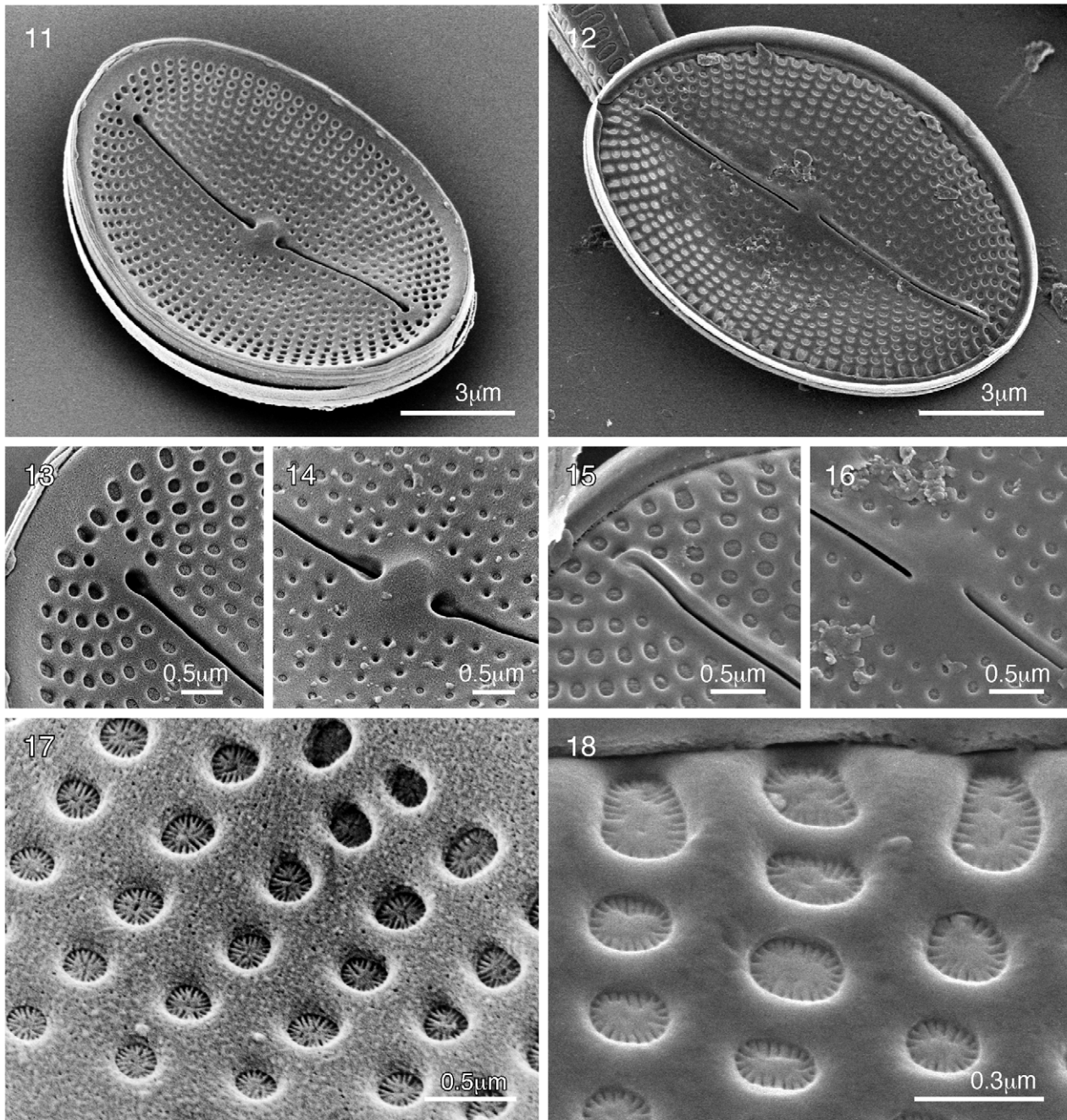


FIGURES 1–10: *Cocconeis churalis*. LM images of holotype and other specimens. Figs 1–8: Raphid valves (RV) (Figs 1–4) and araphid valves (ARV) (Figs 5–8) of the same frustule. Figs 1, 5: Specimens from holotype slide. Figs 9, 10. Specimens from fixed sample. Fig. 9. Cell showing a C-shaped and elaborately lobed plastid. Fig. 10. *C. churalis* (arrows) and *Gomphonemopsis pseudexigua* (arrowheads), epiphytic on *Murrayella pericladus*.

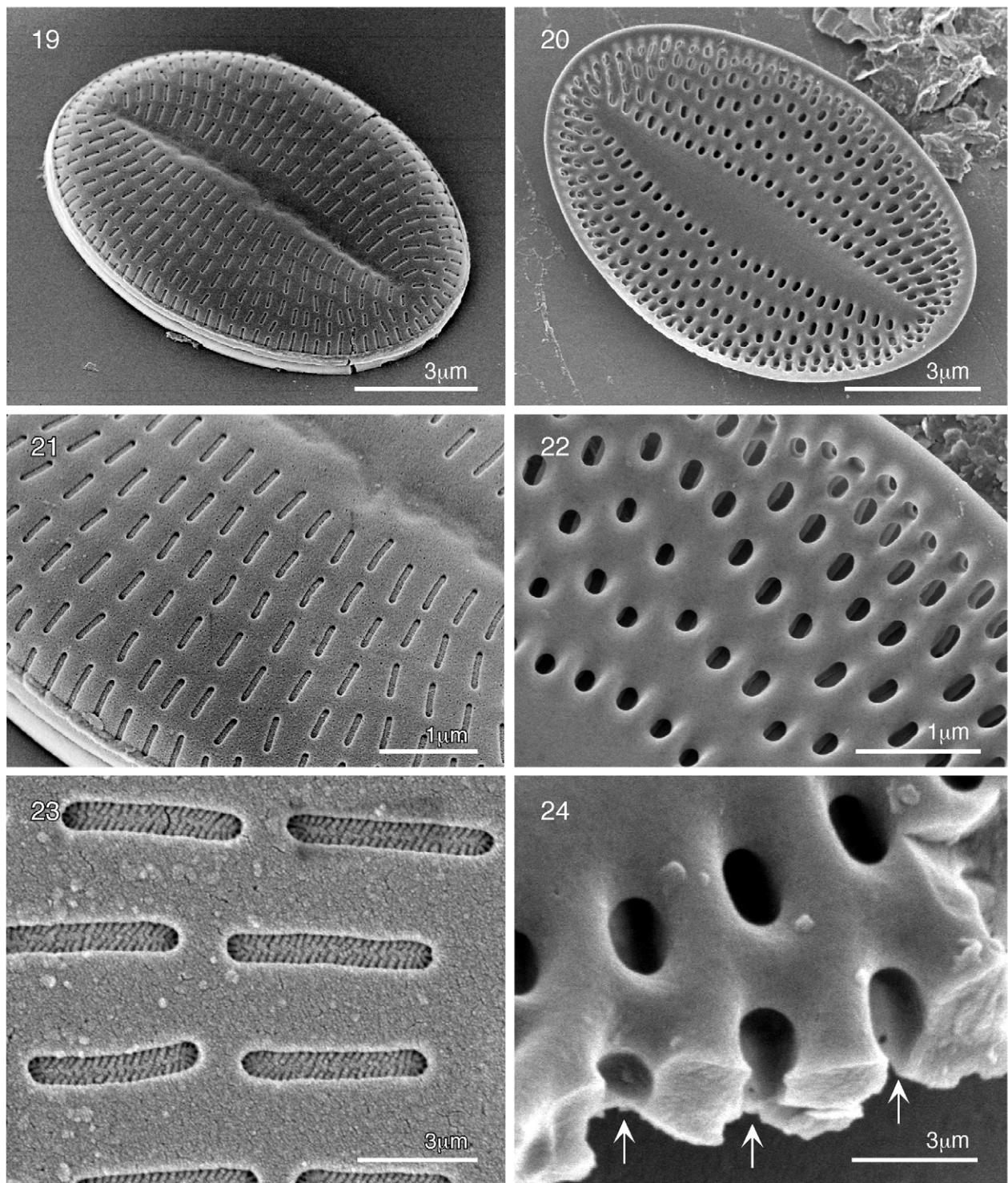
Etymology:—The specific epithet “chura” is derived from the Okinawa dialect meaning ‘beautiful’.

Observations:—Frustules with a single flat plastid, C-shaped, which is either simple or elaborately lobed (Fig. 9) as in some other species of *Cocconeis* (cf. Suzuki *et al.* 2001b–d, 2008, Suzuki & Nagumo 2003b). The frustules are composed of very small and elliptic to oval valves (Figs 1–8), measuring 8.5–20.0 μm in length, 6.0–15.0 μm in breadth. Striae densities at the centre of the valves are 29–36 in 10 μm for the raphid valve (RV), 32–38 in 10 μm for the araphid valve (ARV). The RV is concave (Fig. 11); the curvature of the valve face is concave at the transapical axis not at the apical axis, as in *Cocconeis convexa* Giffen (1967: 257, see Suzuki

et al. 2001c). The raphe appears simple, with a slightly sigmoid slit (Fig. 11) as in *Cocconeis subtilissima* Meister (1935: 99, see Suzuki *et al.* 2008) but not more curved than that found in *Cocconeis heteroidea* Hantzsch (in Rabenhorst 1863: 21, see Suzuki *et al.* 2001a). The inner raphe fissures lie in a very narrow, but raised, axial area (Fig. 12). The proximal raphe ends are coaxial and somewhat dilated externally (Fig. 14) but internally they are undilated and deflected in opposite directions (Fig. 16). The distal raphe ends are dilated externally (Fig. 13) but, internally, terminate in short, narrow and small helictoglossa (Fig. 15). The central area is round and small (Fig. 14). The striae consist of small round areolae and are radiate and uniseriate (Fig. 11). Each areola is circular and occluded by a hymen with perforations arranged in a centric array (Figs 17, 18, see Mann 1981). These hymenes are circular in outline and located near the internal surface of the valve (Fig. 18). A submarginal hyaline area is not recognizable; a narrow marginal hyaline area is visible (Fig. 11).



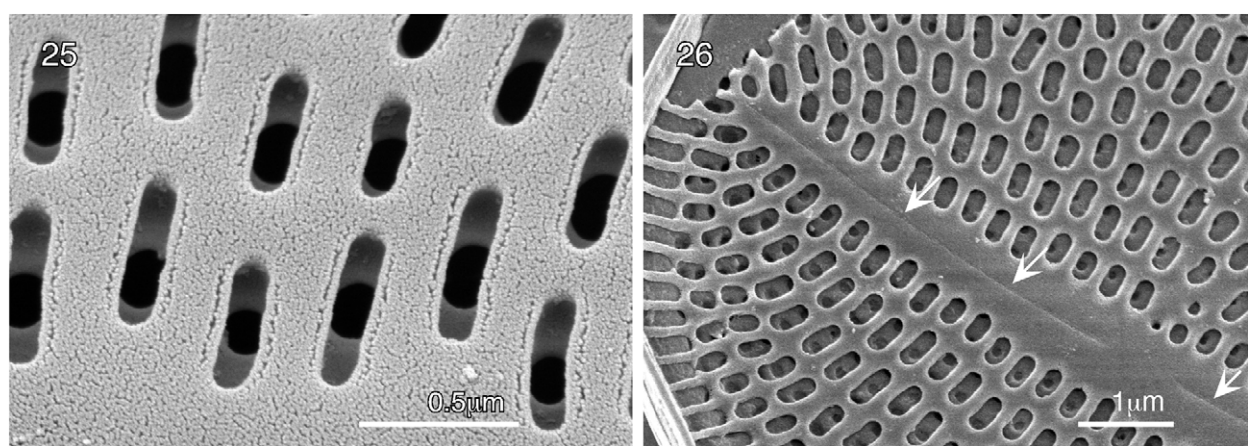
FIGURES 11–18: *Cocconeis churalis*. SEM images of raphid valves (RV). Figs 11, 13, 14, 17: External views of RV. Figs 12, 15, 16, 18: Internal views of RV. Figs 11, 12: Whole valves. Figs 13, 15: Distal raphe ends in terminal area. Figs 14, 16: Proximal raphe ends in central area. Figs 17, 18: Areolae occluded by the hymenes with linear perforations in a centric array.



FIGURES 19–24: *Cocconeis churalis*. SEM images of araphid valves (ARV). Figs 19, 21, 23: External views of ARV. Figs 20, 22, 24: Internal views of ARV. Figs 19, 20: Whole valves. Figs 21, 22: Marginal areas. Fig. 23: Areolae occluded by the hymenes with perforations in a parallel array. Fig. 24: Alveoli occluding by hymenes (arrows) located near the outer surface.

The ARV is convex and corresponds to the curvature of the RV. The axial area is a narrow, slightly sigmoid furrow on the outer surface (Fig. 19) and, internally, lanceolate (Fig. 20). In some valves, a vestigial raphe is observed (Fig. 26, arrows). The striae that consist of several alveoli (Fig. 21) are radiate and uniseriate (Fig. 19). Internally, each alveolus opens by means of a circular to elliptic foramen (Figs 20, 22). Each alveolus is occluded by a hymen located near the outer surface (Fig. 24, arrows). The perforations of the

hymen are linear, oblique and arranged in a parallel array (Fig. 23, see Mann 1981). The structure of the alveolus of *Cocconeis churalis* is essentially the same as that of *Cocconeis dirupta* Gregory (1857: 491, see Kobayasi & Nagumo 1985), *C. pellucida* Grunow (1863: 145, see Kobayasi & Nagumo 1985 and Suzuki *et al.* 2008), *C. heteroidea* (Suzuki *et al.* 2001a), *C. shikinensis* Hide. Suzuki (Suzuki *et al.* 2001b: 138), *C. convexa* (Suzuki *et al.* 2001c), *C. pseudomarginata* Gregory var. *intermedia* Grunow (1867: 13, see Suzuki *et al.* 2001d and Suzuki *et al.* 2008), *C. nagumoi* Hide. Suzuki (Suzuki in Suzuki & Tanaka 2006: 282) and *C. subtilissima* (De Stefano & Romero 2005, Suzuki *et al.* 2008). The external face of an immature ARV illustrates the structure of the internal perforations of alveoli (Fig. 25).



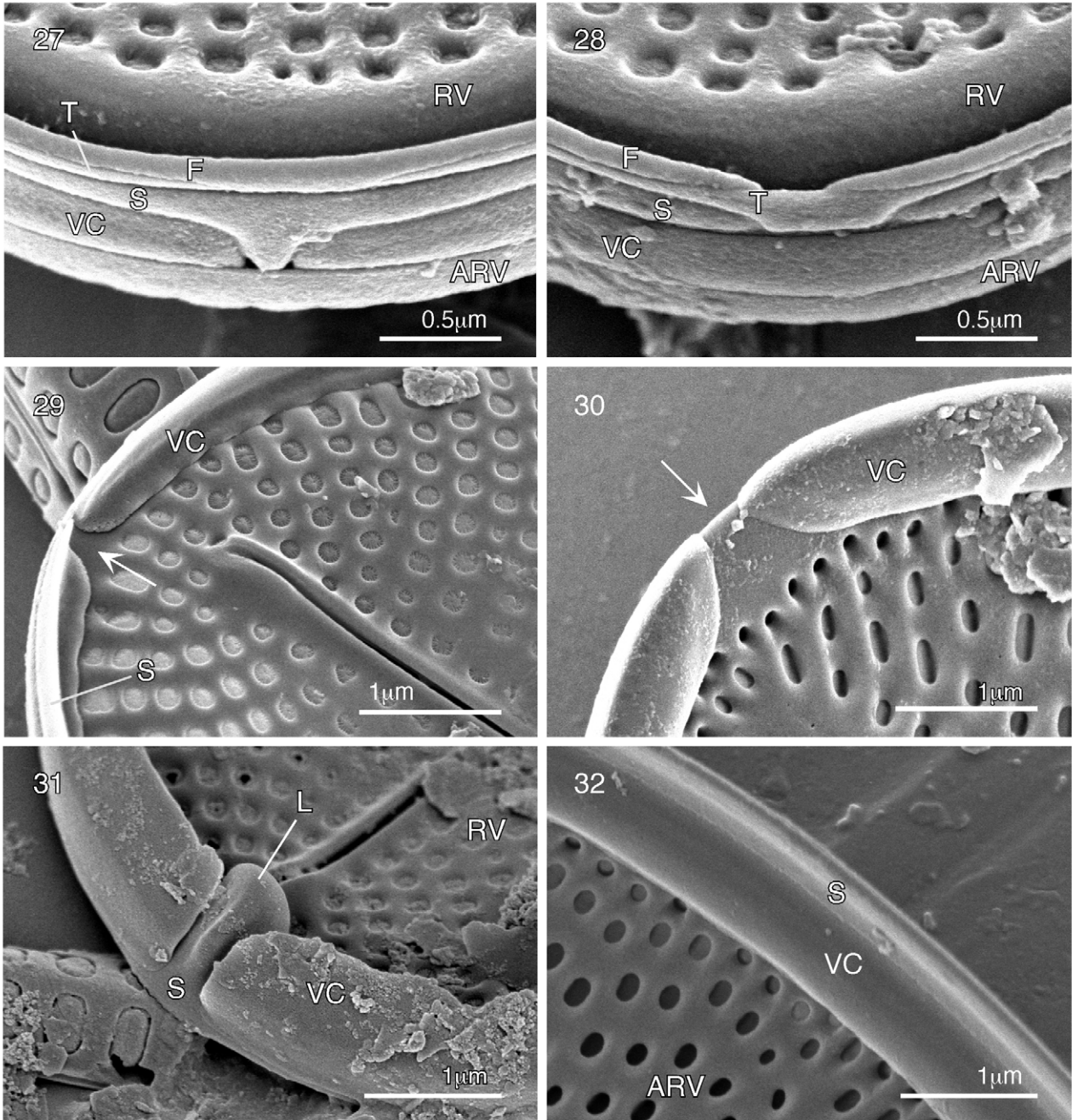
FIGURES 25, 26: *Cocconeis churalis*. SEM images of araphid valves (ARV). Fig. 25: External face of immature ARV showing alveoli, each with one foramen. Fig. 26: Early stage of ARV formation, with rudimentary raphe (arrows).

The mature cingulum consists of four girdle bands (Figs 27, 28): a valvocopula and three bands (the second, the third and the fourth bands), which are all narrower and thinner than the valvocopula. The valvocopula of each valve is open at one pole (Figs 29, 30, arrows) and has no fimbriae; their inner edges are smooth (Fig. 32). The second band, adjacent to the valvocopula, is open at the opposite pole and possesses a ligula (Fig. 31, L). The third and fourth bands are also open (Figs 27, 28). The structure of the cingulum is like that of: *C. dirupta* (Kobayasi & Nagumo 1985), *C. pellucida* (Kobayasi & Nagumo 1985), *C. heteroidea* (Suzuki *et al.* 2001a), *C. convexa* (Suzuki *et al.* 2001c), *C. pseudomarginata* var. *intermedia* (Suzuki *et al.* 2001d) and *C. subtilissima* (Suzuki *et al.* 2008).

The RV morphology of *Cocconeis churalis* is similar to that of *C. subtilissima* (De Stefano & Romero 2005, Suzuki *et al.* 2008) but *Cocconeis churalis* can be readily distinguished by the following characters:

- i) The curvature of the RV is concave at the transapical axis;
- ii) The slightly sigmoid raphe slits terminate in short, narrow and small helictoglossa, not hooked;
- iii) The terminal hyaline area is small and round, not an arrowhead type; and
- iv) The density of striae is higher than that of *C. subtilissima* (26–28 in 10 μm ; Suzuki *et al.* 2008).

Cocconeis churalis is similar to *C. dirupta* (Kobayasi & Nagumo 1985) but can be readily distinguished from it as *C. dirupta* lacks a stauros in the central area of the RV, has a broad, sigmoid lanceolate axial area on the ARV, and a higher density of the areolae on both valves (22 in 10 μm on the RV, 20 in 10 μm on the ARV; Kobayasi & Nagumo 1985).



FIGURES 27–32: *Cocconeis churalis*. SEM images of cingula. Fig. 27: Valvocopula (VC), and second (S), third (T) and fourth (F) band of ARV. Fig. 28: Opposite pole. Figs 29, 30: Internal views of the terminal areas of RV and ARV with valvocopula (VC), respectively. Arrows indicate the open parts of valvocopula. Fig. 31: Valvocopula (VC) and the second band (S) with ligula (L), remaining on RV. Fig. 32: Valvocopula (VC) and second band (S) of araphid valve (ARV).

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