

# Morphological study of the genus *Cocconeis* Ehrenberg (Bacillariophyceae) collected during the 1897–1899 Belgian Antarctic Expedition

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## Abstract

Henri Van Heurck examined a sample collection of sea ice and underlying sea floor sediment material during the Belgian Antarctic Expedition (1897–1899). He described eight new taxa of the monoraphid diatom genus *Cocconeis* from this collection including: *C. antiqua* var. *tenuistriata*, *C. gautierii* var. *gautierii* and var. *inornata*, *C. heydrichii*, *C. japonica* var. *antarctica*, *C. litigiosa*, *C. schuettii* var. *schuettii* and var. *minor*. All these *Cocconeis* taxa share well-silicified sternum valves with wide, apical hyaline areas, more or less lenticular in shape, and narrow hyaline bands at mid-distance between the apical axis and the margin, while the more delicate raphe-sternum valves bear uniseriate striae, a hemistaurus associated with the central raphe area, and crescent-shaped terminal hyaline areas. Since their original description in the early 20th century, these *Cocconeis* taxa have been rarely reported. I studied newly described *Cocconeis* taxa from Van Heurck's type material by light microscopy. The main valve features of *C. gautierii* var. *gautierii* and var. *inornata*, *C. litigiosa*, and *C. schuettii* var. *schuettii* and var. *minor* agree well with those of *Cocconeis antiqua*; I propose these five taxa be reduced to synonymy of *C. antiqua*.

**Keywords:** Antarctic; *Cocconeis*; diatom; herbarium collection.

## Introduction

During the first Antarctic marine explorations, Van Heurck (1909) studied soft sediment and sea ice diatom material collected off the Antarctic Peninsula (~61°–70° S, 61°–102° W) during the 1897–1899 Belgian Expedition. Among this collection, he reported the occurrence of 10 *Cocconeis* taxa, providing descriptions of new taxonomic entities and illustrations for eight of them: *C. antiqua* var. *tenuistriata*, *C. gautierii* var. *gautierii* and var. *inornata*, *C. heydrichii*, *C. japonica* var. *antarctica*, *C. litigiosa*, *C. schuettii* var. *schuettii* and var. *minor*. These eight newly described *Coc-*

*coneis* taxa share some common morphological valve features. The well-silicified sternum valve (SV) has a broad median hyaline area, more or less apically lenticular in shape, and another narrow hyaline area at mid-distance between the sternum and the margin, which sometimes merges with the median lenticular area on one or both sides. As in many *Cocconeis* taxa (Romero and Navarro 1999, Riaux-Gobin and Romero 2003, De Stefano and Romero 2005), the raphe-sternum valve (RSV) is less silicified than the SV and is characterized by uniseriate striae and a short, transapical hyaline area associated with the central raphe endings, while crescent-shaped hyaline areas of different lengths are present at the valve apices.

Except for *Cocconeis costata* Gregory var. *costata* and var. *pacifica* Grunow (Romero and Rivera 1996), the eight taxa newly described by Van Heurck (1909) have been reported rarely elsewhere in the literature. The few reports of these *Cocconeis* taxa led in turn to nomenclatural changes. Peragallo (1921) when studying diatom material collected during the second French Antarctic Expedition, recorded most of the *Cocconeis* previously described by Van Heurck, and he renamed selected species and varieties. Similarly, Frenguelli and Orlando (1958) also recorded most of Van Heurck's *Cocconeis* taxa. Finally, in a diatom survey conducted at Terre Adélie, Manguin (1960) described most of the *Cocconeis* taxa defined by Van Heurck (1909) with few nomenclatural changes.

Because there are so few records of the *Cocconeis* taxa described by Van Heurck (1909) and no detailed examinations, I examined by light microscopy the type material of these *Cocconeis* taxa described from samples collected during the 1897–1899 Belgian Antarctic Expedition. Biometric data and morphological features of eight *Cocconeis* taxa newly described by Van Heurck (1909) are documented here and the nomenclatural status of each taxon is revisited and discussed.

## Materials and methods

The diatom material collected during the 1897–1899 Belgian Antarctic Expedition of the *S.Y. Belgica*, is held at the Van Heurck Diatom Collection, which is curated by the National Botanic Garden of Belgium (BR) at Meise. Van Heurck (1909) analyzed three sea ice samples and 11 surface sediment samples (“*Sondage*” in the original publication) collected between 425 and 3690 m water depths off the western Antarctic Peninsula (~61°–70° S, 61°–102° W; Table 1). All permanent slide preparations housed at the Van Heurck Dia-

**Table 1** List of original diatom material collected during the 1897–1899 Belgian Antarctic Expedition and examined by Van Heurck (1909).

| Sediment sample<br>( <i>sondage</i> ) Nr | Latitude (S)                                    | Longitude (W) | Water depth (m)    |
|--|---|---------------|--------------------|
| 6  | 61°05'  | 63°04'        | 3690               |
| 8  | 62°11'  | 61°37'        | 1880               |
| 9  | 64°25'  | 62°02'        | 625                |
| 11                                       | 69°06'  | 78°21'        | 480                |
| 12                                       | 69°46'  | 81°08'        | 565                |
| 20                                       | 71°22'  | 84°56'        | 530                |
| 50                                       | 69°52'  | 85°13'        | 1360               |
| 54                                       | 70°30'  | 94°12'        | 1740               |
| 55                                       | 70°53'  | 97°17'        | 430                |
| 56                                       | 70°51'  | 97°57'        | 425                |
| 58                                       | 70°50'  | 102°13'       | 1195               |
| Sea ice sample Nr                        |   |               | Date of collection |
| 141                                      | 65°15.5'  | 64°30.0'      | 13 February 1898   |
| 145                                      | 67°59.7'  | 70°39.0'      | 16 February 1898   |
| 445                                      | Off Harry Island, Hughes Inlet, Gerlache Strait |               | 25 January 1898    |

tom Collection and labelled either with “*Belgica*” or “*Sondage Nr.*” were studied. All catalogue cards of the Van Heurck Diatom Collection were screened in order to find additional slides that might pertain to the material collected during the *S.Y. Belgica* Expedition. Although a thorough search was undertaken at BR, the raw material corresponding to the permanent slides studied was not found; therefore, this study was only possible using light microscopy (LM) (Olympus® BX51, Tokyo, Japan) at the Department of Cryptogamy, National Botanic Garden, Meise, Belgium.

In addition, the type material of *Cocconeis antiqua* Tempère *et* Brun from Sendai, Japan, was studied in LM (Brun and Tempère 1889). Slides corresponding to *C. antiqua* type material, labelled as 2875, 3407, 3403D and 4337, are curated at the Conservatoire et Jardin Botaniques at Geneva in Switzerland. Although the original raw samples of the Brun and Tempère collection were examined by scanning electron microscopy, no valves belonging to *C. antiqua* were found. Specimens of *C. antiqua* were examined in LM (Olympus® B41) at the Instituto Andaluz de Ciencias de la Tierra, Universidad de Granada, Granada, Spain.

Valve terminology follows Anonymous (1975), Ross *et al.* (1979) and Round *et al.* (1990). Sternum and raphe-sternum valves are abbreviated SV and RSV, respectively. The striae were counted at the centre of the valve face along the apical hyaline area and on the margin opposite to the valve centre. Apical and transapical axes are abbreviated AA and TA, respectively.

## Results

### Material from the Belgian Antarctic Expedition studied by Henri Van Heurck

I found 80 permanent slides corresponding to nine of the 11 surface sediment samples originally listed by Van Heurck

(1909; Table 1) in the Van Heurck Diatom Collection. Most of the slides corresponded to surface sediment samples Nr 6, 8, 9 and 12, while no permanent slide preparations were located for samples Nr 11 and 20. Surface sediment samples Nr 50, 54, 55, 56 and 58 have no specimens of *Cocconeis*. Sea ice samples Nr 141, 145 and 445, also reported by Van Heurck (1909; Table 1), lack *Cocconeis* valves. Surface sediment sample Nr 9 contained the highest species number as well as the highest abundance of *Cocconeis* valves. Moreover, the present observations on the occurrence of *Cocconeis* taxa in the Belgian Antarctic Expedition material differ slightly from the original observations by Van Heurck (1909; Table 2). Van Heurck (1909) recorded seven out of 10 *Cocconeis* taxa in sample Nr 9, but I observed all eight newly described *Cocconeis* taxa in slide material from surface sediment sample Nr 9 (Table 2). Although not listed originally by Van Heurck (1909), *C. imperatrix* Schmidt (Riaux-Gobin and Romero 2003), *C. fasciolata* (Ehrenberg) Brown and *C. pinnata* Gregory (Romero and Rivera 1996) were com-

**Table 2** List of *Cocconeis* taxa found in the original Van Heurck collection of Antarctic diatom material.

| Taxon   | Surface sediment samples<br>( <i>sondage</i> ) Nr |     |     |    |
|---|---|-----|-----|----|
|   | 6   | 8   | 9   | 12 |
| <i>C. antiqua</i> var. <i>tenuistriata</i> (SV) |   | VH* | *   |    |
| <i>C. gautierii</i> var. <i>gautierii</i> (SV)  |   |     | VH* | *  |
| <i>C. gautierii</i> var. <i>inornata</i> (SV)   |   |     | VH* |    |
| <i>C. heydrichii</i> (RSV)                      |   |     | VH* |    |
| <i>C. japonica</i> var. <i>antarctica</i> (SV)  | *   | *   | VH* |    |
| <i>C. litigiosa</i> (RSV)                       |   |     | VH* | *  |
| <i>C. schuettii</i> var. <i>schuettii</i> (RSV) |   |     | VH* |    |
| <i>C. schuettii</i> var. <i>minor</i> (SV)      |   |     | VH* |    |

\*This study. RSV, raphe-sternum valve; SV, sternum valve; VH, originally listed and described by Van Heurck (1909).

monly found in surface sediment sample Nr 9. Similarly, the occurrence of *C. antiqua* var. *tenuistriata* is confirmed in surface sediment sample Nr 8.

### Van Heurck's *Cocconeis* taxa revisited

Following the 1897–1899 Belgian Antarctic Expedition, Van Heurck (1909) reported the occurrence of 10 *Cocconeis* taxa of which he considered eight as new taxonomic entities: *C. antiqua* var. *tenuistriata* Van Heurck, *C. costata* Gregory var. *costata* and var. *pacifica* Grunow, *C. gautierii* Van Heurck var. *gautierii* and var. *inornata* Van Heurck, *C. heydrichii* Van Heurck, *C. japonica* var. *antarctica* Van Heurck, *C. litigiosa* Van Heurck, *C. schuettii* Van Heurck var. *schuettii* and var. *minor* Van Heurck. His original drawings of the eight new *Cocconeis* taxa are reproduced here in Figures 1–9; these new *Cocconeis* taxa are treated below.

### *Cocconeis antiqua* var. *tenuistriata* Van Heurck 1909 Figures 1, 10–12

**Reference** Van Heurck 1909, p. 16, pl. 2, fig. 27.

**Description** Only SV found. Valves elliptical to linear-elliptical, AA: 78.5–120  $\mu\text{m}$ ; TA: 47.0–67.3  $\mu\text{m}$ . The valve face is strongly concave along the apical axis, distally con-

vex, abruptly falling into the mantle. A wide, apical, hyaline area, more or less lenticular in shape and a narrow hyaline band at mid-distance are present between the apical axis and the margin. The striae are radiate, uniseriate and slightly increasing in density from the centre (12–15 in 10  $\mu\text{m}$ ) to the valve margin (13–16 in 10  $\mu\text{m}$ ). Striae appear better organized close to the apical hyaline broad area, where areolae form short, more or less radiate rows, than near the margin where striae are irregular and segmented.

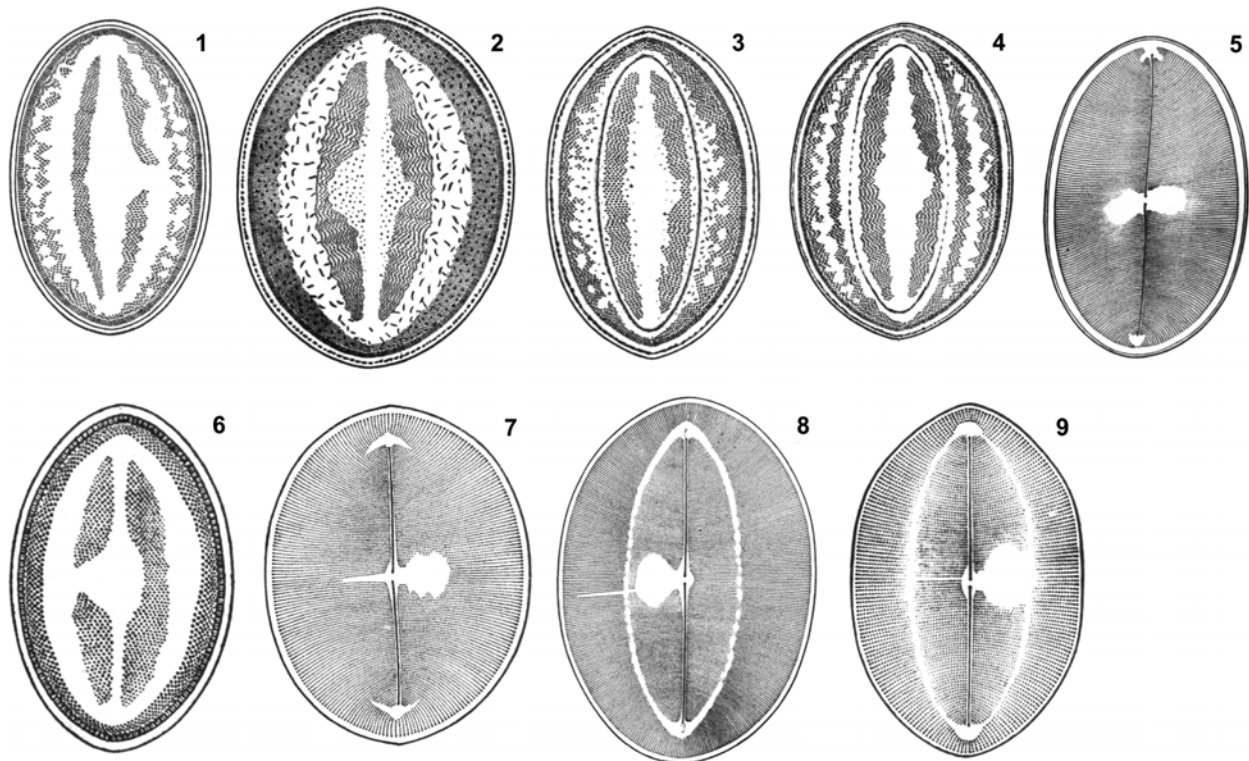
**Lectotype** Slide III-20-B3, Van Heurck Diatom Collection, National Botanic Garden of Belgium (BR), Meise, Belgium. Lectotype specimen illustrated in Figure 11.

**Type locality** Surface sediment (*sondage*), 625 m deep, sample Nr 9 (64°25' S, 62°02' W), Gerlache Strait, Antarctic Peninsula, 1897–1899 Belgian Antarctic Expedition.

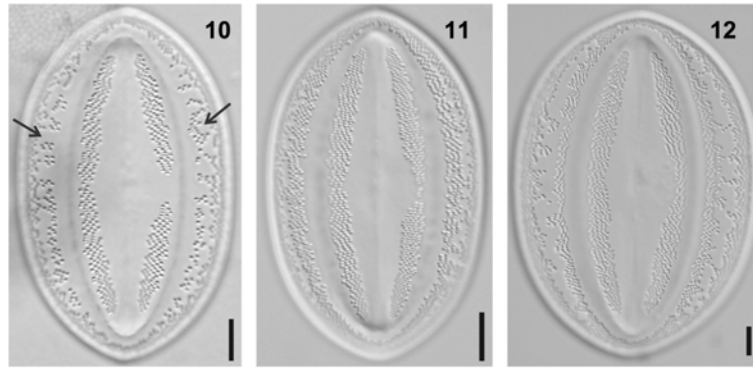
**Distribution** Off Livingston Island, South Shetlands Islands and in Gerlache Strait, Antarctic Peninsula (Table 2).

### *Cocconeis gautierii* Van Heurck 1909 var. *gautierii* Figures 2, 13–15

**Reference** Van Heurck 1909, p. 17, pl. 2, fig. 30.



**Figures 1–9** Original line drawings of *Cocconeis* taxa described by Van Heurck (1909) from the 1897–1899 Belgian Antarctic Expedition. AA, apical axis; RSV, raphe-sternum valve; SV, sternum valve; TA, transapical axis. (1) *C. antiqua* var. *tenuistriata*, SV (AA: 97  $\mu\text{m}$ , TA: 62  $\mu\text{m}$ ). (2) *C. gautierii* var. *gautierii*, SV (AA: 126  $\mu\text{m}$ , TA: 99  $\mu\text{m}$ ). (3 and 4) *C. gautierii* var. *inornata*, SV (3, AA: 98  $\mu\text{m}$ , TA: 67  $\mu\text{m}$ ; 4, AA: 123  $\mu\text{m}$ , TA: 89  $\mu\text{m}$ ). (5) *C. heydrichii*, RSV (AA: 130  $\mu\text{m}$ , TA: 84  $\mu\text{m}$ ). (6) *C. japonica* var. *antarctica*, SV (AA: 62  $\mu\text{m}$ , TA: 41  $\mu\text{m}$ ). (7) *C. litigiosa*, RSV (AA: 104  $\mu\text{m}$ , TA: 84  $\mu\text{m}$ ). (8) *C. schuettii* var. *schuettii*, RSV (AA: 174  $\mu\text{m}$ , TA: 124  $\mu\text{m}$ ). (9) *C. schuettii* var. *minor*, RSV (AA: 88  $\mu\text{m}$ , TA: 58  $\mu\text{m}$ ).



**Figures 10–12** Sternum valves of *Cocconeis antiqua* var. *tenuistriata* in LM from the type material of Van Heurck (1909) collected during the 1897–1899 Belgian Antarctic Expedition.

(10) Sample Nr 9, slide III-21-B4, 40 $\times$ . Arrows indicate segmented striae close to the valve margin. (11) Lectotype specimen from sample Nr 9, slide III-20-B3, 40 $\times$ . (12) Sample Nr 9, slide III-20-B2, 40 $\times$ . Scale bars=10  $\mu$ m.

**Description** Only SV found. Valves elliptical, AA: 61.5–111  $\mu$ m; TA: 42.3–90.1  $\mu$ m. The valve face is concave along the apical axis, distally convex, abruptly falling into a convex mantle. A narrow apical, hyaline area widens asymmetrically at the valve centre. A hyaline band is present at mid-distance between the apical axis and the margin and is fully ornamented with randomly dispersed siliceous outgrowths. Striae are short, uniseriate, straight and almost parallel near the centre and radiate and slightly curved toward the apex, ranging from 13–15 in 10  $\mu$ m.

**Lectotype** Slide III-22-B3, Van Heurck Diatom Collection, National Botanic Garden of Belgium (BR), Meise, Belgium. Lectotype specimen illustrated in Figure 15.

**Type locality** Surface sediment (*sondage*), 625 m deep, sample Nr 9 (64 $^{\circ}$ 25' S, 62 $^{\circ}$ 02' W), Gerlache Strait, Antarctic Peninsula, 1897–1899 Belgian Antarctic Expedition.

**Distribution** Gerlache Strait, Antarctic Peninsula and in Bellingshausen Sea (Table 2).

***Cocconeis gautierii* var. *inornata* Van Heurck 1909  
Figures 3, 4, 16–18**

**Reference** Van Heurck 1909, p. 18, pl. 2, figs. 31, 33.

**Description** Only SV found. Valves elliptical to linear-elliptical, AA: 62.0–111  $\mu$ m; TA: 44.9–73.1  $\mu$ m. The overall morphology resembles that of the nominate variety. Both hyaline areas are ornamented with a few siliceous outgrowths, randomly arranged, though less abundant and smaller than in the nominate variety. Striae are better organized close to the apical hyaline broad area while near margin the striae are irregular and segmented.

**Lectotype** Slide III-20-B1, Van Heurck Diatom Collection, National Botanic Garden of Belgium (BR), Meise, Belgium. Lectotype specimen illustrated in Figure 16.

**Type locality** Surface sediment (*sondage*), 625 m deep, sample Nr 9 (64 $^{\circ}$ 25' S, 62 $^{\circ}$ 02' W), Gerlache Strait, Antarctic Peninsula, 1897–1899 Belgian Antarctic Expedition.

**Distribution** Gerlache Strait, Antarctic Peninsula (Table 2).

***Cocconeis heydrichii* Van Heurck 1909 Figures 5, 23**

**Reference** Van Heurck 1909, p. 18, pl. 2, fig. 34.

**Description** Only RSV found. Valves linear-elliptical, AA: 125.2  $\mu$ m; TA: 77.8  $\mu$ m. The valve face is externally convex along the apical axis and concave in the distal part, with a distinct bow-tie-shaped central area. The raphe is mostly straight, gently sinuous at the apex, with approximate and co-axial proximal endings; distal endings terminating in short, crescent-shaped terminal areas located at some distance from the apex. Striae are uniseriate, strongly radiate, slightly oblique at mid-valve, ranging from 19–20 in 10  $\mu$ m near the raphe to 17–18 in 10  $\mu$ m close to the valve margin.

**Lectotype** Slide III-22-B3, Van Heurck Diatom Collection, National Botanic Garden of Belgium (BR), Meise, Belgium. Lectotype specimen illustrated in Figure 23.

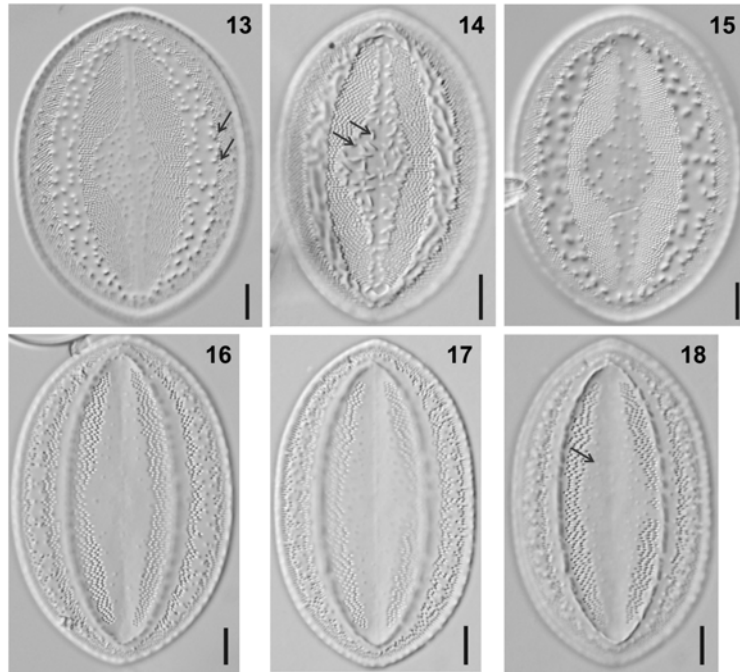
**Type locality** Surface sediment (*sondage*), 625 m deep, sample Nr 9 (64 $^{\circ}$ 25' S, 62 $^{\circ}$ 02' W), Gerlache Strait, Antarctic Peninsula, 1897–1899 Belgian Antarctic Expedition.

**Distribution** Gerlache Strait, Antarctic Peninsula (Table 2).

***Cocconeis japonica* var. *antarctica* Van Heurck 1909  
Figures 6, 19–22**

**Reference** Van Heurck 1909, p. 17, pl. 2, fig. 26.

**Description** Only SV found. Valves elliptical, AA: 53.4–101  $\mu$ m, TA: 32.5–79.1  $\mu$ m. The valve face is concave along



**Figures 13–18** Sternum valves of *Cocconeis gautierii* in LM from the type material of Van Heurck (1909) collected during the 1897–1899 Belgian Antarctic Expedition.

(13–15) *C. gautierii* var. *gautierii*. (13) Sample Nr 9, slide III-20-B3, focused on lateral hyaline areas, 40 $\times$ . Arrows indicate segmented striae close to the valve margin. (14) Sample Nr 9, slide III-20-B3, focused on the sternum, 40 $\times$ . Arrows indicate randomly arranged outgrowths along the apically lenticular hyaline area. (15) Lectotype specimen from sample Nr 9, slide III-22-B3, 40 $\times$ . (16–18) *C. gautierii* var. *inornata*. Lectotype specimen from sample Nr 9, slide III-20-B1, focused on transapical striae close to the sternum and to lateral areas, 40 $\times$ . (17) Sample Nr 9, slide III-21-B4, focused on valve margin, 40 $\times$ . (18) Sample Nr 9, slide III-21-B4, focused on striae close to the sternum, 40 $\times$ . Arrow indicates randomly arranged outgrowths along the apically lenticular hyaline area. Scale bars=10  $\mu$ m.

the AA, distally convex. The two hyaline lateral areas resemble those on the SV of *Cocconeis gautierii* var. *gautierii* and var. *inornata*. The broad apical hyaline area merges either on one or both sides with the narrow hyaline band at mid-distance between the apical axis and the margin. Striae are uniseriate, radiate, varying in density from 15–19(21)/10  $\mu$ m, and are composed by areolae arranged in a quincunx.

**Lectotype** Slide III-20-A1, Van Heurck Diatom Collection, National Botanic Garden of Belgium (BR), Meise, Belgium. Lectotype specimen illustrated in Figure 20.

**Type locality** Surface sediment (*sondage*), 625 m deep, sample Nr 9 (64°25' S, 62°02' W), Gerlache Strait, Antarctic Peninsula, 1897–1899 Belgian Antarctic Expedition.

**Distribution** Off Livingston Island, South Shetlands Islands and in Gerlache Strait, Antarctic Peninsula (Table 2).

***Cocconeis litigiosa* Van Heurck 1909**

**Figures 7, 24, 25**

**Reference** Van Heurck 1909, p. 18, pl. 2, fig. 28.

**Description** Only RSV found. Valves elliptical to oval-elliptical, AA: 55.1–110  $\mu$ m, TA: 35.0–85.5  $\mu$ m. The raphe consists of two straight branches, with approximate and co-

axial central endings and elongated distal endings terminating in crescent-shaped terminal areas located far from the valve apices; an apically enlarged helictoglossa is present. An asymmetrical, sub-circular area is present on one side of the valve while a narrow, short and elongate stauros-like structure appears on the opposite side. Striae are uniseriate and radiate throughout the valve, ranging from (11) 12–16 in 10  $\mu$ m near the raphe to 9–14 in 10  $\mu$ m close to the valve margin.

**Lectotype** Slide III-21-A9, Van Heurck Diatom Collection, National Botanic Garden of Belgium (BR), Meise, Belgium. Lectotype specimen illustrated in Figure 25.

**Type locality** Surface sediment (*sondage*), 625 m deep, sample Nr 9 (64°25' S, 62°02' W), Gerlache Strait, Antarctic Peninsula, 1897–1899 Belgian Antarctic Expedition.

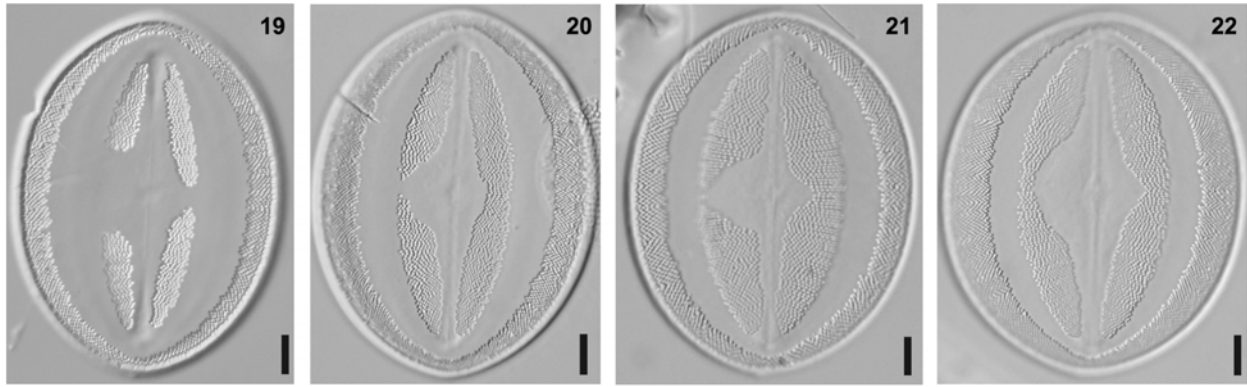
**Distribution** Gerlache Strait, Antarctic Peninsula and in Bellingshausen Sea (Table 2).

***Cocconeis schuettii* Van Heurck 1909 var. *schuettii***

**Figures 8, 27–29**

**Reference** Van Heurck 1909, p. 18, pl. 2, fig. 29.

**Description** Only a unique frustule was found. Valves elliptical, AA: 110  $\mu$ m, TA: 73.1  $\mu$ m. The SV is concave



**Figures 19–22** Sternum valves of *Cocconeis japonica* var. *antarctica* in LM from the type material of Van Heurck (1909) collected during the 1897–1899 Belgian Antarctic Expedition.

(19) Sample Nr 9, slide III-22-B3, focused on sternum, adjacent areolae and lateral hyaline areas, 40 $\times$ . (20) Lectotype specimen from sample Nr 9, slide III-20-A1, focused on sternum, adjacent areolae and lateral hyaline areas, 40 $\times$ . (21) Sample Nr 9, slide III-20-B2, focused on lateral hyaline areas, 40 $\times$ . (22) Sample Nr 9, slide III-20-B4, focused on lateral hyaline areas, 40 $\times$ . Scale bars=10  $\mu$ m.

along the AA and bears two hyaline areas: one situated apically, more or less lenticular in shape, and another narrow hyaline area at mid-distance between the sternum and the margin. The RSV is concave along the AA. The raphe consists of two straight branches ending centrally in an asymmetrical, sub-circular hyaline area on one side of the valve. The proximal raphe endings are close to each other and co-axial, while the distal endings are elongated and terminate at some distance from the valve apices. Striae are uniseriate and radiate throughout the valve, ranging from 13–14 in 10  $\mu$ m near the raphe to 17–18 in 10  $\mu$ m close to the valve margin.

**Lectotype** Slide III-22-B3, Van Heurck Diatom Collection, National Botanic Garden of Belgium (BR), Meise, Belgium. Lectotype specimen illustrated in Figure 27.

**Type locality** Surface sediment (*sondage*), 625 m deep, sample Nr 9 (64 $^{\circ}$ 25' S, 62 $^{\circ}$ 02' W), Gerlache Strait, Antarctic Peninsula, 1897–1899 Belgian Antarctic Expedition.

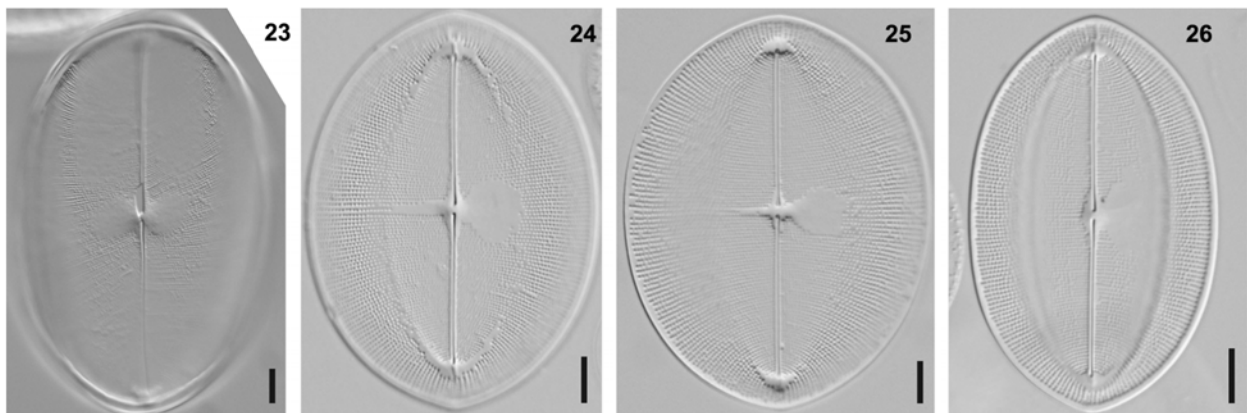
**Distribution** Gerlache Strait, Antarctic Peninsula (Table 2).

***Cocconeis schuettii* var. *minor* Van Heurck 1909**

**Figures 9, 26**

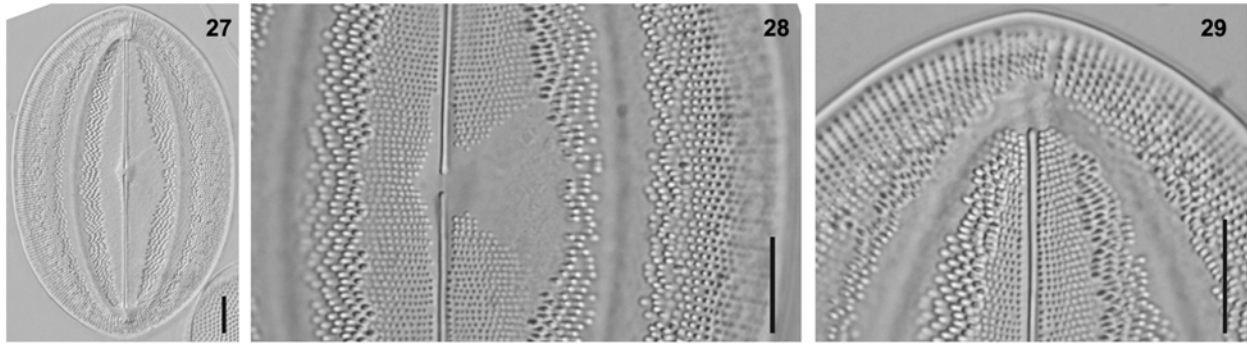
**Reference** Van Heurck 1909, p. 19, pl. 2, fig. 32.

**Description** Only RSV found. Valves elliptical, AA: 73.3–116  $\mu$ m, TA: 47.0–80.8  $\mu$ m. The straight raphe has approximate and co-axial proximal endings. An asymmetrical, triangular-shaped central area is present. A narrow hyaline area



**Figures 23–26** Raphe-sternum valves of *Cocconeis heydrichii*, *C. litigiosa* and *C. schuettii* var. *minor* in LM from the type material of Van Heurck (1909) collected during the 1897–1899 Belgian Antarctic Expedition.

(23) Lectotype specimen of *C. heydrichii* from sample Nr 9, slide III-22-B3, 40 $\times$ . (24) Sample Nr 9, slide III-21-A9, focus on the raphe-sternum, crescentic terminal hyaline areas and submarginal striae, 40 $\times$ . (25) Lectotype specimen of *C. litigiosa* from sample Nr 9, slide III-21-A8, focus on the asymmetrical central area, sternum, and crescent-shaped terminal hyaline areas, 40 $\times$ . (26) Lectotype specimen of *C. schuettii* var. *minor* from sample Nr 9, slide III-01-B4, focus on the sternum and marginal striae, 40 $\times$ . Note the absence of a hemistaurus. Scale bars=10  $\mu$ m.



**Figures 27–29** Lectotype specimen of a complete frustule of *Cocconeis schuettii* var. *schuettii* in LM from the type material of Van Heurck (1909) collected during the 1897–1899 Belgian Antarctic Expedition. (27–29) Sample Nr 9, slide III-22-B3. (27) Frustule, 40 $\times$ . (28) Detail of the mid-valve, 100 $\times$ . (29) Detail of the valve apex, 100 $\times$ . Scale bars=10  $\mu$ m.

runs midway between the apical axis and the valve margin. Striae are uniseriate and radiate, ranging from 13 in 10  $\mu$ m near the raphe to 17–18 in 10  $\mu$ m close to the valve margin.

**Lectotype** Slide III-01-B4, Van Heurck Diatom Collection, National Botanic Garden of Belgium (BR), Meise, Belgium. Lectotype specimen illustrated in Figure 26.

**Type locality** Surface sediment (*sondage*), 625 m deep, sample Nr 9 (64°25' S, 62°02' W), Gerlache Strait, Antarctic Peninsula, 1897–1899 Belgian Antarctic Expedition.

**Distribution** Gerlache Strait, Antarctic Peninsula (Table 2).

#### Description of *Cocconeis antiqua* Tempère et Brun

In view of the morphological similarities among *Cocconeis* taxa described by Van Heurck (1909) and later synonymizations proposed by some authors (De Stefano and Romero 2005), the type material of *Cocconeis antiqua* was also studied.

#### *Cocconeis antiqua* Tempère et Brun Figures 30–35

**Reference** Brun and Tempère 1889, p. 32, pl. 8, fig. 5.

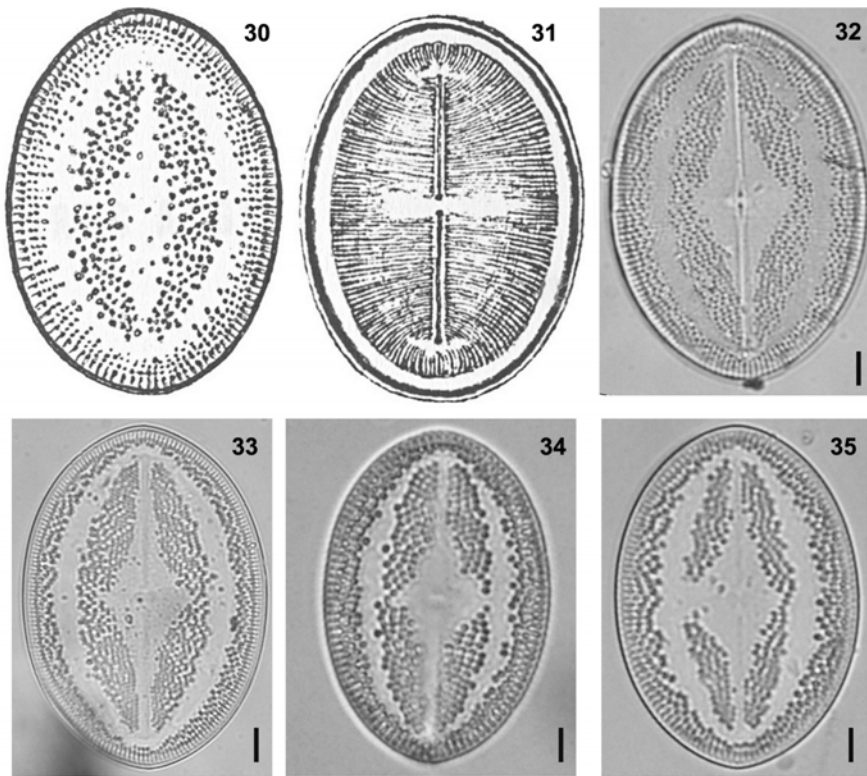
**Description** Only a few valves of the type material of *Cocconeis antiqua* were retrieved and examined by light microscopy (Figures 32–35). The SV is concave along the apical axis and falls into a convex mantle. As in the SV of *C. antiqua* var. *tenuistriata*, *C. gautierii* var. *gautierii* and var. *inornata*, and *C. japonica* var. *antarctica*, two lunate hyaline areas separate the valve face and the mantle. The radiate striae of the SV are uniseriate and slightly decrease in density from the centre to the margin. The RSV is externally convex and the mantle is concave. The RSV has a straight raphe with approximate and co-axial central endings and distal endings terminating in crescent-shaped terminal areas located at some distance from the valve apices. Striae are uniseriate and radiate, varying from (11) 12–16 in 10  $\mu$ m near the raphe-sternum to 9–14 in 10  $\mu$ m close to the valve

margin. This species was described from fossil material collected in Sendaï and Yedo, Japan (Brun and Tempère 1889).

#### Discussion

The main characteristics common to the eight *Cocconeis* taxa described by Van Heurck (1909) from collections made during the 1897–1899 Belgian Antarctic Expedition are the well-silicified sternum valves, which usually have a large hyaline area along the apical axis, more or less apically lenticular in shape, and another narrow hyaline area at mid-distance between the apical axis and the margin, sometimes merging with the median lenticular area on one or both sides. The few raphe-sternum valves studied are less silicified than the sternum valves and have delicate, uniseriate striae, unilateral, sub-circular hyaline area on one side of the mid-valve, and crescent-shaped terminal hyaline areas. Although Van Heurck (1909) did not report frustules with both valves still attached together, he assigned all specimens to the monoraphid diatom genus *Cocconeis* Ehrenberg. In this regard, most of his original descriptions of these *Cocconeis* taxa were incomplete, because he depicted only the SV (*C. antiqua* var. *tenuistriata*, *C. gautierii* var. *gautierii* and var. *inornata*, *C. japonica* var. *antarctica*) or the RSV (*C. heydrichii*, *C. litigiosa*, and *C. schuettii* var. *schuettii* and var. *minor*).

Few records have reported the occurrence of Van Heurck's *Cocconeis* taxa from other Antarctic locations. During the second French Antarctic Expedition, Peragallo (1921) reported 23 *Cocconeis* taxa including one new species and several new varieties, and two nomenclatural changes to a varietal status of two species described by Van Heurck (1909). However, he did not provide illustrations for three new varieties of *C. gautierii*: var. *craticula*, var. *maxima* and var. *minor*. He further questioned the separation of *C. gautierii* from *C. schuettii* but he refrained from reuniting them, noting, however, that the striae in the mid-valve of *C. gautierii* build wavy longitudinal rows that are not present in *C. schuettii*. Interestingly, VanLandingham (1968) listed *C. gautierii* var. *craticula* as a synonym of *C. gautierii* var. *gautierii*, while



**Figures 30–35** Line drawings and type material of *Cocconeis antiqua* in LM.

AA, apical axis; TA, transapical axis. (30 and 31) Original line drawings (30, AA: 78  $\mu\text{m}$ , TA: 55  $\mu\text{m}$ ; 31, AA: 77, TA: 57). (32–35) Type material, Sendai, Japan. (32) Frustule, focus on sternum valve, 100 $\times$ . (33–35) Sternum valves, 100 $\times$ . The sternum valve in Figures 33 and 34 best resembles those originally drawn by Brun and Tempère (1889) and reproduced here in Figure 30. Scale bars=10  $\mu\text{m}$ .

he considered both var. *maxima* and var. *minor* to be synonyms of *C. antiqua* var. *tenuistriata*, without further explanation.

Later when surveying the marine phytoplankton of the Antarctic Peninsula, Frenguelli and Orlando (1958) reported the occurrence of 18 *Cocconeis* taxa, including five of eight Van Heurck taxa. They presented a more conservative taxonomic approach than that of Peragallo (1921). In particular, they disagreed with the morphological similarity between *C. gautierii* and *C. schuettii* noted by Peragallo (1921), who probably misidentified *C. schuettii* as *C. gautierii*. In addition, Frenguelli and Orlando (1958) disagreed with Van Heurck's *C. japonica* var. *antarctica*, preferring to raise it to the species level as *C. antarctica* (Van Heurck) Frenguelli et Orlando, while they considered *C. litigiosa* as an distinct taxon from *C. schuettii* var. *schuettii* and var. *minor*.

A few years later when studying the marine diatoms from Adélie Land, Manguin (1960) described nine *Cocconeis* taxa, including three new taxonomic entities. Generally agreeing with the nomenclatural position of Peragallo (1921) on *Cocconeis*, Manguin (1960) conserved the varietal status of *C. schuettii* var. *litigiosa* (Van Heurck) M. Peragallo, as previously suggested by Peragallo (1921), and synonymized both *C. gautierii* var. *gautierii* and var. *craticula* under *C. schuettii* var. *craticula* (M. Peragallo) Manguin, and *C. japonica* var. *antarctica* under *C. schuettii* var. *minor*. As originally reported by Van Heurck (1909), Manguin (1960) also recorded the presence of an asymmetrical central area

in the RSV of *C. schuettii* var. *litigiosa*, more extended on one hemivalve, with a crescentic hyaline areas closely located to the terminal nodules.

In a survey of Antarctic marine diatoms, Scott and Thomas (2005) listed *Cocconeis gautierii*, *C. litigiosa* and *C. schuettii* var. *minor* and var. *litigiosa* as synonyms of *C. schuettii* without supporting evidence. They presented scanning electron micrographs of *C. schuettii* that closely resemble those of *C. antiqua* published by De Stefano and Romero (2005). Based on overall morphology, De Stefano and Romero (2005) suggested that *C. schuettii* might possibly be considered a synonym of *C. antiqua*. Although *C. antiqua* was described 20 years earlier than the first Antarctic *Cocconeis* taxa described by Van Heurck (1909), there has been no discussion of morphological similarities among these taxa (Peragallo 1921, Frenguelli and Orlando 1958, Manguin 1960). This is still the case, even though several *Cocconeis* taxon names have been reduced to synonymy of *C. antiqua* (VanLandingham 1968, De Stefano and Romero 2005).

#### **Nomenclatural position on Van Heurck's *Cocconeis* taxa from Antarctica**

A main challenge with monoraphid *Cocconeis* taxonomy is the difficulty of retrieving both valves still attached to the frustule. This was also true for most of the Van Heurck's



**Table 3** Morphometric data for the original Van Heurck's *Cocconeis* taxa and *Cocconeis antiqua* examined in light microscopy.

| Taxon                                      | n  | AA ( $\mu\text{m}$ ) | TA ( $\mu\text{m}$ ) | SV striae in<br>10 $\mu\text{m}$ | RSV striae in<br>10 $\mu\text{m}$ |
|--|----|----------------------|----------------------|----------------------------------|-----------------------------------|
| <i>C. antiqua</i> var. <i>tenuistriata</i> | 19 | 78.5–120             | 47.0–67.3            | 12–15*<br>13–16**                | nd                                |
| <i>C. gautierii</i> var. <i>gautierii</i>  | 45 | 61.5–111             | 42.3–90.1            | 13–15                            | nd                                |
| <i>C. gautierii</i> var. <i>inornata</i>   | 23 | 62.0–111             | 44.9–73.1            | 13–14*<br>14–15**                | nd                                |
| <i>C. heydrichii</i>                       | 1  | 125.2                | 77.8                 | nd                               | 19–20*<br>17–18**                 |
| <i>C. japonica</i> var. <i>antarctica</i>  | 22 | 53.4–101             | 32.5–79.1            | 15–19 (21)                       | nd                                |
| <i>C. litigiosa</i>                        | 45 | 55.1–110             | 35.0–85.5            | nd                               | (11) 12–16*<br>9–14**             |
| <i>C. schuettii</i> var. <i>schuettii</i>  | 1  | 110                  | 73.1                 | nd                               | 13–14*<br>17–18**                 |
| <i>C. schuettii</i> var. <i>minor</i>      | 16 | 73.3–116             | 47.0–80.8            | nd                               | 13*<br>17–18**                    |
| <i>C. antiqua</i>                          | 4  | 95.3–106             | 64.3–75.0            | 9–10*<br>10–12**                 | (11) 12–16*<br>9–14**             |

\*Striae measured at valve centre; \*\*striae measured at valve margin. AA, apical axis; n, number of specimens examined; nd, not detected; RSV, raphe-sternum valve; SV, sternum valve; TA, transapical axis.

type material from the Belgian Antarctic Expedition, where in virtually all cases, only SV or RSV were present on slides. Unfortunately, samples of the type material used by Van Heurck (1909) to prepare the permanent slide collection were not found at the National Botanic Garden of Belgium. They were probably misplaced, or perhaps lost, during the move of the Van Heurck Diatom Collection material from its original location in Antwerp to current repository at BR in Meise (B. Van de Vijver, personal communication). The absence of raw samples prevents a detailed electron microscopic examination of the type material of these *Cocconeis* taxa described by Van Heurck (1909).

Without additional electron microscopy observations, light microscopic observations suggest that the overall morphology of *Cocconeis gautierii* var. *gautierii* (Figures 13–15) and var. *inornata* (Figures 16–18) closely resemble that of *C. antiqua* (Figures 30–35) (Table 3). The main valve features shared by these three *Cocconeis* taxa are the presence of a broad hyaline area, which is more or less apically lenticular in shape, another narrow hyaline area at mid-distance between the apical axis and the margin, sometimes merging with the median lenticular area on one or both sides, and the presence of siliceous outgrowths, randomly disposed on the hyaline areas. The obvious difference in the size of the valve outgrowths, which are larger in *C. gautierii* var. *gautierii* than in var. *inornata* (Figures 14, 18) may reflect a difference in the degree of valve silicification.

*Cocconeis litigiosa* (Figures 24, 25) resembles *C. schuettii* (Figures 27–29). Both taxa share the presence of a narrow hyaline area at the apex associated with a convexity located mid-way between the sternum and the valve margin, and a unilateral, sub-circular area and a narrow, elongate area on the opposite side. The morphological differences between *C. schuettii* var. *minor* (Figure 26) and the nominate variety (Figures 27–29) are meaningless (Table 3). The overall valve features and the morphometric data for *C. litigiosa* and

*C. schuettii* var. *schuettii* and var. *minor* agree well with those of *C. antiqua*. Therefore, the following synonyms are proposed under *Cocconeis antiqua*:

*Cocconeis gautierii* var. *gautierii* Van Heurck 1909.

*Cocconeis gautierii* var. *inornata* Van Heurck 1909.

*Cocconeis litigiosa* Van Heurck 1909.

*Cocconeis schuettii* var. *schuettii* Van Heurck 1909.

*Cocconeis schuettii* var. *minor* Van Heurck 1909.

The taxonomic situation is less conclusive for *Cocconeis antiqua* var. *tenuistriata* (Figures 10–12) and *C. japonica* var. *antarctica* (Figures 19–22). Van Heurck (1909) defined *C. japonica* var. *antarctica* based only on the SV. Although the valve features and morphometric data for *C. japonica* var. *antarctica* resemble those of the other *Cocconeis* taxa discussed above, the striae density is slightly higher than those in all other *Cocconeis* taxa defined by Van Heurck (Table 3). Therefore, based on the present observations, I propose keeping *C. japonica* var. *antarctica* as a distinct variety, as originally proposed by Van Heurck (1909). Similarly, no SV attached to RSV of *C. heydrichii* (Figure 23) was observed, and I propose maintaining *C. heydrichii* as a valid species until additional observations are obtained.

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